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THE

MINERAL INDUSTRY

ITS

STATISTICS, TECHNOLOGY & TRADE

1903

ISSUED ANNUALLY

The
MINERAL INDUSTRY

ITS STATISTICS, TECHNOLOGY AND TRADE

IN THE UNITED STATES AND OTHER COUNTRIES

AN annual technical encyclopedia, incorporating the most recent developments and advances evolved in the mining and metallurgical world. Embracing the latest sta

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THE MINERAL INDUSTRY

ITS

STATISTICS, TECHNOLOGY AND TRADE

IN THE

UNITED STATES AND OTHER COUNTRIES

TO THE END OF

1902

FOUNDED BY THE LATE

RICHARD P. ROTHWELL

EDITED BY

JOSEPH STRUTHERS, PH.D

VOL. XI

SUPPLEMENTING VOLUMES I TO X

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25·4000	0·304801	0·914402	1·60935	= 1 =	3·70	29·57	0·94636	3·78544	16·387	0·02832	0·765	0·35242
50·8001	0·609601	1·828804	3·21869	= 2 =	7·39	59·15	1·89272	7·57088	32·774	0·05663	1·529	0·70485
76·2001	0·914402	2·743205	4·82804	= 3 =	11·09	88·72	2·83908	11·35632	49·161	0·08495	2·294	1·05727
101·6002	1·219202	3·657607	6·43739	= 4 =	14·79	118·30	3·78544	15·14176	65·549	0·11327	3·058	1·40969
127·0002	1·524003	4·572009	8·04674	= 5 =	18·48	147·87	4·73180	18·92720	81·936	0·14158	3·823	1·76211
152·4003	1·828804	5·486411	9·65608	= 6 =	22·18	177·44	5·67816	22·71264	98·323	0·16990	4·587	2·11454
177·8003	2·133604	6·400813	11·26543	= 7 =	25·88	207·02	6·62452	26·49808	114·710	0·19822	5·352	2·46696
203·2004	2·438405	7·315215	12·87478	= 8 =	29·57	236·59	7·57088	30·28352	131·097	0·22654	6·116	2·81938
228·6004	2·743205	8·229616	14·48412	= 9 =	33·28	266·16	8·51724	34·06896	147·484	0·25485	6·881	3·17181

SQUARE.					WEIGHT.			
Square Inches to Square Centimeters.	Square Feet to Square Decimeters.	Square Yards to Square Meters.	Acres to Hectares.		Grains to Milligrams.	Avoirdupois Ounces to Grams.	Avoirdupois Pound to Kilograms.	Troy Ounces to Grams.
6·452	9·290	0·836	0·4047	=1=	64·7989	28·3495	0·45359	31·10348
12·903	18·581	1·672	0·8094	=2=	129·5978	56·6991	0·90719	62·20696
19·355	27·871	2·508	1·2141	=3=	194·3968	85·0486	1·36078	93·31044
25·807	37·161	3·344	1·6187	=4=	259·1957	113·3981	1·81437	124·41392
32·258	46·452	4·181	2·0234	=5=	323·9946	141·7476	2·26796	155·51740
38·710	55·742	5·017	2·4281	=6=	388·7935	170·0972	2·72156	186·62089
45·161	65·032	5·853	2·8328	=7=	453·5924	198·4467	3·17515	217·72437
51·613	74·323	6·689	3·2375	=8=	518·3914	226·7962	3·62874	248·82785
58·065	83·613	7·525	3·6422	=9=	583·1903	255·1457	4·08233	279·93133

1 chain	=	20·1169	meters.
1 square mile	=	259	hectares.
1 fathom	=	1·829	meters.
1 nautical mile	=	1853·27	meters.
1 foot = 0·304801 meter,		9·4840158	log.
1 avoir, pound	=	453·5924277	gram.
15432·35639 grains	=	1	kilogram.

TABLES FOR CONVERTING METRIC TO UNITED STATES WEIGHTS AND MEASURES.

LINEAR.					CAPACITY.							
Meters to Inches.	Meters to Feet.	Meters to Yards.	Kilometers to Miles.		Milliliters or Cubic Centiliters to Fluid Drams.	Centiliters to Fluid Ounces.	Liters to Quarts.	Dekaliters to Gallons.	Hectoliters to Bushels.	Cubic Centimeters to Cubic Inches.	Cubic Meters to Cubic Feet.	Cubic Meters to Cubic Yards.
39·3700	3·28083	1·093611	0·62137	= 1 =	0·27	0·338	1·0567	2·6417	2·8375	0·0610	35·314	1·308
78·7400	6·56167	2·187222	1·24274	= 2 =	0·54	0·076	2·1134	5·2834	5·6750	0·1220	70·629	2·616
118·1100	9·84250	3·280833	1·86411	= 3 =	0·81	1·014	3·1700	7·9251	8·5125	0·1831	105·943	3·924
157·4800	13·12333	4·374444	2·48548	= 4 =	1·08	1·352	4·2267	10·5668	11·3500	0·2441	141·258	5·232
196·8500	16·40117	5·468056	3·10685	= 5 =	1·35	1·691	5·2834	13·2085	14·1875	0·3051	176·572	6·540
236·2200	19·68500	6·561667	3·72822	= 6 =	1·62	2·029	6·3401	15·8502	17·0250	0·3661	211·887	7·848
275·5900	22·96583	7·655278	4·34959	= 7 =	1·89	2·368	7·3968	18·4919	19·8625	0·4272	247·201	9·156
314·9600	26·24667	8·748889	4·97096	= 8 =	2·16	2·706	8·4534	21·1336	22·7000	0·4882	282·516	10·464
354·3300	29·52750	9·842500	5·59233	= 9 =	2·43	3·043	9·5101	23·7753	25·5375	0·5492	317·830	11·771

SQUARE.					WEIGHT.			
Square Centimeters to Square Inches.	Square Meters to Square Feet.	Square Meters to Square Yards.	Hectares to Acres.		Kilograms to Grains.	Hectograms to Ounces Avoirdupois.	Kilograms to Pounds Avoirdupois.	Grams to Ounces Troy.
0·1550	10·764	1·196	2·471	= 1 =	15432·36	3·5274	2·20462	0·03215
0·3100	21·528	2·392	4·942	= 2 =	30864·71	7·0548	4·40924	0·06430
0·4650	32·292	3·588	7·413	= 3 =	46297·07	10·5822	6·61386	0·09645
0·6200	43·055	4·784	9·884	= 4 =	61729·43	14·1096	8·81849	0·12860
0·7750	53·819	5·980	12·355	= 5 =	77161·78	17·6370	11·02311	0·16075
0·9350	64·583	7·176	14·826	= 6 =	92594·14	21·1644	13·22773	0·19290
1·0850	75·347	8·372	17·297	= 7 =	108026·49	24·6918	15·43235	0·22505
1·2400	86·111	9·568	19·768	= 8 =	123458·85	28·2192	17·63697	0·25721
1·3950	96·874	10·764	22·2	= 9 =	138891·21	31·7466	19·84159	0·28936

The only material standard of customary length authorized by the U. S. Government is the Troughton scale, whose length at 59°.62 Fahr. conforms to the British standard. The yard in use in the United States is therefore equal to the British yard.

The only authorized material standard of customary weight is the Troy pound (5,760 grains) of the Mint. It is of brass of unknown density, and therefore not suitable for a standard of mass. It was derived from the British standard Troy pound of 1758 by direct comparison. The British avoirdupois pound was also derived from the latter, and contains 7,000 grains troy.

The grain Troy is therefore the same as the grain avoirdupois, and the pound avoirdupois in use in the United States is equal to the British pound avoirdupois.

The British gallon = 4·54346 liters.

The British bushel = 36·3477 liters.

By the concurrent action of the principal Governments of the world an International Bureau of Weights and Measures has been established near Paris. Under the direction of the International Committee, two ingots were cast of pure platinum-iridium in the proportion of 9 parts of the former to 1 of the latter metal. From one of these a certain number of kilograms were prepared, from the other a definite number of meter bars. These standards of weight and length were intercompared, without preference, and certain ones were selected as International prototype standards. The others were distributed by lot to the different Governments and are called National prototype standards.

The metric system was legalized in the United States in 1866.

The International Standard Meter is derived from the Metre des Archives, and its length is defined by the distance between two lines at 0° Centigrade, on a platinum-iridium bar deposited at the International Bureau of Weights and Measures.

The International Standard Kilogram is a mass of platinum-iridium deposited at the same place, and its weight *in vacuo* is the same as that of the Kilogramme des Archives.

The liter is equal to a cubic decimeter of water, and it is measured by the quantity of distilled water which, at its maximum density, will counterpoise the standard kilogram in a vacuum, the volume of such a quantity of water being, as nearly as has been ascertained, equal to a cubic decimeter.

Long ton: 2240 lb. avoirdupois = 1016 kilogram.
Short ton: 2000 " " = 907·2 "
Pound avoirdupois = 453·6 grams.
Flask of Mercury=76·5 lb. avoir. = 34·7 kilograms.
Troy ounce = 31·104 grams.
Gallon = 3·785 liters.

Barrel of petroleum = 42 gal. = 1·59 hectoliter.
" " salt = 280 lb. = 127 kilogram.
" " lime = 200 " = 90·720 "
" " natural cement = 300 " = 136·080 "
" " Portland cement = 400 " = 181·440 "
Gold coining value per oz. Troy $20·6718=$0·6646 per gram.
Silver " " " Troy $1·2929=$0·04157 "

OFFICIAL UNITED STATES VALUES OF FOREIGN COINS, JANUARY 1, 1908.

Country.	Standard.	Unit.	Value in U. S. Gold.	Coins.
			cts.	
Argentina.	Gold	Peso	96·5	Gold: argentine ($4·824) and ½ argentine. Silver: peso and divisions.
Austria-Hungary	Gold	Crown	20·3	Gold: former system—4 florins ($1·929), 8 florins ($3·858), ducat ($2·287), and 4 ducats ($9·149). Silver: 1 and 2 florins. Present system—Gold: 20 crowns ($4·052) and 10 crowns ($2·026).
Belgium	Gold	Franc	19·3	Gold: 10 and 20 francs. Silver: 5 francs.
Bolivia	Silver	Boliviano	36·1	Silver: boliviano and divisions.
Brazil	Gold	Milreis	54·6	Gold: 5, 10, and 20 milreis. Silver: ½, 1, and 2 milreis.
Canada	Gold	Dollar	100·0	
Central America				
Costa Rica	Gold	Colon	46·5	Gold: 2, 5, 10, and 20 colons ($9·307). Silver: 5, 10, 25, and 50 centimos.
British Honduras	Gold	Dollar	100·0	
Guatemala	Silver	Peso	36·1	Silver: peso and divisions.
Honduras				
Nicaragua				
Salvador				
Chile	Gold	Peso	36·5	Gold: escudo ($1·825), doubloon ($3·650), and condor ($7·300). Silver: peso and divisions.
China	Silver	Tael*	59·4	
Colombia	Silver	Peso	36·1	Gold: condor ($9·647) and double condor. Silver: peso.
Cuba	Gold	Peso	92·6	Gold: doubloon Isabella, centem ($5·017). Alphonse ($4·823). Silver: peso.
Denmark	Gold	Crown	26·8	Gold: 10 and 20 crowns.
Ecuador	Gold	Sucre	48·7	Gold: 10 sucres ($4·8665). Silver: sucre and divisions.
Egypt	Gold	Pound	494·3	Gold: pound (100 piasters), 5, 10, 20, and 50 piasters. Silver: 1, 2 5, 10 and 20 piasters.
Finland	Gold	Mark	19·3	Gold: 20 marks ($3·859), 10 marks ($1·93).
France	Gold	Franc	19·3	Gold: 5, 10, 20, 50, and 100 francs. Silver: 5 francs.
German Empire	Gold	Mark	23·8	Gold: 5, 10, and 20 marks.
Greece	Gold	Drachma	19·3	Gold: 5, 10, 20, 50 and 100 drachmas. Silver: 5 drachmas.
Haiti	Gold	Gourde	96·5	Gold: 1, 2, 5 and 10 gourdes. Silver: gourde and divisions.
India	Gold	Pound †	486·65	Gold: sovereign (pound sterling). Silver: rupee and divisions.
Italy	Gold	Lira	19·3	Gold: 5, 10, 20, 50 and 100 lire. Silver: 5 lire.
Japan	Gold	Yen	49·8	Gold: 5, 10, and 20 yen. Silver: 10, 20, and 50 sen.
Liberia	Gold	Dollar	100·0	
Mexico	Silver	Dollar	39·2	Gold: dollar ($0·983), 2½, 5, 10, and 20 dollars. Silver: dollar (or peso) and divisions.
Netherlands	Gold	Florin	40·2	Gold: 10 florins. Silver: ½, 1, and 2½ florins.
Newfoundland	Gold	Dollar	101·4	Gold: 2 dollars ($2·027).
Norway	Gold	Crown	26·8	Gold: 10 and 20 crowns.
Persia	Silver	Kran	6·6	Gold: ⅕, 1 and 2 tomans ($3·409). Silver: ¼, ½, 1, 2 and 5 krans.
Peru	Gold	Sol	48·7	Gold: libra ($4·8665). Silver: sol and divisions.
Portugal	Gold	Milreis	108·0	Gold: 1, 2, 5, and 10 milreis.
Russia	Gold	Ruble	51·5	Gold: imperial 15 rubles ($7·718) and ½ imperial, 7½ rubles ($3·859). Silver: ¼, ½, and 1 ruble.
Spain	Gold	Peseta	19·3	Gold: 25 pesetas. Silver: 5 pesetas.
Sweden	Gold	Crown	26·8	Gold: 10 and 20 crowns.
Switzerland	Gold	Franc	19·3	Gold: 5, 10, 20, 50 and 100 francs. Silver: 5 francs.
Turkey	Gold	Piaster	4·4	Gold: 25, 50, 100, 250, and 500 piasters.
United Kingdom	Gold	Pound	486·65	Gold: sovereign (pound sterling) and ½ sovereign.
Uruguay	Gold	Peso	103·4	Gold: peso. Silver: peso and divisions.
Venezuela	Gold	Bolivar	19·3	Gold: 5, 10, 20, 50, and 100 bolivars. Silver: 5 bolivars.

* **Haikwan (Customs).** † The sovereign is the standard coin of India, but the rupee ($0·324) is the money of account, current at 15 to the sovereign.

Fac-simile of the Gold Medal Awarded to The Mineral Industry
by the
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in recognition of
Its Services to the World's Industry and Commerce.

JOSEPH STRUTHERS.

CONTRIBUTORS.

It is impossible to name here all who have aided us in the collection of statistics and other information for the present volume, but we give in the following pages brief biographies of the most of those who have contributed special articles, in order that readers may appreciate the high professional standing of those who have assisted in the work.

Besides the contributors of special articles, however, the preparation of this volume has been aided by the courteous co-operation of many thousands of producers who have furnished statistics of their output, and by many persons prominent in various branches of the mineral industry who have given special information. Exceedingly valuable assistance has been furnished also by the officials of many railways in the United States and Mexico, and by the State geologists, commissioners of mines, and inspectors of mines in most of the States of the Union. The statisticians of foreign countries have been extremely courteous in their co-operation, by furnishing copies of their latest publications, often in manuscripts. Professional men and experts of the whole world have rendered exceedingly valuable assistance, as have also the officials of the United States Government at Washington and abroad, and have added greatly to the value of this work. Among the thousands who have thus aided us, and by their assistance made possible the publication of this volume, as well as its predecessors, it would be invidious to select names, and in making such an attempt we should not know where to draw the line, since the contributions of almost all have been indispensable. Consequently we have decided to limit ourselves to this general acknowledgment, relying upon the belief that each of our friends will feel amply repaid for his work in the knowledge that he has contributed to the preparation of a volume which is everywhere recognized to be of the highest value to the mineral industry of the world. This high appreciation has been generously and delicately expressed by the French "Société d'Encouragement pour l'Industrie Nationale," which, since the appearance of Vol. VI., has granted to THE MINERAL INDUSTRY and its founder, the magnificent gold medal of the society, which is voted to the work or the author of the work, which, during the six preceding years, has contributed most to the cause of the national industry.

ARGALL, PHILIP, was born in 1854, near Belfast, Ireland, and gained his first experience in mining at the Wicklow copper mines of that island. Since then he has been engaged in important mining and metallurgical work in Wales, England, France, New Zealand, Mexico, and elsewhere. He came to the United States early in 1887 as manager of La Plata Mining & Smelting Co., of Leadville, Colo. During the last nine years Mr. Argall has devoted his attention to the treatment of ores by the cyanide process, and has taken a leading position in this field. He designed the works of the Metallic Extraction Co., at Cyanide, Colo., in 1895, and managed them until February, 1901, when he resigned to resume the practice of consulting mining and metallurgical engineer. His success in the treatment of telluride ores are on a large scale, has commanded much attention in metallurgical circles. For THE MINERAL INDUSTRY, Volume VI., he wrote an article on "Cyaniding Telluride Ores," which is recognized as the most authoritative discussion of this subject published. To the present volume Mr. Argall contributes the paper "Cyaniding Sulpho-Telluride Ores."

CAMPBELL, WILLIAM, entered the University of Durham College of Science, England, in October, 1895, with a Yorkshire County Council scholarship. In September, 1896, was made a corporation exhibitioner. In June, 1897, obtained the title of A. Sc., and the following year the degree of B. Sc. (honors). During 1898-9 acted as instructor in metallurgy and lecturer in geology. In June, 1899, the Royal Commissioners for the exhibition of 1851 awarded him a scholarship for scientific research. Entered the Royal School of Mines, London, October of same year. Scholarship renewed for a second year to continue research under Sir William Roberts-Austen, and renewed June, 1901, for an exceptional third year to work under Prof. H. M. Howe at Columbia University. October, 1901, post-graduate work in metallurgy. Carnegie scholar of Iron and Steel Institute, May, 1902; University Fellow in Metallurgy, June, 1902; M. Sc. Durham University, June, 1903. To the present volume he contributes the paper "Progress of Metallography in 1902."

Douglas, James, was born in Canada, but has made his home in the United States since 1875. His first experience in mining and metallurgy was acquired in trying to unravel the complicated affairs of an unsuccessful Canadian mining enterprise. He came to the States in order to take charge of copper works established in Phœnixville, Pa., for the utilization of local copper ores, whose supply, however, proved deficient; but he is best known through his connection with the copper industry of Arizona and Northern Sonora, with which he has been intimately associated almost since its initiation. He is a past president of the American Institute of Mining Engineers and president of the Copper Queen Consolidated Mining Co., of other Arizona and Mexican concerns, including the El Paso and Southwestern Railroad and the Nacazari Railroad. Such original work as he has done was chiefly in connection with the late eminent chemist, Dr. T. Sterry Hunt, in the field of the hydrometallurgy of copper. Mr. Douglas has contributed to the present volume the notes on the copper industry in Arizona.

Dow, Allan W., was graduated from the course of analytical and applied chemistry of the School of Mines, Columbia College (now Columbia University), New York, N. Y., receiving the degree of Ph. B. in the year 1888. He spent one year studying in the quantitative laboratory of the university, and in 1889 accepted the position of first assistant chemist in the laboratory of the Barber Asphalt Paving Co. in New York City. This position he held until the year 1894, when he was appointed inspector of asphalt and cements for the District of Columbia by the United States Government, which position he still holds. Besides his work for the Government, he has a private practice as specialist on oils, bitumens and bituminous paving construction. He has written several articles pertaining to hydraulic cements, bitumens and bituminous paving, and to the present volume he has contributed the paper "Petroleum and Maltha Products Used in the Paving Industry."

Dvorkovitz, Paul, in 1877-78 was appointed sanitary chemist to the hospital of the Princess of Oldeburg in the Russo-Turkish war. Afterward he studied chemistry at the University of Moscow, and in 1883 he took the position of technical manager of an oil refinery at Baku. There he discovered a method of utilizing the soda and acid by-products obtained in course of refining, and invented a special still for continuous distillation. Later, in England, Mr. Dvorkovitz worked to develop the use of solar oil for enriching water gas, and invented an apparatus for gasifying oil and producing aromatic hydrocarbons. Five years ago he built for the Mineral Oils Corporation in London the first refinery in England, and prepared all the plans for another large refinery erected by the Shell Transport & Trading Co., Ltd., in Borneo. In 1899, he started the *Petroleum Review*. In August, 1900, Mr. Dvorkovitz was instrumental in forming the petroleum congress in Paris, which resulted in the establishing of a permanent commission for organizing international petroleum congresses every two years in the future, with a central committee in Paris, and local committees all over the world. In 1901 he founded the Petroleum Institute in London. Mr. Dvorkovitz contributes to this volume the paper, "Petroleum in Foreign Countries during 1902."

Eckel, Edwin C., was graduated from the School of Civil Engineering, New York University, in 1896, and supplemented his college work with a post-graduate course in geology under Prof. J. J. Stevenson. In 1899 he became connected with the New York State Museum, receiving an appointment as Assistant in Geology in 1900. While holding this position, Mr. Eckel published reports on the cements of New York State, on the quarry industry, the emery deposits, and on several minor economic products. In 1902 Mr. Eckel received an appointment on the U. S. Geological Survey, and has reported on the Mississippi and Tennessee clays, Virginia salt and gypsum, and other mineral products. In addition to this work in economic geology, Mr. Eckel has published a number of papers on various phases of cement technology and slag utilization. Mr. Eckel is a member of the American Society of Civil Engineers, and of the Society of Chemical Industry, and to the present volume he contributes the articles on "The Manufacture of Mineral Wool" and "Slag Cement and Slag Brick Manufacture during 1902."

FALDING, F. J., was born in England and was educated at Amersham Hall, London, and at the Bergakademie at Freiberg in Saxony, although he did not graduate from the latter. In 1878-79 he made a study of the Canadian apatite deposits, and in 1880 returned to Europe, where he studied the manufacture of sulphuric acid and fertilizers in England and Germany. In 1881 he returned to Canada and unwatered the Capelton pyrites mines, now worked by the Nichols Chemical Co. From 1882 to 1886 he practiced as a mining engineer, with headquarters in New York, making a specialty of pyrites and phosphate mining. In 1888 he entered the employ of the Grasselli Chemical Co. as engineer, in charge of its mines, becoming in 1890 the chief engineer. During this time he designed the company's new works at East Chicago, Ill. In 1889 he was one of the charter members and first directors of the Canadian Institute of Mining Engineers. In 1895 he established himself in New York as a consulting chemical engineer, since when he has constructed and rebuilt many sulphuric acid plants in various parts of the United States. He contributes to this volume the paper, "Progress in the Sulphuric Acid Industry in the United States during 1902."

FISHER, HENRY, was graduated in 1895 from the College of the City of New York, and in 1899 from the School of Chemistry, Columbia University, receiving the degree of B. S. from both institutions. For one year after his graduation, he was assistant in the department of analytical chemistry and assaying at Columbia University, and then was chemist for Ricketts & Banks, New York. He is a member of the American Chemical Society and of the Society of Chemical Industry. Mr. Fisher has been assistant on the editorial staff of the present volume.

FOWLER, SAMUEL S., born in New York, 1860, was educated at Columbia College (now Columbia University) and graduated from the School of Mines with the degree of E. M. in 1884. After his graduation he was engaged for two years in civil engineering work in New York and vicinity. In 1886 he was connected with the Iron Hill Mining and Milling Company at Black Hills, Dak., and from 1887 to 1889 he was engaged in smelting works in Texas and Idaho. In 1889 he went to British Columbia, and since 1896 he has been affiliated with the London and British Columbia Goldfields, Whitewater Mines, Ltd., Ymir Gold Miles, Ltd., and Enterprise Mines. To the present volume Mr. Fowler has contributed notes on gold, silver, lead and copper mining in British Columbia.

FULTON, CHARLES H., educated in the Brooklyn public schools, Pratt Institute Technical High School, and the School of Mines, Columbia University, graduating from this latter institution with the degree of mining engineer in 1897. He has been assistant in assaying in the School of Mines, Columbia University, assayer and superintendent of a gold mine and cyanide mill in Colorado, and instructor in mining and metallurgy in the University of Wyoming for a year. For the last three years he has been professor of mining and metallurgy in the South Dakota State School of Mines, and has had a private practice as mining and metallurgical engineer. Mr. Fulton has written for the technical press on metallurgical subjects, and to the present volume contributes "A Review of the Cyanide Process in the Year 1902."

HAMMON, W. H., was born in 1860. He was graduated at Allegheny College, Meadville, Pa., in 1881, and afterwards spent one year in post-graduate work in Columbian University, Washington, D. C., and two years in advance physical and mathematical work at Cornell University, Ithaca, N. Y. In the early eighties he was employed on the engineering corps of the Standard Oil interests in the Bradford and adjacent fields, and was afterward connected with the United States Weather Bureau, serving as observer at Cleveland and St. Louis, and as Forecast Official in St. Louis and San Francisco. In January, 1899, he was appointed professor of meteorology in the Weather Bureau, which position he shortly afterward resigned to accept a position as assistant to the general manager of the Philadelphia Company, at Pittsburg, Pa., which position he has held for the past four years. Mr. Hammon contributes to this volume the paper "The Natural Gas Industry of the United States during 1902."

Hobart, Frederick, A. M., was graduated from the College of the City of New York, and served in the United States Army. He has been connected with the Jersey City Locomotive Works, the Bullock Ore-dressing Machine Co., Jersey City; the Wrigley Machine Works, Newark, N. J.; the Camden & Amboy Railroad, and the Grant Locomotive Works, Paterson, N. J., and has been assistant editor of the *Railroad Gazette*, as well as contributor to various technical periodicals and the translator of "Notes on Steam Hammers, Economies in the Combustion of Fuel," and other technical works. Since 1893, Mr. Hobart has been an associate editor of the *Engineering and Mining Journal*, from the death of Mr. R. P. Rothwell, on April 17, 1901, until the appointment of Dr. David T. Day, and from the period of Dr. Day's resignation until the close of 1902, he had entire charge of the conduct of the paper. Mr. Hobart acted as associate editor of The Mineral Industry, Volumes III. and IV., and to the present volume he contributes the paper on "Iron and Steel," and the reviews of the various metal markets.

Hofman, H. O., was born in 1852 at Heidelberg, Germany. He studied at the Bergakademie at Clausthal, where he graduated in 1877 in mining engineering and metallurgy. He was then appointed chemist and assistant at the smelting and refining works at Lautenthal in the Harz. In 1881 he came to the United States and was employed successively at Mine La Motte, in Missouri, at the Argentine smelting and refining works of the Consolidated Kansas City Smelting & Refining Co., and as metallurgist of the Delaware Lead Co., in Philadelphia. When the last named works were closed he went to Colorado, and after running the Rico smeltery for a short time went to Park City, Utah, to study the amalgamation and lixiviation of silver ores at the Ontario mill. After a short time spent in charge of a smeltery in Mexico he was appointed assistant to Prof. Richards at the Massachusetts Institute of Technology in Boston; from there he went to the School of Mines of South Dakota as professor of metallurgy and assaying, where he remained until called back to the Massachusetts Institute of Technology to the professorship of metallurgy, which he now holds. Dr. Hofman has made numerous contributions to technical literature, his most important work being the admirable treatise on *The Metallurgy of Lead*. For his paper on the "Dry Assay of Tin Ores" the degree of Ph.D. was conferred on him by the University of Ohio. To the present volume he has contributed the article, "Recent Improvements in Lead Smelting."

Huddle, W. J., born in Attica, Ind., in 1878, was graduated from the course of chemistry at Indiana University in 1901, receiving the degree of M.A. in 1903. In 1902 he was engaged by the Western Storage Battery Co., Indianapolis, Ind. From 1902 to 1903 he has been a member of the staff in chemistry at the University of Wisconsin. Mr. Huddle is at present chemist in charge of the by-products recovery plant of the Western Gas Construction Co., Fort Wayne, Ind. To the present volume he contributes the review on "Rare Elements."

Ingalls, Walter Renton, was born at Lynn, Mass., in 1865, and was graduated from the Massachusetts Institute of Technology, in 1886. In 1886-90 he was engaged in mining at Leadville and elsewhere in Colorado. In 1890-92 he was assistant editor of the *Engineering and Mining Journal*, resigning that position to go to Mexico to open tin mines in the State of Durango for the Pittsburg & Mexican Tin Mining Co. In 1893 and 1894 he established himself in New York, and visited professionally various mining districts in the United States, Canada, Belgium, Germany and Poland, devoting himself especially to the metallurgy of zinc. During a part of 1894 he had charge of the operations of the Illinois Phosphate Co., in Florida, and later in the year became connected

WILLIAM CAMPBELL.

PHILIP ARGALL.

JAMES DOUGLAS.

ALLAN W. DOW.

PAUL DVORKOVITZ.

FREDERICK J. FALDING.

EDWIN C. ECKEL.

CHARLES H. FULTON.

SAMUEL S. FOWLER.

WILLIAM H. HAMMON.

HENRY O. HOFMAN.

WALTER RENTON INGALLS.

JOHN B. C. KERSHAW

JAMES F. KEMP.

with the Gold & Silver Extraction Co. of America, Ltd., as metallurgist. In 1895 he was manager of a cyanide works at Cripple Creek, Colo., and in 1896 of copper-matte smelting works in Durango, Mexico, returning to New York in 1897. He was assistant editor of THE MINERAL INDUSTRY, Vols. V., VI. and VII., and is now located in Boston, Mass., as consulting engineer. For this volume he contributes the paper, "A Review of Progress in the Metallurgy of Zinc in 1902."

KEMP, JAMES FURMAN, was born in New York in 1859, and was graduated from Adelphi Academy, Brooklyn, in 1876, from Amherst College in 1881, receiving the degree of A. B., and from the School of Mines, Columbia College (now Columbia University) in 1884 with the degree of E. M. After graduation, he was private assistant to Prof. J. S. Newberry for one year, and then studied at the University of Munich. On his return he became instructor of geology at Cornell University and assistant professor in 1888. In 1891 he was made Adjunct Professor of Geology in Columbia College, and professor in 1892. Professor Kemp has been connected with the New York State and the United States Geological Surveys. He is a member of many scientific societies, vice-president of the American Institute of Mining Engineers, and associate editor of the *Zeitschrift fuer praktische Geologie*. He has also been vice-president of the American Association for the Advancement of Science, and the New York Academy of Science. He is the author of "*Ore Deposits of the United States and Canada*" and "*Handbook of Rocks*," and has been a contributor to all the volumes of THE MINERAL INDUSTRY. To the present volume he contributes "A Review of the General Literature on Ore Deposits during 1901 and 1902."

KERSHAW, JOHN B. C., was born at Southport, Eng., and was educated at Bickerton House School, Southport, and at Owens College, Manchester. In 1879 Mr. Kershaw entered the Sutton Lodge Chemical Works, St. Helens, Eng., and remained there for twelve years, rising in this period to the position of chief chemist and assistant manager. In 1892 Mr. Kershaw went to Germany and pursued his studies of chemistry and allied sciences at Bonn University. Since 1896 he has been engaged in practice as consulting chemist, and as a technical journalist in London and Liverpool and has devoted himself especially to work relating to electrochemical processes and industries. He is a member of several chemical and other societies, and is also on the staff of abstractors for *Science Abstracts*. Mr. Kershaw has written numerous articles in recent years upon electrochemical and electrometallurgical subjects. He is the translator and editor of Dr. Neumann's German work on *Electrolytic Methods of Analysis*, and is at present engaged upon two of the volumes of the series of monographs upon "Angewandte Electro-Chemie," now being published by Knapp & Co., of Halle. To the present volume he contributes the articles, "Progress in the Aluminum Industry in 1902," and the general review of the "Progress in Electrochemistry and Electrometallurgy in 1902."

LEWIS, FREDERICK H., studied civil engineering at the University of Pennsylvania, graduating in 1878. He then became heliotroper on the United States Coast Survey, serving during the summer of 1878, and for three years afterwards was assistant engineer of the construction department of the Pennsylvania Railroad Co.'s lines west of Pittsburg. From 1882 to 1885 he was superintendent of bridges and buildings of the Northern Pacific Railway, being situated at St. Paul, Minn., and he was also in charge of the location of the company's terminal lines between St. Paul and Minneapolis. In 1885 and 1886 he was resident engineer of the South Pennsylvania Railroad, at Sideling Hill tunnel, Fulton County, Pa. From 1886 to 1893 he was an Eastern manager of the Pittsburg Testing Laboratory at Philadelphia. Since 1893 he has been practising as consulting engineer at Philadelphia, and has also been consulting engineer for the firm of Booth, Garrett & Blair, in their department of physical tests and inspection. He is manager and chief engineer of the Virginia Portland Cement Co., and contributes to this volume the paper on "The Mechanical Equipment of a Modern Portland Cement Plant."

MALCOLMSON, JAMES W., was born in 1866, learned the trade of machinist at Woolwich from 1880 to 1885, and obtained a Whitworth Engineering Scholarship in 1886. In 1889 he was graduated in mining from the Associate Royal School of Mines. He then went to Mexico as assistant mining and mechanical engineer for the Michoacan Railway & Mining Co. In 1892 he was engaged by the Consolidated Kansas City Smelting and Refining Co. as mining engineer and ore purchasing agent, becoming assistant manager in 1897. Later he became manager of the mining department in Mexico of the American Smelting & Refining Co. Since 1902 he has been engaged in a general consulting business, acting as engineer for several mines in New Mexico and Mexico, and is at present secretary of the Esmeralda Mining Co. of Santa Eulalia, Chihuahua. He has contributed papers to the transactions of the Institution of Civil Engineers and the American Institute of Mining Engineers. To the present volume he contributes notes on gold, silver, lead and copper mining in Mexico.

MATHEWS, JOHN ALEXANDER, was born in Washington, Pa., May 20, 1872, and was graduated from Washington and Jefferson College in 1893 with the degree of B.Sc. Later he entered Columbia University as a graduate student in chemistry, and received therefrom the degrees of M.A. and Ph.D. He was awarded by Columbia University the University Fellowship in Chemistry in 1897, and the Barnard Fellowship for the Encouragement of Scientific Research in 1900, 1901 and 1902, by the Iron and Steel Institute of Great Britain, the Andrew Carnegie Research Scholarship in 1901, and the honorary degree of Sc. D. from Washington and Jefferson College in 1902. From 1897 to 1900 Dr. Mathews was instructor in the department of chemistry of Columbia University. He resigned in 1900 to follow research work on alloys in the laboratory of the late Prof. Sir William C. Roberts-Austen, London, which has since been continued at Columbia University under Prof. Henry M. Howe. President McKinley appointed Dr. Mathews a member of the United States Assay Commission in 1900, and the first Andrew Carnegie gold medal for research was awarded him by the Iron and Steel Institute in 1902. Dr. Mathews is a member of several societies, and is on the committee for testing the magnetic properties of iron and steel of the American Society for Testing Materials. He has written many scientific articles, and to the present volume he has contributed the paper "Alloy Steels."

MCILHINEY, PARKER C., was born in 1870, at Jersey City, N. J., and in 1892 he was graduated from the School of Mines, Columbia College, in the course of chemistry, receiving in 1894 the degree of Ph.D. for special work in chemistry and physics. From 1894 until 1900 he was connected with the departments of chemistry and metallurgy, Columbia University, and, in addition to general chemical practice he has given considerable time to the manufacture of glass, metal, enamel and pottery art works. Dr. McIlhiney contributes to this volume the paper, "Progress in the Manufacture of White Lead during 1902."

MCKENNA, CHARLES F., was born in New York in 1861, and was educated in arts at St. Francis Xavier College and in science at the School of Mines, Columbia College (now Columbia University), receiving the degree of Ph.B. from the latter institution in 1883, and of Ph.D. in 1894. He is consulting chemist to the Municipal Explosives Commission of New York City, a member of several societies abroad and at home, and is engaged in a general consulting practice. To the present volume Dr. McKenna contributes the review of "The Cement Industry in the United States during 1902."

MEMMINGER, C. GUSTAVUS, was born at Charleston, S. C., in 1864, and began work as mining engineer in the phosphate industry of South Carolina. He took an active part in the mineral development of the South, and when the Florida phosphate deposits were opened he was prominent in the furthering of the new industry there. After building and successfully operating the largest pebble phosphate mining plant in Florida, Mr. Memminger, in 1900, moved to Nashville, Tenn., from whence he removed to Florida in 1901, and is at present actively engaged in the development and mining of phosphates. Mr. Memminger contributes to this volume the paper, "Phosphate Mining Industry of the United States during 1902."

Newland, David H., was graduated from Hamilton College in 1894, and for three years thereafter was a student of geology and related sciences at the Universities of Munich, Heidelberg and Columbia. In 1897 and 1898 he was employed by the State of New York mapping the geology of portions of the Adirondack Mountains, the results of this work appearing in the Eighteenth Annual Report of the State Geologist. He has been engaged from time to time in other geological investigations, particularly in determining the petrographical relations of metamorphosed rocks, and has contributed to scientific journals and other publications. For the past three years Mr. Newland has been connected with the editorial staff of The Mineral Industry.

Nicholson, Frank, born in Dallas, Texas, in 1860, was graduated from the School of Mines, Washington University, St. Louis, in 1880, with the degree of M.E., and in 1883 received the degree of M.Sc. from the same institution. Since his graduation he has acted as manager for smelting works in Arizona, Colorado, Missouri, New Mexico and Mexico, and also as consulting engineer for a large number of properties. Since 1898 he has confined himself almost exclusively to the Joplin zinc district, Missouri. Mr. Nicholson has done a large amount of expert work covering properties in the United States, British Columbia, Nova Scotia and Mexico, and is a member of several engineering and technical societies. To the present volume he has contributed the review of "The Progress in the Zinc Industry in Missouri during 1902."

Obalski, J., was born in France in 1852, and studied at the Ecole des Mines at Paris; after graduation he occupied several positions in connection with the mining industry in France and Spain, and visited various mining districts in those countries, Belgium and Portugal. In 1881 he was called by the government of the Province of Quebec to fill the position of mining engineer and inspector of mines, which post he still occupies. He has contributed to the present volume notes on asbestos, chrome ore, copper ore, graphite, phosphate and mica mining in Quebec.

Power, Frederick Danvers, was born at Lee, England, in 1861. He received his technical training in Swansea, South Wales; at the Royal School of Mines, London, and at the Bergakademie of Clausthal, Germany. He has travelled in South Africa and North Africa, but has spent most of his professional life in various parts of Australasia and the South Seas, having arrived in Victoria in 1885. He has held various appointments for British and Colonial companies, and has contributed several scientific papers to English and Colonial journals and transactions of scientific societies. He is also the author of a *Pocketbook for Miners and Metallurgists*, published by Messrs. Crosby, Lockwood & Son. He has been on the council of the Australasian Institute of Mining Engineers from its foundation, and has acted both as vice president and president; he was formerly examiner of Mining at the University of Melbourne; vice-president of the New South Wales Chamber of Mines, and is a life member of the American Institute of Mining Engineers, the Institute of Mining and Metallurgy and the Royal Geological Society, London. To the present volume he contributes special notes on the mining industries in the Australasian States during 1902, and "Cobalt in New Caledonia."

Reybold, Edwin C., Jr., was graduated from Delaware College with the degree of A.B. in 1896; and received the degree of A.M. in 1903. From 1897 to 1900 he was employed at the smelting works of the Deadwood & Delaware Smelting Co., and the Golden Reward Mining Co., at Deadwood, S. D., and from 1900 to the present time he has been with the Clear Creek Mining Co., operating the smelter at Golden, and mines in Gilpin County, Colo. Mr. Reybold contributes to the present volume, "Notes on Pyritic Smelting."

Richards, Robert Hallowell, professor of mining and metallurgy at the Massachusetts Institute of Technology, was born in 1844 at Gardiner, Me. He graduated in 1868 from the Massachusetts Institute, being a member of its first class, and became assistant in chemistry in the corps of instruction, passing successively to the post of instructor, assistant professor of chemistry, professor of mineralogy and assaying, professor of mining engineering, and in 1884 to his present professorship of mining and metallurgy. Under his administration the mining and metallurgical laboratory, which was the first of its kind in an educational institution, has been developed to a high degree of excellence, and has been a model for similar laboratories in other colleges. In addition to his professional duties, Prof. Richards has been actively engaged as a consulting engineer in mining and metallurgical work, and has been the inventor of several ingenious devices, which have found extended use in practice. He has contributed many valuable papers to the technical press, and to the transactions of various scientific societies. His most recent work on the principles of ore dressing is the admiration of the entire body of engineers engaged in that business. To this, as in previous volumes, he has contributed the reviews, "Reviews of the Literature on Ore Dressing in 1902," and "Progress in Gold Mining during 1902."

Rickard, Thomas A., was born in 1864, at Pertusola, Italy, and spent his boyhood in Italy, Switzerland and Russia (the Urals). Educated in Russia and in England, he graduated from the Royal School of Mines in 1885 and immediately afterward went to Colorado. In 1887 he was appointed superintendent of the Union Mine at San Andreas, Cal. In July, 1889, he went to Australia, and for two years visited and studied most of the important mining districts of New Zealand, Queensland, New South Wales, Victoria and Tasmania. In 1891 Mr. Rickard was manager of mines near Allemont, in the Isère, France. During 1892 he returned to Colorado and began general practice as consulting engineer and during the next five years examined mines throughout the West; in 1895 he was appointed State geologist of Colorado holding this honorary office for three successive terms, covering six years. In 1897 he examined a number of mines in British Columbia and Western Australia for a London financial house and in 1899 became consulting engineer to several important mines in Colorado. On January 1, 1903, Mr. Rickard became editor of the *Engineering and Mining Journal*, to which he had been for many years a frequent contributor. He has contributed largely to technical literature, especially the *Transactions of the American Institute of Mining Engineers*, the *Institution of Mining and Metallurgy* and the publications of other technical societies. He is also the author of *The Stamp Milling of Gold Ores*, published in 1897. To the present volume he contributes the article "The Sampling and Estimation of Ore in a Mine."

Ries, Heinrich, Ph.B., A.M., Ph.D., was graduated in 1892 from the School of Mines, Columbia College (now Columbia University), New York City. After his graduation he was employed as assistant geologist on the New York State Geological Survey, and during the World's Fair at Chicago he was assistant director of the New York scientific exhibit. From 1893 to 1895 he held the University Fellowship in Mineralogy at Columbia University, and was awarded the Barnard Fellowship for scientific research by the same institution from 1897 to 1900. In 1898 he was appointed Assistant Professor of Economic Geology at Cornell University, Ithaca, N. Y. Dr. Ries has made a special study of the economic geology of clays, has made extensive investigations of both domestic and foreign deposits, and since 1895 has acted as clay specialist for the United States Geological Survey. He has prepared special reports on the clays of New York, Michigan, North Carolina, Alabama, Louisiana, Maryland and New Jersey. In 1895 he was judge of clays at the Cotton States Exposition, and a member of the jury of awards at the Pan-American Exposition at Buffalo, N. Y. To the present volume Dr. Ries contributes the paper, "Review of the Literature of Clays and Clay Products in 1902."

Rossi, Auguste J., was born in Paris in 1839. In 1855 he was graduated from the University of France, receiving the degree of B.A. and B.S. and in 1859 received the degree of civil and mining engineer from the Ecole Centrale of Arts and Manufactures of Paris. Soon afterward he came to the United States, of which he has long been an adopted citizen. Mr. Rossi, in the course of his professional practice, has been with the Morris & Essex Railroad, with the Boonton blast furnaces and with the New York Ice Machine Co. For the past eight years he has devoted himself particularly to electrometallurgy, and as consulting mining engineer has been engaged in the study of the metallurgy of titanium. He is a member of the American Institute of Mining Engineers, the American Chemical Society and of the American Electro-Chemical Society, and various articles from his pen

CHARLES F. MC KENNA.

FREDERICK H. LEWIS.

JAMES W. MALCOLMSON.

JOHN A. MATHEWS.

FRANK NICHOLSON.

ROBERT H. RICHARDS.

F. DANVERS POWER.

HEINRICH RIES.

THOMAS A. RICKARD.

AUGUSTE J. ROSSI.

F. SCHNIEWIND.

VINCENTE SPIREK.

WALTER H. WEED.

TITUS ULKE.

have appeared in the published proceedings of these societies, and in other technical publications. To this volume Mr. Rossi contributes the paper, "Progress in the Manufacture and Use of Titanium and Similar Alloys."

Sanford, Samuel, born in Middletown, R. I., 1865; after taking a course in mining geology, was graduated from Harvard University in 1890. After graduation he was engaged in landscape work in New Jersey. From 1891 to 1892 he was employed by the Lake Superior Geological Survey on the Marquette and Menominee ranges in Michigan, and in 1893 he was superintendent of the field operations of the Duluth Iron Co. on the Mesabi Range, Minn. From 1894 to 1897 he was engaged in research work, and from 1899 to 1902 Mr. Sanford has been on the editorial staff of the *Engineering and Mining Journal*. To the present volume he contributes notes on anthracite and bituminous coals in the United States.

Schniewind, Frederick, was born at Bochum, Westphalia, in 1861. He studied at the institutes of technology at Charlottenburg and Munich and at the universities of Berlin, Munich and Heidelberg, receiving the degree of Ph.D. at the latter university. He then entered the laboratory of a Westphalian blast furnace and subsequently had charge of analytical laboratories at Cleveland, O., and Crystal Falls, Mich. Since its inception he has been connected with the United Coke and Gas Co., which builds and operates by-product coke ovens, especially of the Otto-Hoffmann type. He adapted by-product coke ovens to the manufacture of illuminating gas and has made a number of improvements in their construction. He is the author of numerous articles on coal distillation in coke-ovens, and to the present volume he contributes the paper, "By-Product Coke Ovens."

Spirek, Vincente, was born in 1852, at Bubovice, near Prague, Bohemia, and was graduated from the Bergakademie at Pribram in 1876. He entered at once into active mining and in 1878-1879 became an officer of the government mining bureau in Bosnia and Herzegovina. He was employed under Exeli in Idria, and from 1876 to 1890 he was associated there with Cermak in the remodeling of the works and the design of the well-known Cermak-Spirek quicksilver furnace. After service as an officer in the army in Bosnia and Herzegovina he resigned his position of Oberhuetteningenieur in the State Mines Direction to take charge of the quicksilver works at Monte Amiata, Italy. Mr. Spirek has received several government medals in recognition of his special work as an engineer, and he has written a number of technical articles. To the present volume he has contributed notes on the recent improvements in the Cermak-Spirek furnace for quicksilver ores.

Struthers, Joseph, was born at New York City in 1865, and attended the School of Mines, Columbia College (now Columbia University), graduating therefrom in the course of chemistry in 1885, and in 1895, receiving the degree of Ph.D. from that institution. For fifteen years after his graduation he was on the staff of instructors of the department of metallurgy at Columbia University, first assisting Dr. Thomas Egleston, and later Prof. Henry M. Howe; later becoming honorary lecturer in metallurgy at Columbia University. In 1896 he organized and conducted the first summer school in practical metallurgy of Columbia University, which was held at Butte, Mont. Dr. Struthers has visited many metallurgical plants in the United States and Europe, and he has carried on special metallurgical investigations. He has written numerous articles for the *Engineering and Mining Journal, Mineral Resources of the United States, Twelfth Census of the United States* and *School of Mines Quarterly*, and from 1892 to the present time he has been on the Board of Editors of the latter publication, acting for most of this period as business manager. As assistant editor of The Mineral Industry, Vols. VIII. and IX. and editor of Vols. X. and XI., he has had entire charge of their preparation, and has contributed to them by far the greater number of the unsigned articles. In November, 1901, Dr. Struthers was appointed Field Assistant to the United States Geological Survey for 1901 and 1902, and in May, 1903, he was appointed special agent for the United States Census.

Ulke, Titus, was born in 1866, at Washington, D. C. In 1889 he was graduated from the Royal School of Mines at Freiberg, Saxony, as metallurgical engineer. After spending some time in visiting the various mines and metallurgical works in Europe, Mr. Ulke returned to this country and was engaged as chemist to the Harney Peak Tin Co., in South Dakota. In 1891 he became assayer for the United Smelting Co., and afterwards was engaged by the Anaconda Mining Co., as chemist at its electrolytic copper refining works. In 1893 Mr. Ulke acted as metallurgist to the Mines and Mining Department of the Chicago Columbian Fair, and was later employed at the Guggenheim works at Perth Amboy, N. J. As triangulator for the U. S. Geological Survey in 1897, he had charge of a party to survey the Montana timber reserves. Soon after the declaration of war with Spain, Mr. Ulke was appointed Assistant Inspector of Ordnance, U. S. A., and in 1900 he became metallurgical engineer to the Lake Superior Power Co., Sault Ste. Marie, Ont. He is now connected with the Ordnance Department at Watervliet Arsenal, N. Y. Mr. Ulke has contributed to the present volume the reviews of "Progress in the Electrolytic Refining of Copper" and "Progress in the Metallurgy of Nickel in 1902."

Weed, Walter Harvey, was born in St. Louis, Mo., May 1, 1862, and was graduated in 1883 from Columbia College School of Mines in the course of mining engineering. Mr. Weed was appointed assistant geologist U. S. Geological Survey in June, 1883; in 1885 discovered the vegetable origin of the siliceous sinter of Yellowstone; and the following year discovered and described Death Gulch, Yellowstone Park. Following his specialty of economic and applied geology, Mr. Weed has investigated and reported on various coal, gold and silver districts of Montana, and has made careful studies of the copper and gold regions of Virginia and the Carolinas, Cripple Creek district, and others in Colorado, Arizona, California, Wyoming and Mexico. To the present volume Mr. Weed contributes notes on copper, gold and silver mining in Montana.

INTRODUCTION.

THE total value at the place of production of the mineral and metal output from both domestic and foreign ores and bullion of the United States in 1902 was $1,431,072,789, as compared with $1,367,983,548, in 1901, a gain of $63,089,241 for the year.

Of these vast sums, which are without precedent in the history of the mineral industry, ores and minerals contributed $758,562,272 in 1902 and $721,938,333 in 1901; metals, $510,553,421 in 1902 and $486,981,619 in 1901; secondary products, $84,688,884 in 1902 and $72,935,106 in 1901; while the value of metals smelted or refined from foreign material was $77,268,212 in 1902 and $86,128,490 in 1901. In these gross totals of value are included certain duplications, such as those of the manganese and iron ore used in making ferromanganese and pig iron; bauxite used in making aluminum and alum; coal used in making coke; lead used in making white and red lead and litharge, and a few other duplications, the whole amounting in 1902 to $115,644,546 and in 1901 to $93,629,061. Deducting these amounts and also the values of the crude foreign ores or metals smelted or refined here, the net value of the mineral industry of the United States was $1,238,160,031 in 1902 and $1,188,225,997 in 1901.

In the preparation of the statistics for this volume, the figures previously reported for 1901 have been revised in the light of later and more minute investigation, in accordance with our practice, wherefore it is important for students to observe the caution to use always the figures in the latest volume of THE MINERAL INDUSTRY. There are no statistical reports of this nature which are absolutely correct, owing to the practical impossibility of obtaining accurate reports from all the producers in some extensive and greatly subdivided industries, the absence of records on the part of many producers which prevents them from making returns, the unwillingness of a few to give figures, and confusion as to the stage in which many products are to be reported. The last difficulty is especially likely to lead to errors in values, some producers estimating the worth of their product at the pit's mouth, and others reporting it in a more or less advanced stage of completion, including thus not only the cost of carriage, but also the cost of manipulation. These difficulties appear not only in our own statistics, but also in the statistics reported by various governments. In our own work, however, we make a practice of going backward and correcting figures previously reported, whenever mistakes are discovered by subsequent investigation.

For the greater part of the statistics relating to the domestic production of the United States during 1901 and 1902 we have been indebted to Department of Mineral Resources of the United States Geological Survey, and for the production of gold and silver in the United States during these years to Mr. George E. Roberts, Director of the Mint. Special acknowledgment is due to both of these departments for their active and hearty co-operation.

We have made great use of the reports of several State geological surveys, especially those of Alabama, Kansas, Iowa and Indiana, and the State mining bureaus of California and Colorado. We have generally credited these figures to the proper sources in the subsequent pages, but this acknowledgment may stand for any unintentional oversights.

PRODUCTION OF ORES AND MINERALS IN THE UNITED STATES. (FIRST PRODUCTS.)

Number.	Products.	Customary Measures.	1901.				1902.			
			Quantity.		Value at Place of Production. *a*		Quantity.		Value at Place of Production. *a*	
			Customary Measures.	Metric Tons.	Totals.	Per M. Ton.	Customary Measures.	Metric Tons.	Totals.	Pr. M. Ton.
					$	$			$	$
1	Asbestos	Sh. T.	747	678	13,498	19·91	1,010	916	12,400	13·54
2	Asphaltum	Sh. T.	20,416	18,521	337,359	18·21	29,903	27,128	389,602	14·36
3	Asphaltic limestone	Sh. T.	6,970	6,325	33,375	5·28	1,859	1,686	7,782	4·62
4	Bitumin's sandstone	Sh. T.	34,248	31,078	138,601	4·46	57,837	52,469	157,093	2·99
5	Barytes	Sh. T.	49,070	44,528	157,844	3·54	58,149	52,752	186,713	3·54
6	Bauxite	L. T.	18,905	19,214	79,914	4·16	27,322	27,759	121,465	4·38
7	Bismuth ore	Sh. T.	319	289	25,488	88·19	37	34	2,960	87·06
8	Bromine	Lb.	552,023	250	149,045	596·18	513,913	233	128,472	551·39
9	Calcium borate. *c*	Sh. T.	23,231	21,075	1,012,118	48·02	17,202	15,605	2,434,994	156·03
10	Cement, nat. hydraul.	*g* Bbls	7,084,823	963,921	3,056,278	3·17	9,083,759	1,236,110	4,087,692	3·31
11	Cement, Portland	*h* Bbls	12,711,225	2,306,756	12,532,360	5·43	16,535,000	3,000,090	16,637,500	5·54
12	Chrome ore	L. T.	498	506	7,740	15·23	315	320	4,725	14·77
13	Clay products	......	......	......	110,211,587	......	......	......	*e* 100,000,000	......
14	Coal, anthracite	Sh. T.	67,538,536	61,270,558	112,704,055	1·84	41,451,267	37,604,343	83,002,229	2·20
15	Coal, bituminous	Sh. T.	225,759,980	204,808,110	236,305,214	1·15	258,371,987	234,393,529	285,574,339	1·11
16	Coal, cannel	Sh. T.	(*ff*)	......	......	......	(*ff*)	......	......	......
17	Cobalt oxide	Lb.	13,360	*k* 6,062	24,048	*k* 3·97	*Nil.*	......	......	......
18	Copper sulphate. *f*	Lb.	78,004,257	35,282	*m* 3,674,000	90·38	48,763,538	22,119	2,028,563	91·71
19	Corundum }	Sh. T.	4,305	3,905	146,040	37·40	......	......	95,135	......
20	Emery }	Sh. T.								
21	Feldspar	L. T.	31,019	31,517	220,422	6·99	(*gg*)	......	......	......
22	Fluorspar	Sh. T.	19,586	17,773	113,803	6·40	27,127	27,561	143,520	5·19
23	Fullers earth	Sh. T.	14,112	12,802	96,835	7·57	14,100	12,791	109,980	8·56
24	Garnet	Sh. T.	4,444	4,033	158,100	39·20	3,722	3,376	88,270	26·15
25	Gilsonite	Sh. T.	1,500	1,653	46,000	27·82	4,052	3,676	61,182	16·64
26	Graphite, crystalline	Lb.	3,967,612	*k* 1,800,187	135,914	*k* 0·08	4,176,824	1,895	153,147	80·80
27	Graphite, amorphous	Sh. T.	809	734	31,800	43·32	4,739	4,299	55,964	12·01
28	Gypsum	Sh. T.	659,659	598,602	1,577,493	2·64	......	......	......	......
29	Iron ore	L. T.	27,887,479	28,333,679	47,408,714	1·67	34,636,121	35,190,299	64,769,546	1·84
30	Lepidolite	Sh. T.	*e* 110	100	4,070	40·66	(*gg*)	......	......	......
31	Magnesite. *c*	Sh. T.	13,172	11,949	43,057	3·60	3,466	3,144	21,362	6·79
32	Manganese ore. *i*	L. T.	638,795	649,016	1,644,117	2·53	(*gg*)	......	......	......
33	Mica, scrap	Sh. T.	2,165	1,964	19,719	10·04	(*gg*)	......	......	......
34	Mica, sheet	Lb.	360,060	*k* 163,322	98,859	*k* 0·61	(*gg*)	......	......	......
35	Molybdenum ore	Sh. T.	15	15	750	5·14	15	15	750	5·14
36	Monazite	Lb.	748,736	340	59,262	174·30	(*gg*)	......	......	......
37	Natural gas	......	......	......	27,067,500	......	......	......	*e* 30,000,000	......
38	Ocher. *p*	Sh. T.	43,036	39,042	*n* 516,308	13·48	55,320	50,186	705,026	14·05
39	Petroleum, crude	*y* Bbls	69,389,194	8,839,263	66,417,335	7·51	84,250,738	12,174,961	70,628,100	5·80
40	Phosphate rock	L. T.	1,483,723	1,507,463	5,316,403	3·53	1,464,668	1,488,103	4,636,516	3·12
41	Precious stones	......	......	......	289,050	......	......	......	318,300	......
42	Pyrites	L. T.	234,825	238,661	1,024,449	4·29	228,198	231,849	971,796	4·19
43	Salt. *q*	Bbls.	20,566,661	2,613,299	6,617,449	2·53	23,849,221	3,029,022	5,668,636	1·87
44	Silica, brick	M.	55,000	......	1,018,050	......	*e* 60,000	......	*e* 1,200,000	......
45	Diatom. earth	Sh. T.	*dd* 4,020	3,647	52,950	14·52	4,855	4,404	49,974	11·33
46	Quartz	Sh. T.	14,050	12,476	41,500	3·26	13,904	12,614	117,423	9·13
47	Sand, etc	L. T.	*e* 900,000	914,400	*e* 1,353,912	1·48	*e* 1,000,000	1,016,000	*e* 1,500,000	1·48
48	Pumice	Sh. T.	*Nil.*	......	......	......	100	91	500	5·49
49	Grindstones	Sh. T.	*bb* 16,807	15,247	580,703	......	......	......	656,832	......
50	Whetstones	......	......	......	158,300	......	......	......	219,172	......
51	Tripoli	Sh. T.	(*ee*)	......	......	......	(*ee*)	......	......	......
52	Slate, roofing	Sq'es.	1,304,379	394,072	4,114,410	*j* 3·15	(*gg*)	......	......	......
53	Manufactures	......	......	......	673,115	......	(*gg*)	......	......	......
54	Pigment	Sh. T.	4,865	4,413	41,211	9·34	(*gg*)	......	......	......
55	Soapstone	Sh. T.	(*cc*)	......	......	......	(*cc*)	......	......	......
56	Soda, natural. *r*	Sh. T.	15,000	13,608	197,000	14·48	16,000	14,515	208,000	14·33
57	Stone, for building	......	......	......	55,615,926	......	(*gg*)	......	......	......
58	Stone, limestone (flux)	L. T.	8,540,168	8,679,656	4,659,836	0·54	9,490,090	9,644,931	5,504,252	0·59
59	Stone, lithographic	Sh. T.	*Nil.*	......	......	......	(*gg*)	......	......	......
60	Sulphur	L. T.	6,976	7,088	223,430	31·52	7,443	7,562	220,560	29·03
61	Sulphuric acid. *f. l.*	Sh. T.	98,000	88,905	*m* 2,293,200	25·75	(*gg*)	......	......	......
62	Talc, common	Sh. T.	28,643	25,984	424,888	16·35	21,640	19,632	413,497	21·06
63	Talc, fibrous	Sh. T.	69,200	62,778	483,600	7·69	71,100	64,501	615,350	9·64
64	Tungsten ore	L. T.	160	162	27,720	171·11	221	224	38,600	172·32
65	Uranium ore	Sh. T.	375	340	102,500	301·47	810	735	......	......
66	Zinc sulphate	Sh. T.	7,500	6,804	322,425	47·39	(*gg*)	......	......	......
67	Zinc ore, exported	Sh. T.	44,156	40,058	1,167,684	29·15	54,613	49,582	1,449,104	29·23
68	Zinc white. *s*	Sh. T.	46,500	42,185	3,720,000	88·18	52,730	46,929	4,023,299	85·73
69	Zinc-lead	Sh. T.	2,500	2,268	150,000	66·14	4,000	3,629	225,000	62·00
70	Est. prod. unspecified		......	......	5,000,000	......	......	......	63,915,000	......
	Totals		......	......	721,938,333	......	......	......	758,562,272	......

PRODUCTION OF METALS IN THE UNITED STATES.

Number.	Products.	Customary Measures.	1901.				1902.			
			Quantity.		Value at Place of Production.		Quantity.		Value at Place of Production.	
			Custom'ry Measures.	Metric Tons.	Totals.	Per M. Ton.	Custom'y Measures.	Metric Tons.	Totals.	Per M. Ton.
					$	$			$	$
71	Aluminum	Lb.	7,150,000	*k* 3,243,219	2,238,000	*k* 0·69	7,300,000	3,312,258	2,284,590	0·69
72	Antimony	Lb.	5,298,000	2,404	542,020	225·47	7,122,000	3,230	634,506	196·44
73	Copper	Lb.	597,443,212	270,998	*t* 86,629,266	319·67	610,815,384	277,064	*t* 71,072,586	256·55
74	Ferromanganese*u*	L. T.	291,461	295,124	16,589,960	56·21	212,981	216,389	13,852,199	64·01
75	Ferromolybden'm	Lb.	16,000	7	19,600	2,800·00	16,000	7	19,600	2,800·00
76	Ferrotungsten	Lb.	13,000	6	3,770	628·34	14,000	6	4,060	676·66
77	Gold	Oz(*w*)	3,805,500	*k* 118,363	78,666,700	*k* 664·60	3,870,000	*k*120,369	79,992,800	*k*664·60
78	Iron, pig	L. T.	15,586,893	15,836,283	232,800,328	14·70	17,608,326	17,890,059	289,304,796	16·19
79	Iridium	Oz(*w*)	253	7·9	5,060	*k* 642·62	20	....	400	*k*642·62
80	Lead	Sh. T.	279,922	253,944	24,241,245	95·46	280,524	254,489	22,829,043	89·70
81	Molybdenum	Lb.	35,000	16	62,125	3,882·81	35,000	16	62,125	3,882·81
82	Nickel	Lb.	6,700	3,040	3,551	*k* 1·17	*Nil.*	....	....	....
83	Platinum	Oz(*w*)	1,408	*k* 44	27,526	625·59	94	....	1,814	*k*620·17
84	Quicksilver (*x*)	Fl'sks	29,727	1,031	1,382,305	1,340·74	34,451	1,195	1,500,142	1,255·35
85	Silver	Oz(*w*)	55,214,000	*k* 1,717,334	32,458,653	*k* 18·95	55,500,000	*k*1,726,229	28,948,800	*k*16·77
86	Tungsten	Lb.	75,000	34	45,750	1,345·59	82,000	37	50,020	1,351·89
87	Zinc	Sh. T.	140,822	127,788	11,265,760	88·16	158,237	143,552	15,317,342	36·80
	Totals	......	....	....	$486,981,619	....	....	....	510,553,421	....

SECONDARY MINERAL AND CHEMICAL PRODUCTS OF THE UNITED STATES.

Number.	Products.	Customary Measures.	1901.				1902.			
			Quantity.		Value at Place of Production. *a*		Quantity.		Value at Place of Production. *a*	
			Customary Measures.	Metric Tons.	Totals.	Per M. Ton.	Custom'ry Measures.	Metric Tons.	Totals.	Per M. Ton.
					$	$			$	$
88	Alum	Sh. T.	7,755	7,036	208,846	29·68	8,539	7,747	229,500	29·63
89	Aluminum sulphate	Sh. T.	74,721	67,786	1,355,720	20·00	87,075	78,994	1,938,671	24·59
90	Ammonium sulphate	Sh. T.	66,138	60,000	3,665,400	61·09	71,649	65,000	4,264,650	65·61
91	Carborundum	Lb.	3,838,175	1,741	345,435	198·41	3,741,500	1,697	374,150	220·48
92	Cement, slag	*h*Bbls	272,689	49,490	198,151	4·00	547,175	99,279	465,099	4·68
93	Coke	Sh. T.	21,795,883	19,773,095	44,445,923	2·25	23,090,342	20,947,421	51,864,575	2·48
94	Copperas	Sh. T.	23,586	21,397	112,366	5·25	19,784	17,948	118,474	6·60
95	Crushed steel	Sh. T.	345	313	37,950	121·25	368	333	51,450	154·50
96	Graphite, artificial	Lb.	2,500,000	*k*1,134,301	119,000	*k* 0·10	2,358,828	1,060,996	110,700	0·10
97	Lead, white	Sh. T.	100,787	91,433	11,252,653	123·07	114,658	104,011	11,978,172	115·16
98	Lead, red	Sh. T.	13,103	11,887	1,448,550	121·95	11,669	10,586	1,262,712	119·28
99	Lead, orange miner'l	Sh. T.	1,087	986	224,667	227·86	867	787	138,349	175·79
100	Litharge	Sh. T.	9,460	8,582	979,586	114·14	12,755	11,571	1,299,443	112·30
101	Mineral wool	Sh. T.	6,272	5,690	68,992	12·15	10,843	9,837	105,814	10·75
102	Soda, manufactured	M. T.	480,000	480,000	8,318,400	17·33	562,000	562,000	10,290,220	18·31
103	Venetian red	Sh. T.	9,201	8,347	153,467	18·39	11,758	10,667	196,905	18·46
	Totals	......	....	....	$72,935,106	....	....	....	$84,688,884	....

METALS PRODUCED FROM FOREIGN ORES AND BULLION. (*aa*)

Metals.	Customary Measures.	1901.			1902.		
		Quantities.		Values.	Quantities.		Values.
		Customary Measures.	Kg.		Customary Measures.	Kg.	
				$			$
Copper	Pounds	102,645,963	46,520,209	16,536,265	85,000,000	38,555,747	9,891,450
Gold	Troy oz.	1,730,856	53,835	35,776,794	1,689,991	52,564	34,932,211
Lead	Short tons.	22,260	20,194,272	1,927,716	34.922	31,681,031	2,841,952
Nickel	Pounds	8,664,614	3,930,198	4,087,710	10,391,478	4,713,544	4,520,293
Silver	Troy oz.	45,410,085	1,412,404	27,850,005	48,087,244	1,495,668	25,082,306
Total values	....	....	....	$86,128,490	....	....	$77,268,212
Total ores and minerals				721,938,333			758,562,272
Total metals				486,981,619			510,553,421
Total secondary products				72,935,106			84,688,884
Grand total, values				$1,367,983,548			$1,431,072,789

In using the statistics in the foregoing tables reference should also be made to the detailed tables under the respective captions further on in this volume, where many explanatory notes as to the statistics will be found. The following notes refer to the four preceding tables: (*a*) Except where otherwise specified. (*b*) Not enumerated. (*c*) Crude mineral. In 1901 includes 5,344 short tons of refined borax, valued at $697,307. (*d*) Partly estimated. (*e*) Estimated. (*f*) Includes copper sulphate made from metallic copper. (*g*) Barrels of 800 lb. (*h*) Barrels of 400 lb. (*i*) Includes manganiferous iron ore; this is not duplicated in the report of iron ore. (*j*) Value per square, *i.e.*, 100 sq. ft., lapped and laid; the weights are calculated on the basis 8 squares=2,000 lb., but these figures are only approximately correct. (*k*) Kilograms or per kilogram. (*l*) Reduced to a basis of 60° B. (*m*) Average market price at New York. (*n*) Nominal. (*o*) Value before grinding. (*p*) Includes ocher, umber, sienna, and oxide of iron. (*q*) Includes salt used for the manufacture of alkali; the barrel of salt weighs 280 lb. (*r*) Reduced to a basis of 58% ash. (*s*) Includes a small amount made from spelter. (*t*) Average value of Lake copper at New York, less 0·25c. per lb. (*u*) Includes spiegeleisen, though the total value is reckoned as if the whole product were ferromanganese. (*v*) Average market price at Pittsburg. (*w*) Troy oz. (*x*) Flasks of 76·5 lb. (*y*) Barrels of 42 gal. (*z*) Includes a comparatively small amount made directly from ores. (*aa*) Not included in the preceding tables. (*bb*) Does not include 40,980 pieces of unspecified weight; the value, however, is included in the total. (*cc*) Included with common talc. (*dd*) Includes tripoli. (*ee*) Included with diatomaceous earth. (*ff*) Included with bituminous. (*gg*) Statistics not collected.

Abbreviations: Sh. T., short tons (2,000 lb.); L. T., long tons (2,240 lb.); M. T., metric tons (2,204 lb.).

METALS AND ALLOYS.

Aluminum.—The production of aluminum in the United States in 1902 was 7,300,000 lb. ($2,284,590), as compared with 7,150,000 lb. ($2,238,000) in 1901.

Antimony.—The production of antimony in the United States in 1902 was 7,122,000 lb. ($634,506) as compared with 5,298,000 lb. ($542,020) in 1901.

Copper.—The production increased from 597,443,212 lb. ($86,629,266) to 610,815,384 lb. ($71,072,586) in 1902. The main increases were in Montana, Michigan, Utah and the Southern States. California and Arizonia reported decreases. In addition to the domestic copper produced in 1902, there were 85,000,000 lb. derived from foreign sources.

Ferromanganese.—The production of ferromanganese, including spiegeleisen, was 212,981 long tons ($13,852,199), as compared with 291,461 long tons ($16,589,960) in 1901.

Ferromolybdenum.—The production in 1902 is estimated at 16,000 lb. ($19,600), as compared with the same totals in 1901.

Gold and Silver.—The domestic production of gold in 1902 was 3,870,000 troy oz. ($79,992,800), as compared with 3,805,500 troy oz. ($78,666,700) in 1901. The production of silver was 55,500,000 troy oz. ($28,948,800), as compared with 55,214,000 troy oz. ($32,458,653). There was a slight increase in the production of gold in Colorado; and Alaska, Arizona and South Dakota also contributed to the enlarged production. Besides the production reported, 1,689,991 oz. of gold and 48,087,244 oz. of silver were smelted in the United States from imported ores. The average value of silver in the United States in 1902 was 52·16c. per oz., against 58·95c. per oz. in 1901.

Iron.—The production of pig iron in 1902, exclusive of ferromanganese and spiegeleisen, was 17,608,326 long tons ($289,304,796), as compared with 15,586,893 long tons ($232,800,328) in 1901. Of the production in 1902 10,393,168 long tons were Bessemer pig iron against 9,546,793 long tons in 1901. The production of basic pig was 2,438,590 long tons, against 1,448,850 long tons. The remainder of the output is classed as foundry and forge iron.

Lead.—The domestic production in 1902 was 280,524 short tons ($22,829,043), against 279,922 short tons ($24,241,245) in 1901. There was a large increase in the output of the Idaho mines. The average price of lead at New York in 1902 was 4·069c., against 4·33c. per lb. in 1901. Besides the above, the American smelters in 1902 recovered 34,922 tons of lead from foreign ore and base bullion, against 22,260 in 1901.

Molybdenum.—Some 35,000 lb. of molybdenum ($62,125) were produced in

1902, as compared with an equal output in 1901. A considerable portion of the ore came from Arizona.

Nickel.—There was no domestic production of nickel in 1902, as compared with an output of 6,700 lb. ($3,551) in 1901.

Platinum.—There was a production of 94 troy oz. ($1,814) of platinum from domestic ores in 1902, as compared with 1,408 oz. ($27,526) in 1901. The value of bar platinum at New York in 1902 averaged $20·15 per oz.

Quicksilver.—The production of quicksilver increased from 29,727 flasks ($1,382,305) to 34,451 flasks ($1,500,142) in 1902. Texas contributed 5,252 flasks to the total, but there was no production in Oregon.

Tungsten.—The production was 82,000 lb. ($50,020) in 1902, against 75,000 lb. ($45,750) in 1901. The production of ferrotungsten in 1902 was 14,000 lb. ($4,060).

Zinc.—The production in 1902 was 158,237 short tons ($15,317,342), as compared with 140,822 short tons ($11,265,760) in 1901. There was a large increase in Kansas. The average price of spelter in New York in 1902 was 4·84c. per lb., against 4·07c. per lb. in 1901.

ORES, MINERALS AND CHEMICAL PRODUCTS.

Alum and Aluminum Sulphate.—The production of crystallized alum in the United States in 1902 was 8,539 short tons ($229,500), as compared with 7,755 short tons ($208,846) in 1901. The production of aluminum sulphate in 1902 was 87,075 short tons ($1,938,671), as compared with 74,721 short tons ($1,355,720) in 1901.

Ammonium Sulphate.—The amount of ammonium sulphate recovered in the United States in 1902 was 65,000 metric tons ($4,264,650), as compared with 60,000 metric tons ($3,665,400) in 1901. The value of sulphate, basis 25%, was $65·61 per metric ton at New York in 1902, against $61·09 in 1901.

Asbestos.—The domestic production was 1,010 short tons ($12,400) in 1902, as compared with 747 short tons ($13,498) in 1901. In each year the production was made almost entirely by one mine in Georgia.

Asphaltum and Asphaltum Products.—The production of asphaltum, liquid and solid, in 1902 was 29,903 short tons ($389,602), as compared with 20,416 short tons ($337,359) in 1901, the output coming from California and Indian Territory. California, Indian Territory and Kentucky produced 57,837 tons ($157,093) of bituminous rock in 1902, as compared with 34,248 tons ($138,601) in 1901. Arkansas and Indian Territory produced 1,859 short tons ($7,782) of asphaltic limestone, as compared with 6,970 tons ($33,375) in 1901. There was no output in Utah, and Indian Territory showed a large decrease. The production of grahamite or gilsonite in 1902 was 4,052 tons, as compared with 1,500 tons in 1901.

Barytes.—The production in 1902 was 58,149 short tons ($186,713), as compared with 49,070 short tons ($157,844) in 1901. Of the production in 1902, Virginia furnished the larger part of the output, the remainder being obtained in North Carolina, Tennessee and Missouri.

Bauxite.—The production in 1902 was 27,322 long tons ($121,465), as compared with 18,905 long tons ($79,914) in 1901.

Bromine.—The production in 1902 was 513,913 lb. ($128,472), against 552,023 lb. ($149,045) in 1901. These figures include the bromine equivalent of potassium bromide, which is produced in Michigan.

Calcium Borate.—The production in 1902 was 17,202 short tons, as compared with 23,231 short tons in 1900. Most of the product is obtained from colemanite, which is mined in California. The value of the production in 1902 was $2,434,994, against $1,012,118 in 1901.

Carborundum.—The production reported by the sole producer was 3,741,500 lb. ($374,150) in 1902, as compared with 3,838,175 lb. ($345,435) in 1901.

Cement.—The total production of Portland cement in 1902 was 16,535,000 bbl. of 400 lb., valued at $16,637,500, as compared with 12,711,225 bbl. ($12,532,360) in 1901. The Lehigh district of Pennsylvania and New Jersey has maintained its supremacy as a center of production, and Michigan and other States also showed important gains. Aside from the remarkable increase in production, the year 1902 was notable for the very low prices commanded by cement in the Eastern markets. The production of natural rock cement in 1902 was 9,083,759 bbl. of 300 lb., valued at $4,087,692, as compared with 7,084,823 bbl. ($3,056,278) in 1901. As in previous years, the Kentucky-Indiana district and Ulster County, N. Y., were the largest producers. The production of slag cement in 1902 was 547,175 bbl. of 400 lb., valued at $465,099, against 272,689 bbl. ($198,151) in 1901.

Chrome Ore.—The production in 1902 was 315 long tons ($4,725), against 498 long tons ($7,740) in 1901. The entire production in 1901 and 1902 was mined in California.

Clay.—The value of brick and other clay products made in the United States in 1901 was $110,211,587, as compared with $78,704,678 in the previous year.

Coal and Coke.—The total production of coal in the United States in 1902 was 299,823,254 short tons ($368,576,568), as compared with 293,298,516 short tons ($349,009,269) in 1901. The production of anthracite, all of it from Pennsylvania, with the exception of small amounts from Colorado and New Mexico, was 41,451,267 short tons ($83,002,229) in 1902, as compared with 67,538,536 short tons ($112,704,055) in 1901. Kentucky's production of cannel coal is included under the production of bituminous. The output of bituminous coal, of which Pennsylvania and the Central States are the largest producers, was 258,371,987 short tons ($285,574,339) in 1902, as compared with 225,759,980 ($236,305,214) in 1901. There was an increase in the output of most of the important coal producing States in 1902. The total production of coke in 1902 was 23,090,342 short tons ($51,864,575), as compared with 21,795,883 short tons ($44,445,923) in 1901. Pennsylvania furnished about two-thirds of the output each year.

Cobalt Oxide.—There was no production of cobalt oxide in 1902, against 13,360 lb. ($24,048) in 1901.

Copperas.—The production in 1902 was 19,784 short tons ($118,474), as compared with 23,586 short tons ($112,366) in 1901. The chief producer in this country is the United States Steel Corporation, which controls all the wire and rod works recovering copperas as a by-product. The above statistics do not include copperas converted into Venetian and Indian reds at the works of original production.

Copper Sulphate.—The production in 1902 was 48,763,538 lb., as compared with 78,004,257 lb. in 1901. Of this the amount recovered as a by-product chiefly by gold and silver refiners, was 35,879,212 lb. in 1902, and 51,000,000 lb. in 1901. The remainder of the output each year was made from metallic copper and from ore, the former being included in the production of copper. The average value of copper sulphate at New York per 100 lb. was $4·16 in 1902, as compared with $4·10 in 1901.

Corundum and Emery.—The production of corundum and emery in 1902 was valued at $95,135, as compared with 4,305 short tons ($146,040) in 1901. The production of steel emery or crushed steel in 1902 was 735,000 lb. ($51,450), against 690,000 lb. ($37,950) in 1901, the entire product each year being supplied by a single concern—the Pittsburg Crushed Steel Co.

Feldspar.—The production in 1901 was 31,019 long tons, valued at $220,422. The statistics for 1902 are not yet available. Pennsylvania, Massachusetts and New York are the principal producers of feldspar.

Fluorspar.—The production in 1902 was 27,127 short tons ($143,520), as compared with 19,586 short tons ($113,803) in 1901, Illinois, Kentucky and Tennessee furnishing the entire output.

Fullers Earth.—The output in 1902 was 14,100 short tons ($109,980), as compared with 14,112 short tons ($96,835) in 1901.

Garnet.—The production in 1902 was 3,722 short tons ($88,270), as compared with 4,444 short tons ($158,100) in 1901, the output each year being furnished by New York, Pennsylvania and Connecticut. The domestic resources of this mineral are large, but the demand for it is limited.

Graphite.—The production of crystalline graphite in 1902 was 4,176,824 lb. ($153,147), as compared with 3,967,612 lb. ($135,914) in 1901. The production of amorphous graphite in 1902 was 4,739 short tons ($55,964), as compared with 809 short tons ($31,800) in 1901. As in previous years, the larger part of the crystalline product in 1902 was obtained from Ticonderoga, N. Y., although a considerable quantity was mined in Pennsylvania and in Clay County, Alabama. The single producer of artificial graphite reported an output of 2,358,828 lb. ($110,700), as compared with 2,500,000 lb. ($119,000) in 1901.

Gypsum.—The production of gypsum in 1901 was 659, 659 short tons, valued at $1,577,493. These figures represent the amount of crude rock quarried. The larger part of the production is marketed in the form of stucco, or plaster of Paris.

Iron Ore.—The production in 1902 was 34,636,121 long tons, as compared with 27,887,479 long tons in 1901, these figures being exclusive of the production of manganiferous iron ore reported separately under manganese. The increase in the production was due chiefly to the Lake Superior ranges, which furnished by far the greater part of the output.

Lead White, Red Lead and Litharge.—The production of white lead in 1902 was 114,658 short tons ($11,978,172), as compared with 100,787 short tons ($11,252,653) in 1901; of red lead, 11,669 ($1,262,712), as compared with 13,103 ($1,448,550); of litharge, 12,755 ($1,299,443), as compared with 9,460 ($979,586); of orange mineral, 867 ($138,349), as compared with 1,087 ($224,667) in 1901. The larger part of these products is obtained by the corrosion of pig lead, but a small part of the white lead product is made directly from the ores.

Limestone for Iron Flux.—Iron smelters consumed 9,490,090 long tons of limestone in 1902, as compared with 8,540,168 long tons in 1901, the increase being caused by the greater production of pig iron.

Magnesite.—The production in 1902 was 3,466 short tons ($21,362), as compared with 13,172 short tons ($43,057) in 1901. The entire output in both years was mined in California and represented but a small portion of the magnesite consumed in this country. Large quantities of this mineral are imported from Austria and Greece.

Manganese Ore.—The production of manganese ore, including manganiferous iron ore in 1901 was 638,795 long tons.

Mica.—The production of sheet mica in 1901 was 360,060 lb. ($98,859) of scrap mica, 2,165 short tons ($19,719). Mica is mined in South Dakota, New Hampshire, North Carolina and Nevada. The imports of mica into the United States in 1902 were 2,251,856 lb., valued at $466,332, of which 102,299 lb. ($46,970) was cut or trimmed mica.

Mineral Wool.—The production in 1902 was 10,843 short tons ($105,814), as compared with 6,272 short tons ($68,992) in 1901. A part of this product was made from slag and a part by the fusion of natural rock, the latter being the more valuable.

Molybdenum Ore.—The production in 1902 is estimated at 15 short tons, valued at $750, as compared with a like output in 1901. The value of molybdenum ore varies within wide limits, and a nominal value of $50 per ton is placed upon the output.

Monazite.—The output in 1901 was 748,736 lb. ($59,262), and came from North Carolina and South Carolina.

Natural Gas.—The production of natural gas in 1902 is estimated at $30,000,000, as compared with a value of $27,067,500 in 1901.

Ocher and Oxide of Iron Pigments.—The production of ocher, umber, sienna and natural oxide of iron ground pigment, the last being known commonly as metallic paint, was 55,320 short tons ($705,026) in 1902, as compared with 43,036 short tons ($516,308) in 1901. The separation of these products is attended with considerable difficulty, as they merge into one another. Pennsylvania is the largest producer of these pigments.

Petroleum.—The total output in 1902 was 84,250,738 bbl. ($70,628,100), as compared with 69,389,194 bbl. ($66,417,335) in 1901. The large increase was due to the enormous developments in Texas and California, the Appalachian field showing a decided falling off. The average value was considerably lower in 1902 than in 1901, as the Western oil is valued upon a fuel basis.

Phosphate Rock.—The production in 1902 was 1,464,668 long tons ($4,636.-

516), as compared with 1,483,723 long tons ($5,316,403) in 1901. Florida was the only important State to report an increase.

Salt.—The domestic output of salt increased from 20,566,661 bbl. in 1901 to 23,849,221 bbl. in 1902.

Silica.—The production of vein and dike quartz in 1902 was 13,904 short tons ($117,423), as compared with 14,050 short tons ($41,500) in 1901. The uses of quartz are chiefly in pottery, for packing acid towers and for grinding purposes. The production of grindstones, which are made out of quartzite, or a very hard sandstone, in 1902, was valued at $656,832, as compared with 16,807 short tons, and a value of $580,703 in 1901. The weight of the production in 1901 does not include 40,980 pieces of which the weight is not specified, but which are reckoned in the value. The production of oilstones, scythestones and whetstones in 1902 was valued at $219,172, as compared with $158,300 in 1901. The production of pumice in 1902 was 100 short tons, against no output in 1901. The production of diatomaceous earth and tripoli in 1902 was 4,855 short tons ($49,974), as compared with 4,020 short tons ($52,950) in 1901.

Slate.—The production of roofing slate in 1901 was 1,304,379 squares ($4,114,410) and the value of the production of slate manufactures, chiefly blackboard and structural material, was $673,115. The output of slate pigment, including Baraga graphite and various kinds of mineral black, in 1901 was 4,865 short tons, valued at $41,211. Pennsylvania and Vermont lead in the production of slate.

Soda.—The production of soda and soda products from salt, reduced to a common basis of 58% soda ash, was 562,000 metric tons in 1902, as compared with 480,000 metric tons in 1901. The value of the product in the respective years was $10,290,220 and $8,318,400, the average value of 58% ash at the works being $18·31 and $17·33 per metric ton, respectively. There was an output of 25,000 short tons of natural sodium carbonate, equivalent to 16,000 short tons of 58% soda ash, as compared with the equivalent of 15,000 short tons of 58% ash in 1901. The production of natural soda in both years was made in California and Nevada.

Sulphur and Pyrites.—Louisiana, Nevada and Utah produced 7,443 long tons of sulphur in 1902, against 6,976 long tons in 1901. The average price of Sicilian seconds at New York in 1902 was $22·72 per ton, compared with $23·71 in the previous year. The domestic production of pyrites in 1902 was 228,198 long tons ($971,796), as compared with 234,825 long tons ($1,024,449) in 1901. Of the total output in 1902, Virginia contributed more than one-half, followed by Georgia, North Carolina, Colorado, Massachusetts, California, Indiana, Ohio, Missouri and New York. The production from Indiana and Ohio was obtained as a by-product in coal mining. The average prices of concentrated sulphuric acid of 66°B. were $22·40 per 2,000 lb. at New York in 1902, as compared with $23·50 in 1901.

Talc and Soapstone.—The production during 1902 of soapstone for slabs and other manufactured articles and common talc mostly ground to powder, was 21,640 short tons ($413,497), as compared with 28,643 short tons ($424,888) in 1901. These materials were obtained in North Carolina, Virginia, New

Jersey, Pennsylvania and Maryland. The production of fibrous talc, all of it from St. Lawrence County, N. Y., was 71,100 short tons ($615,350) in 1902, as compared with 69,200 short tons ($483,600) in 1901.

Tungsten Ore.—There was a production in 1902 of 250 short tons of tungsten ore, as compared with 179 short tons in 1901. The outputs in each year were nominally valued at $38,600 and $27,720, respectively. Most of the material produced in 1902 came from Colorado.

Uranium Ore.—In 1901, Colorado produced 375 short tons of uranium ore, as compared with 810 tons in 1902.

Venetian and Indian Reds.—The production of these colors in 1902 was 11,758 short tons ($196,905), as compared with 9,201 short tons ($153,467) in 1901. These figures include only the output at works where the original copperas was made, and do not take into account any material that may have been made by second handlers.

Zinc Ore.—The quantity of zinc ore of domestic origin exported from the United States in 1902 was 54,613 short tons ($1,449,109), as compared with 44,156 short tons ($1,167,684) in 1901. Most of the ore exported was mined in New Jersey.

Zinc Sulphate.—There was a production of 7,500 short tons of zinc sulphate in 1901.

Zinc White.—The production in 1902 was 52,730 short tons, as compared with 46,500 short tons in 1901. The total value was $4,023,299, as compared with $3,720,000 in 1901. A large part of the production of zinc white in the United States is made by the New Jersey Zinc Co.

ALUMINUM AND ALUM.

By Joseph Struthers.

Under this general caption are grouped aluminum, alum, bauxite, cryolite, corundum and emery, substances which, previous to Volume VII., appeared under individual captions. The present arrangement is a logical one, since both bauxite and cryolite are used as raw material in the manufacture of aluminum and alum, two industries so interwoven that a logical separation is impossible, and, since corundum, though employed mainly as an abrasive, is now used in part as a source of aluminum. In this view aluminum, alum and the aluminum minerals—bauxite and cryolite, corundum and emery—bear the same relation to one another as do copper, copper sulphate or bluestone and copper ores.

I. Bauxite.

The production of bauxite in 1902 was 27,322 long tons, valued at $120,366, as compared with 18,905 long tons, valued at $79,914 in 1901, being a large increase over the output of the preceding year. Of the production in 1902 Georgia contributed nearly 70% of the total output, the balance being contributed by Arkansas and Alabama in the order named. The following companies were in operation during the year: Republic Mining & Manufacturing Co., in Alabama and Georgia; General Bauxite Co., Harrison Bros., J. H. Hawkins, International Aluminum Mining Co., in Georgia; and General Bauxite Co., Pittsburg Reduction Co., and one minor producer in Arkansas. The mines of the Arkansas Bauxite Co., in Arkansas, and those of the Dixie Bauxite Co., in Alabama, were inoperative during the year.

Bauxite is consumed chiefly for the manufacture of aluminum, although a large quantity is used in the manufacture of aluminum sulphate and crystallized alum. The subjoined table of the production, imports, exports, with values of each, has been prepared to illustrate the annual consumption of bauxite in the United States during the past five years.

PRODUCTION, IMPORTS, EXPORTS, AND CONSUMPTION OF BAUXITE IN THE UNITED STATES.

Year.	Production.						Imports.		Exports.		Consumption.	
	Alabama.	Georgia.	Arkansas.	Total.								
	Lg. Tons.	Lg. Tons.	Long Tons.	Long Tons.	Value.	Per Ton.	Long Tons.	Value.	Long Tons.	Value.	Long Tons.	Value.
1898..	13,848	12,943	....	26,791	$66,978	$2·50	1,201	$4,238	1,000	$2,000	26,992	$69,216
1899..	14,144	19,619	3,052	36,813	101,235	2·75	6,666	23,768	2,080	4,567	41,449	120,436
1900..	650	20,715	2,080	23,445	85,922	3·66	8,656	32,967	1,000	3,000	31,101	115,889
1901.a	18,038		867	18,905	79.914	4·23	18,313	66,107	1,000	3,000	36,218	144,021
1902.a	22,677		4,645	27,322	121,465	4·45	15,790	54,410	*Nil.*	....	43,112	175,875

(*a*) Through the courtesy of the United States Geological Survey.

Imports and Exports.—The unusually large increase in the imports of French bauxite during 1901 and 1902, as contrasted with previous years, resulted mainly from the low ocean freight rates to New York, Philadelphia and Baltimore, which averaged \$2·25 per ton; adding to this amount the duty of \$1 per long ton, allowed the delivery at a cost *exmine* of \$3·30 per ton. Contrasting this cost with the freight rates from Georgia and Alabama of \$3·85 per ton to Philadelphia, and \$5 or more to Boston, shows that the French ore can be delivered to the seaport cities above named more cheaply than the domestic ore. On account of the high iron content of the French bauxite, its use is limited mainly for making aluminum hydrate, which is the raw material utilized for the manufacture of aluminum. There was no export of bauxite from the United States during 1902, as compared with 1,000 long tons in 1901.

Alabama and Georgia.—(By Thomas L. Watson.)—The mining of bauxite in the Southern Appalachian field during 1902 was confined principally to Georgia, a small quantity only being mined in Alabama. The principal producers of bauxite were the Republic Mining & Manufacturing Co., of Hermitage, Floyd County; the Southern Bauxite Mining & Manufacturing Co., of Cave Spring, Floyd County, and John H. Hawkins, of Rome. Several years ago the Dixie Bauxite Co. secured control of the principal properties, and it is claimed that it has 2,500,000 tons of high-grade ore blocked out. This company is awaiting the exhaustion of the other bauxite mines before contributing to the output in order to obtain a higher price for the product. The Republic Mining & Manufacturing Co. confined its operations principally to several land lots in the vicinity of Hermitage which were early exhausted, and to the Fat John bank in the Bobo district, nine miles west of Rome, which yielded a large quantity of ore. The company also mined on the Watters property, five miles north of Rome, where the ore deposit is one of the largest, if not the largest in the State; the product from this mine has been uniformly of high grade. The John H. Hawkins plant is located near McConnel's Station in Walker County, near the county line at the Armington bank. The deposit covers an area of 150×50 ft., and is stated to have an average depth of 36 ft., which is equivalent to a volume of 540,000 cu. ft.; assuming a specific gravity of 2·5 for the ore and allowing 25% loss in preparation, the deposit will yield 31,590 tons of commercial product. The mineral is mined by the open-cut method, and is carried in a side-dump car to a submerged, double log-washer, consisting of two 12-in. square logs, each carrying chilled cast iron lugs placed spirally upon them. They revolve in opposite directions 10 r. p. m. The upper end is 27 in. high, and water is here fed in by a 2·5-in. nozzle. After washing, the mineral is placed in a rotary dryer, 36 in. diameter by 36 ft. long, mounted on cast rollers 16 in. diameter, and revolved by an encircling sprocket chain. The flue end is 6 in. higher than the grate end, and wood is used for fuel. The composition of the crude bauxite averages Al_2O_3 62%, Fe_2O_3 1·5%, SiO_2 2%, and TiO_2 2%. The water is driven off by heating to redness.

On account of its freedom from iron oxide, the greater part of the bauxite produced in Alabama and Georgia is used in the manufacture of alum and aluminum sulphate, a small proportion only being utilized in the manufacture of aluminum. The first grade product is valued (f. o. b.) at \$5·50, and the second grade at \$4·50 per long ton.

Systematic prospecting for deposits of first grade ore was continued over the

Georgia area during 1902, and a number of deposits not sufficiently exploited in the past were favorably reported. The outlook, however, for much first grade ore in the Southern Appalachian field, which in the past has been the principal producer on the continent, is by no means encouraging, and much attention is at present being directed to the deposits of the Arkansas area. The Appalachian field is by no means exhausted of bauxite ores, as large quantities of low-grade ore are abundant, for which there has not been a market in the past, but from necessity will demand serious attention in the near future. The early exhaustion of the first grade ore in the Southern Appalachian field was predicted several years ago, and the shortage in the first grade ore has been felt to some degree during the year 1902 by the uniformly higher prices over those of the previous year. The United States Government has made appropriations to dredge the Coosa River and make it navigable as far as Rome, eight miles from the bauxite deposits, a work which will require at least two years to complete. Water power in the vicinity of Rome to the extent of 16,000 H.P. is available, throughout the entire year, and it is within the range of possibility that, with the expiration of the aluminum patents in the United States in from two to three years (by which time water transportation will be available), establishments for the manufacture of aluminum salts and even the metal itself will be erected at or near Rome.

New deposits of bauxite are not to be expected beyond the limits of the area already defined. A brief description of the limits, general geology and mode of occurrence of the bauxite deposits of the Southern Appalachian region is given in THE MINERAL INDUSTRY, Vol. X.

Arkansas.—The bauxite industry in Arkansas is still in an undeveloped state, and the exploration work that has been done at the mines at Bauxite is not sufficient to determine accurately the depth or quantity of ore in that region nor the character of the underlying stratum. The deposit differs from those in Georgia and Alabama in that the material occurs in narrow veins, thus increasing the cost of mining. On account of the presence of iron oxide, which precludes the use of bauxite for the manufacture of alum and aluminum sulphate, the greater part, if not all of the Arkansas product is used in the manufacture of aluminum hydrate, from which the metal aluminum is made. An analysis of the commercial product is reported as Al_2O_3 63%, SiO_2 2·25%, Fe_2O_3 1·95%, H_2O 31·5 to 32·75%. This composition conforms more closely to the mineral Gibbsite ($Al_2O_3.3H_2O$) than to bauxite ($Al_2O_3.2H_2O$). It is estimated that the extensive deposits contain many millions of tons of bauxite.

The new plant of the Pittsburg Reduction Co., at Bauxite, Saline County, is expected to be completed in 1903. The plant is designed on thoroughly modern principles, with special reference to the mechanical handling of the materials, and elevators, conveyors and cars replace hand labor to a great extent. The furnace equipment consists of a wood-fired cylindrical dryer and two 60-ft. rotary calciners fired by producer gas made in a 10×12-ft. Duffs water-sealed gas-producer. The plant includes a machine shop for building tram cars, etc.; a sawmill and planing mill to furnish the lumber for buildings, more than 30 houses for the workmen, an electric light plant and an ice plant with an attached cold storage room. The buildings are protected with standard fire plugs and hose well situated.

The ore is ground by a series of coarse and fine crushers and handled by elevators and conveyors from the tram cars, which bring the crude ore into the works, to the bins where it is stored ready for shipment. A large proportion of the ground ore is calcined direct, the smaller quantity being washed to remove the siliceous gangue and subsequently dried before calcination.

The new refining plant of the Pittsburg Reduction Co., three miles from East St. Louis, will occupy six acres of ground and will be similar to the works at New Kensington, Pa. It is stated that the calcining furnaces at the latter plant (eight in number) will be removed to the new works as soon as the construction is completed, probably early in 1903. During the last few years crude or calcined bauxite ore has been shipped from the mines to the New Kensington plant for the extraction of pure aluminum oxide, which was sent to Niagara Falls to be reduced to aluminum. The metal was then sent to New Kensington and rolled into sheets or drawn into wire.

The Bayer process for the purification of bauxite has been improved in various details, and now yields a better quality of aluminum oxide at a lesser cost. At the new East St. Louis refining plant the lime process, patented by Mr. Hall, will be used, and at the Niagara Falls plant an electric furnace method of purifying bauxite is in contemplation which may still further reduce the cost of manufacture of pure aluminum metal. Additional details of the processes of purification of bauxite will be found under the caption "Aluminum," given later in this section; also in previous volumes of THE MINERAL INDUSTRY.

THE WORLD'S PRODUCTION OF BAUXITE.

The world's supply of bauxite is derived chiefly from France, Ireland and the United States, and the annual production from 1895 to 1901, inclusive, is detailed in the subjoined table:—

PRODUCTION OF BAUXITE IN THE PRINCIPAL COUNTRIES OF THE WORLD.
(IN METRIC TONS.)

Country.	1895.	1896.	1897.	1898.	1899.	1900.	1901.
France	17.958	33,820	41,740	36.723	48,215	58,530	76.620
United Kingdom	10.574	7,865	13,449	12,600	8.137	5.873	10.357
United States	19,101	17,370	20,919	27,220	37,402	23,556	19,207
Total	47,633	58,555	76,108	76,543	93,754	87,959	106,184

France.—The principal bauxite mines are in the south of France, between the town of Brignoles (Var) and the Department of the Hérault. Formerly the center of the industry was at the town of Baux, from which the name of bauxite was derived. In the Department of the Var there are 31 mines, the most important being at Ampus, Barjols, Cabasse, Carces, Le Cannet du Luc, Le Muy, Le Thorenet, Lorgues, Mazaugues, Meounes, Puget sur Argens, Rougiers, Tourves and Vins.

Three varieties of bauxite are produced—ferruginous, aluminous and spotted. There is but little demand for ferruginous bauxite on account of the high content of iron oxide, which in some cases amounts to 60%. The so-called "aluminous" variety constitutes the highest or first grade product, and contains more than 60% Al_2O_3 and less than 3% SiO_2. It is delivered at Parabon les Baux station at a price of 15 fr. per metric ton. Spotted bauxite is pink or violet in color and occurs at Le Val, Le Vins, La Brasque and St. Christophe in the vicinity of Brignoles. An analysis of this variety yielded Al_2O_3 63·15%, Fe_2O_3 21·99%, SiO_2 0·26%, TiO_2 0·26% and H_2O 12%. With silica less than 3% and Al_2O_3 greater than 60%, the price of spotted bauxite delivered at Brignoles station is 12 fr. per metric ton; freight from Brignoles to Marseilles is 4·2 fr. per ton, loading on steamer, 1·35 fr., making a total of 17·55 fr. per ton f. o. b. Marseilles. The price f. o. b. St. Raphael is 17·1 fr. per ton.

The bauxite deposits of Var occur in two synclinal basins extending in diverging direction westward from Cannet du Luc. This region was once occupied by lakes in which, possibly with the aid of hot springs and geysers, the bauxite was deposited. The completion of the railroad to Bastide de Sevon, where the bauxite mines of the Compagnie des Phosphates et Bauxite de l'Ariege are situated, will permit the increased shipment from this district. Both white and red varieties are mined, of an average content of 65% Al_2O_3, the silica and iron oxide being present in small quantities only. During 1901, the exports of bauxite from Var through St. Raphael amounted to 43,700 metric tons, as compared with 24,656 metric tons in 1900. The first shipments of bauxite from Toulon amounted to several hundred tons in 1901, and the exports of bauxite from Cette were 1,675 tons, as compared with 353 tons in 1900.

Germany has hitherto been the chief purchaser of red and white bauxite, the former containing a smaller proportion of alumina, but the trial shipments of 1,700 tons of the spotted variety to Boston, Mass., in December, 1901, is expected to develop a market in the United States, especially for consumption in the Eastern States, where, by reason of the high railroad freight rates from Georgia and Alabama, the French bauxite can be delivered at seaboard cities (including the duty of $1 per short ton) at a lesser cost than for the domestic ore.

Italy.—(By Giovanni Aichino.)—The deposits of bauxite recently discovered in the central Apennine district were not mined during 1902, although a small amount of exploratory work was made at Pescolido, near Sora, on the left side of the Lori Valley at a short distance from the Rociasecca-Avezzano branch of the Roma-Napoli and Roma-Sulmona railways. The latter deposit is similar to that of Leccene 'Marsi.[1]

The following analyses have been reported by E. Mattirolo, of the Chemical Laboratory of the Royal Board of Mines Geological Survey:—

Components.	No. 1.	No. 2.	No. 3.
	%	%	%
H_2O	1·05	0·86	1·21
H_2O (combined)	11·48	12·25	11·72
SiO_2	5·76	2·52	4·68
TiO_2		1·27	
Fe_2O_3	25·69	24·12	24·68
FeO		0·71	
Al_2O_3	55·89	58·40	57·83
Total	99·82	100·13	99·62

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[1] THE MINERAL INDUSTRY, Vol. X., p. 14.

As far as known the published analyses of the Italian bauxites have an alumina content varying from 47·4 to 58·9%. The large quantity of iron oxide present, which has not been found less than 18% Fe_2O_3, is a serious drawback to the commercial development of the mines. It must be noted, however, that a careful study of the deposits has not yet been made. The occurrence of bauxite containing from 51·13 to 57·52% Al_2O_3 is reported in the Province of Apullia in Southern Italy.

II. CORUNDUM AND EMERY.

The production of corundum and emery and the imports of emery in the United States during the past four years are given in the subjoined tables:—

PRODUCTION OF CORUNDUM AND EMERY IN THE UNITED STATES.

Substance.	1899.			1900.			1901.			1902.		
	Tons. (b)	Value. (a)	Per Ton.	Tons. (b)	Value. (a)	Per Ton.	Tons. (b)	Value. (a)	Per Ton.	Tons. (b)	Value. (a)	Per Ton.
Corundum	970	$78,570	$81·00	880	$58,100	$70·00	4,305	$146,040	$87·40	(c)	$95,185	....
Emery	3,000	150,000	50·00	4,200	189,000	45·00						
Steel emery	337	47,250	140·21	345	48,300	140·00	355	49,700	140·00	368	51,450	$140·00
Total	4,287	$275,820	....	5,875	$295,400	....	4,660	$195,740	....	......	$146,585	....

(a) The values are based on the prices at the mines, but except in the case of steel emery are of slight significance owing to the great range between the different grades of the minerals. The changes in the annual averages do not indicate fluctuations in market quotations so much as changes in the proportion of different grades of mineral in the total. (b) 2,000 lb. (c) The quantity of emery produced was 3,497 short tons.

IMPORTS OF EMERY INTO THE UNITED STATES.

Year.	Grains.		Ore or Rock.		Other M'f'rs.	Total Value.	Year.	Grains.		Ore or Rock.		Other M'f'rs.	Total Value.
	Pounds	Value.	Long Tons.	Value.	Value.			Pounds.	Value	Long Tons.	Value.	Value.	
1895..	678,761	$25,066	6,803	$80,386	27,586	$133,038	1899.	728,299	$29,124	7,435	$116,493	$11,514	$157,131
1896..	751,464	26,520	6.289	119.667	1.971	148,158	1900.	661.482	26,520	11,393	202,380	10,006	239,506
1897..	520,095	20,023	5,209	107,649	2,211	129,882	1901.	1,116,729	43,207	12,441	240,856	10,927	294,990
1898..	577,655	23,320	5,547	106,269	3,810	133,399	1902.	1,665,787	60,079	7,166	151,959	13,776	225,814

PROGRESS OF THE CORUNDUM AND EMERY INDUSTRY DURING 1902.

BY JOSEPH HYDE PRATT.

THERE are few changes to be noted in the corundum and emery industry during 1902, and none of these is of special importance. The principal change is, perhaps, the incorporation of the Blue Corundum Mining Co., which now owns mines at Chester, Mass., and at Peekskill, N. Y., and at the present time controls the larger proportion of the emery produced in this country. The company, however, is doing but little with the development of the corundum deposits in the United States, although it has done extensive work on the deposits of this mineral near Conbemere, Ontario, Canada.

The Montana Corundum Co. continued development work on its deposits near Saleville, Mont., and the Bozeman Corundum Co. was engaged in exploring the Blankenship property near Bozeman. A detailed account of the year's progress in Montana will be found later in this section.

In North Carolina, the North Carolina Corundum Co. has continued operations during 1902 with the result that it has felt warranted in installing a complete mill for treating the ore and preparing the product for the market. Its property adjoins the noted Buck Creek mine, formerly owned by the International Emery & Corundum Co.;.the corundum occurring in the same general formation as that in the Buck Creek mine. Formerly corundum from this locality had to be hauled a distance of from 35 to 40 miles to the railroad, but it can now be landed at the railroad, a distance of 18 miles over a new road that has been built from the mine. This company reports that it will begin shipping corundum early in 1903. While prospecting was being carried on in this vicinity a mass of solid yellow corundum was found weighing 125 lb., which was taken to Pittsburg, Pa., by Mr. Hugh Ferguson. The other localities in the southern field where any considerable work has been done are the Corundum Hill mine at Cullasaja, Macon County, N. C., and the deposits near Tate, Towns County, Ga. The work done at both places was less than that of the year before, and has lately been entirely abandoned.

The Canadian corundum deposits have produced the largest quantity of corundum during 1902, and the results obtained by the Canada Corundum Co. at the Craig mine, Raglan Township, Ont., have been most encouraging. Its successful work has stimulated considerable prospecting for this mineral throughout the Province, and there are now a number of companies that have been formed to develop corundum mines. The Canada Corundum Co. has made a decided increase in production over that in 1901. The capacity of the mill has been enlarged, and the company is now the largest producer of corundum (exclusive of emery) in the world. The experimental work in cleaning the corundum has resulted very favorably, so that now the product marketed is of high grade and is giving good satisfaction. Further details of the corundum deposits in Canada are given later in this section.

There has been an increased production of emery from the Peekskill, N. Y., mines, while the Chester, Mass., deposits have not been operated as extensively as in former years. Thus, although there has been an increasing demand for emery and corundum, there has been quite a decrease in the production in the United States, with a corresponding increase in the importation of emery and corundum, the former being obtained from Naxos, in the Grecian Archipelago, and from Turkey; and the latter principally from Canada with a much smaller quantity from India.

The foreign emery is imported in the crude state, and can be landed on the docks in New York or Boston as cheap, if not cheaper, than the American emery. There have been several new companies organized who are importing emery and preparing it for market. The Canadian corundum is imported as the commercial product ready for manufacture into wheels. The manufacture of artificial corundum and carborundum affects the production of corundum and emery to some extent, but not equal to the total quantity of these artificial abrasives that are manufactured. These artificial abrasives enter more into competition with the corundum than with the emery. With the price of corundum from 8 to 10c. per lb., there will be but little tendency for it to cut into the emery market, but if the price is lowered to 5c., it will replace a large amount of emery. A decrease in price to 5c. per lb., would prevent the operation of some of the mines that are now being developed.

The production of corundum and emery in the United States in 1902 was less than that in 1901, which is not due to a lessened demand for these minerals, but to the close competition with foreign emery, and to an uncertainty regarding the price and market for corundum. There is still too much tendency on the part of the producer to believe that the market for corundum and emery is practically unlimited, for when it is considered that the total amount of these abrasives used in the United States in 1901 was only about 16,000 tons, it can readily be understood how easily the market can be flooded. This would mean a drop in prices, which would be disastrous to many companies.

Montana.—(By Leverett S. Ropes.)—The discovery of corundum in Montana reported in The Mineral Industry, Vol. X., was followed by encouraging developments during 1902, which promise a permanent supply of high-grade product from this source. The mine of the Montana Corundum Co. has been placed on a producing basis, and the Blankenship and Anceny properties have been prospected with favorable results. The mines and prospects are situated in the central belt of gneiss shown on the Three Forks Folio of the U. S. Geological Survey, one property lying to the east and the others to the west of the Ells Creek fault. The geological formation is syenite overlain by beds of hornblendic rock and heavy quartz reefs which may represent metamorphosed sediments of Pre-Cambrian age. Near the boundary of the syenite, the corundum is found in what appear to be veins, although they may represent thin intrusions, as the walls show the effects of great heat. The walls are usually well defined and bear evidence of having been subjected to considerable movement. On the property of the Montana Co. the vein strikes S. 39° W. with a dip of from 42° to 50° N., while at the Anceny prospect the strike is a little south of east and the dip 45° south. The hanging wall is the same for both veins, thus indicating that they occur in the wings of a synclinal fold. The Montana Corundum Co. began developing its property in the early part of 1901, and by the close of the following year had opened up a large supply of ore. A mill was erected during 1902, but the work was so delayed that active operations were not attempted until the beginning of 1903, when the plant was started on a run of eight hours per day, giving an output of 20 tons of graded concentrates. The mill equipment consists of a 10×16-in. Blake crusher delivering to a belt conveyor that carries the crushed product to a 100-ton storage bin in the main mill. From here the ore passes through a set of 27×14-in. New Standard rolls, and is then passed over three vibratory screens of 8-, 5-, and 3-mm. mesh, the oversizes returning to the rolls. The undersizes are treated in 3 two-compartment jigs from which the product is elevated to a storage bin over a second set of rolls, after passing which it goes to a Pratt-Wethey separator with 2·5-mm. screens. The oversize is returned to the rolls, while the undersize passes directly to a muller, which is continuous in its action. From the muller both overflow and spigot products are sent to a hydraulic classifier making three products, two of which pass to rubber-top Bartlett tables, and the third to the tailings pond. The tables bring the concentrates to the required degree of purity, and the latter are then fed to a revolving dryer. From this storage bin the concentrates are fed to the "splitter," a form of reciprocating screen having four 60×30-in. wire or silk coverings, which make five sizes. The four coarser sizes pass to similar machines (graders) while the fines are run through 180-mesh silk. The graders have a 48×40-in. covering, and make four sizes each or 16 in all, which are weighed into 100 lb. canvas bags ready for the market. The results of practical tests of Montana corundum have been favorable, and there is little doubt but that it will find a good demand in the Eastern markets.

Canada.—(Through the courtesy of B. A. C. Craig.)—During 1902 the Canada Corundum Co. produced 796 tons of grain corundum, and the Ontario Corundum Co., a branch of the Levant Emery Co., for a short period shipped a daily average of two tons of ore to its works at Chester, Mass. The demand for the Canadian product has proved very satisfactory, and the industry is now firmly established upon a commercial basis. A considerable increase in the output is expected in 1903, as the Canada Corundum Co. has a new mill under construction which, when completed in September, 1903, will handle from 200 to 300 tons of ore per day.

There are three distinct corundum-bearing areas in Ontario. Of these the most northerly extends for a distance of about 70 miles from Haliburton County eastward along the boundary between Hastings and Renfrew counties, and has an average width of two miles. It contains a number of very large deposits. South of this area, in Frontenac and Lanark counties, there is a second belt about 15 miles long by one-fourth mile in width, which includes two deposits of some size. The third area, known as the Burleigh-Methuen belt, lies southwest of the first in Peterboro County. It contains no deposits of economic importance. The corundum is associated with syenite dikes, whose relations to the surrounding rock have not been definitely determined. The dikes occasionally rise into hills of considerable size, and it is in these localities that the richer deposits are found. Craig Mine Mountain, which is the property of the Canada Corundum Co., is a hill about 540 ft. high and a mile in length. The whole hill consists of eruptive rock, more or less laminated with the planes of schistosity dipping 30° southward. The open-cut workings have exposed the corundum-bearing dike for a distance of from 40 to 72 ft. across the strike, but without reaching its limits.

In the new mill of the Canada Corundum Co. the ore will be conveyed by tramway to a 450-ton ore bin. After passing through a 15×24-in. Blake crusher, it will go to a series of three crushers—two 6×20-in. Blake crushers and one 6×21-in. Gates crusher. From the second bin the ore will pass through two trommels, and will then be fed to four sets of 14×40-in. rolls of extra heavy construction, after which it will be elevated and passed through 10 trommels for sizing. The different sizes will be fed to separate Overstrom and Wilfley tables, numbering 20 in all. The middlings are to be treated on six additional tables, while the concentrates will be carried to bins for draining and then passed through cylindrical dryers. The concentrates after drying will be conveyed to the grader room and passed through magnetic separators, splitters and graders. Three additional concentrating tables and two Hooper pneumatic jigs will be placed in the grader room for reconcentrating any size that may be found impure. Power will be furnished by three 150-H.P. boilers and two engines aggregating 525 H.P.

EMERY.—*Greece.*—The emery deposits on the Island of Naxos are mined by the natives under the control of the Grecian Government, which purchases the crude product at 2·5 fr. ($0·48) per long cwt. (112 lb.). The ore is shipped to the adjacent island of Syra at the expense of the Government, and is there sold at 106·5 fr. ($20·55) per metric ton. The alumina content of the Naxos emery is sometimes as high as 60%. The exports of Naxos emery during 1901 were 5,691 metric tons, valued at $121,215, as compared with 6,328 metric tons, valued at $134,160 in 1900. Of the annual output of Naxos emery, the United States consumes about 25%, the balance being shipped to Europe. The Naxos emery mines have never been leased. Two years ago an American company endeavored to secure a monopoly of the industry by offering the Grecian Government an agreement to purchase 7,000 tons of emery per year for 10 years at 106·5 fr. ($20·55) per ton. The negotiations, however, failed.

Turkey.—The deposits of emery in Turkey are scattered along the coast of the Mediterranean and adjacent islands. The principal mines are at Baltizik, Azizieh, Cosbounar, and Kuluk, near Smyrna. The Turkish Government owns a few of the mines, but many are owned and operated by local companies and individuals. The mined ore is hand-picked before shipment, and is never crushed or washed. The corundum found in the Turkish emery varies from 40 to 57% Al_2O_3, with the exception of Kuluk ore, which is said to contain 37% Al_2O_3. The Kuluk emery is brought down from the neighboring mountains by camels and is shipped at a price f. o. b. Kuluk of $10@$12 per ton. The total annual exports of Smyrna emery range from 17,000 to 20,000 tons, of which about 10,000 tons are shipped to America, the balance going to Europe. During 1901 the value of the quantity of emery exported amounted to $265,140. The price of Smyrna emery varies with the quality from $14@$20 per ton f. o. b. Smyrna. It is reported that emery cannot be produced f. o. b. Smyrna for less than $12·50 per ton.

EMERY WHEEL MANUFACTURE.—The Norton Emery Wheel Co., of Worcester, Mass. (the largest abrasive wheel concern in the world) has erected an extensive plant at Niagara Falls, N. Y., and since the latter part of 1902 this company has been manufacturing artificial corundum from bauxite, which is claimed to possess superior abrasive qualities, exceeding carborundum both in toughness and cutting efficiency. The new abrasive is known as "alurundum," and is made in a manner similar to the process used for the manufacture of carborundum, the impurities being reduced and volatilized by the heat of the electric furnace. The resultant alumina is obtained in a molten condition and assays 98·5% Al_2O_3. It is reported that this abrasive can be produced at a cost less than that of either natural corundum or carborundum. The method of treatment is as follows: The bauxite is charged into the upper end of a coal-fired calcining furnace, and the calcined product when cool is charged into electric furnaces using 500 H.P. When the material becomes molten two carbon electrodes are dipped into the bath and fresh supplies of bauxite are added from time to time as the contents become melted. When the operation is completed the electrodes are removed and the molten material allowed to cool in the furnaces for from three to four hours, after which the solidified mass is removed and placed on the floor for further cooling. The mass is then coarsely broken and shipped to the main works at Worcester. The product is flinty in appearance and contains at times beautiful small crystals of pure alumina resembling sapphire and ruby. In fact these are artificial gems but are too small in size to possess any economic value.

The plant of the Hampden Corundum Wheel Co. at Springfield, Mass., which was destroyed by fire in 1901, has been thoroughly rebuilt with special reference to the replacement of hand labor by mechanical devices to transport the material in the works during treatment. Down-draft kilns are used having the top in the form of a flattened dome which is utilized as a drying floor during the firing. The wheels to be burned are packed in fire brick boxes and are surrounded with coarse emery or corundum in place of quartz formerly used for this purpose; this method not only saves the expense of the quartz supply, but, in addition, the heat otherwise lost is utilized to burn the crude material. The general arrangement of the new plant is as follows: The crude ore is crushed in the crusher room and distributed to the grading room, where it is washed, dried and elevated to the molding room, where the wheels are fashioned by hand or hydraulic press. The molding room is directly below the grading room, and the wheels when molded are conveyed to the drying room directly above the kilns and dried. They are then placed in the kilns and burned. The fired wheels are dressed and hubbed in the turning room; and when finished are carried to the stock room and stored ready for shipment.

III. Cryolite.

The imports of cryolite into the United States continue to be derived from the mines in Greenland, and the statistics of quantity and value since 1891 are given in the subjoined table. These shipments were made by the Pennsylvania Salt Manufacturing Co., of Natrona, Pa., which possesses the exclusive privilege to import this mineral into North and South America. The remainder of the output of the Ivigtut mines is shipped to Copenhagen.

IMPORTS OF CRYOLITE INTO THE UNITED STATES FROM 1891 TO 1902, INCLUSIVE. (*a*)

Year.	Long Tons.	Value.	Year.	Long Tons.	Value.	Year.	Long Tons.	Value.	Year.	Long Tons.	Value.
1891..	8,298	$76,850	1894..	10,684	$142,494	1897..	10,115	$135,114	1900..	5,437	$72,768
1892..	7,241	96,982	1895..	9,425	125,368	1898..	6,201	88,501	1901..	5,383	70,886
1893..	9,574	126,688	1896..	8,009	40,056	1899..	5,879	78,676	1902..	6,188	85,640

(*a*) The values are those reported by the Custom House and represent the estimated cost at the mines. There being no United States Consul at shipping point in Greenland, a *pro forma* invoice is prepared for Custom House purposes, wherein the value represents only a small part of the actual cost at buyers' factory.

The value of cryolite in the United States is stated to be $80 per ton of 2,240 lb., and results from the following items: Cost at the mine in Greenland, royalty to Danish Government, ocean freight, inland or domestic freight, cost of separating the pure cryolite, grinding and packing in barrels, and other minor expenses.

According to a report furnished by the Danish Government the total output of cryolite from the mines at Ivigtut, Greenland, was 8,960 metric tons in 1900, and 7,997 metric tons in 1901. An article on sodium fluoride will be found in the section on "Fluorspar," later in this volume.

IV. ALUMINUM.

The production of aluminum in the United States continues to be supplied by the sole producer, the Pittsburg Reduction Co., of Niagara Falls, N. Y., and during 1902 the quantity produced was 7,300,000 lb. as compared with 7,150,000 lb. in 1901. The demand for the light metal in the electrical trade, particularly for purposes of electric current conduction, and in the metal trade as a substitute for zinc and brass, continues to be large. The details of the production and prices of aluminum together with its utilization, properties, etc., will be found in the special review of progress in the aluminum industry during 1902 which is given later in this section.

The subjoined tables give the production, imports and exports of aluminum in the United States and other of the principal countries in the world from 1898 to 1902 inclusive.

PRODUCTION, IMPORTS, AND CONSUMPTION OF ALUMINUM IN THE UNITED STATES.

Year	Production.			Imports. (b)	Exports.	Consumption. (a)
	Pounds.	Value.	Per Lb.	Value.	Value.	Value.
1898	5,200,000	$1,690,000	$0·325	$4,879	$238,997	$1,454,882
1899	6,500,000	2,112,500	0·325	14,840	291,515	1,835,825
1900	7,150,000	2,288,000	0·32	47,688	281,821	2,053,847
1901	7,150,000	2,238,000	0·31	104,168	183,579	2,158,589
1902	7,300,000	2,284,590	0·318	215,032	116,052	2,383,570

(a) The consumption each year includes a certain amount of manufactures imported; while the production represents the crude aluminum only. (b) The bulk of the imports is in crude condition.

The statistics of aluminum production in Europe are not authoritative, several of the important companies being unwilling to make their figures public. The *Metallgesellschaft*, of Frankfort-on-Main, gives the following statistics for Europe in its last annual report, to which we have added our own figures for the United States, the official figures for France, and those of C. Le Neve Foster for England previous to 1900.

ALUMINUM: WORLD'S PRODUCTION AND COMMERCE. (IN KILOGRAMS.)

Year.	Germany.	Switzerland.		England.	France.			United States. (a)		Total Production.
	Imports.	Production.	Exports.	Production.	Production.	Imports.	Exports.	Production.	Imports.	
1897..	942,400	800,000	706,000	[b]310,000	470,000	6.360	224,000	1,814,388	854	3,394,448
1898..	1,104,000	800,000	677.300	310,000	565.000	5,972	187,955	2,358,705	27	4,033,705
1899..	922,000	1,300,000	604.200	559,000	763,000	8,468	256,242	2,948,381	24,323	6.570,389
1900..	943,400	2,500,000	571,200	568,960	1,026,000	8,300	323,700	3,243,219	116,853	7,338,173
1901..	1,089,600	2,500,000	504,100	560,000	1,200,000	11,400	806,600	3,311,218	255,696	7,571,211

(a) The United States has been an exporter of aluminum for several years, but these exportations were not enumerated by the Bureau of Statistics of the Treasury Department until 1898, in which year they amounted to $239,997. (b) C. Le Neve Foster, British Mineral Statistics for 1897.

United States Duty.—The duty on aluminum imported into the United States is 8c. per lb. on ingot metal and 13c. per lb. on sheet and manufactured metal.

PROGRESS IN THE ALUMINUM INDUSTRY IN 1902.

BY JOHN B. C. KERSHAW.

PRODUCTION.

THE number of works actually producing aluminum has not been increased during 1902 and the following table from THE MINERAL INDUSTRY, Vol. X., p. 21, still represents the production side of the industry:—

TABLE I.—DETAILS OF ALUMINUM WORKS IN EUROPE AND AMERICA.

No.	Name of Company.	Locality of Works.	Horse Power.		Process.	Capital.
			Available	In Use.(a)		
1	The Pittsburg Reduction Co	Niagara Falls	....	10,000	Hall	31,600,000
2	The Pittsburg Reduction Co	Niagara Falls	....		Hall	
3	The Pittsburg Reduction Co. (b)	Shawinigan Falls	6,000	5,000	Hall	....
4	The British Aluminium Co	Foyers	14,000	5,000	Heroult	$3,560,000
5	Société Electro-Metallurgique Française	Le Praz	12,500	5,000	Heroult	2,880,000
6	Compagnie des Produits Chimiques d'Alais	St. Michel	6,000	2,000	Hall & Minet	....
7	Société Anonyme pour l'Industrie de l'Aluminium	Neuhausen	4,000	4,000	Heroult	$3,077,000
8	Société Anonyme pour l'Industrie de l'Aluminium	Rheinfelden	5,000	5,000	Heroult	
9	Société Anonyme pour l'Industrie de l'Aluminium	Lend Gastein	5,000	(?)	Heroult	

(a) With the exception of the American and Canadian works, all these works manufacture other products in addition to aluminum. (b) The Royal Aluminum Co.

The power available for the reduction of aluminum in these nine factories, lies between 36,000 and 40,000 H.P., but other products are made in several of the European factories, and the total power available is no criterion of that actually in use for aluminum production. The maximum output of the metal possible with the present installations of plant, would be about 11,500 tons, per annum, but it will be some years before this total is attained. Official figures for the aluminum production in Europe, in the years 1901 and 1902 are again withheld, but there have been indications that during 1902, the leading European companies have curtailed production, in order to work off the accumulation of stocks, resulting from over-production in previous years.

The Neuhausen company has declined to provide any figures for publication, and one can only base an estimate on the last published return—namely 2,500 tons for the year 1900. Probably this total is greater than the output of the three works of this company situated at Neuhausen, Rheinfelden and Lend Gastien during the years 1901 and 1902.

With regard to the output in France, M. Heroult has informed me that the production of 1902 has not differed materially from that of the previous year. As stocks are stated to be large, it is probable that if there has been any change it has been in the downward direction. In 1900, France produced between 1,000 and 1,500 tons of the metal, and no advance upon the latter total is likely to have occurred in 1901 or 1902.

In the United Kingdom, the position has been complicated by the financial difficulties of the only producing company, the British Aluminium Co., with works at Foyers, and no reliable estimate of the output at this works can therefore be made.

As regards the production in America, the output of the Pittsburg Reduction Company for 1901 has been given as 3,240 metric tons; while according to

Prof. Richards the 1902 production in the three works situated at Niagara Falls, N. Y., and Shawinigan Falls, Canada, will reach 4,500 tons.*

Using these figures as basis for calculation, I estimate that the total world's production of aluminum in the nine factories manufacturing the metal in 1901 and 1902, has been as follows:—

	1901.	1902.
European works (6)	4,000 metric tons.	3,800 metric tons.
American works (3)	3,240 metric tons.	4,200 metric tons.
Total	7,240 metric tons.	8,000 metric tons.

In spite of the fact that the production of aluminum in recent years has been rather in excess of the demand, two new works are being planned, and one of these is in course of erection.

At Massena, N. Y., the Pittsburg Reduction Co. has bought land, and has commenced to erect a works for the utilization of the water power already developed at this spot, by the St. Lawrence Power Co. This company in the years 1898-1901 has erected large hydraulic engineering works between the Grass River and the St. Lawrence River, developing 50,000 H.P. at Massena, at a capital expenditure of $10,500,000. Unfortunately the St. Lawrence Power Co. has become involved in financial troubles, and the plant and works have now passed into the possession of a syndicate representing some of the original bondholders. The reorganization of the affairs of the company, which is now proceeding, may possibly retard the manufacturing operations of the Pittsburg Reduction Co., but it is stated that the new factory will be in operation by April, 1903. The plant now being installed is of 1,200-H.P. capacity, and consists of four 300-H.P. sets, generating current at 500 volts. It is intended gradually to increase the plant as the demand for aluminum grows, and an ultimate utilization of 12,000 H.P. is in prospect.[1]

The second new aluminum works is being promoted by a Franco-Spanish syndicate, and it is intended to erect a works at Zudavic in Spain. Water power is to be used, but no other details of the new venture have yet been published. In view of the present unsatisfactory state of the industry in Europe, it is probable that the development of this new center for production of aluminum will be long delayed.

As regards prices in 1902 there is little variation to report, as compared with 1901. The November, 1902, prices for the products of the Pittsburg Reduction Co., were as follows: No. 1, *metal,* guaranteed over 99% Al, 33@37c. per pound; No. 2, *metal,* guaranteed over 90% Al, 31@34c. per pound; nickel-aluminum alloy (less than 10% Ni), 33@39c. per pound; powdered aluminum, 90c.@$1 per pound; aluminum castings, 45c. per pound.

All the above prices were subject to discounts ranging between 10% and 15%.

Rod and wire varied in price between 38 and 52c. per lb., according to the gauge, and a rebate of from 3 to 4c. per lb. was allowed off the list

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* The production of aluminum by the Pittsburg Reduction Co. at Niagara Falls during 1902 amounted to approximately 3,300 metric tons.—[EDITOR.]

[1] *The Electrical Review*, New York, Sept. 20, 1902.

prices, according to the total value of the order. Excepting in the case of the rod and wire, these prices do not differ materially from those of November, 1901.

The prices of some of the manufactured articles of aluminum have in recent years fallen considerably in America, and in the aluminum comb industry there has been much competition and cutting of prices. The American Aluminum Association has therefore been formed by manufacturers to regulate prices and the first convention was held at Pittsburg, on Sept. 19 and 20, 1902. It is expected that as a result of this meeting, some arrangement will be made which will put an end to the over-competition and consequent unsatisfactory financial position existing in the aluminum comb industry.

With regard to the position in Europe, the first meeting between the various producers, for the purpose of regulating the output and price of the metal, was referred to in THE MINERAL INDUSTRY, Vol. X. One or two later meetings are reported to have occurred during 1902. No official account of the proceedings has been published, but the new Chairman of the British Aluminium Company has stated publicly that he is dissatisfied with the present position,[2] and that an attempt is to be made, to obtain a larger share of the European business for the British company. Early in the year, this company raised its price for No. 6 alloy from 27 to 27·5c. per pound, and its latest price list contains the following values: Ingot metal, guaranteed over 99% Al, 33c. per pound, less 7·5% discount; ingot metal (98 to 99% Al), 30c. per pound, less 7·5% discount; ingot metal (No. 4 alloy), 30c. per pound, less 2·5% discount; ingot metal (No. 6 alloy), 27·5c. per pound, less 2·5% discount; wolframinium alloy, 35c. per pound, less 2·5% discount; aluminum wire Nos. 1-14 I. S. W. G., 46·5c. per pound, less 2·5% discount.

In this connection it is interesting to note that at the annual meeting of the shareholders of this company, in November, 1902, Mr. Wallace, K.C., the former chairman, expressed the opinion that the financial difficulties of the company were partly due to the maintenance of too high a price for their products, a policy which had caused an invasion of the British market by foreign producers, who had no hostile tariff to face.

Turning to a consideration of the financial position, the following are the latest figures for the capitalization and dividends of the various producing companies:—

The Pittsburg Reduction Co., with two works at Niagara Falls, N. Y., and one at Shawinigan Falls, Canada. Capital, $1,600,000 ($1,000,000 in ordinary stock paying 10%, and $600,000 in preferred stock paying 6%). The surplus profits of this company are reported to have been invested in new construction work, but no official balance sheets are available and it is impossible to state the total sum that has been expended in this way. The low capitalization, as compared with the European companies, is partly due to the fact that the water power at Niagara Falls and at Shawinigan Falls, has been developed by independent companies.

The Aluminium Industrie Aktien Gesellschaft, with works at Neuhausen,

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[2] *Electrical Review*, London, Nov. 28, 1902

Rheinfelden and Lend Gastein. Capital, $3,077,000. Gross profits for 1901, $391,027. Dividend for 1901, 13%, an advance of 0·5% upon that paid in 1900. It is interesting to note that this company is carrying out extended trials with Heroult's process for the electrical reduction of iron ores, and that it also utilizes some portion of its available power for calcium carbide production.

The *Société Electro-Metallurgique Française,* with works at Froges and Le Praz. Capital, $2,880,000. No details are available relative to profits or dividends. This company produces ferrochromium and ferrosilicon in addition to aluminum,—and it is also experimenting at Le Praz with the Heroult process for the direct production of iron and steel in the electric furnace.

The British Aluminium Co., with works at Foyers, Scotland. Capital liability, $3,079,000 (authorized capital, $3,360,000). This company has never been able to pay a dividend on its ordinary share capital, but for some years it has kept up payments on the debentures and preferred shares. In the year 1901, the profits did not admit of payment of the preferred interest, and in 1902, the profits were insufficient to meet the interest payments due on the debentures. Payment falling due on Nov. 1, 1902, was defaulted, and the control of the company is now practically in the hands of the bondholders—representing $1,440,000.

The managing director of the company, Mr. Ristori, resigned in May, 1902, and the chairman, Mr. Roger Wallace, K.C., has also resigned, but retains his seat on the Board. A loan of $48,000 has been raised to provide the necessary working capital, and it is hoped that the changes made in the business and technical management of the company under the new chairman, Mr. J. D. Bonner, will lead in time to a more favorable financial result. The sales of aluminum by the British Aluminium Co. in 1902, are reported to have increased 40%, as one result of the improvements effected by the new management. In my opinion, over-capitalization and bad management on the technical side of the business, have contributed largely to this company's difficulties; and time and patience will be required, before it finds itself free from the more permanent effects of these embarrassments. In the directors' statement to the shareholders, the following contributary causes are also mentioned: Overvaluation of stocks; lock-up of capital in large Scotch water-power schemes; legal expenses in attempting to prolong life of patents; and bad speculative investments in bauxite properties in Ireland.

The Compagnie des Produits Chimiques d'Alais, with works at St. Michel, in France. No details relative to capitalization and profits, are available for publication.

The position as regards patents has not undergone alteration in 1902. The Heroult Patents for the United Kingdom, have now expired, but under the conditions obtaining at present in the industry, it is unlikely that any attempt will be made by British manufacturers to enter into competition with the Foyers Works.

With regard to details of the reduction process as actually carried out in the works, Haber and Geipert have published details of laboratory investigations which throw some light upon this subject.[3] They state that aluminum of high purity was easily produced in their experiments with currents of 2,800 amperes per sq. ft. at an E.M.F. of from 7 to 10 volts. The baths contained a fused mixture of aluminum fluoride, sodium fluoride, and alumina in equal proportions, as electrolyte. It was found that these raw materials must be free from impurities, and the carbons used as anodes free from ash, if pure aluminum was to be obtained. The metal obtained by the authors in their experiments contained from 0·034 to 0·30% Si, and only 0·05% C. The tensile strength averaged 21,000 lb. per sq. in. In their opinion the recent improvements in the reduction process are the result, not of secret modifications in the process, but of greater care in the selection of the raw materials and of the carbons used in the reduction baths.

UTILIZATION.

Electrical Conductors.—The use of aluminum as a substitute for copper for bare overhead transmission lines, is still expanding in America, and this use continues to be one of the most important outlets for the metal produced at Niagara Falls and Shawinigan Falls. In Europe there is less readiness to try the new metal for overhead work, and the number of instances in which aluminum has been used in place of copper, are comparatively few and unimportant. This attitude is partly due to the unsatisfactory results obtained in some of the early trials of aluminum for such work, and partly due to the greater stability of European installations, and the consequent demand for the most durable metals and construction, in all overhead transmission work. The American system of scrapping machinery and plant every few years has not yet become popular in Europe.

The following are the more important facts relative to the use of aluminum for electrical purposes, which have come under my notice during 1902: In the United States, The Lewiston & Auburn Electric Co. has purchased 21 miles of wire for transmission purposes; the Boston & Maine Railroad, 20 miles for use at Concord, N. H.; and the Boston Electric Light Co. 100,000 lb. A transmission line 84 miles in length is being erected between the power station at Shawinigan Falls and Montreal. Seven strands of No. 6 wire are to be employed, and according to one account 1,000,000 lb. of aluminum will be required for this line. The transmission is to be at 50,000 volts. The Massachusetts Electric Co. has recently purchased 500,000 lb. of aluminum for overhead transmission work, and another Boston firm is reported to have made a still larger purchase of the new metal. The Old Colony Street Railway Co., of Massachusetts, has experimented with 10 miles of aluminum wire for feed lines, and is reported to be quite satisfied with the results. With regard to the condition of the existing aluminum lines in America, the following abstracts of reports which have appeared[4] will be read with interest:—

1. Snoqualmie Falls,—76 miles of cable,—erected two years. Satisfactory.
2. Bay Counties Power Co., San Francisco, Cal.—90 miles of wire, equal in

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[3] *Zeitschrift fuer Elektrochemie*, Jan. 2 and 9, 1902.

[4] *Aluminum World*, May, 1902.

carrying capacity to No. 6 copper,—erected one year,—no trouble experienced, but gauge too small.

3. Standard Electric Co., San Francisco, Cal.—200 miles of cable,—time not mentioned. Satisfactory.

4. City of Healdsburg, Cal.—8·75 miles No. 4 wire, and the same length of No. 10 wire,—erected 3 years. No trouble experienced.

5. Kansas City and Leavensworth Railway, Wolcott, Kan.—feed wires in use 2 years. Satisfactory.

6. Hartford Electric Light Co., Hartford, Conn.—11 miles of cable,—erected 3 years. Entirely satisfactory.[*]

These reports speak well for aluminum, but there is a note at the end of the article referred to, which seems to indicate that the new metal in its normal state, is not quite so resistant to weather influences as the reports would lead one to believe. This note is to the effect that: "Weatherproof aluminum wire is being largely introduced in the distributing systems of many of the cities in California and Washington." *"Weatherproof wire,"* can only mean wire coated with some protective composition. If bare aluminum is so entirely satisfactory when used for overhead transmission lines, why is *weatherproof* wire now being introduced?

As regards the use of aluminum for conducting purposes in Europe, there is little progress to report. Mr. J. Gavey, the English Post Office Electrician, has informed me that no further trials have been made with aluminum wire for telegraphic or telephonic purposes, and that at present there is no intention to institute fresh experiments. No reports have yet appeared relating to the condition of the three Italian transmission lines constructed of aluminum, and there is a similar lack of information respecting the lighting installation at Northallerton in England.

Mr. F. C. Perkins, an American writer, in an article which appeared in translated form,[5] gave a *résumé* of the position, as regards the use of aluminum and copper, for electrical purposes. This article contained little that has not been published in previous volumes of THE MINERAL INDUSTRY. No reference was made to the experiments upon durability carried out by Gavey and others, and Mr. Perkins cannot be considered to have given a fair and impartial decision upon the relative merits of the two metals, when used for overhead work.

My own series of exposure tests, with aluminum and other wires at Waterloo, England, commenced in 1899, have been continued during 1902, and some details of the latest results obtained, will be found under the sub-heading *"Properties."*

Alloys.—Guillet, during 1902, has read a paper before the French Académie des Sciences, giving an account of the properties of alloys of aluminum and tungsten obtained by the Goldschmidt process. Three alloys were obtained—represented by the formulæ: AlW_2, Al_3W, and Al_4W. The last named alloy had

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[*] In addition to the above-mentioned equipments 21 miles of aluminum wire were purchased by the Lewiston & Auburn Electric Co., for the transmission of electric power; 20 miles of aluminum wire by the Boston & Maine Railroad for use at Concord, N. H., and 100,000 lb. of aluminum wire by the Boston Electric Light Co.

[5] *Zeitschrift fuer Elektrochemie*, Aug. 14, 1902.

a sp. gr. of 5·58.[6] Boudonard has been examining the alloys of aluminum and magnesium, of which "Magnalium" is the best known representative. Two well defined alloys were found to exist, represented by the formulæ $AlMg_2$ and AlMg. Kaempfer has stated that magnalium turns well and can be drilled and milled easily. Its tensile strength is from 13 to 15 tons per sq. in., and its sp. gr. is about 2·52. Its fracture has a fine grain, like that of steel. Siemens & Halske, of Berlin, is reported to be using it in the manufacture of armatures, and for motor car construction, while opticians are using it in preference to pure aluminum because it is harder, and the threads of screws last longer, when turned in this alloy. The chief drawback to the use of magnalium is the difficulty of making a durable joint with solder.[7]

"McAdamite" is another patented alloy of aluminum for which considerable sale is expected by its inventor and those at present interested in its manufacture. This alloy is composed of 72% Al, 24% Zn, and 4% Cu. It is silvery white in color and takes a high polish. Its tensile strength is reported to be 44,250 lb. per sq. in. It is intended to be used as a substitute for brass for all purposes. Two companies have been formed in America for the manufacture of this alloy, but according to the latest information in my hands, negotiations for amalgamation are now taking place. The McAdamite Metal Co., of Canada, has a nominal capital of $800,000 and owns a small plant at St. John.

Prof. Wilson, of King's College, London, has been carrying on exposure tests with samples of various alloys of aluminum, and in a paper read before the British Association at Belfast, in September, 1902, he described the results obtained in his experiments. The specimens exposed were in the form of wire 0·126 in. in diameter, and the exposure lasted 13 months. Corrosion was found to increase with the percentage of copper. Nickel or iron alloyed with the copper, had the effect of slightly increasing the conductivity of the alloy after exposure. The conclusions based by Prof. Wilson upon these trials were: That it was a mistake to use copper alone, in light aluminum alloys, if these were to be submitted to exposure to atmospheric influences; and that the presence of equal amounts of nickel and copper certainly reduced conductivity, but this loss was compensated by the gain in mechanical and non-corrosive properties.[8]

E. S. Sperry[9] has described an alloy of aluminum, called "aluminum-silver," which contains 57% Cu, 20% Ni, 20% Zn, and 3% Al. It takes a high polish, and resembles silver in color and luster. It is said to be used in typewriter construction.

The American Gramophone Co. is reported to be using one of the zinc-aluminum alloys, containing 95% Zn and 5% Al, for the metallic portions of their machines.

The use of "Partinum" for motor car construction by Paris builders, is referred to later on under the section "Balloons and Motor Cars." In this connection it is interesting to note that M. Heroult reports the increased demand for aluminum in France during 1902, to be partly due to this use of the metal.

Balloons, Cycles and Motor Cars.—The year 1902 has been rather disastrous

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[6] *Comptes rendus*, 1902.

[7] *Electrical Review*, London, May 30, 1902.

[8] *Electrician*, Sept. 19, 1902.

[9] *Aluminum World*, February, 1902.

for those aëronauts who have been experimenting with flying machines, and there is little to record beyond a series of accidents, not, it may be remarked, in any way due to the aluminum used in the construction of these navigable balloons.

The Zeppelin airship, which two years ago was attracting much attention, has been broken up, owing to the financial troubles of its designer, and the aluminum rod and wire used in its construction (reported to amount to 5 tons in weight) have been sold. The Severo airship, in which aluminum was used for strengthening the bamboo at many points in the structure, also came to grief early in 1902, and the inventor and his assistant lost their lives at Paris, in the explosion which brought about the collapse of the balloon in mid-air. M. Santos-Dumont, hitherto the most lucky and successful of the aëronauts who have experimented with navigable balloons, has also made little advance during 1902. His latest airship is constructed of cypress and bamboo rods, strengthened by aluminum thimbles at the splices; but nothing noteworthy has been done with it during the past year.

It will be noticed from the above that the tendency in airship construction is to use bamboo and similar light woods for the frames in place of the metal aluminum, and to employ the latter metal only for strengthening the frame at the joints.

As regards the use of aluminum for cycle construction, there is also little progress to report during 1902, but in motor car work the new metal and its alloys are growing in favor and usefulness. The Winton Co., of Cleveland, Ohio, is using aluminum, and J. M. Quinby & Co., of Newark, N. J., is reported to have constructed a 16-H.P. automobile of the Panhard type, with the body of the vehicle constructed entirely of the light metal.[10] At the Paris (1902) show of cycles and automobiles, Charpentier & Co., of Valdois, had an exhibit of aluminum which attracted considerable attention. Sheets and ornamental panels of strengthened aluminum (renforcée) were the chief novelties of this exhibit. The use of aluminum for wheels of automobiles has also been tried by one French builder, while the automobile firm, Charron, Girardot & Voigt, is using aluminum and the alloy, partinum, to a large extent in construction work.

Printing.—The use of aluminum as a substitute for stone and zinc in lithographic work is rapidly extending, and both in London and New York companies have been formed to manufacture the special rotary printing presses, designed for this new departure in lithography. The Aluminum Press Co. is the name of the American company, and the Aluminium Rotary Press, Limited, is the title of the English company, which has been floated with a capital of $960,000 to purchase the English patents and to equip a factory for the manufacture of the presses at Otley, in Yorkshire. Thirty of the new rotary aluminum presses are stated to have been sold in Enrope, and the list of well-known lithographic printers who have one or more of the new presses in use, or who have ordered one, is growing in number every day. W. H. Smith & Co., of London; De la Rue & Sons, of Bolton, and E. S. & A. Robinson, of Bristol, are a few of the English firms who have started during 1902 to use the new metal for

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[10] *Electricity*, New York, July 30, 1902.

lithographic work. The first named firm has informed me, that it finds the new metal an excellent substitute for stone in lithographic work. The manipulation required is so different from that required when stone is used, that considerable experience in the handling of the new material is necessary in order to obtain the best results. The best practical information relating to this new application of aluminum is to be found in a series of articles published in the journal named below.[11] A further development in this use of aluminum has been patented by Hoz, who has devised a method of printing on textile goods with aluminum rolls.[12]

Foundry and Metallurgical Use.—Although this remains one of the most important outlets for the aluminum produced in Europe and America, little new information relating to it has been published during 1902. In France the sales of aluminum for foundry work are reported to reach 400 tons per annum, and according to the chairman of the British Aluminium Co., when the metal has once been used for this purpose it is rarely given up. In the United Kingdom the sales of the metal to the steel works have been small and disappointing; but in the United States this use is believed to absorb a considerable portion of the output of the Pittsburg Reduction Co.

The industries depending upon the Goldschmidt process for the production of intense heat by means of powdered aluminum, have made progress during 1902. At Essen, the Chemische-thermo Industrie continues to manufacture "thermite" and alloys of iron and the rare metals. In a recent independent engineer's report on tramway construction, welded rails were specially mentioned as superior to all forms of bonded joints, and the Goldschmidt method of welding with thermite was put forward as the most convenient and useful method of obtaining such welded joints in practice. It is possible, therefore, that this use of aluminum may grow relatively large and important, during the construction of the tracks for the numerous tramway and light railway schemes now in course of development in America and in Europe.

Miscellaneous Uses.—Bobbins.—English Patent No. 12,193, of 1901, describes the manufacture of aluminum bobbins. Machinery is used to fashion flat discs of the metal into the ordinary bobbin with a central tube and two flanges.

Art Work.—The Indian Aluminium Co., which has grown out of Mr. Alfred Chatterton's efforts to introduce aluminum to Indian art-workers at the Madras School of Art, is increasing its capital and plant in order to cope with its extending business. This company paid a dividend of 7% for the first half of 1902, and its manufactures embrace both useful and ornamental articles in the new metal.

Combs.—The manufacture of aluminum hair combs has grown into a large industry in the United States, and according to one authority the daily output of all the factories is 25,000.[13] The competition has, accordingly, become severe, and the Aluminum Manufacturers' Association, the meeting of which at Pittsburg in September, has already been referred to, has appointed a sub-committee to regulate output and prices.

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[11] *Aluminum World*, October and December, 1901; January and February, 1902.

[12] *Zeitschrift fuer Angewandte Chemie*, Dec. 18, 1902.

[13] *Aluminum World*, February, 1902.

Chemical Apparatus.—According to O. Guttman, aluminum is proving of value in the manufacture of explosives. In the preparation of nitro-cellulose it is requisite to use vessels which are unattacked by a mixture of sulphuric and nitric acids. An aluminum vessel has successfully resisted the action of these acids for some months, although either acid alone was found to have action upon it.[14]

Explosives.—"Ammonal," a new explosive patented by Fuhrer, of Vienna, contains 25% Al in the state of powder, and ammonium nitrate. The Electrosmelting (Zinnoxyd) Co. of London, which would appear to be a subsidiary of the company operating at Essen, also manufactures an explosive of which powdered aluminum is an ingredient, but I am unable to say whether this compound is similar in all other respects to ammonal. This company reported a dividend of 12% in 1902.

Fuse Wires.—A novel use of aluminum is found on the Niagara-Buffalo transmission line, where the new metal is used not only for the main conductors but also for the fuse wires. This transmission is at 11,000 volts.

Gramophones.—The American Gramophone Co. is trying an alloy composed of 95% Zn and 5% Al for the metallic portions of its machines. A somewhat similar use is that of aluminum for the diaphragms of telephones.

Golf Clubs.—W. Mills, of Sunderland, England, who makes a special feature of aluminum castings and has attained much success in this direction, has cast a set of golf-clubs heads in the light metal. H. H. Hilton, the noted golf player, has seen these novel clubs and is reported to have recommended them.

Lamps.—According to a writer in the paper named below,[15] aluminum is used by several makers of miners' lamps in Germany. The new metal is also reported to be in use for making the reflectors of acetylene lamps, but as there is not a great sale for these, the consumption of aluminum for this purpose cannot be large.

Machinery and Other Castings.—At the foundry of W. Mills, Sunderland, England, 75 men are reported to be constantly at work on aluminum castings.

Whetstones and Sharpening Wheels.—According to A. Bernard, of Hamburg, Germany, a valuable property of aluminum has been discovered in its ability to sharpen cutlery. Aluminum has a fine-grained structure and develops during the whetting process an exceedingly fine metal-setting substance which is greasy to the touch and adheres strongly to steel. An examination of a knife blade whetted on aluminum under the microscope at 1,000 diameters magnification, shows the edge of the steel to be perfectly uniform and unbroken, which is not the case when steel is sharpened on stone.

PROPERTIES OF ALUMINUM.

Reference has already been made to the laboratory experiments of Haber and Geipert upon the electrolytic separation of aluminum in baths of fused cryolite. These investigators examined the chemical and mechanical properties of the

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[14] *Aluminum World*, July, 1902. From *Journal of the Society of Chemical Industry*.

[15] *Engineering*, London, Aug. 22, 1902.

metal obtained in their experiments, and they found that the tensile strength averaged 21,000 lb. per sq. in. The first series of chemical tests gave 0·034% Si and 0·05% C, but in a second series of tests made by a more reliable method, the percentages of Si rose to 0·25 and 0·3%. These specimens of aluminum would, however, appear to have been more pure than the "pure" aluminum of commerce, which is rarely guaranteed over 99·5% purity.

With reference to the influence of impurities upon the resistance offered by aluminum to exposure, Mr. Alfred Chatterton, of the Madras School of Art, has stated that anything above 0·1% Fe is exceedingly deleterious, even when the metal is merely intended for domestic use.[16] There is no doubt that this fact has not been sufficiently recognized in the past, and many of the cases in which the new metal has given unsatisfactory results, may be attributed to the presence of excessive amounts of impurity. Messrs. Haber and Geipert have shown that remarkably pure metal can be obtained by the electrolytic process,[17] when sufficient care is given to the preparation of the raw materials used in the reduction, and there is every reason to believe that the producers of aluminum in the various countries are now fully alive to the importance of carefully testing and controlling this side of the manufacture. The exposure tests with aluminum and other wires, commenced by me in 1899, have been continued during 1902 at Waterloo. No sample of aluminum wire has yet been obtained, which can stand twelve months' exposure in the comparatively good atmosphere of Waterloo, without extensive and deep corrosion. The rods of aluminum have undergone three years' exposure at Waterloo with much less corrosion than the wires. This fact would seem to indicate that the mechanical properties of aluminum undergo considerable change during the drawing operations which are necessary to produce wire, and that this change renders the metal more liable to corrosion by atmospheric influences. Full details of these exposure tests will be published in London during 1903.

As regards plating and soldering aluminum, nothing worthy of special note has been published during 1902.

RAW MATERIALS OF THE MANUFACTURE.

There has been considerable increase in the consumption of bauxite by aluminum producers in recent years, and Lienau has suggested that this increase indicates that a direct method of electrical reduction has been discovered.[18] There is no confirmation of this suggestion, however, and it is unlikely that such an advance in the cheapened production of aluminum could have occurred without the publication of the patents or of the process in the technical journals of London or New York. The Pittsburg Reduction Co. is reported by Prof. Richards to be using an improved process for extracting pure alumina from bauxite at the new plant in Arkansas. This process is known as the "Lime" process, and is patented by Hall. It is reported to yield a product of remarkable purity. According to the same authority, the electrical method

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[16] *Electrochemist and Electrometallurgist*, March, 1902.

[17] *Zeitschrift fuer Elektrochemie*, Jan. 2 and 9, 1902.

[18] *Elektrochemische Zeitschrift*, August, 1902.

of removing the impurities from bauxite, described in THE MINERAL INDUSTRY, Vol. X., and based upon incipient fusion with sufficient carbon to reduce the iron and silicon present as oxides, is about to be operated at Niagara Falls.[19] From these statements it is evident that the Pittsburg company is alive to the importance of reducing the cost of the raw materials of the manufacture.

Interesting historical notes relating to the development of the aluminum industry in America have appeared in the journals named below during the past year.[20]

V. ALUM AND ALUMINUM SULPHATE.

ALUM, ARTIFICIAL.—The reported production of aluminum sulphate in the United States during 1902 amounted to 87,075 short tons, valued at $1,938,671, as compared with 74,721 short tons, valued at $1,793,304 in 1901, while the production of crystallized alum was 8,539 short tons, valued at $229,500, as compared with 7,755 short tons, valued at $233,250 in 1901. The apparent large decrease in the production of crystallized alum during 1901 and 1902, as compared with preceding years, has resulted from the method of calculation necessary prior to 1901, the year in which statistics of production were first collected directly from the producers.

The statistics of the production of alum and aluminum sulphate given in the following table previous to 1901 are computed from the consumption of bauxite and cryolite in the United States, and the production of metallic aluminum, it being assumed that what was not used for the manufacture of aluminum, was used for making the sulphates. The yield of American bauxite, and the quantity imported are well known, consequently the method of determining the production in so far as it is expressed in terms of crystallized alum is fairly accurate. The division into crystallized alum and aluminum sulphate is estimated, and is therefore approximate. However, since it is apt to be misleading to report the entire production as crystallized alum, of which really only a comparatively small quantity is made, the statistics for 1898 to 1900 have been reported in the modified form. Any apparent discrepancy is thus accounted for. The statistics for 1901 and 1902 have been collected directly from the producers.

UNITED STATES PRODUCTION AND IMPORTS OF ALUM FROM 1898 TO 1902.

Year.	Production.								Imports. (a)		
	Alum.			Aluminum Sulphate.			Total Reckoned as Alum. Sh. Tons.	Total Value.	Short Tons.	Value.	Per Ton.
	Short Tons.	Value.	Per Ton.	Short Tons.	Value.	Per Ton.					
1898..	18,791	$563,730	$30·00	56,668	$1,416,675	$25·00	97,302	$1,980,405	(b) 893	$16,187	$18·13
1899..	27,276	845,556	31·00	81,805	2,106,479	25·75	127,430	2,952,035	(b) 858	14,953	17·49
1900..	20,531	615,930	30·00	61,678	1,480,272	24·00	105,743	2,096,202	(b) 1,169	22,288	19·07
1901.c	7,775	233,250	30·00	74,721	1,793,304	24·00	....	2,026,554	(b) 1,091	20,781	19·05
1902.c	8,539	229,500	26·85	87,075	1,938,671	22·25	....	2,168,171	(b) 929	16,808	18·09

(a) Includes alumina, alum, alum cake, aluminum sulphate, aluminous cake, and alum in crystals or ground. (b) There was also imported in 1898, 1,205 short tons ($76,884) of aluminum hydrate, or refined bauxite, in 1899, 1,996 short tons ($119,202), in 1900, 2,207 short tons ($148,332), in 1901, 1,986 short tons ($146,468), and in 1902, 889 short tons ($21,235). (c) Through the courtesy of the United States Geological Survey.

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[19] *Aluminum World*, October, 1902.

[20] *Electrochemical Industry*, No. 1, 1902; *Electrical Review*, New York, Nov. 15, 1902.

According to the Twelfth Census report of the United States there were 13 concerns engaged in the manufacture of alum in the United States in 1900, whose aggregate production was as follows: 3,290 tons ($102,308) of ammonia alum; 7,100 tons ($215,004) of potash alum; 8,014 tons ($403,100) of burnt alum; 51,508 tons ($1,062,547) of concentrated alum, also known as aluminum sulphate, 2,024 tons ($34,047) of alum cake; and 17,796 tons ($629,570) of other alums. The total make was therefore 89,734 tons, valued at $2,446,576. For this purpose there was consumed 34,000 tons ($230,000) of bauxite, 5,000 tons ($110,000) of cryolite, 2,000 tons ($4,100) of salt cake and niter cake, 360 tons ($21,900) of ammonium sulphate, 477 tons ($19,600) of potassium sulphate, and 61,424 tons of sulphuric acid. In making the acid, there was used 3,323 tons ($66,000) of brimstone, 49,081 tons ($107,000) of pyrites, and 513 tons ($18,000) of sodium nitrate. The statistics of alum production are reported in tons of 2,000 lb., and the values are for the product at the works. Of the 13 works engaged in the business, six are in Pennsylvania, three in Massachusetts and the remaining four in Illinois, New York and Michigan.

The following named companies produced either alum or aluminum sulphate, or both of these salts during 1902: General Chemical Co., Pennsylvania Salt Manufacturing Co., Harrison Brothers, Charles Lennig & Co., Erie Chemical Co., Cochrane Chemical Co., Merrimac Chemical Co., and Detroit Chemical Co.

New York Market.—New York price of lump alum during 1902 was $1·75 per 100 lb. For ground alum the price during the first three weeks of January was $1·80 per 100 lb. for the balance of the year it remained steady at $1·85; powdered alum was quoted at $3 per 100 lb. during the entire year. Commercial aluminum sulphate was quoted at $1·15@$1·25 per 100 lb., and the purest quality at $2.

NATURAL ALUM.—The production of alum shale in the United Kingdom in 1901 was 4,019 long tons, valued at $2,470, as compared with 1,329 long tons, valued at $820 in 1900. The Australian Alum Co., at Bulladelah, New South Wales, during 1901 shipped to the United Alkali Co.'s works at Runcorn, England, 3,146 long tons of alunite, valued at £9,438, as compared with 1,915 tons, valued at £5,745 in 1900.

Italy.—(By Giovanni Aichino.)—The deposit of alunite at Tolfa near Civitavecchia is the only source of this mineral in Italy, and the production of alum salts from this deposit is decreasing on account of the general condition of the market and of the increased difficulties in mining. During 1901 the production of alunite amounted to 5,200 metric tons, of which 4,100 tons were exported, the remainder being manufactured by the Compagnie Generale dell'Allume at Civitavecchia into alum 595 metric tons, refined alum 210 tons and aluminum sulphate 860 tons.

AMMONIA AND AMMONIUM SULPHATE.

By Henry Fisher.

The production of ammonia (reported as its equivalent sulphate salt) and ammonium sulphate by by-product coke oven plants in the United States during 1902 is estimated at 65,000 metric tons, and for 1901 at 60,000 metric tons, which shows the active development of this industry due chiefly to the increase in the number of by-product coke ovens now in operation. The manufacture of ammonia and ammonium sulphate in the United States and in Europe during recent years is discussed in complete detail in the paper by Dr. F. Schniewind, on "The Manufacture of Coke, with Especial Reference to the Markets for By-products," which is given in The Mineral Industry, Vol. X., pp. 135 to 166.

The imports of ammonium sulphate into the United States, from 1898 to 1902, were as follows:—

Year.	Pounds.	Metric Tons.	Value.	Value per Metric Ton.
1898	11,057,762	5,016	$210,078	$41·88
1899	17,121,988	7,766	406,578	52·35
1900	24,024,188	10,897	591,987	54·32
1901	31,711,065	14,384	728,085	50·62
1902	35,535,558	16,119	858,036	53·23

The world's production of ammonium sulphate during 1902 exceeded 548,500 metric tons, as compared with 523,000 metric tons in 1901. Of this quantity, Germany contributed 135,000 tons and France 65,000 tons. The product is used mainly in the manufacture of fertilizers.

The following table shows the world's production of ammonium sulphate and exports of sodium nitrate from Chile, the latter being practically identical with

WORLD'S PRODUCTION OF AMMONIUM SULPHATE AND SODIUM NITRATE. (*a*)
(IN METRIC TONS.)

	1898.	1899.	1900.	1901.	1902.
Ammonium sulphate:					
Great Britain	196,500	208,000	210,000	220,000	225,500
Germany	100,000	110,000	120,000	130,000	135,000
United States	49,000	52,000	58,000	60,000	65,000
France	35,000	36,000	37,000	38,000	40,000
Belgium, Holland, Sweden, Norway and Denmark	30,000	32,000	33,000	35,000	38,000
Austria, Russia, Spain, and other European countries	30,000	30,000	35,000	40,000	45,000
Total production	440,500	468,000	493,000	523,000	548,500
Sodium nitrate:					
Exports from Chile	1,265,000	1,370,000	1,430,000	1,270,000	1,335,000
Nitrogen equivalent in metric tons of world's sulphate production	87,220	92,600	97,610	103,550	112,990
Nitrogen equivalent, in metric tons, of Chile's nitrate exports	197,970	214,400	223,800	198,760	208,930
Total	285,190	307,060	321,410	302,310	321,920
Percentage of sulphate	30·6%	30·2%	30·3%	34·2%	35·1%
Price of 2,000 lb. nitrogen at Liverpool, in—					
Sulphate (10.101 lb.)	$208·80	$248·20	$244·15	$232·50	$260·00
Nitrate (12,779 lb.)	191·05	222·10	235·50	249·40	258·80

(*a*) *Zeitschrift fuer angewandte Chemie*, April 23, 1901: *L'Engrais*, Jan. 24, 1902 and 1903; Annual Report of the German Sulphate Syndicate for 1901.

the world's production. This table shows (1) that the nitrogen equivalent of the sulphate production is only about one-half that of sodium nitrate. (2) That the production of sulphate has been constantly increasing even during the period when the price of its nitrogen equivalent was higher than that of nitrate. The progress will doubtless be continued.

The average prices per 100 lb. of gas liquor ammonium sulphate, basis 25%, in New York in 1899, 1900, 1901 and 1902, were as follows:—

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1899	$2·716	$2·663	$2·667	$2·810	$2·975	$3·837	$3·190	$3·111	$3·065	$2·975	$2·850	$2·995	$2·988
1900	2·925	2·956	3·081	2·981	2·887	2·840	2·725	2·825	2·755	2·750	2·775	2·775	2·856
1901	2·788	2·801	2·813	2·700	2·731	2·750	2·721	2·745	2·769	2·819	2·820	2·794	2·771
1902	2·937	2·927	2·931	2·978	3·085	3·109	3·001	2·952	3·019	2·959	2·955	3·019	2·976

Germany.—The report[1] of the German Ammonia Syndicate of Bochum for the year 1902 states that the year has been signalized by favorable conditions for the production and sale of ammonium sulphate, in marked contrast to the previous year. English competition was not as active as in 1901, and the average price obtained for the ammonium sulphate was considerably above that of the previous year. The German syndicate prices are primarily controlled by the position of the nitrate market, and in 1902 these prices were influenced also by considerable stocks on hand at the beginning of the year, which had to be disposed of mostly at the prices ruling in 1902. The average price for 1902, on the basis of percentage of nitrogen, was equal to that obtained for nitrate, although this has not been the case previous to this year. The imports of ammonium sulphate into Germany in 1902 were 44,250 tons, as compared with 44,400 in 1901, 32,000 tons being shipped from the United Kingdom. The syndicate not only marketed its output, but sold in addition 9,000 tons of old stock, due to the appreciation of the value of ammonium sulphate for agricultural purposes, and its use in place of Chilean nitrate. The replacement was partly caused by the speculative operations of a Hamburg importer, who at the beginning of the year increased the price of nitrate, so that the farmers were forced to buy ammonium sulphate. The production of the syndicate works in 1902 was 57,000 tons; the deliveries were 62,465 tons, as compared with 48,957 tons in 1901; while the exports showed a decrease, being only 3,500 tons, as compared with 9,275 tons in the previous year. The production of strong ammoniacal solution was 3,089 tons, and weak solution 15,470 tons, a total of 18,559 tons, as compared with 9,519 tons in 1901. The syndicate, which added three companies to its membership during 1902, also sold ammonium sulphate for a number of gas works and private firms.

United Kingdom.—According to the annual report of the Chief Inspector of Alkali Works, etc., for the United Kingdom, the production of ammonium sulphate during 1901 amounted to 217,213 long tons, as compared with 213,726 long tons in 1900. The expected increase in the output of ammonium sulphate by the coke ovens has not taken place, due to the depressed condition of the iron industry. The unofficial figures for 1902 state that the production amounted to 221,500 long tons. The production from the different works was as follows:—

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[1] *Iron and Coal Trades Review*, LXVI., April 23, 1903, 1076.

STATISTICS OF AMMONIUM SULPHATE PRODUCTION AND CONSUMPTION OF THE UNITED KINGDOM FROM 1896 TO 1902, INCLUSIVE. (a) (LONG TONS.)

	1896.	1897.	1898.	1899.	1900.	1901.	1902.
From gas plants	127,000	153,000	130,000	133,768	142,419	142,708	146,000
From blast furnace	16,500	18,000	17,700	17,968	16,959	16,353	17,000
From shale works	38,000	37,000	37,300	38,780	37,267	40,011	38,000
From coke ovens, producers, etc.	9,000	10,000	11,500	15,209	17,081	18,146	20.500
Total production	190,500	498,000	196,500	205,720	213,726	(b) 217,218	(c) 221,500
Consumption of United Kingdom	65,000	45,000	59,600	67,600	64,700	69,800	58,746

(a) *Zeitschrift fuer angewandte Chemie*, April 23, 1901, and *Bradbury & Hirsch's Review* for 1902, excepting for 1899, 1900 and 1901, which are from the *Annual Report of the Chief Inspector of Alkali Works*, etc. (b) Of this amount, England furnished 139,716 tons; Scotland, 75,063 tons; and Ireland, 2,336 tons. (c) Of this amount, it is estimated that England contributed 145,000 tons; Scotland, 74,000 tons; and Ireland, 2,500 tons.

In the removal of hydrogen sulphide from the gases evolved in the manufacture of ammonium sulphate by the Hemingway iron sulphite process, the following reaction takes place:—

$$FeSO_3+3H_2S=FeS+3S+3H_2O.$$

The exports of the United Kingdom during 1902 were 162,754 long tons, of which 10,084 tons were shipped to the United States. The consumption of the United Kingdom in 1902 is assumed to be 58,746 long tons, the difference between the production and exports.

ANTIMONY.

BY JOSEPH STRUTHERS.

THE process of smelting antimony ores and refining the metallic product is one of extreme difficulty, and very few metallurgists know the complete details of modern practice. Successful smelting, therefore, can only be accomplished under special conditions. This fact, together with large production of the metal in foreign countries, the recent removal of the import duty on crude antimony and cheap ocean freight rates from foreign countries, hinders, if not precludes, the profitable production of antimony metal from domestic ores in the United States.

There was but little, if any, metallic antimony produced from domestic ores in the United States during 1902, due to the tariff decision rendered April 22, 1902, before the United States General Appraisers at New York, which removed the former 20% ad valorem duty on crude antimony (the partly refined sulphide ore), thus placing it on the free list. The production of metallic antimony from domestic ores during 1901 amounted to but 50 tons, an extremely small quantity when compared with the total annual consumption of this metal in the United States.

Practically the entire control of the production and trade in antimony is in the hands of Mathison & Co., of London, which operates the smelting plant at Chelsea, Staten Island, N. Y., and the works of the affiliated concern, the Chapman Smelting Co., of San Francisco, Cal. Since the removal of the duty on crude antimony the works of the Chapman Smelting Co., which formerly smelted the entire domestic output of antimony ores in the United States, has been closed. Under existing conditions it is very probable that from time to time small lots of domestic antimony ore will be offered for treatment in the United States, but it is doubtful if there will be any marked progress in the production of metallic antimony from domestic ores in the United States unless the industry is aided by legislation.

It has not been possible to ascertain the actual quantity of metallic antimony produced in the United States from imported ores, but on the assumption of an average extraction of 42% of metal from the net quantity of antimony ore imported during 1902, *i.e.*, allowing for re-export, the production from this source amounted to 715 short tons, as compared with 364 short tons in 1901.

The quantity of antimony contained in the net imports of regulus or metal during 1902 amounted to 2,858 short tons, as compared with 1,837 short tons in 1901.

The antimony content of the 10,485 short tons of hard lead produced in the United States during 1902 as a by-product from smelting both domestic and foreign ores amounted to 2,904 short tons.

The aggregate quantity of antimony metal, or its equivalent in antimony alloys or salts, produced from the above-mentioned sources in the United States during 1902 amounted to 12,486,000 lb., as compared with 8,971,884 lb. in 1901.

A large part of the domestic demand for antimony metal, particularly for manufacture into anti-friction and similar alloys, is supplied in the form of antimonial or hard lead, containing generally from 18 to 27% Sb.

The statistics of imports, production and consumption of antimony in the United States, from 1898 to 1902, inclusive, are given in the subjoined table.

IMPORTS, EXPORTS, PRODUCTION AND CONSUMPTION OF ANTIMONY IN THE UNITED STATES.

Year.	Imports.					Exports.			
	Metal or Regulus.		Ore.		Total Value.	Metal or Regulus.		Ore.	
	Pounds.	Value.	Pounds	Value.		Pounds.	Value.	Pounds.	Value.
1898	2,025,183	$143,909	3,725,222	$50,256	$194,165	25,275	$1,729	34,312	$784
1899	3,160,697	240,988	3,982,133	47,841	288,829	16,815	1,275	*Nil.*	....
1900	3,682,843	285,749	6,035,734	78,581	364,330	23,520	2,352	*Nil.*	....
1901	3,674,928	255,846	1,731,956	24,256	278,597	*Nil.*	....	49,655	1,536
1902	5,425,928	336,311	3,387,600	67,570	377,375	37,184	2,710	208,531	4,602

Year.	Production.				Consumption.
	In Hard Lead. (*a*)	From Domestic Ores	From Imported Ores. (*b*)	From Imported Regulus or Metal.	Total Supply.
	Short Tons.	Short Tons.	Short Tons.	Short Tons.	Short Tons.
1898	2,118	250	870	1,052	4,290
1899	1,586	234	1,041	1,495	4,356
1900	2,476	151	1,599	1,827	6,053
1901	2,235	50	364	1,837	4,486
1902	2,904	*Nil.*	626	2,718	6,248

(*a*) Estimated at 25% of the total quantity of hard lead produced, except for 1902 which was estimated at 27%. (*b*) Estimated 40% extraction from net import of ore.

The large increase in the quantity of antimony ores and regulus imported and exported during 1902 has been due to a peculiar condition of the freight rates from China, which strangely enough were about 10s. per ton from China to New York, and 30s. from China to England. The freight rate from New York to England being about 10s. per ton, shipments were made first to New York, where the metal was trans-shipped to England, thus saving practically one-third of the cost of direct transportation.

The supply of antimony for domestic consumption as metal or as lead alloy is derived from the following sources: (1) hard lead produced as a by-product from the smelting or refining of lead ores and bullion of both domestic and foreign origin, (2) imported ores or crude antimony, (3) imported metal or regulus, and (4) domestic ores. The only antimony ore of commercial importance in the United States is stibnite, antimony trisulphide (Sb_2S_3), and while many deposits of this mineral occur in the Western States, the production of metal therefrom has never reached an important position, the largest quantity produced annually being but 295 short tons in 1895 in an estimated total production of 4,000 tons of metal from all sources. Since 1895 the production of antimony from domestic ores has declined until there was none so produced in 1902.

WORLD'S PRODUCTION OF ANTIMONY ORE. (*a*) (IN METRIC TONS.)

Year.	Austria.		Bolivia.		France and Algeria.		Hungary.		Italy.		Japan.	Mexico. (*f*)	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Tons.	Value.
1897...	864	$38,255	......	....	5,466	$83,538	1,800	$34,563	2,150	$27,657	848	5,873	$71,835
1898...	679	22,867	591	$221,725	4,571	69,462	2,201	20,219	1,931	43,822	1,006	5,982	98,815
1899...	410	15,244	1,213	454,866	7,592	130,498	1,965	34,205	3,791	44,862	712	10,882	115,292
1900...	201	7,065	1,174	440,775	7,936	115,978	2,378	37,720	7,609	72,468	81	2,818	23,319
1901...	126	4,557	190	38,309	9,867	156,834	1,691	19,500	8,818	68,513	(*e*)	5,103	51,064

Year.	New South Wales. (*h*)		New Zealand.		Portugal.		Queensland.		Spain.		Turkey. (*b*) (*d*)	United States.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Tons.	Value.
1897....	172	$18,060	10	$763	417	$28,063	(*c*)	....	354	$6,483	400	454	$16,000
1898....	84	4,580	*Nil.*	....	245	6,736	*Nil.*	....	180	2,149	(*g*)	(*g*)	....
1899....	332	13,470	*Nil.*	....	59	2,123	41	$1,000	50	1,560	1,178	544	20,000
1900	252	12,145	5	505	38	554	*Nil.*	....	30	900	267	300	10,500
1901....	90	5,915	30	680	*b* 126	2.650	*Nil.*	....	10	150	(*e*)	100	3,500

(*a*) The foreign statistics are derived from the official reports of the several governments; those for the United States were collected specially for THE MINERAL INDUSTRY. (*b*) Export figures. (*c*) Not yet reported. (*d*) Fiscal years. The Turkish statistics are of doubtful accuracy. (*e*) Mostly crude antimony. (*f*) Export figures, values in Mexican dollars. (*g*) Statistics not collected. (*h*) Metal and ore.

WORLD'S PRODUCTION OF ANTIMONY METAL. (*a*) (IN METRIC TONS.)

Year.	Austria.		France and Algeria.		Germany. (*d*)		Hungary. (*b*)		Italy.		Japan.	Servia.		United States. (*f*)	
	Tons.	Value	Tons.	Value.	Tons.	Value.	Tons	Value.	Tons.	Value.	Tons.	Tons.	Value.	Tons.	Value.
1897	424	$51,350	1,033	$141,857	1,665	$156,111	523	$63.360	404	$57,072	824	......	....	2,777	$409,345
1898	843	42,236	1.226	163,200	2.711	210,744	855	109,681	380	62,550	233	163	$23,782	2,987	519,138
1899	271	33,772	1,499	243,840	3,149	302,892	940	139.502	581	87,900	239	180	26,280	2,595	525,087
1900	158	14,844	1 578	246.090	3,338	347,200	838	122,400	1,174	154,360	349	119	32,568	3,334	754,086
1901	114	10,434	1,786	240,000	2,526	268,250	705	82,920	1,721	195,550	(*e*)	243	40,824	2,408	425.024

(*a*) From the official reports of the respective countries. (*b*) Crude antimony and regulus. (*d*) Includes manganese. (*e*) Statistics not yet available. (*f*) Includes antimony content of hard lead produced during the year.

Australia.—The production of antimony metal in New South Wales during 1902 amounted in value to £542.

Borneo.—The export of antimony from Borneo during 1900 amounted to 85 tons.

Canada.—The Dominion Antimony Co., capitalized at $1,000,000, was organized early in 1903 to exploit the gold-bearing antimony deposits at West Gore, 20 miles from Windsor, Halifax County, Nova Scotia. The property is situated two miles from the Midland railroad.

China.—Antimony sulphide ore is mined in the Hanchow district, 1,000 miles west of Shanghai. The crude ore is carried by boats to Hanchow and refined to the so-called "Chinese-needle" antimony sulphide, which contains Sb, 72·25%; As, 1 to 1·5%; S, 26·25%, and a trace of iron. The refined product is shipped to Shanghai for export to Hamburg, London and New York. During 1902 the shipment to the last-named port was favored by cheap freight rates, as compared with European ports. The export of refined antimony sulphide ore from Shanghai during 1902 amounted to 2,200 long tons, as compared with 150 long tons in 1901, while the exports of partly refined ore from Hankow during 1902 are reported at 3,254 long tons, valued at $83,170, as compared with 10,363 long tons, valued at $285,675 in 1901.

France.—There were 26 antimony mines in France actively operated during 1901-1902, including six on which exploratory work only had been made. The properties are situated in the order of their importance in the following districts: Haute-Loire, Mayenne, Creuse, Corse, Cantal, Ardèche and Lozère.

Mexico.—The antimony production from Catorce in the State of San Luis Potosi, in recent years, has been large enough to dominate the price of the metal in Mexico. The ore occurs as an earthy oxide in limestone near the surface, and as shipped, contains more than 45% Sb. A metallurgical plant for local treatment of lower grade ores containing from 30 to 40% Sb has been erected at Wadley. Heretofore the ore has been shipped to Newcastle, England.

Portugal.—The principal antimony mines are on the Commune of Gondomar, in the Porto district; the ore occurs also in the Braganza district. During 1902 the exports of antimony ore amounted to 54 metric tons, valued at $1,720 as compared with 126 tons, valued at $2,650 in 1901.

Turkey.—The supply of antimony ore is derived from the mines at Allkhar, near Rozdau, and near Aidin. The export shipments of ore from Salonica during 1900 amounted to 267 metric tons, valued at $13,965.

The New York Antimony Market in 1902.—Although the consumption of antimony in 1902 was larger than in 1901, the market was rather depressed throughout the year, prices ruling considerably below the figures of the previous twelve months. Sales of wholesale lots were difficult to effect. The Italian, French, Japanese and Hungarian brands made heavy inroads in the trade previously controlled by the standard English (Cookson's and Hallett's) brands, partly on account of the fancy prices asked, especially for Cookson's metal, and partly on account of the improving quality of the cheaper grades.

The comparatively easy tone of the antimonial lead market also tended to restrict the demand for antimony.

The year opened with Cookson's selling at 10c.; Hallett's, 8·25c.; Hungarian, Italian, Japanese and U. S. Star at 7·75c. From month to month the prices declined, holders being anxious to sell and willing to make concessions for fair-sized orders. The market closed rather dull and depressed at the lowest quotations of the year, 8·5@8·75c. for Cookson's, 7@7·125c. for Hallett's, 6@8·75c. for Italian, French, Japanese, Hungarian and U. S. Star brands.

AVERAGE MONTHLY PRICES OF ANTIMONY IN NEW YORK. (IN CENTS PER POUND.)

Year.	Brand.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1898....	Cookson's	8·00	8·00	8·25	8·37	9·20	9·65	9·75	9·75	9·75	9·70	9·25	9·25	9·08
	Hallett's	7·37	7·56	7·81	7·96	8·64	8·97	9·06	9·06	9·06	9·08	8·81	8·81	8·51
	U. S. Star	7·50	7·59	7·81	7·92	8·64	8·97	9·06	9·06	9·06	9·03	8·81	8·81	8·52
	Japanese'	7·44	7·58	7·81	7·90	8·59	8·97	9·06	9·06	9·06	9·03	8·81	8·81	8·51
1899....	Cookson's	9·31	10·25	10·37	10·10	10·50	10·50	10·50	10·50	10·50	10·50	10·50	10 50	10·37
	Hallett's	8·81	9·62	9·75	9·80	10·00	10·00	10·00	9·81	9·65	9·72	9·75	9·75	9·67
	U. S. Star	8·81	9·62	9·75	9·80	10·00	10·00	10·00	9·81	9·56	9·50	9·50	9·50	9·65
	Chapman's	.....	9·62	9·75	9·80	10·00	10·00	10·00	.....	.....	.....	.....	.....	.....
	Hungarian	.....	.....	9·75	9·80	10·00	10·00	.....	9·75	9·56	9·50	9·50	9·50	.....
1900....	Cookson's	10·50	10·50	10·50	10·50	10·50	10·50	10·50	10·50	10·10	10·00	10·00	10·00	10·34
	Hallett's	9·75	9·75	9·75	9·75	9·69	9·62	9·53	9·50	9·30	9·25	9·25	9·25	9·53
	U. S. Star	9·50	9·50	9·50	9·50	9·50	9·50	9·50	9·50	9·30	9·25	9·25	9·25	9·42
1901....	Cookson's	10·00	10·00	10·00	10·31	10·25	10·25	10·25	10·25	10·12	10·09	10·00	10·00	10·12
	Hallett's	9·12	9·22	8·90	8·94	8·75	8·75	8·75	8·63	8·50	8·47	8·37	8·31	8·74
	U. S. Star	9·25	9·06	8·80	8·73	8·63	8·63	8·63	8·50	8·37	8·34	8·25	8·00	8 69
	Hungarian	.....	8·75	8·75	8·73	8·63	8·63	8·63	8·50	8·37	8·34	8·25	8·00	8·51
	Italian	.....	8·75	8·75	8·73	8·63	8·63	8·63	8·50	8·37	8·34	8·25	8 00	8·51
	Japanese	.....	.....	.....	8·73	8·63	8·63	8·63	8·50	8·37	8·34	8·25	8·00	8·48
1902....	Cookson's	10·00	10·00	9·87	9·87	9·87	9·87	9·75	9·75	9·69	9·44	9·25	9·20	9·71
	Hallett's	8·17	8·04	8·06	8·06	8·17	8·25	8·25	8·15	7·92	7·72	7·44	7·25	7·96
	U. S. Star	7·86	7·75	7·75	7·75	7·90	8·00	8·00	7·90	7·65	7·37	7·22	6·92	7·67
	Hungarian	7·86	7·75	7·75	7·75	7·90	8·00	8·00	7·90	7·65	7·37	7·22	6 92	7·67
	Italian	7·86	7·75	7·75	7·75	7 90	8·00	8·00	7·90	7·65	7·87	7·22	6·92	7·67
	Japanese	7·86	7·75	7·75	7·75	7·90	8·00	8·00	7·90	7·65	7·37	7·22	6·92	7·67

TECHNOLOGY.

Electrolytic Extraction of Antimony from Ores.—I. Izart[1] describes a process for the extraction of antimony by dissolving the antimony sulphide in the ore with sodium sulphide. The solution is electrolyzed in a vat divided by a diaphragm, the antimony solution being put in the cathode compartment while the anode compartment is filled with a 17% caustic soda solution to which sufficient ammonium chloride is added to raise the sp. gr. to that of the antimony solution. In an experimental plant at Cassagnes, France, a scaly, lustrous deposit of metallic antimony was obtained with a current density of 0·8 ampere per square decimeter and an electromotive force of 1·6 volts, the current efficiency being 76%. The output was 0·55 kg. antimony per kilowatt hour, which was subsequently raised to 0·621 kg. (See also p. 226 of this volume.)

Improved Method of Antimony Smelting.—Thomas C. Sanderson,[2] of Chelsea, S. I., New York, has patented a continuous method of antimony smelting which has been in successful operation for more than a year. A suitable quantity of ferrous sulphide is melted to form a bath on the hearth of a reverberatory furnace, and after shutting off the draught, the hot ore is charged and quickly rabbled into the molten bath; when thoroughly mixed, scrap iron is added to decompose the antimony sulphide. The temperature of the furnace is then raised, the doors being closed, and when sufficiently hot, the contents of the furnace are thoroughly rabbled. When the reaction is completed, the metallic antimony is tapped from the sump of the furnace until iron sulphide appears. The slag is skimmed from the bath in the furnace, and a sufficient quantity of iron sulphide is removed to lower the level of the bath to its original position, the furnace then being ready for another charge of ore. Metallic iron is sometimes added and rabbled in order to recover a small quantity of antimony from the floating slag, which being most part alloyed with iron, remains in the furnace to be treated with the next charge. Oxidized ores may be treated in a similar way, the metal being reduced by iron or carbon, or both.

N. C. Cookson has patented[3] improvements in the method of smelting antimony ores in reverberatory furnaces to prevent volatilization.

White Antimony Oxide.—A. S. Plews has patented[4] a process of making white antimony oxide, in which the ore is heated to a bright red temperature, and the atmosphere of the furnace made alternately oxidizing and reducing as long as antimonial fumes are evolved. Steam is injected into the fumes and the antimony oxide is condensed and collected in a separate chamber provided with means to extract all of the oxide so that the exit gases contain not even a trace.

Determination of Antimony and Arsenic.—L. B. Skinner and R. H. Hawley[5] have published a method for determining antimony and arsenic in mixed precipitated sulphides, based on distilling off the arsenic after adding $CuCl_2$ and $ZnCl_2$ and titrating the $AsCl_3$ with I, followed by distilling the antimony with

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[1] *L'Electricien*, XXII., I., p. 307 and II., p. 33, 1902; also *Journal of the Society of Chemical Industry*, XXI., p. 1237, Oct. 15, 1902.

[2] United States Patent No. 714,040, Nov. 18, 1902.

[3] English Patent No. 20,981 of 1902.

[4] United States Patent No. 704,367, July 8, 1902.

[5] *Engineering and Mining Journal*, p. 148, Aug. 2, 1902.

HCl gas, precipitating the $SbCl_3$ with H_2S, and weighing the Sb_2S_3 formed. The chloride solution for arsenic is prepared by dissolving 300 g. $CuCl_2$ crystals in 1 liter of HCl (sp. gr. 1·2), and adding a solution of $ZnCl_2$ with boiling point of 180°C. The $ZnCl_2$ solution may be prepared by adding 1 lb. stick zinc to 1,250 c.c. HCl (sp. gr. 1·2), boiling and evaporating to bring the boiling point to 180°C. The I in 1 c.c. of the iodine solution corresponds to 0·005 g. As. It is prepared by dissolving 40 g. KI in water, adding 17 g. I and diluting to 1 liter when the I is dissolved. In order to standardize it, 300 mg. As_2O_3 are dissolved in KOH or NaOH, the solution is diluted to 1,200 c.c., and slightly acidified with HCl, 2 g. $NaHCO_3$ are added, and the titration carried to a permanent blue. A check should be made by dissolving 300 mg. As_2O_3 as before, precipitating with H_2S, distilling the sulphide (as shown below), titrating the distillate, and deducting from assays the number of c.c. required in excess of the standard. A check distillation of the $CuCl_2$ and 200 mg. C. P. Cu is necessary, and the distillate titrated; the number of c.c. required have to be deducted. The determination is as follows: Weigh 1 g. ore, place in a casserole, add 10 c.c. HNO_3 (sp. gr. 1·42) and warm. When the evolution of red fumes ceases, add 10 c.c. H_2SO_4 (sp. gr. 1·84) heat only to copious fumes of SO_3, as arsenic is liable to be volatilized. Allow the solution to cool, add 40 c.c. water and 10 c.c. HCl, and boil to dissolve all soluble matter. If antimony is to be determined, add $H_2C_4H_4O_6$. Filter if necessary, otherwise wash into a beaker, reduce to a colorless solution with a mixture of one part NH_4HSO_4 and two parts concentrated NH_4OH, adding it drop by drop, and stirring until the precipitate re-dissolves. In case any of the hydrates formed do not dissolve, add HCl. In the presence of much Au, Se, or Te, these metals will be precipitated by an excess of H_2SO_3, and will darken the nearly colorless solution. Darkening of the solution shows that enough reducing agent has been added. Boil to drive off excess of SO_2, introduce H_2S in a rapid stream until the precipitates begins to collect, filter, wash free from iron salts, and test filtrate with H_2S. Wash precipitate with dilute HCl (1 part water to 1 part HCl, sp. gr. 1·2) into a distillation flask, connected with a Liebig condenser set vertically. Add 50 c.c. $CuCl_2$, close flask with a rubber stopper containing a thermometer reaching to within 0·25 in. of the bottom, and let end of condenser dip 0·5 in. into 40 c.c. water in a beaker. Heat to 115°C. and collect distillate. If much arsenic is present, remove rubber stopper, add 15 c.c. to 25 c.c. strong HCl and distil again. Make the distillate alkaline with NH_4OH, acidify with HCl, cool, add 2 g. $NaHCO_3$, then starch solution and titrate.

If antimony is to be determined, replace the stopper holding the thermometer by another, with a glass tube reaching nearly to the bottom of flask and connect with a HCl gas generator. Heat the distilling flask until the contents are nearly dry and collect the distillate in cold water as before. (Overheating causes $CuCl_2$ to pass over.) When the distillation is finished, add a little $H_2C_4H_4O_6$ to distillate, nearly neutralize with NH_4OH and pass in H_2S. If colored Sb_2S_3 is precipitated, repeat distillation until no Sb is precipitated. Filter the Sb_2S_3 through a Gooch crucible, heat in an air bath at 225°C. for one hour and weigh; the weight obtained multiplied by 0·714 gives the antimony content. The arsenic and antimony distillations take about 15 minutes. The results are accurate, and 0·6% higher than those obtained by the Pearce method for arsenic. In the presence of molybdenum, however, the results for antimony are liable to be a little too high. Experiments to replace $CuCl_2$ with Fe_2Cl_6 proved unsatisfactory.

Specific Gravity and Composition of Hard Lead.—The determination of the exact composition of a hard lead alloy containing 20% Sb has been made by F. W. Küster, Ph. Siedler, and A. Thiel[6] with the following results:—

Specific Gravity.	Antimony.	Correction.	Specific Gravity.	Antimony.	Correction.
	%	%		%	%
9·972	20·03	+0·03	9·977	20·00	0·00
9·974	20·05	+0·05	9·978	19·98	—0·02
9·975	20·03	+0·03	9·979	19·97	—0·03
9·976	20·02	+0·02	9·982	19·92	—0·08

The small quantities of copper, iron, arsenic, etc., which occur in hard lead do not interfere with the determination. When making the determination, care must be taken to cool the alloy gradually, otherwise the outer layer may cool first, leaving a hard shell with a molten interior, which on cooling contracts and leaves air spaces.

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[6] *Chemiker Zeitung*, XXVI., Nov. 19, 1902, p. 1107.

ARSENIC.

By Joseph Struthers.

The production of arsenious oxide (white arsenic) in the United States during 1902 was 1,353 short tons, as compared with 300 short tons in 1901. The entire product was made by the Puget Sound Reduction Co., at Everett, Wash., which began the manufacture of this important product in 1901. The largely increased output in 1902 is a very favorable sign of the success of the new industry. Aside from the arsenic ores which occur in the United States, there are several chemical and metallurgical by-products rich in arsenic—as speiss from the lead smelters, and precipitated arsenic sulphide produced in the purification of sulphuric acid—which should be utilized in some way to replace the large quantities of arsenic compounds that are imported annually from Europe and Canada. The occurrence of arsenic ores and the metallurgical practice of England and Germany are described in Vols. II. and IV. of The Mineral Industry.

Imports.—The quantity and value of the imports into the United States of white arsenic (arsenious oxide), metallic arsenic and arsenic sulphides (orpiment and realgar) during the past five years are as follows: 1898—8,686,681 lb. ($370,347); 1899—9,040,871 lb. ($386,791); 1900—5,765,559 lb. ($265,500); 1901—6,989,668 lb. ($316,525); and 1902—6,110,898 lb. ($280,055).

New York Market.—The average monthly price of white arsenic at New York during 1902 was as follows: January, 3·34c. per lb.; February, 3·58c.; March, 3·5c.; April, 3·37c.; May, 3·25c.; June, 3·16c.; July, 3·04c.; August to December (inclusive), 2·94c., giving an average of 3·16c. per lb. for the entire year, as compared with 3·92c. during 1901. The average monthly price of red arsenic (from Germany) at New York during 1902 was: January, 7·03c. per lb.; February, 7c.; March, 6·87c.; April, 6·63c.; May, 6·72c.; June to December (inclusive), 6·88c., giving an average of 6·86c. per lb. during the entire year, as compared with 7·04c. during 1901. Pure Paris green in bulk sold at 11@12·5c. per lb. during 1902, as compared with 12@12·5c. during 1901.

Prior to 1899 the world's supply of arsenic and arsenical compounds was derived chiefly from the mines at Cornwall and Devon, England, and at Freiburg, Germany, but the closing of the Devon Great Consols mine, near Tavistock, in 1901, called for an increased or new supply from other localities. In 1900 Canada contributed a small quota, which has since been largely increased, and in 1901 the United States became a producer on a small scale, and more than quadrupled its output for 1902.

The statistics of the world's production of arsenic and its compounds are given in the subjoined table:—

THE WORLD'S PRODUCTION OF METALLIC ARSENIC AND ITS COMPOUNDS. (*a*) (*f*)
(IN METRIC TONS.)

Year.	Canada. (*e*)		Germany.				Italy. (*c*)		Japan.	Portugal.		Spain. (*d*)		United Kingdom. (*e*)	
			Prussia.		Saxony. (*b*)										
	Tons.	Value	Tons.	Value.	Tons	Value.	Tons.	Value.	Tons.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1897	*Nil.*	......	1,924	$143,775	1,063	$152,122	200	$18,600	13	524	$20,369	244	$29,256	4,232	$373,975
1898	*Nil.*	......	1,634	121,818	1,053	131,710	215	15,700	7	751	44,764	111	13,320	4,241	268,935
1899	52	$4,842	1,469	123,678	953	133,572	304	26,483	5	1,033	61,356	101	12,156	3,890	271,180
1900	275	22,725	1,583	133,663	829	124,587	120	12,098	5	1,031	62,522	150	13,036	4,148	335,140
1901	630	41,676	1,446	108.430	1,100	148,162	*Nil.*	....	....	527	35,277	120	14,400	3,416	197,270

(*a*) From official reports of the respective countries. (*b*) Arsenious oxide. (*c*) Metallic arsenic and arsenious acid. (*d*) Natural arsenic sulphide; does not include the manufactured oxide. (*e*) Arsenious oxide. (*f*) 274 metric tons of orpiment and realgar, valued at $21,600, were exported from Turkey during 1900; the production of arsenious oxide in the United States during 1901 was 272 metric tons, valued at $18,000.

Canada.—The production of arsenious oxide (white arsenic) in Canada during 1902 was 800 short tons, valued at $48,000, as compared with 695 short tons, valued at $41,676 in 1901. The entire production was made by the Canadian Goldfields, Ltd., at the Deloro mine, Ontario, in connection with the extraction of gold from arsenical pyrites by the Sulman-Teed bromo-cyanide process. Mr. P. Kirkgaard has kindly contributed the following description of the present method of treatment: The mispickel when pure has the composition: Fe, 34·35%; S, 19·64%; As, 46·01%. The mined ore is chiefly quartz, more or less heavily impregnated with mispickel, which is gold bearing. It is crushed in a 30-stamp mill, wherein an average of from 57 to 60% of the gold value is recovered by amalgamation, and the tailings from the plates are concentrated on Wilfley and Bartlett tables to a product assaying about SiO_2, 18·63%; Fe, 29·26%; S, 15·44%; As, 28·75%, and undetermined, 7·92%. The gold is extracted therefrom by the Sulman-Teed bromo-cyanide process, whereby a recovery of about 90·5% is effected, which, added to the recovery by amalgamation, gives a total winning of from 88 to 90% of the gold content of the original ore.

After the leaching of the gold, the mispickel concentrates (40-mesh size) containing an average of As, 30% and S, 16% are roasted in two Oxland furnaces, arranged in series. The first is 29·5×5·5 ft., and the second is 60×6·5 ft. A tube conveys the ore from the first to the second furnace on the lower level. The furnaces are divided internally into quadrants by means of tiling (evidently an adaptation of the Rothwell diaphragms) which extends to within 4 ft. of the feed end, where spiral ribs are arranged to enable the ore to pass down into the compartments. The first cylinder is operated by mechanical draft; the second has an independent fireplace and chimney. Nearly all of the arsenic is volatilized in the first furnace, the burnt ore therefrom assaying about SiO_2, 43·23%; Fe_2O_3, 44·66%; S, 5·06%; As, 0·36%, and undetermined, 6·60%.

The fumes from both furnaces are drawn mechanically through a dust chamber 100 ft. long, arranged to discharge the settlings automatically back into the first furnace and then through zigzag chambers 12 ft. wide, in which the pure white arsenic is deposited and drawn by gravity into cars beneath the chambers.

The product resulting from this operation is a crude arsenic containing about As_2O_3, 85%, and S, 2 to 4%, the balance being silica in a finely divided state.

The crude arsenic is sublimed in two specially designed single-hearth reverberatory furnaces, the charge in each case being 1,600 lb. Each furnace has a capacity of three charges per 24 hours. The arsenic, upon being volatilized, is driven through a long hot flue and thence into an uptake or hot chamber; during the passage through these any impurities that may have been carried over with the highly heated gases are deposited when the cooling commences, being assisted by mechanical means, throughout a series of cooling chambers. When the gases have been cooled to 80°F. they are forcibly ejected into a large condenser and made to expand and contract alternately until perfectly cooled and free from arsenic. They then escape into the open air.

The resultant arsenious oxide is pure; analyses showing from 99·6 to 100% As_2O_3. The impurity is silica, doubtless derived from the mortar and brick of which the chambers are built. The refined arsenic is withdrawn from the chambers every two weeks; it is dropped into hutches, which are tightly closed for the double purpose of keeping the oxide warm as long as possible and preventing the escape of the poisonous dust into the building. Finally, the arsenic is ground to a 200-mesh size and a conveyor takes it to the packer, where it is automatically packed in substantial wooden kegs containing an average of 500 lb. each and is ready for the market.

A new occurrence of native arsenic has been reported at the Corporation (Forsyth) quarry, near Montreal, Ontario. The mineral occurs in concentric layers forming masses often of several pounds in weight. An analysis gives As, 98·14%; Sb, 1·65%; S, 0·16%; insoluble, 0·15%. No silver, bismuth, or other metal was found.

France.—The production of arsenic ore in France during 1901 amounted to 7,500 metric tons, valued at $38,000. The entire output was derived from two mispickel properties in Villanière et du Salsigne (Aude).

Germany.—The production of arsenic ore in Germany during 1901 was 4,060 metric tons, valued at $78,000, as compared with 4,380 tons in 1900, valued at $79,000.

India.—Arsenic sulphide ores occur at Munsiari, in Kumaon, Chitral, in the Punjab, and in various localities in Upper Burma and Unan. The annual imports of orpiment and realgar during the past three years have averaged 638,400 lb. The foreign imports in 1900-1901 amounted to 309,792 lb., valued at 56,390 rupees, and were derived mainly from Germany, the United Kingdom, Hongkong, and the Straits Settlements. It is impossible to determine what proportion of the imports of pigments (if any) represent arsenic, but the consumption of white arsenic, orpiment and realgar in the industries of India must be extensive.

Italy.—During 1901 there were produced 6 metric tons of arsenic ore, valued at $96.

Spain.—A white arsenic works has been established at Badalona, near Barcelona, by Messrs. Gironés and Henrich, to treat the arsenical pyrites of Caralps in the Province of Gerona. It is reported that these works produce 10 tons per diem of pure white arsenic assaying from 99·8 to 99·9% arsenious oxide.

United Kingdom.—The arsenic industry in England during 1902 has been greatly depressed, as the price obtainable for white arsenic fell to so low a figure that its manufacture from arsenic ores became unprofitable in many cases. Underground mining at the Devon Great Consols Co., Ltd., was discontinued early in 1902 pending negotiations affecting the renewal of the lease of the mines. The production of arsenious oxide in 1902 was 2,464 metric tons, as compared with 3,416 tons, valued at $197,270 in 1901, and 4,146 metric tons, valued at $335,140 in 1900. According to the thirty-eighth report of the Alkali Inspector, an improvement in arsenic manufacture in Great Britain has been the erection at one works of a condensing tower containing 2 tons of iron rods suspended about an inch apart, whereby 70% of the arsenious acid passing through the tower is removed. This appears to be an adaptation of the Roesing wire system to arsenious oxide condensation.

Determination of Arsenic and Copper in Iron Ores.—F. Bischoff[1] passes H_2S for 30 minutes into the solution of iron, copper and arsenic, which is maintained at a temperature of 70°C. The solution is allowed to stand for 10 hours and is then passed through a filter; the precipitate is washed with H_2S water, placed in a beaker, a 10% NaClO solution added and Cl gas passed until the solution assumes a green color. It is allowed to stand for a few hours, filtered, washed, HCl added, and Cl expelled by boiling, then transferred to a platinum dish, KOH added, and boiled. The precipitated copper hydrate is filtered, washed, dissolved and determined in the usual manner. To the filtrate containing the arsenic HCl is added, then NH_4Cl and NH_4OH to alkaline reaction, the solution is cooled and the arsenic precipitated with magnesia mixture.

Determination of Arsenic and Antimony in Sulphides.—See under the section devoted to "Antimony" earlier in this volume.

The Westman Electric Furnace Process for Arsenic.—See page 226 of this volume.

Recovery of Arsenic Fume from Furnace Gases.—George C. Stone has patented[2] a method for the separation and recovery of arsenic fumes from furnace gases in the manufacture of sulphuric acid, which consists in cooling the gases to the temperature of condensation of the fumes, collecting the deposited material in a suitable filter, and the subsequent recovery of the arsenic or similar compounds by submitting the filter with contents to heat, whereby the volatile oxides are expelled, condensed and collected.

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[1] *Stahl und Eisen*, Vol. XXII., 756.

[2] United States Patent No. 711,187, Oct. 14, 1902.

ASBESTOS.

By Henry Fisher.

There was an increase of nearly 50% in the production of asbestos in the United States during 1902 over the previous year, the output being 1,010 short tons, valued at $12,400, as compared with 747 short tons, valued at $13,498 in 1901. The value of the product at the mine decreased from $18·07 per ton in 1901 to $12·27 in 1902, a decrease of nearly 50%. The Sall Mountain Asbestos Co., at Sall Mountain, White County, Ga., continues to be the largest producer of asbestos in this country.

PRODUCTION AND IMPORTS OF ASBESTOS IN THE UNITED STATES.

Year.	Production.				Imports.		
	Short Tons.	Metric Tons.	Value.	Value per Metric Ton.	Manufactured.	Unmanufactured.	Total.
1898	885	803	$13,425	$16·72	$12,899	$287,636	$300,535
1899	912	827	13,860	16·76	8,949	303,119	312,068
1900	1,100	998	16,500	16·54	24,155	331,796	355,951
1901	747	678	13,498	19·91	24,741	667,087	691,828
1902	1,010	916	12,400	13·54	33,318	729,421	762,734

PRODUCTION OF ASBESTOS IN THE WORLD. (*a*) (IN METRIC TONS.)

Year.	Canada.		Cape Colony.(*c*)		Italy.		Russia.		United States.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1898	21,577	$486,227	161	$10,185	131	$9,000	1,665	$60,600	803	$13,425
1899	22,938	483,299	(*b*)	....	81	7,264	2,693	97,342	827	13,860
1900	27,797	748,431	157	12,785	(*b*)	....	(*d*)	....	998	16,500
1901	36,475	1,259,759	89	7,165	(*b*)	....	(*d*)	....	678	13,498
1902	36,668	1,203,452	(*d*)	....	(*d*)	....	(*d*)	....	916	12,400

(*a*) From official reports of the respective countries. (*b*) Not stated in the reports. (*c*) Exports. (*d*) Statistics not yet available.

Several discoveries of asbestos have been made in 1902. Five asbestos claims have been located in the chrome district in Tehama County, Cal., and another deposit has been located in Pinto Creek, near Globe, Ariz. The fiber from the latter deposit, which is reported to be large, is of the long variety. The Pine Mountain Mica & Asbestos Mining Co. has been organized at Indianapolis, Ind., to develop asbestos and mica mines in Georgia and North Carolina. The Mad River Asbestos & Talc Co. has been incorporated at Kittery, Me., to mine asbestos, talc and other minerals.

Uralite is the name given to a new fireproof material composed of asbestos fiber, chalk, sodium bicarbonate and silicate, invented by a Russian artillery officer and chemist named Imschenetzky. It is a non-conductor of heat and electricity and is practically waterproof. The manufacture of uralite consists in teasing the asbestos fiber and freeing it from sand and other foreign substances, after which a little whiting is added, and the mixture is run through a disintegrator, and is then separated again by air blast and sieving. A quantity of whiting, equal in weight to that of the asbestos, is made into a paste, and the asbestos is added and thoroughly mixed. The mixture is delivered to a revolving blanket, and passed through a series of rolls, where it is partly dried and compacted. Fourteen or fifteen thicknesses are passed to a revolving drum, and a solution of sodium silicate and sodium carbonate added to serve as an adhesive. The layers are subjected to a pressure which is finally increased to 200 lb. per sq. in. and left for 1·5 hours, after which they are dried for one day. When dry they are gradually heated in a gas-fired oven, cooled, steeped in a solution of sodium silicate, washed, dried and again heated. These operations are repeated till the proper hardness is attained.

Another fireproof asbestos preparation is called salamanderite. It is claimed that this is not only fireproof, but that it can be used to duplicate the decorative effects of wood in cabinet work.

Canada.—The production of asbestos during 1902 was 40,420 short tons, valued at $1,203,452, as compared with 40,200 short tons, valued at $1,259,759 in 1901. The exports of asbestos, which are divided into three grades, for the fiscal year ending June 30, 1902, were 33,072 short tons, valued at $1,131,202, divided as follows: 25,053 tons to the United States, 4,088 tons to the United Kingdom, 2,270 tons to Germany, 827 tons to Belgium, 469 tons to Italy, and 365 tons to France. Owing to an excess of production in Quebec during 1902, according to J. Obalski, the prices declined slightly. The asbestos mines at Danville, Thetford, Black Lake and Broughton were in operation during the greater part of 1902, but toward the end of the year a few mills were closed on account of the bad season and scarcity of coal due to the strike in the United States. The Bell Asbestos Co., which owns mines at Thetford, for the year 1902 reports a net profit of £4,395, to which is to be added the amount brought forward from the previous year, £2,538, a total of £6,933. The company opened up new sections of its territory, using a steam shovel instead of hand labor to remove the earth from the surface covering the serpentine. The New England & Canadian Asbestos Co., of Providence, R. I., purchased the Beaver Asbestos Co., and the Black Lake and Fraser mines, in Broughton, owned by the Canadian Asbestos Co. The mills at the Johnson and Standard Co.'s mines were put in operation. Several mills will be erected and others completed in 1903. The total shipments from the Province of Quebec in 1902 were 30,634 short tons of asbestos, valued at $1,161,970, and 40,398 short tons of asbestic, valued at $12,738. Of the total shipments of asbestos, 1,319 tons ($240,401) were first grade crude, 3,131 tons ($305,312) second grade crude, 15,502 tons ($412,388) fiber, and 10,682 tons ($203,869) paper stock.

ASPHALTUM.

By Joseph Struthers.

The aggregate production in the United States during 1902 of all mineral bituminous products, embracing as well that portion of the residuum from the refining of petroleum which is sold and used as asphaltum, was 83,651 short tons, valued at $615,659, as compared with 63,134 short tons, valued at $555,335 in 1902.

PRODUCTION OF ASPHALTUM AND BITUMINOUS ROCK IN THE UNITED STATES. (IN TONS OF 2,000 LB.)

States.	1900.			1901.			1902.		
	Tons.	Value.	Per Ton.	Tons.	Value.	Per Ton.	Tons.	Value.	Per Ton.
Bituminous sandstone:									
California	a25,355	a$101,420	$4·00	24,306	$77,661	$3·15	33,489	$79,809	$2·38
Kentucky	8,922	37,472	4·20	8,942	56,610	6·33	22,498	68,704	3·05
Indian Territory	....	....	....	1,000	4,330	4·33	(e) 1,050	4,580	4·36
Arkansas	....	....	....	....	....	....	800	4,000	5·00
Total	34,277	$138,892	$4·05	34,248	$138,601	$4·05	57,837	$157,093	$2·72
Asphaltic limestone:									
Utah	2,550	12,750	5·00	*Nil.*	....	....	*Nil.*	....	....
Indian Territory	1,360	4,080	3·00	2,970	15,375	5·20	1,130	4,020	3·56
Texas	....	....	....	4,000	18,000	4·50	*Nil.*	....	....
Arkansas	....	....	....	....	....	....	700	3,500	5·00
California	....	....	....	....	....	....	29	262	9·03
Total	3,910	$16,830	$4·30	6,970	$33,375	$4·79	1,859	$7,782	$4·19
Asphaltum:									
California	d11,140	218,520	19·62	b 19,988	316,559	15·83	f(g)29,282	382,391	13·06
Indian Territory	....	....	....	98	1,000	10·20	376	3,219	8·56
Texas	....	....	....	330	19,800	60·00	(g) 245	3,992	16·29
Gilsonite:									
Utah	3,279	98,370	30·00	c 1,500	46,000	30·67	4,052	61,188	15·10

(a) Statistics of the California State Mineralogist. (b) Includes 1,000 tons of liquid asphaltum valued at $49,850. (c) Estimated. (d) Includes production in Indian Territory. (e) Includes production of Oklahoma Territory. (f) Includes 1,600 tons of liquid asphaltum, valued at $20,187. (g) Includes by-product asphaltum from refining crude oil.

The production of bituminous sandstone in the United States during 1902 was 57,837 short tons ($157,093) as compared with 34,248 short tons ($138,601) in 1901. Practically the entire output was obtained from California and Kentucky. The quantity of bituminous limestone produced in 1902 from the deposits of Indian Territory and Arkansas amounted to 1,859 short tons ($7,782), as compared with 6,970 short tons ($33,375) in 1901; probably a part of the by-product asphaltum from the refining of crude oil was included in the Texan statistics for 1901. The production of hard asphaltum in California, Indian Territory and Texas during 1902 (including by-product from oil refining and 1,605 tons of the liquid product, valued at $20,172) was 29,903 short tons ($389,602), as compared with 20,416 short tons ($337,359) in 1901. The quantity of gilsonite produced in 1902 was 4,052 short tons ($61,182), as compared with a production estimated at 1,500 tons ($46,000) in 1901.

A complete schedule of the various subsidiary companies that formed the National Asphalt Co. and the Asphalt Co. of America, incorporated in 1900 with a capitalization of $22,000,000 was filed March 18, 1903, in the United States Circuit Court at Trenton, N. J., by John M. Mack and Henry Tatnall, receivers of the defunct trust. There are 41 subsidiary companies of the Asphalt Co. of America which show a net loss of $1,594,000, and the 25 subsidiary companies of the National Asphalt Co., which show a net loss of $60,000, aggregating a total net loss of $1,654,000. On May 16, at Trenton, N. J., the assets of both companies were sold at auction for $6,000,000 to Henry C. Everdell, representing the reorganization committee.

Arkansas.—According to C. W. Hayes, in *The Engineering and Mining Journal*, Dec. 13, 1902, bituminous matter in the form of a heavy semi-fluid residuum or asphalt occurs at a number of points in Arkansas, Indian Territory and Texas. In Arkansas the rock formation consists largely of coarse unconsolidated sands, with beds of clay, calcareous lenses and fossiliferous limestones, overlying beds of shale and sandstone. The largest deposit of asphaltum in Arkansas occurs near Pike City, Pike County, and is being developed by the Arkansas Asphalt Co. The deposit is in the form of a sand stratum, varying in thickness from 6 to 12 ft., and contains various quantities of asphaltum. A pit 12 ft. deep has been sunk through the bed, and the asphalt oozes out into the pit. Several specimens of asphaltic rock have been analyzed with the following results:—

Components.	Gray-banded Rock.	Brown Cap Rock.	Black Sand Rock.	Black, Gummy Rock.	Calcareous Sandstone.
	%	%	%	%	%
Petrolene	6·68	1·78	14·18	6·61	3·46
Asphaltene		3·83	2·40	2·25	1·12
Silica	69·15	93·40	81·20	79·50	49·42
Calcium carbonate	20·35	....	....	6·14	46·00

Test borings show that the asphaltum beds extend over an area of several acres. A pit 100 ft. in diameter has been sunk and a tramway has been built to the railroad half a mile distant. The occurrence of limestone with the sandstone in some portions of the bed makes it possible to use the material for paving purposes without the addition of other material. At other places of the deposit the material is too rich in asphaltic matter to be used directly for paving purposes, but tests of these portions in the preparation of a paving mixture have been made by the St. Louis Testing & Sampling Works with excellent results. The extent to which the deposit can be used for paving purposes in competition with other asphalts will be determined entirely by the matter of freight rates. It should easily control the market in adjacent cities, as Little Rock, Texarkana and Fort Smith, and the richer portions of the deposit should compete advantageously with other asphalts in cities as far distant as Memphis and St. Louis. Borings have been made for oil also, but without success, the sandstone not being of a nature to retain oil.

Kentucky.—(By William E. Burk.)—The deposits of bituminous sandstone or asphalt rock in Kentucky occur chiefly in the counties of Logan, Warren, Edmonson, Butler, Grayson and Breckinridge, occupying a strip in the central part of the State that extends from Breckinridge County on the north to Logan County on the south. A few deposits are found also in the western parts of Hardin, Hart and Larue counties. The asphalt-bearing territory apparently follows the line of the Coal Measures, and is about 20 miles wide by 50 miles in length. The main basin of highly mineralized rock is located well to the south, the richest deposits being found in Logan and Edmonson counties. A bituminous deposit also exists in Carter County, in the northeastern part of the State; the material is impregnated sandstone, but it appears to lie in a basin altogether different from that which extends into West Virginia, and portions of which are found scattered over other eastern counties of Kentucky. The deposits occur in fine-grained sandstone of the Sub-Carboniferous formation. The strata usually approximate their normal horizontal position, and from geological evidence, it is probable that the bituminous or asphalt material represents the residual matter from pre-existing petroleum beds. The soft, porous sandstone, which once was saturated with petroleum, has been eroded away, and the channel streams of ancient rivers have cut deeply into the rock. This has resulted in valleys and hills of sandstone from which the lighter products and oil have distilled and drained away, leaving residual petroleum products constituting the asphalt or bitumen. The fact that petroleum-bearing rock formerly existed where the present asphalt rock occurs should not be taken to mean that quantities of petroleum must occur at lower depths, for the underlying strata may represent altogether different formative conditions. The bituminous deposits, though quite generously distributed in Grayson and Edmonson counties, are in no sense uniform as to richness and magnitude. The horizontal ledges vary in thickness from 2 to 20 ft. In many cases the deposits are quite lean; the material locally called "black-rock" contains only a small percentage of bituminous material, and has no commercial value. The known deposits of commercially valuable material are few. The richer deposits are usually enclosed by strata of "black-rock" from 1 to 2 ft. in thickness, while the intervening portion of asphalt ledge varies from 3 to 15 ft. in thickness, and contains from 5 to 15% total bituminous matter. When containing under 4%, the material passes under the class of "black-rock." Deposits containing as high as 20% are of small extent, and usually due to local concentration conditions. Of the total bituminous content about 20% is of the nature known as asphaltene, and 80% of petrolene. After the removal of the bituminous matter the sandstone crumbles to a very fine sand. One characteristic sample upon examination showed 8·5% of sand that passed through a 150-mesh, and 82·5% that passed through a 75-mesh sieve. In the present state of development only those deposits lying conveniently near railroad or river have received attention, and of such only those have been worked which offer the least difficulty in the way of uncovering. Although rich material is sometimes exposed in bluffs, no tunnelling or drifting has been attempted. This district is entered by the Green River and its prominent tributaries. Considerable asphalt rock has been moved by barge to Ohio River points. The Green River Asphalt Co., operating near Young's Ferry, on Green River, has shipped its product to Evansville, Ind., by barge, and from there by rail, but recently the company changed its policy, and is now shipping to Bowling Green by water. The field is reached by two railroads, the Illinois Central Railroad crossing the field at the north, and the Louisville & Nashville Railroad passing in a southerly direction to the east of, and finally crossing the Logan County deposits at Russellville.

Among the incorporated companies owning or controlling deposits are the American Standard Asphalt Co., the Green River Asphalt Co., the Breckinridge Asphalt Co., the Federal Asphalt Co., the Natural Asphalt Co., and the National Rock Asphalt Co. The only companies, owning property that is developed to any extent and equipped with mining plants, are the American Standard Asphalt Co., the Green River Asphalt Co., and the Breckinridge Asphalt Co. It is the policy of these companies to mine material as needed, no considerable quantity of rock being carried in storage. This occasions quite irregular production. The total output during 1902 of the Green River Asphalt Co., the American Standard Asphalt Co., and the Breckinridge Asphalt Co. amounted to 22,498 short tons ($68,704). The Federal Asphalt Co. shipped a few carloads of product, presumably for experimental purposes. The first streets constructed of Kentucky asphalt rock were laid in the city of Buffalo, in 1890, when 12 miles were paved by the Breckinridge Asphalt Co.

The natural asphalt rock quite often contains bitumen in percentages of asphaltene and petrolene suited for street making purposes, but in most cases bitumen must be added. In exceptional cases the asphalt rock as it comes from the quarries is too rich in bitumen to admit of proper mixing, and the American Standard Asphalt Co. is considering the extraction of bituminous matter by solvent process. For street composition the crushed natural rock is mixed with pulverized limestone or marl and an asphaltic cement. The asphaltic cement consists, as the conditions may require, of Trinidad gum asphalt or petroleum residuum, in amounts determined by the character of the asphalt rock used. The crushing of the natural rock is usually done at or near the quarries, while the mixing of ground material with rock and asphalfic cement is done near the street under construction.

The property of the American Standard Asphalt Co. lies about four miles northeast of Russellville, in Logan County, and is quite extensively developed, the quarry face showing about 17 ft. of asphalt ledge. The plant consists of a 250-ton gyratory crusher, with plain 14×18-in. rolls. Quarries, mill and tipple are connected by 1·5 miles of narrow gauge track, with 45 tram cars in operation. At Louisville, Ky., the same company is equipped with a plant for mixing and preparing asphalt material for street work. One short ton of crushed asphalt rock lays about 11 sq. yd. of 2-in. pavement. The plant of this company has a capacity of preparing material to cover 2,000 sq. yd. of street area per day.

The property of the Green River Asphalt Co. lies near Green River, at Young's Ferry, in Warren County. The overburden is moderately light, and the deposit is quarried. The location of the ledge is high above the water level, affording the advantage of gravity in handling the spalls from quarry to crusher and from crusher to barge. Recently the company has established a crushing plant at Bowling Green, to which point the spalls are shipped by water. In this plant corrugated rolls are used and hot air is injected into the stream of ore as it comes from the crusher to expel moisture. This plant has a capacity of 200 tons per day.

The property of the Breckinridge Asphalt Co. is situated in Breckinridge County near the town of Garfield. At the plant of this company the broken asphalt rock passes through beaters revolving about a horizontal shaft. The first beater revolves at a velocity of 600 revolutions per minute, delivering the rock to a 2-in. screen. A second beater revolving at a velocity of 1,200 revolutions per minute takes the material and delivers it to a 0·25-in. screen. Material over 0·0625-in. ($\frac{1}{16}$) is returned to beaters. The capacity of the plant approximates 100 tons per day.

The property of the Federal Asphalt Co., near Big Clifty, in Grayson County, has been slowly developed, owing to a fire which destroyed the mill on the first day of operation. The erection of another plant of large capacity is contemplated.

THE WORLD'S PRODUCTION OF ASPHALTUM AND ASPHALTIC ROCK. (*a*) (IN METRIC TONS.)

Year.	Austria.	France.		Germany	Hungary.	Italy.		Russia.	Spain.	
	Asph. Rock.	Asphaltum	Asph. Limestone. (*b*)	Asphaltum.	Asphaltum.	Asphaltum. (*h*)	Asph. Rock.	Asphalt.	Asphaltum	Asph. Rock.
1897	300	17,988	30,946	61,645	3,057	18,644	55,839	22,222	1,878	1,656
1898	643	18,832	36,000	67,649	3,125	17,813	98,750	12,018	2,354	2,354
1899	2,685	22,100	39,000	74,770	3,060	41,782	81,987	23,061	2,646	2,549
1900	887	25,228	34,093	89,685	2,900	33,127	101,738	(*d*)	2,331	4,198
1901	541	20,891	29,815	90,198	2,878	31,814	104,111	(*d*)	4,169	3,956

Year.	Trinidad. (*e*)	United States.		Venezu'la (Bermudez). (*e*)
		Asphaltum. (*f*)	Asphaltic Rock. (*g*)	
1897....	133,310	24,854	45,233	11,528
1898....	108,792	23,306	57,728	*Nil.*
1899....	144,840	18,662	50,061	12,014
1900....	161,299	(*i*)8,826	41,029	17,981
1901....	167,253	(*i*)19,882	37,398	22,115

(*a*) From the official reports of the respective countries, except where noted to the contrary. The production of gilsonite in the United States and Manjak in Barbados is not included. (*b*) France produces a large amount of bituminous shales, used for distilling oil, which is not included in these statistics. (*d*) Not yet reported. (*e*) Exports (crude equivalent) reported by The New Trinidad Lake Asphalt Co. (*f*) Statistics reported by the California State Mineralogist, practically the entire American product being derived from California. (*g*) Statistics based on direct reports from the producers, including asphaltic limestone and sandstone. (*h*) Including mastic and bitumen. (*i*) Statistics of the United States Geological Survey.

NOTE.—There is a considerable production of asphaltic stone in Switzerland of which no account is taken in the above table, the Swiss Government not publishing any mineral statistics.

THE ASPHALTUM INDUSTRY IN FOREIGN COUNTRIES.

Cuba.[1]—(By H. C. Brown.)—The output of asphalt in 1901 amounted to 4,554 tons, valued at $96,380, of which all but 500 tons were exported. Of the total shipments New York received 3,300 tons, while 754 tons went to Europe, the bulk of which went to Germany and a small portion to England. The selling price ranged from $12 to $50 per ton, according to quality. There were nine concerns engaged in mining asphalt, and the individual output varied from 24 tons to 1,400 tons.

Province of Pinar del Rio.—A Spanish company has denounced asphalt

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[1] Through the courtesy of the United States Geological Survey.

property north of the Sierra de Oro, and is engaged in developing several mines. The Magdalena and Rodas Concepcion mines, which have been worked to some extent in the past, were re-opened, and a railroad was constructed to Mariel Bay to furnish an outlet for the product. The company operating these mines has entered into a contract with the Trinidad Asphalt Manufacturing Co., of St. Louis, to furnish 200 tons of asphalt per month, and has arranged also to forward shipments at their convenience to New York. An analysis of asphalt from La Union shows: total bitumen, 53·90%; insoluble material, 3·29%; volatile oils, 0·77%; moisture, 2·83%; rock material (principally limestone), 39·21%.

Province of Havana.—The West Indies Co., of New York, which operates the Angela Elmira mine near Bejucal, has shipped asphalt to New York and Washington for use as paving material, it being known in trade as the "Royal Palm" brand. An analysis of this asphalt is given in THE MINERAL INDUSTRY, Vol. X. The Habana mine, situated on the United Railways of Havana, about 19 miles east of the city of Havana, was worked during the year, and the product shipped to New York and European ports. The material is pronounced a pure gilsonite suitable for varnish and japan manufacture. The Arizona-Cuban Asphalt & Mining Co., incorporated with a capital stock of $5,000,000, has denounced asphalt properties near Jaruco, and is said to own 13 claims in the eastern provinces.

Province of Matanzas.—The property known as "La Paz," situated 10 miles from the town of Perico, was operated and the product shipped from Havana to Hamburg, Germany. This mine is owned by a Cuban company which is also developing a deposit near Ranchuelo that is said to yield asphalt suitable for roofing and pavement. Analysis of the material shows: Carbon and combustible substances, 52%; residue, 45·5%; moisture and gases, 2·5%. Of the several deposits around the Bay of Cardenas, the Perseverancia was alone operative last year. It produces an inferior grade of asphalt, which sells in New York for $20 per ton. The most productive of the mineral tar deposits near Sabanilla de la Palma was operated by the Hamel-Reynolds Asphalt Mining Co. The mineral tar is won by sinking a well and removing the material from time to time which oozes into the excavation from the surrounding rock. The well owned by the company is 250 ft. deep, and yields about one ton per day. It is planned to erect a refinery and to continue the development of the property. Near the mouth of the Rio de la Palma a deposit of soft bitumen has been prospected.

Province of Santa Clara.—The most important asphalt mine in the vicinity of Santa Clara is on the Santa Eloisa property in the Barrio de Loma Cruz. A portion of the product, which is characterized as a hard glance pitch is used with coal in gas manufacture, while some of it has been sent to New York and used in the manufacture of paint and varnish. Of the mines in the district of Yaguajay, near the boundary of Santa Clara and Puerto Principe, only one, the Santa Rosa Eufemia, is at present productive. The asphalt from this mine resembled gilsonite very closely, but contains a large proportion of sulphur. It is used in the manufacture of fine varnishes.

Province of Puerto Principe.—The Talaren mine, which yields glance pitch, has been operative for several years, and the product is well established in the markets of the United States.

France.—The Val de Travers Asphalte Paving Co., Ltd., reports an income of £46,199 during 1902, and expenses, including depreciation, £12,423. A dividend of £20,000 at the rate of 20% for the year was paid, leaving £2,776 to be brought forward, which, with £10,271 from the previous year, gave a total of £13,047. This company holds the concessions from the Société des Asphaltes du Val de Travers for the exclusive supply to the United Kingdom of rock from the Val de Travers mine, Neuchâtel, Switzerland. It has also acquired the Compagnie Générale des Asphaltes de France for £184,000, to be paid in stock, which company owns property at Pyriment-Seyssel, Seyssel Volant, Chavaroche, and elsewhere in France; bituminous property in Venezuela, mines in Sicily, and property in New York, Alexandria and Charenton, France.

Italy.—In Sicily the asphalt industry is in the hands of a few large companies, who are increasing the capacity of their factories for extracting the bitumen from the asphalt rock and compressing it into blocks, and also for pulverizing the rock for shipment in bags. The three largest concerns are the French Company, which has important mines at Ragusa and Vizzini; the United Limmer and the Sicula Company. A large part of the output is exported from Syracuse and Mazzarellis. In 1901 the exports amounted to 62,770 tons, of which the United States received 11,870 tons, Germany 29,300 tons, Holland 3,750 tons, Great Britain 7,630 tons, and France and Austria-Hungary the balance.

Trinidad and Tobago.—The exports of asphalt from the Island of Trinidad are given in the following table, for which we are indebted to the courtesy of the New Trinidad Lake Asphalt Co., Ltd. Seven-eighths of the asphalt exported is dug from Pitch Lake, which is leased to the company till 1930. The removal of 1,885,000 long tons of asphalt during the past 35 years has apparently made but little impression on the deposit. The New Trinidad Lake Asphalt Co. contributes the greater bulk of the exports, although some 30,000 tons are annually handled by smaller shippers from other properties. The lake contains no liquid asphalt, but in other parts of the island this variety, from which illuminating and lubricating oils can be distilled, is found widely distributed. Glance pitch, also is found on the island, and is used for electric insulations and for black varnishes. Manjak, another variety, has recently been discovered in quantity, about 10 miles north of the pitch lake.

EXPORTS OF LAND ASPHALT FROM TRINIDAD. (*a*) (IN TONS OF 2,240 LB.)

Year.	To United States.			To Europe.			To Other Countries.			Grand Total of Exports in Crude Equivalent.
	Crude.	Épuré.	Total Equivalent in Crude.	Crude.	Épuré.	Total Equivalent in Crude.	Crude.	Épuré.	Total Equivalent in Crude.	
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons	Tons.	Tons.
1898....	18,160	*Nil.*	18,160	700	258	1,087	404	812	872	20,119
1899....	25,618	345	26,130	275	280	695	....	100	150	26,975
1900....	34,796	(*b*)	34,796	251	(*b*)	251	197	(*b*)	197	35,244
1901....	31,767	11	31,767	1,704	(*b*)	1,704	1,446	(*b*)	1.446	34,917
1902....	25,008	100	25,158	200	....	200	15	50	90	25,448

EXPORTS OF PITCH-LAKE ASPHALT FROM TRINIDAD. (*a*) (IN TONS OF 2,240 LB.)

Year.	To United States.			To Europe.			To Other Countries.			Grand Total of Exports in Crude Equivalent.
	Crude.	Dried.	Total Equivalent in Crude.	Crude.	Épuré and Dried.	Total Equivalent in Crude.	Crude.	Épuré and Dried.	Total Equivalent in Crude.	
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1898....	46,089	1,692	48,424	15,708	13,228	35,537	698	1,646	2,999	86,960
1899....	70,111	480	70,777	21,337	13,749	41,956	....	1,699	2,359	115,092
1900....	67,758	3,180	70,938	23,886	16,114	47,352	1,422	2,420	4,453	122,743
1901....	80,449	*Nil.*	80,449	31,218	15,815	54,761	....	586	844	136,054
1902....	101,876	2,211	104,956	17,711	10,509	33,474	....	536	746	139,176

(*a*) The exports prior to 1898 will be found in THE MINERAL INDUSTRY, Vol. VIII. (*b*) Included in the shipments of crude.

At the Island of Barbados, nine manjak mines were operated during 1902, three of which were controlled by the Barbados Manjak Mines, Ltd., employing from 70 to 100 laborers. No statistics of production are made to the Government, but the custom returns showed that during 1901, 1,044 tons of manjak, valued at £9,394, were exported from Barbados. The chief uses for manjak ore, or glance pitch, as it is sometimes called, is to make Brunswick varnish, used to insulate electric cables, etc. The exports from Barbados in long tons during recent years are reported as follows: 1897, 1,880; 1898, 1,160; 1899, 1,026; 1900, 1,120; 1901, 1,043.

Turkey.—The asphalt resources of Turkey have been described by J. E. Spurr in *The Engineering and Mining Journal,* Oct. 4, 1902. There are a number of asphalt deposits, of which the best known are in Albana, near the Adriatic Sea, and in Palestine. Selinitza is the chief producing locality in Albania, where the deposits are operated by the Imperial Ottoman Bank. The asphalt, which is not of superior quality, brings $13 per ton in Trieste. The deposits in the region of the Dead Sea (Lake Asphaltsi) have long been noted, and bituminous springs at Nebi Musa contain from 30 to 40% asphaltum. The so-called Assyrian asphalt is mined near Hasbaya, in the Province of Damas, by the Civil List of the Sultan. The mineral is of great purity and is used chiefly in the manufacture of varnishes and aniline dyes. It is marketed chiefly at Trieste, where it is quoted at $84 per ton, boxed and delivered. The demand, however, is limited, so that the yearly output is only a few hundred tons. An Anglo-German company, with headquarters at Constantinople, has been formed to work other deposits in Palestine, but so far, it has not obtained the concession. An effort is being made to exploit the bituminous schists near Beyrouth, and a large lot has been sent to England for trial. Bituminous springs occur opposite the town of Nasarieh, Province of Busreh, 100 miles from the site of Babylon. Although near a navigable river, the asphalt is exploited only to a minor extent by the natives, who use it as a building cement and as a substitute for ceiling wax.

Venezuela.—The exports of Bermudez asphalt from Venezuela to the United States during 1902, were 7,677 long tons crude, and 422 long tons dried, a total of 8,099 long tons, as compared with 21,767 long tons in 1901. The large decrease during the past year was due to the litigation in which the Bermudez Co. was engaged.

OZOKERITE.

The ozokerite deposits at Boryslaw in Galicia, Austria, still continue to supply practically the entire output of the world. The methods of mining and refining the crude material and the uses of the refined product have been fully described in former volumes of THE MINERAL INDUSTRY. Early in 1903, J. Muck published a complete description of the occurrence and refining of ozokerite at Boryslaw, in Galicia, Austria, in a book entitled "Der Erdwachsbergbau in Boryslaw" (Julius Springer, Berlin, 1903).

In the United States during 1902, the Summit Placer Mining Co. and the Utah & Wasatch Co. produced 20 short tons of ozokerite from the deposits at Soldier Summit, Utah. The property, consisting of 16 lode claims, is covered by six 160-acre placer claims. The crude ozokerite is melted and cast into 10-lb. cakes and shipped in sacks, each containing 10 cakes. In 1903, the deposits at Soldier Summit, at Colton (seven miles east of Soldier Summit), and at Midway (four miles west of Soldier Summit) will be operated.

In 1901, the exports of crude ozokerite from Austria amounted to 2,717 metric tons ($554,400) as compared with 5,109 tons ($1,047,085) in 1900, while the exports of the refined product (ceresin) in 1901 were 771 metric tons ($205,200) as compared with 906 metric tons ($234,546) in 1900. Of the quantity exported in 1901 the shipments to Germany amounted to 7·3 metric tons and those to the United States to 24·7 metric tons. The output of ozokerite in Galicia in 1902 was 3,275 metric tons, of which Boryslaw produced 2,565 tons, Dzwiniacz-Starunia 650 tons and Truskawiec 60 tons. There were 8 mines in operation in 1902, as follows: Galizische Kreditbank and Aktiengesellschaft "Boryslaw," in Dzwiniacz; Aktiengesellschaft "Boryslaw," Lautmann; Lucki & Co.; Wolfarth in Starunia; Compes & Co. and Ochrymowicz & Co., in Truskawiec. The average price for the year per metric ton was 1,100 crowns ($220).

PETROLEUM AND MALTHA PRODUCTS USED IN THE PAVING INDUSTRY.

BY A. W. DOW.

THERE is practically nothing known of the chemistry of the petroleum and maltha products, and there are no reliable chemical tests for estimating their value for paving purposes. The greatest demand for such materials is in the bituminous paving industry, where they are largely employed to soften or "flux" hard asphalt for paving cements. They are used also as paving cements without the addition of any of the hard natural asphalt, and in small quantities to grout brick and stone pavements.

Bituminous or asphalt pavements are of two classes, *i.e.,* sheet asphalt, which is laid with a continuous surface; and asphalt block, consisting of paving material pressed into blocks and laid in this form. The same process is used in the manufacture of the paving material in both classes of pavement. The asphalt, if too hard, is softened to the desired consistency by the addition of a suitable flux, this fluxed asphalt being known as asphalt paving cement. The asphalt paving cement, in a molten state is mixed with the heated mineral ingredients, and the asphalt mixture is either hauled to the street and laid as sheet asphalt pavement or compressed into blocks for the block asphalt pavement. In both classes of pavements the asphalt cement should show only slight changes in physical properties as a result of evaporation or oxidation at the temperatures employed in the manufacture of the pavement. For sheet asphalt laid in one continuous expanse, it is essential that the asphalt cement should be ductile at low temperatures to allow for the contraction of the pavement. It is also necessary that the asphalt cement be but slightly susceptible to changes in temperature, so that the pavement will not soften too much in the summer or become so hard in the winter as to lose its ductility and permit the pavement to crack or grind away. In asphalt block pavements the requirements as to ductility are not so rigid, as the pavement is laid in small blocks, thus reducing to a minimum the danger of cracking from contraction. It is important, however, that the paving cement should not be brittle at low temperatures, for then the blocks wear very rapidly in cold weather by chipping of the edges; while, on the other hand, the blocks must not be so soft as to lose their shape in hot weather. In other words especial care must be exercised that the asphalt cement be as little susceptible to changes in temperature as is possible. In selecting the cements used in the two classes of pavements, it is evident that the cement for sheet asphalt must be ductile at all temperatures, and to attain this quality the susceptibility to changes in temperature may be sacrificed to some extent. In the case of asphalt block cement, however, the effects of variations in temperature must be reduced even at the expense of ductility. There is no cement known that shows both ductility and non-susceptibility to changes in temperature; and for successful work it is necessary that the properties of the cement should accord with the purpose for which it is to be used.

The flux that has been most extensively used for asphalt (undoubtedly owing to the cheapness in price) is ordinary residuum from the distilling of Eastern or paraffine petroleum oils. These residuums do not completely dissolve asphalts, and they produce cements inferior to those resulting from the use of heavy oils containing fewer of the paraffine hydrocarbons, such as the residuums from oils, chiefly from the Beaumont field, Texas, and the asphaltic oils or malthas. They are not sufficiently objectionable, however, to prohibit their use with soft asphalts, which require comparatively little flux to produce a cement of proper consistency.

The residuum of paraffine petroleums vary in character according to the quality of the crude oil from which they are derived and the process used in refining. It is generally considered that the best residuums are obtained when low temperatures and steam are used in the refining, that is, when there is a minimum amount of cracking of the oil in the distillation. The better grades of these residuums are fluid at ordinary temperatures, they have a specific gravity ranging from 0·946 to 0·921, or from 18° to 22° Baumé, a flashing point above 400°F., they are not homogeneous liquids and contain considerable paraffine.

The residuums from Texas petroleum have been used but little as fluxes before 1902, most of them are produced from the Beaumont oils. Their general characteristics are: Fluidity at ordinary temperatures, sp. gr. from 0·972 to 0·9589, or 14° to 16° Baumé, and flashing point about 50° lower than that of the paraffine residuums. They contain traces only of paraffine scale, and produce paving cements that are superior to the paraffine residuum cement in ductility and cementing properties, but they are slightly more susceptible to changes in temperature.

The malthas or asphaltic oils from California have been used almost exclusively in the past for fluxing hard asphalts that were only slightly soluble in paraffine residuums; but during the past year they have been supplanted to a large extent by the residuums from Texas oils, due to the cheapness of the latter. The asphaltic oils are very viscous fluids at ordinary temperatures, with a specific gravity ranging from 1 to 0·986 or from 10° to 12° Baumé, and a flashing point somewhat lower than that of the average Texas residuum. They contain no paraffine scales and are homogeneous liquids. Asphalt cements made with these fluxes are more ductile and cementitious but more susceptible to changes in temperature than cement made with the former two oils.

In the early days of the asphalt industry, wax tailings or still-wax was employed in rare cases as a flux for asphalts, but owing to its variable character its use has not expanded. Petroleum refiners state that they are never certain as to the quality of the still-wax to be produced from the run of the still, and no two runs are ever identical even when the same oil is used apparently under the same conditions.

The first solid product from oil for use in the paving industry was produced by refining California maltha by distillation until the residue had the consistency of asphalt paving cement. These asphalt cements were produced about 1890, but they were not extensively used until 1895. When these cements are obtained by ordinary process of distillation, they are characterized by great ductility and cementitiousness, but are very brittle and very susceptible to changes in temperature and in some cases they harden too rapidly by ageing.

In 1892 a patent[1] was obtained for an artificial asphalt, produced by treating petroleum residuum with sulphur at a temperature of about 400°F. The action of sulphur on the oil appears to promote the removal of hydrogen from some of the heavier products of the residuum, forming hydrogen sulphide. This artificial asphalt known to the trade as "Pittsburg flux" is a rubber-like substance even at low temperature; it lacks ductility, and is but little affected by changes in temperature. The inventor, doubtless, intended to use this material in pavements as a substitute for asphalt, but the cementing powers were so low that it has never reached beyond the experiment stage. The material was used to a limited extent, together with residuum, as a flux for asphalt in sheet asphalt pavements, and although the asphalt cements showed less susceptibility to changes in temperature, the improvement was counterbalanced by a decrease in ductility, and for this reason its use for the purpose was abandoned. However, as a flux in the manufacture of asphalt blocks, where the danger from lack of ductility is reduced to a minimum, it has proved superior to the ordinary petroleum residuum.

The same artificial process was applied in 1895 to the asphaltic oils of California; the product obtained possessed greater cementing powers and more ductility than that produced from the paraffine oils. This artificial asphalt was manufactured and used with some success in paving for several years until the patent was bought by the Asphalt Trust.

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[1] United States Patent No. 468,867, Feb. 16, 1892.

The action of sulphur on paraffine oils differs from that on the asphaltic oils. With the former, the addition of sulphur beyond a certain limit has no influence, the sulphur remaining inert. In the case of asphaltic oil the action of the sulphur continues until the material is changed to a coke. In 1894 a patent[2] was granted on a product known commercially as "Byerlite," which is obtained by blowing air into petroleum residuum heated to a high temperature. The reaction is similar to that produced by sulphur, *i.e.*, hydrogen is removed from the oils with the formation of water. The reaction between the air and the oils is not limited, however, as in the case of sulphur. The products obtained from residuum of paraffine petroleums are quite similar to those obtained by treating these oils with sulphur.

This oxidation process has recently been applied to the Beaumont residuum oil and produces a material resembling that from the paraffine residuum except that it is slightly more brittle and more ductile. Products made by the oxidation of paraffine residuum and Texas residuum are now being used by the asphalt block manufacturers as fluxes for asphalt, and they produce a cement which is far superior for this purpose than those formerly made with residuum oil. This process of oxidation is now being applied to the refining of California malthas and the material produced is itself an excellent paving cement for sheet asphalt pavement. A patent[3] has lately been granted to me on a process of treating maltha that is similar to the two processes above mentioned. Instead of removing the hydrogen atoms by the use of sulphur or oxygen, I subject the oil to a long, continuous heating at a high temperature which produces a more or less severe cracking, and causes the oil to break up into light hydrocarbons, proportionally richer in hydrogen atoms than the original oil, and which volatilize when considerably dehydrogenated.

The following tables give the tests that illustrate the different physical properties of asphalt cements, the first as made from the same maltha, but by the different processes mentioned, and the second table as made by fluxing the same asphalt with different fluxes:—

Asphalt Cement from Maltha.	Susceptibility to Change in Temperature Consistency by Penetration at				Ductility at 77° F.
	32° F.	77° F.	100° F.	115° F.	
Ordinary distillation	7·5	46	149	340	70
Distilled with air	15	47	109	215	25
Distilled with sulphur	16	46	101	190	20
Cracking process	14	45	104	209	22
Excessive air treatment	30	48	70	106	6
Excessive sulphur treatment	27	44	65	100	4

Kind of Cement.	Consistency by Penetration at 115° F.	Brittleness by Impact at 32° F.	Ductility at 77° F.
Asphalt and residuum	78	10	10
Asphalt and Byerlite	60	35	4
Asphalt and Pittsburg flux	56	88	4

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[2] United States Patent No. 524,130, Aug. 7, 1894; Nos. 635,429, 635,430, Oct. 24, 1899; and Nos. 694,621, 694,622, March 4, 1902.

[3] United States Patent No. 688,073, Dec 18, 1901.

BARYTES.

By Joseph Struthers and Henry Fisher.

The production of barytes in the United States[1] during 1902 amounted to 58,149 short tons valued at $186,713, as compared with 49,070 short tons valued at $157,844, in 1901, showing an increase of 9,079 short tons. The supply was obtained from Virginia, North Carolina, Tennessee, Missouri, and in the order of their production.

The following tables give the production, imports and consumption of barytes in the United States from 1898 to 1902 and the world's output for the years 1898 to 1902, inclusive.

PRODUCTION, IMPORTS, AND CONSUMPTION OF BARYTES IN THE UNITED STATES.

(In tons of 2,000 lb.)

Year.	Production.			Imports.			Consumption.	
	Quantity.	Value Per Ton.	Value.	Quantity.	Value Per Ton.	Value.	Quantity.	Value.
1898..........	28,247	$4·00	$112,988	1,914	$5·93	$11,856	30,161	$124,844
1899..........	32,636	4·20	137,071	4,312	6·59	28,407	36,948	165,478
1900..........	41,466	3·90	161,717	5,625	5·77	32,461	47,091	194.178
1901..........	49,070	3·22	157,844	5,604	7·04	39,442	54,674	197,286
1902..........	58,149	3·21	186,713	7,836	6·59	51,711	65,985	238,424

PRODUCTION OF BARYTES IN THE PRINCIPAL COUNTRIES. (*a*) (IN METRIC TONS.)

Year.	Belgium.	Canada.	France.	Germany.				United Kingdom.	United States.
				Baden.	Bavaria.	Prussia. (*b*)	Saxony.		
1898....	21,700	971	2,763	1,100	4,339	48,082	478	21,514	28,247
1899....	25,900	653	4,058	2,430	6,214	52,920	216	25,059	29,607
1900....	38,800	1,207	3,635	2,970	10,515	60,099	516	29,987	37,618
1901....	22,800	592	4.145	3,991	8,711	75,534	410	28,054	44,516
1902....	(*c*)	909	(*c*)	(*c*)	8,034	(*c*)	(*c*)	23,986	52,661

(*a*) From official reports of the respective countries, except the statistics for the United States. (*b*) Output of the mining districts of Clausthal and Bonn. (*c*) Statistics not yet available.

Missouri.—Barytes is found with galena occurring in pockets within a few feet of the surface of thick beds of residual clay overlying limestone in Washington and Crawford counties. The mineral is graded according to quality; the pure white variety constituting the first class; the second and third classes consisting of barytes stained with iron oxides. The inferior grades can be bleached by

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[1] Through the courtesy of the U. S. Geological Survey.

digesting the finely pulverized material with sulphuric acid which dissolves the iron oxide, 66·67 lb. of 60°B. acid being required for each percent of iron per ton.

North Carolina.—Barytes, according to J. H. Pratt[2] is mined in Madison and Gaston counties, in the former near Marshall, Stackhouse, Sandy Bottom and Hot Springs, and in the latter near Bessemer City, Kings, Crowder's and Anderson mountains. Small seams and elongated pockets of pure barytes from 3 to 10 ft. wide, are found in Madison County, and in Gaston County veins of the mineral occur between walls of micaceous, argillaceous schist, the width varying from 2·5 to 6 ft. In 1901, the output of these two counties amounted to 7,390 tons valued at $22,615. The Carolina Mineral Co. cleans and grinds the mineral at its mill at Marshall, but the other companies sell their crude output to the manufacturers.

Tennessee.—According to R. A. Shiflett, there were produced in 1902, 3,255 short tons of barytes valued at $14,647. Only one mine was operated during the year, employing 26 men at average wages of $1 per day. There are mines at Cleveland, Sweetwater and Madisonville; also at Sinking Springs, in Sevier County.

Virginia.—The Tri-State Mining & Manufacturing Co., operating mines in Tazewell and Russell counties, is producing daily at its plant in Richlands 30 tons of finished barytes, which analyzes 95% pure, and is sold for $18 per ton. The doubling of the present capacity of the plant is being considered. A vein of barytes has been uncovered showing a 30-ft. breast, but its depth has not yet been ascertained. A tram road 11 miles long is to be built to transport the ore from the mines to Swords Creek, where it is loaded on the Norfolk & Western Railroad, and shipped to the mill.

Market.—Consumption in 1902 was good and prices ruled steady. New York quotations were: Crude, No. 1 domestic, $9 per short ton; No. 2, $8; No. 3, $7·75; for wholesale quantities. German barytes, gray in color, was $14·50 per ton, and white, $17. Blanc fixe (artificial barium sulphate) was 2c. per pound.

Canada.—During 1902, Canada produced 909 metric tons of barytes, valued at $3,957, as compared with 592 metric tons, valued at $3,842 in 1901. Nova Scotia produced 545 metric tons, Quebec 484 metric tons, valued at $3,055, of which 353 tons, valued at $2,471 were exported, and Newfoundland produced 315 tons, valued at $630, the total output being exported to the United States.

TECHNOLOGY.

Barium Chloride.—Three methods are used to make barium chloride: (1) By the smelting process from barytes; (2) from barium carbonate with hydrochloric acid; (3) from barium sulphide with hydrochloric acid. In the first method, a mixture of 300 parts of ground barytes, 176 parts of calcium chloride and from 115 to 120 parts of coal are heated in a reverberatory furnace, the mass being rabbled from time to time, which yields barium chloride according to the following reactions: $BaSO_4+4C=BaS+4CO$, and $BaS+CaCl_2=BaCl_2+CaS$. The operation requires from 2·5 to 3 hours. The molten mass which has a black-

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[2] "The Mining Industry in North Carolina in 1901," North Carolina Geological Survey, Paper No. 6.

ish gray color is subsequently allowed to cool in iron boxes, and dissolved in water, from which barium chloride is crystallized. In the second method hydrochloric acid is added to witherite, and the barium chloride is crystallized from the solution. In the third method, the finely ground barytes is mixed with coal, and roasted in a reverberatory furnace at a high temperature, the mass being rabbled from time to time. The resultant barium sulphide is cooled in iron boxes out of contact with the air and moisture, and the cooled mass is lixiviated in iron tanks placed in terraces, the water running from the highest tank to the ones set at lower levels, until the solution is of the right strength. Hydrochloric acid is then added to the yellow solution of barium sulphide, and barium chloride and hydrogen sulphide gas are formed. The barium chloride is then crystallized from the solution.

Barium Oxide.—The United Barium Co., of Niagara Falls, N. Y., is operating two furnaces of the direct heating arc type, and is producing about 12 tons of barium hydrate per day. A third furnace is held in reserve. Each furnace uses 400 H.P. and requires 2,500 amperes at 120 volts, the efficiency being about 74%. One ton of barium sulphate treated, evolves SO_3 sufficient to make 0·5 ton of 50% H_2SO_4. The barytes used was first obtained from Missouri at a cost of $6 per ton at Niagara Falls, and was about 90% pure. The company now owns a large barytes deposit on the north shore of Lake Superior near Silver Island, estimated to contain 250,000 tons. Barium hydrate is used for making white paint, blanc fixe, for the recovery of sugar remaining uncrystallized in molasses, and for softening boiler water. The barium sulphide and sulphydrate in the mother liquor is used in removing hair from hides, in making lithophone and barium carbonate, the latter being used in the manufacture of cyanides and bricks. When mixed in small proportions with clay it is said that it prevents red bricks from turning white, and white bricks from turning green.

C. B. Jacobs[2] purifies barium hydrate crystals by a process which consists in fusing the crystals in their own water of crystallization, and then treating with superheated steam.

Lithophone.—The German manufacturers of this pigment have combined to regulate the scale of prices, 23 marks per 100 kg. being asked for 30% ZnS and 16 marks for 16% ZnS, the price varying with the zinc sulphide content. The best lithophone is white, while the inferior grades are grayish or yellowish due to the presence of carbon and iron oxide. The United States continues to import lithophone, although it is made in this country by several companies, chiefly the Grasselli Chemical Co. and the New Jersey Zinc Co. Lithophone is used in enameling oilcloth and iron. It becomes dark on exposure to sunlight, but regains its whiteness when removed from the light. To analyze lithophone, according to P. Drawe[3] from 1 to 1·5 g. is treated with 10 c.c. HCl (sp. gr. 1·9) and a little $KClO_3$, and evaporated to one-half its volume on a water bath. The solution is diluted, H_2SO_4 added, and the insoluble matter filtered off. The filtrate is neutralized with Na_2CO_3, the zinc precipitated, washed, ignited, and

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[3] United States Patent No. 720,927, Feb. 17, 1903.

[4] *Zeitschrift fuer angewandte Chemie*, XV., 1902, 8, 174, and *Journal of the Society of Chemical Industry*, March 31, 1902, 427.

weighed as ZnO, from which the total Zn in the lithophone may be calculated. A second portion of 1 g. is digested for half an hour with 1% $HC_2H_3O_2$, the insoluble matter filtered off and treated as stated above. The result gives ZnO, in quantity corresponding to ZnS of the original, the ZnO being soluble in dilute $HC_2H_3O_2$ is determined by difference. The CO_2 and SO_3 in the pigment are determined by the usual methods, and calculated to the corresponding zinc compounds. The insoluble residue is $BaSO_4$. W. J. Armbruster[4] makes lithophone by mixing solutions of zinc sulphate, an alkali metal carbonate and barium sulphide, and recovering the resulting precipitates. Another process[5] consists of adding the hydrate of an alkali metal to a soluble salt of zinc, then adding a salt of barium, and recovering the resulting precipitates.

W. G. Waring[6] makes a white pigment consisting of barium sulphate and zinc oxide, by precipitating a mixed solution of zinc sulphate and chloride with an emulsion composed of magnesium oxide suspended in a solution of barium chloride.

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[5] United States Patent No. 719,415, Feb. 3, 1903.

[6] United States Patent No. 724,285, March 31, 1903.

[7] United States Patent No. 718,555, Jan. 13, 1903.

BISMUTH.

BY JOSEPH STRUTHERS.

COLORADO continues to supply the output of bismuth ores in the United States, which amounted to 37·5 short tons in 1902, as compared with the marketed output of 318·6 tons in 1901. The entire production during 1902 was obtained from the Ballard mine, but was not sold during that year. The output during 1901 was purchased by the Leadville Sampler, at Leadville, and the State Ore Sampling works at Denver, or was shipped direct to Johnson, Matthey & Co., Ltd., England.

The production and price of bismuth and its ores continue under the control of Johnson, Matthey & Co., Ltd., and the Government of Saxony—a combination of interests formed in order to maintain for the products a price at which the mines could be operated with profit. The supply of metallic bismuth far exceeds the demand, and unless the output be restricted the price would fall to a point which would render the manufacture of the metal no longer profitable. The schedule of prices of ore is based on the market price of the metal. The latest published figures for Colorado, with metal at $1·25 per pound, were: 10% ore, $150 per ton; 15% ore, $250 per ton; 20% ore, $350 per ton; 30% ore, $550 per ton; 40% ore, $750 per ton; 50% ore, $1,000 per ton. The price in the United States for the bismuth content of the ore varies from $8 to $11 per unit, the producers being paid also for the gold and silver contents. No price was quoted for the output during 1902, but as near as can be ascertained the value of the output in 1901 was $80 per ton, not including charges for transportation or treatment. The wholesale price for metallic bismuth throughout 1902, f. o. b. works, was $1·50 per lb.

Bismuth occurs both free and combined in many of the Western States. In Colorado it has been found as metallic bismuth, bismuth carbonate, bismuth telluride, and bismuth tellurate. A recent discovery of bismuth carbonate ore is reported in Arizona, on Salt River, near its junction with the Verde River, between Fort McDowell and Superstition Mountain, and excellent specimens of bismuth tellurate (the mineral montanite, $Bi_2O_8.TeO_3.2H_2O$) have been obtained from Salida, Chaffee County, Colo. Bismuth ore varies greatly in composition. That produced during 1901 assayed from 4 to 12% of bismuth, from 1 to 2 oz. of gold, and from 5 to 6 oz. of silver per ton. That produced in 1902 contained from 7·8 to 27·1% of bismuth, from 3·5 to 22·6 oz. of gold, and from 3·45 to 3·5 oz. of silver per ton.

Bismuth is usually found in ores containing other metals which render its extraction somewhat complex. The trade and the price being under control and the domestic demand being comparatively small, the erection of new works to manufacture and refine this metal in the United States is hardly attractive from a commercial point of view.

Imports.—The imports of metallic bismuth into the United States in 1902 were 190,837 lb., valued at $213,704, as compared with 165,182 lb., valued at $239,061, in 1901. There was imported also a small quantity of bismuth salts in pharmaceutical compounds.

Australia.—The output of bismuth and bismuth ore in New South Wales during 1902 amounted in value to £3,100, as compared with 21 long tons, valued at £6,665 in 1901, and 10 tons, valued at £5,640 in 1900. Early in 1902 the price of ore containing at least 20% metallic bismuth was at the rate of 2s. per lb. of bismuth content. A 5% ore is salable, but it is doubtful if it would be profitable. The demand being small, the market is restricted. In Queensland the production of bismuth ore, during 1902 had decreased to 1 long ton, valued at £123, as compared with 20 long tons, valued at £3,684 in 1901. An analysis of a sample of ore from the mine of the Mt. Black Proprietary Mining Co., in Tasmania, is reported as Bi 7·44%, Cu 0·8% and 0·95 oz. gold and 0·48 oz. silver per ton. The minerals of the deposit are quartz, tourmaline, fluorite, pyrite, chalcopyrite, wolframite and bismuthinite.

Review of Analytical Chemistry.—The determination of bismuth as molybdate, according to H. J. Riederer,[1] is as follows: The ore is decomposed with HNO_3 and evaporated to fumes with H_2SO_4, diluted, the residue filtered off and treated again with HNO_3, diluted and filtered. The filtrates are combined, and the bismuth is precipitated with H_2S, filtered and washed. The bismuth sulphide is dissolved in HNO_3, the solution is exactly neutralized with NH_4OH, using methyl orange as an indicator, and then made acid again with one or two drops of 30% HNO_3. A large excess of ammonium molybdate is added and the solution is heated gently until the precipitate collects. It is then filtered and washed with a 3% $(NH_4)_2SO_4$ solution. The precipitate is dissolved in H_2SO_4, passed through a column of zinc (Jones reductor) with suction, and titrated with potassium permanganate. If copper is present with the bismuth it may be separated by adding to the acid solution of the ore, 30 c.c. of a saturated solution of $H_2C_4H_4O_6$, and making the solution alkaline with KOH. The precipitated bismuth hydroxide is dissolved in a slight excess of KCN, and the solution is saturated with H_2S. Bismuth sulphide only is precipitated, which is then treated as outlined above.

Leaching Process for Bismuth Ore.—According to F. G. Eulert, of La Paz, Bolivia,[2] a row of wooden vats with filter bottoms are arranged in steps. About 1,000 kg. of finely ground ore is charged in each vat, and a solution of common salt, saltpeter and sulphuric acid is introduced into the first of the series. The liquor flows through each vat in succession, finally yielding a concentrated solution of bismuth which flows into a vat wherein it is diluted with water; the precipitated bismuth oxychloride is removed, dried and smelted for the metal.

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[1] Dissertation. "The Volumetric Determination of Bismuth and Its Separation from Copper," Columbia University. 1902.

[2] German Patent No. 130,968.

BORAX.

By Joseph Struthers.

The production of borax in the United States continues to be supplied chiefly from the colemanite deposits of California, although the marsh deposits of California and Nevada contributed a small portion of the total output of 1902. The reported returns of production of refined borax and boric acid during 1902 amounted to 17,202 short tons, valued at $2,434,994, of which 862 short tons, valued at $155,000, were boric acid.

IMPORTS OF BORATES, ETC., INTO THE UNITED STATES.

	1901.			1902.		
	Metric Tons.	Pounds.	Value.	Metric Tons.	Pounds.	Value.
Borax	247·29	545,045	$20,643	310·50	684,537	$30,795
Borates of lime or soda (crude sodium borate and refined sodium borate)	47·05	103.700	9,411	84·73	186,807	12,007
Boric acid	328·95	725,005	26,629	373·27	822,907	30,482

California.—The colemanite mines at Borate, 12 miles N. E. of Daggett, which are operated by the Pacific Coast Borax Co., continue to yield a sufficient quantity of ore to satisfy the market requirements. In the mining of this material the increasing depth has added to the cost of extraction. The ore at Borate occurs in large masses more or less connected by stringers and bands, consisting of colemanite in bedded deposits of from 5 to 30 ft. in thickness. The refined product reaches the market in the form of sodium bi borate (borax) ($Na_2B_4O_7$, $10H_2O$) and boric acid (old name, boracic acid, H_3BO_3). Other bedded deposits have been found in a number of places in Death Valley, and about Owens Lake, but they have not yet been exploited sufficiently to determine their limits. During 1902 the Pacific Coast Borax Co. has continued the search for colemanite deposits in the Death Valley region, and has acquired much additional property. The deposits in the Armagosa Valley are under careful examination, the ore therefrom being carried by traction engines to the railroad at Manvel, a distance of 100 miles, from whence it is shipped to the refinery in order to determine its value. The extent of the deposits on this property will soon be determined.

The large refining plant at Bayonne, N. J., which was destroyed by fire in April, 1902, has been entirely rebuilt. The Pacific Coast Borax Co. continues to supply by far the greater part of the borax output of the United States as well as a large proportion of the boric acid production, and the control of the domestic market of borax is practically in its hands.

The American Borax Co., which is under the control of the Standard Sanitary Co., of Pittsburg, Pa., has greatly extended its plant at Daggett, and now has installed ten 20,000-gal. digesters in which the crude material from the mud deposits in that vicinity is treated by sulphurous acid. The new plant has largely increased the output of boric acid and boric acid concentrates by this company, and owing to the satisfactory results obtained, it is contemplated to extend the works still further during the coming winter season. A new refinery is being erected near Pittsburg, Pa., for the final treatment of the products from Daggett.

The Stauffer Chemical Co., of San Francisco, is actively developing the colemanite mines in Ventura County, which yield at present from 75 to 100 tons of very high grade ore per month. This ore is used solely for the manufacture of refined boric acid at the company's works in San Francisco.

There has been a small output from the marshes in California and Nevada, but the quantity is comparatively so insignificant that it has not affected the market.

The saline deposits of California have been fully described by M. R. Campbell in *Bulletin* No. 200, of the United States Geological Survey (1902), and by Gilbert E. Bailey in *Bulletin* No. 24 of the California State Mining Bureau (1902).

Oregon.—In recent years the marsh deposits of sodium borate in Harney County have contributed yearly an output of refined borax amounting to about 400 tons. For 1902, however, no production was reported, the operations at the deposits having been confined solely to development work. The principal concern in this region is the Rose Valley Borax Co., which controls 2,000 acres of the richest portion of the marsh deposit near Lake Alvord, which extends over a total area of 10,000 acres. The description of this deposit and the method of obtaining the ore is given in the section on "Borax" contained in THE MINERAL INDUSTRY, Vol. X.

Market.—The price of borax fluctuated but little during 1902, averaging from 7@7·25c. for refined borax and from 6·75@7c. for concentrated borax. The latter grade is gradually disappearing from the market owing to its non-uniform quality. The refined article is now being marketed under guarantee.

THE WORLD'S PRODUCTION OF BORATES, ETC. (*a*) (IN METRIC TONS.)

Year.	United States. Calcium Borate	Chile. Calcium Borate. (*b*)	India. Borax. (*b*)	Germany. Boracite.	Italy. Boric Acid, Crude.	Peru. Calcium Borate. (*b*)	Turkey. Pandermite (*b*) (*c*)
1897	17,600	3,168	280	198	2,704	11,850	11,375
1898	18,911	7,084	184	230	2,650	7,178	(*e*,*f*)
1899	21,834	14,951	250	188	2,674	7,638	(*e*,*f*)
1900	23,456	13,177	224	282	2,491	7,080	(*e*,*f*)
1901	16,227	11,547	162	184	2,558	(*e*)	(*e*)

(*a*) From official reports of the respective countries except the United States. (*b*) Exports. (*c*) Fiscal years. The manufacture of boric acid was begun in the United States in 1896, in which year there was a production of 621,000 lb. There are no statistics for subsequent years. (*e*) Not reported. (*f*) Total exports, 1897 to 1901 inclusive, were 43,851 tons.

The Borax Consolidated, Ltd., (the international borax combination) has issued £400,000 of 5%, second mortgage debenture stock, the company now being capitalized at £2,800,000. For the fiscal year ending Sept. 30, 1902, gross profits are reported of £250,209, as compared with £258,021 for the year preceding. From the gross profits for 1902 the following disbursements were made: Interest £47,625, dividends on common and preferred shares £52,000, (the total dividends thus amounting to £99,625), income tax £3,201, which gave a balance of £147,383. Adding to this balance £15,795 brought forward from the previous year and subtracting £17,825 for depreciation on reserve and sinking fund leaves a surplus of £142,353, out of which it is proposed to pay a dividend of £1 per share, less income tax, on the ordinary shares, making a total dividend payment of 17·5% for the year. The net profits for 1902 amounted to £181,658 as compared with £190,278 in 1901. The working of the mines, deposits and factories have been satisfactory and by effecting economies in the cost of production, the lower prices obtained for some of the products have been counterbalanced.

Argentina.—Calcium borate deposits varying in thickness from a few inches to several feet, are found in the "National Territory of the Andes," (now a part of Argentina), the principal districts being Caurchari, Antuco, Partos Grandes, Hombre Muerto, Ratones and Diabillos. The altitude of these districts ranges from 18,000 to 18,500 ft., and the transport of the mineral is accomplished by mule-back over precipitous trails to the railroad at Salta, a distance of from 150 to 200 miles. A load of 300 lb. is carried by each mule, and the time occupied in transport amounts to 7 or 8 days. Under the present conditions of labor, the cost per ton, including mining and transportation, f. o. b. ship at the coast is about £7 6s. 5d. Adding to this amount the ocean freight of £1, and insurance, etc., 1s. 6d., makes the total cost per ton delivered in England £8 7s. 11d.

Bolivia.—The production of calcium borate in Bolivia during 1901 amounted to 3,065 metric tons, valued at $410,524 (Bolivian currency), as compared with 1,485 metric tons, valued at $148,510 in 1900.

Chile.—The borate deposit of Ascotan in the interior of the Province of Antofagasta produces the greater part of the total output of boracite and borax. Of the production during 1900, which amounted to 13,177 metric tons of calcined boracite and 27 metric tons of borax, Ascotan contributed 10,920 metric tons the balance being obtained from the deposits in the Province of Carcota. The exports of calcium borate during 1901 amounted to 11,455 metric tons ($1,302,410 Chilean currency), as compared with 13,177 metric tons ($1,317,676).

Italy.—The production of boric acid in Italy during 1901 amounted to 2,558 metric tons, valued at $194,408, as compared with 2,491 metric tons, valued at $169,425 in 1900. The entire production is obtained from the natural steam fumaroles in the provinces of Pisa and Grosetto.

Peru.—Though borates occur in many localities in Peru, the only deposit which is operated with profit is at Salinas near the boundary of the provinces of Arequipa and Moquegua. In 1900 the exports of borates amounted to 7,080 metric tons, valued at £56,638.

Turkey.—The boracite deposits in Turkey were discovered in 1856, but were not operated until recent years. The mines of Sultan-Tchaïr are situated within the Sandjak of Karassi and in the Merkez-caza of Balikesser and Nahie of Ivet, and all are now under control of the Borax Consolidated Co., Ltd. The total quantity of mineral exported from 1897 to 1901 inclusive, amounted to 43,851 tons, valued at £789,318. The quantity reported to have been produced from March 1, 1899, to March 1, 1902, is 28,420 tons, making an average yearly output of 9,473 tons for this period. The mineral is exported from Panderma.

BROMINE.

BY JOSEPH STRUTHERS.

THE production of bromine in the United States during 1902, including the quantity of bromine contained in potassium bromide, amounted to 513,913 lb., as compared with 552,043 lb. in 1901. The price per lb. during 1902 averaged 25c., as compared with 28c. in 1901. The production of bromine in the world continues to be controlled by the associated American producers and by the Leopoldshall-Stassfurt convention, the latter being operative for several years to come.

PRODUCTION OF BROMINE IN THE UNITED STATES.

Year.	Michigan.	Ohio.	Pennsylvania.	West Virginia.	Total.	Metric Tons.	Value.	
							Total.	Per Pound.
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.			
1898	(a) 141,232	106,860	119,998	118,888	486,978	221	$136,354	28c.
1899	(a) 138,272	82,868	111,150	101,218	433,003	196	125,571	29c.
1900	(a) 210,400	91,182	105,592	114,270	521,444	237	140,790	27c.
1901	(a) 217,995	125,467	101,595	106,986	(b) 552,043	250	154,572	28c.
1902	(a) 226,452	100,491	93,595	93,375	513,913	233	128,478	25c.

(a) Including the bromine equivalent of the product recovered as potassium bromide. (b) Of the total production, 348,913 pounds were in the liquid form.

Michigan.—The greater part of the bromine output of the United States continues to be supplied by Michigan. The brines of this State have been well described by Alfred C. Lane in the report on Lower Michigan Mineral Waters, U. S. Geological Survey, Water Supply and Irrigation Paper No. 31, 1899. So far as known the entire central basin of the lower peninsula of Michigan contains one vast brine deposit, which carries a larger percentage of bromine than any brines yet discovered. This deposit extends from the Indiana boundary line on the south, to Grayling on the north, and from the Saginaw Valley on the east to Lake Michigan on the west. The highest percentages of bromine are reported from the wells in Midland and Gratiot counties. The supply of brine seems to be unlimited, and wells in Midland County which have been pumped for more than twenty years show no signs of exhaustion. Since 1883 thirteen companies have been engaged in the bromine industry in Midland, and eight companies at different times have manufactured bromine at other localities in this basin. At present, however, the entire production of the State is made by two companies in Midland. The Saint Louis Chemical Co., at Saint Louis, Gratiot County, is now drilling its second well, and it will probably contribute to the production in the near future.

The producers of bromine in the United States are as follows: The Dow Chemical Co., Midland, Mich.; Myers Bros. Drug Co., St Louis, Mo. (works at Midland, Mich.); Independent Chemical Co., Saginaw, Mich.; Wayne Chemical Co., Saginaw, Mich.; John A. Beck & Co., Allegheny, Pa.; J. L. Dickinson & Co., Malden, W. V.; Hope Salt and Coal Co., Mason, W. Va.; Liverpool Salt and Coal Co., Hartford, W. Va.; Hartford City Salt Co., Hartford, W. Va.; Syracuse Coal & Salt Co., Syracuse, O.; Coal Ridge Salt Co., Pomeroy, O.; Buckeye Salt Co., Pomeroy, O.; Excelsior Salt Works, Pomeroy, O., and United Salt Co., Pomeroy, O. The last-mentioned concern has made no output since 1900.

The brines found at all of the above-named localities, except Midland, have practically the same composition. On the average 360 gal. of brine are required for one barrel (280 lb.) of salt, and 100 bbl. of salt yield 55 lb. of bromine, but at Pittsburg the yield is as high as 75 to 80 lb. per 100 bbl. The brines contain calcium and magnesium chlorides, iron, and traces of sodium and potassium sulphates. An analysis of water from the Coal Ridge Salt Co.'s wells, near Pomeroy, O., published in Vol. VI. of the Ohio Geological Survey reports, showed total solids amounting to 9·528%, with the following composition: $NaCl$, 79·273%; $CaCl_2$, 14·397%; $MgCl_2$, 6·097%; $MgBr_2$, 0·097%; NaI, 0·012%; SiO_2, 0·043%; Fe_2O_3 and Al_2O_3, 0·082%. The composition of the Pittsburg brine may be deduced from the above by adding 0·043% $MgBr_2$.

With the exception of the Dow Chemical Co., all of the companies use the same process of recovery. H_2SO_4 and $KClO_3$ are added to the brine in stone stills of from 400 to 800 gal. capacity, and the liquid is agitated by steam jets under about 40 lb. pressure. The Midland brine, which is nearly four times richer in bromine than the brines of Ohio and West Virginia, is treated by a special process, briefly outlined as follows: The unoxidized bromides contained in the brine are brought into contact first with air and subsequently with a mixture of air and free chlorine. All natural brines carrying bromine contain, apart from sodium chloride, in many cases, KCl, $CaCl_2$, $MgCl_2$ and $LiCl$ as well as $FeCO_3$; in other cases, H_2S and traces of iodides are present; furthermore, natural brine deposits frequently contain oil. The Dow process[1] is worked in the cold, and the oxidation of impurities is accomplished mainly by air supplemented by wash gases containing traces of chlorine and bromine. Considering that natural brines contain less than 0·1% Br, the importance of air oxidation is evident, for if chlorine alone be used as an oxidizing agent, several times the quantity would be necessary. The oxidizers in present use consist of a series of electrolytic cells of special construction. By the Dow process, bromide containing less than 0·3% Cl is made without difficulty, whereas by the former blowing-out process, it was impossible to extract much more than one-half the bromine in the brine without having the product so contaminated with chlorides as to render it unsalable.

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[1] United States Patent No. 714,610, Nov. 25, 1902, H. H. Dow.

CALCIUM CARBIDE AND ACETYLENE.

By Henry Fisher.

That the use of acetylene gas will increase from year to year cannot be doubted, when consideration is given to the simple apparatus needed for its manufacture, and the few substances required for its production. Especially will this be the case, when all dangers of explosion have been eliminated as now seems fairly in the way of being accomplished.

Acetylene Generators.—During 1902 many patents were taken out in the United States and in Europe for acetylene gas generators, more than 75 patents being granted by the United States Government alone, covering claims for various improvements. Some of these generators operate on the "carbide-to-water" and some on the "water-to-carbide" principle. There were 186 firms in the United States in 1902 engaged in manufacturing various forms of acetylene apparatus.

Lamps.—For mine lighting, a new form of acetylene lamp has been introduced, which consists of a body holding the water supply, a gas chamber and a carbide holder. Each lamp is provided with an extra gas chamber and carbide holder in order that the supply may be renewed while the light is kept burning. The lamp is very compact, burns from two to three hours, and gives a bright light of about 20 candle power.

Car Lighting.—In an article[1] entitled "Acetylene Stored and Transported in Safety," J. S. Seymour states that if a steel cylinder be packed with porous brick of 80% porosity, or with asbestos disks covered with an alkaline silicate, and a quantity of acetone be introduced equal in volume to 40% of the capacity of the cylinder, the latter at room temperature will hold 240 volumes of acetylene at 10 atmospheres pressure. In a cylinder of this description, all danger from accidental explosions is eliminated, or if an explosion be produced intentionally, it is localized. In order to prove this assertion, a spark apparatus was introduced into a tank charged with acetylene and a spark produced. No explosion took place, but on opening the cylinder, it was found that the asbestos disks about the plug were covered with carbon, showing that the acetylene had been decomposed. He also states instances where these tanks of acetylene have been used on railroad cars and yachts with perfect satisfaction.

To prevent the explosion of acetylene within the storage apparatus with disastrous results, a patent[2] has been obtained by M. Toltz and A. Lipschutz, for the use of a fusible valve on the storage tank, and of lengths of fusible pipe, providing piping also is used, which fusible material melts below the dissociation point of acetylene, so that in case the gas becomes unduly heated from any cause, instead of exploding it escapes and burns.

In studying the explosion limits of combustible gases and vapors with air,

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[1] *Journal of the Franklin Institute*, July, 1903, pp. 1-18.

[2] English Patent No. 24,577, Dec. 3, 1901; United States Patent No. 699,725, May 13, 1902.

P. Eitner[3] found that the explosive limits of acetylene in the Bunte burette, stated in percentages of moist combustible gas in the mixture, were: Lower limit, 3·35% and upper limit, 52·3%; the actual quantity of acetylene present in the two cases being 3·25% and 51·3%, respectively.

According to F. Gaud,[4] the clogging of acetylene burners having small orifices by the deposition of carbon due to the decomposition of the gas, is caused by the presence of hydrogen sulphide and other sulphur compounds in the acetylene. The impurities increase the tendency of the gas to decompose into its elements, but when purified acetylene is used, there is no fouling of the burner, provided the normal rate of consumption of gas is observed, if the rate of flow be reduced, however, clogging cannot be prevented.

According to the statements of G. Keppler,[5] the impurities in acetylene are phosphorus and sulphur compounds, ammonia, oxygen, air, hydrogen, carbon monoxide, hydrogen silicide, methane and other hydrocarbons. For purifying acetylene five substances have been proposed, as follows: (1) ferric hydroxide; (2) "heratol," a solution of chromic acid in acetic or sulphuric acid absorbed in kieselguhr; (3) "acagine," a mixture of bleaching powder with 15% lead chromate; (4) "puratylene," a mixture of bleaching powder with calcium chloride and calcium hydroxide, prepared by a special process to give it porosity, and (5) "frankoline," a solution of cuprous and ferric chloride in strong hydrochloric acid absorbed in kieselguhr.

CALCIUM CARBIDE.—*Market.*—In Europe, the Nuremberg Syndicate at the head of which stands the Neuhausen Aluminium Werke, with its plant at Lend Gastein, has fixed the price of calcium carbide for 1903 for home consumption, at 24·5 marks per 100 kg. in southern Germany, at 25·55 marks in Berlin, and at 25·95 marks in Cologne. All the French carbide plants belong to the syndicate. Lots of one ton and more in drums of 100 kg. each, cost 345 fr. at Annecy and 399 fr. in Caen. The annual consumption of Germany is estimated at 10,000 tons. The annual production in France is estimated at 18,000 tons. France exports more than 1,000 tons of carbide, chiefly to Brazil, Argentina, Madagascar, the West Coast of Africa, China and Japan. The expense of shipping carbide to Brazil is 143 fr. per metric ton, so that French carbide costs about 550 fr. per ton in Brazil. Some of the plants that are independent of the Nuremberg Syndicate are at Gurtnelle, Paterno, a small Hungarian works at Jadvoelgy near Nagy-Varad, and at Terni (Italy). The last produces annually 20,000 tons of carbide, of which one-half is exported.

In the United States, the Union Carbide Co. at Niagara Falls, N. Y., is making daily 50 to 60 tons of carbide at a reported cost of $24 per ton. Export carbide is sold f. o. b. ship at New York at $50 per ton, but for home consumption in lots of one ton and upward $70 per ton is charged, or $3·75 per 100 lb. The product is graded into three sizes, the smallest including pieces from 0·0833 ($\frac{1}{12}$) to 0·25 ($\frac{1}{4}$) in., the next from 0·5 to 2 in., and the largest from 2 to 3·5 in.

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[3] *Journal fuer Gasbeleuchtung*, 45 (2), pp. 21-24; (5), pp. 69-72; (6), pp. 90-93, and (7), pp. 112-115; abstract in the *Journal of the Society of Chemical Industry*, March 31, 1902, pp. 395-396.

[4] *Comptes rendus*, 134 (3), pp, 175-177.

[5] *Journal fuer Gasbeleuchtung*, 1902, 45, pp. 777, 802 and 820; abstract in the *Journal of Society of Chemical Industry*, Nov. 29, 1902, pp. 1386-1388.

It is estimated that the United States consumes annually 16,000 tons, practically all of it being used for lighting purposes.

Manufacture.—It is stated by V. Rothmund[6] that for the formation of calcium carbide more than 700 watts are necessary, and that the reaction takes place at a temperature of 1,620°C.

I. L. Roberts has patented[7] a process for making calcium carbide in which he uses anthracite coal in place of coke. The coal having a higher specific gravity than the coke, does not separate from the lime when charged into the furnace. The resulting carbide is stated to be less porous, and therefore more permanent than the carbide made with coke.

A process for making calcium carbide cartridges consists in compressing the material and immersing it in molten naphthalene. The naphthalene is said to retard the too rapid action of the water on the carbide, while the heat evolved by that action volatilizes the naphthalene, which in the gaseous form mixes with the acetylene and improves its illuminating power. As the cartridges contain the same amount of carbide each time, they yield the same amount of gas.

Uses.—Calcium carbide is used to destroy the phylloxera in the vineyards of France and Italy, and the higher the percentage of phosphorus it contains, the greater is its germidical property. This seems to be due to the evolution of hydrogen phosphide when the carbide is exposed to moisture.

R. Hopfelt uses in the arc light, electrodes made of carbide covered with aluminum or a waterproof material, and claims that he obtains a brighter and more powerful light.

Reducing Agent.—According to Dr. B. Neumann[8] calcium carbide, like aluminum, acts as a reducing agent when brought in contact with metallic oxides and salts, but it is not as powerful a reducer as aluminum. Warren, Moissan, Siemens and Halske and von Kügelgen, also, experimented with carbide as a reducing agent. The reaction which takes place, according to Neumann is as follows:—

$$3M_2O+CaC_2=3M_2+CaO+2CO;\quad 2M_2O+2MCl+CaC=3M_2+CaCl_2+2CO,$$

while von Kügelgen claims that the reaction which takes place is:—

$$5M_2O+CaC_2=5M_2+CaO+2CO_2;\quad 4M_2O+2MCl+CaC_2=5M_2+CaCl_2+2CO_2.$$

M indicating a monovalent metal. The former claims that carbon monoxide is produced, and that one part of carbide reduces six parts of metal, the latter that carbon dioxide is produced, and that one part of carbide reduces ten parts of metal.

This property has recently been made the basis of a process for making the alkaline metals. A simple or double fluoride or silicofluoride of the metal is mixed with calcium carbide and heated to red heat when a double decomposition takes place, and an alkali carbide and calcium fluoride result. On heating the mixture still higher, the alkali carbide breaks up, and the liberated metal can be distilled over. If nitrogen or ammonia gas is led over the metal to prevent oxidation, a part of the carbide is converted into cyanide which can be recovered by the lixiviation of the fused mass.

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[6] *Chemiker Centralblatt*, 1 (18), p. 1045.

[7] United States, Patent No. 708,921, Sept. 9, 1902.

[8] *Zeitschrift fuer Elektrochemie*, Oct. 2, 1902, p. 772.

CARBORUNDUM.

The production of carborundum during 1902 by the sole manufacturer using two units of 1,000 H.P. each, amounted to 3,741,500 lb., valued at $374,150, as compared with 3,838,175 lb. of crude carborundum, valued at $345,435 in 1901, and 1,741,245 lb., valued at $216,090 in 1900. The average price in 1900 was 12·4c. per lb.; in 1901, 8·9c. per lb., and in 1902, 10c. per lb. It is reported that the cost of manufacturing this material is 4 or 5c. per lb. The cost of material is 0·75c; labor, 0·5c.; power, 1·25c., and final washing and grading, 1·5 to 2·5c. per lb. The crystals are graded in 20 sizes, from No. 8, passing through an 8-mesh sieve, to No. 220, passing through a 220-mesh sieve. The three grades of fineness F, FF, and FFF, known as "carborundum flour," are obtained by washing the finest crystals. By stirring the fine powder in water and allowing it to settle one, two, four or more minutes and then decanting the water and allowing it to settle, powders called "hand-washed" one, two, four, etc., minute powders are obtained.

PRODUCTION OF CARBORUNDUM IN THE UNITED STATES.

Year.	Quantity.	Value.
	Pounds.	
1900	1,741,245	$216,090
1901	3,838,175	345,435
1902	3,741,500	374,150

CEMENT.

THE production of Portland cement, natural hydraulic cement and dry cement in the United States during 1902 was as follows: Portland cement, 16,535,000 bbl. (of 400 lb.), valued at $16,637,500, as compared with 12,711,225 bbl., valued at $12,532,360 in 1901; natural hydraulic cement, 9,083,759 bbl. (of 300 lb.), valued at $4,087,692, as compared with 7,084,823 bbl., valued at $3,056,278 in 1901, and slag cement, 547,175 bbl. (of 400 lb.), valued at $465,099, as compared with 272,689 bbl., valued at $198,151 in 1901.

PRODUCTION OF PORTLAND CEMENT IN THE UNITED STATES. (IN BARRELS OF 400 LB.) (380 LB. NET.)

States.	1901.			1902. (c)		
	Barrels.	Value at Works.		Barrels.	Value at Works.	
		Total.	Per Bbl.		Total.	Per Bbl.
California	146,848	$513,968	$3·50	220,000	$770,000	$3·50
Colorado	....	....	....	100,000	110,000	1·10
Illinois	....	....	....	900,000	990,000	1·10
Indiana	....	....	....	400,000	440,000	1·10
Kansas	....	....	....	500,000	550,000	1·10
Michigan	1,025,718	1,128,290	1·10	2,400,000	2,640,000	1·10
New Jersey	1,612,000	1,450,800	0·90	1,900,000	1,710,000	0·90
New York	617,228	617,228	1·00	990,000	990,000	1·00
Ohio	519,852	571,837	1·10	700,000	770,000	1·10
Pennsylvania	7,091,500	6,382,350	0·90	8,000,000	7,200,000	0·90
Texas	....	....	....	200,000	220,000	1·10
Utah	(b)	....	....	(b)	....	....
Virginia	....	....	....	225,000	247,500	1·10
Other States (a)	1,698,079	1,867,887	1·10	....	....	....
Total	12,711,225	$12,532,360	$0·98	16,535,000	$16,637,500	$1·01

(a) Includes Arkansas, Illinois, Indiana, Kansas, Virginia, North Dakota, South Dakota, and Texas. (b) Included in California. (c) Compiled by Charles F. McKenna.

PRODUCTION OF NATURAL HYDRAULIC CEMENT IN THE UNITED STATES. (IN BARRELS OF 300 LB.)

States.	1901.			1902. (e)		
	Barrels.	Value at Works.		Barrels.	Value at Works.	
		Total.	Per Bbl.		Total.	Per Bbl.
Illinois	469,842	$187,936	$0·40	(f)	....	....
Indiana and Kentucky	2,150,000	752,500	0·35	(f)	....	....
Kansas	145,760	72,880	0·50	(f)	....	....
Maryland	351,329	175,665	0·50	250,000	$112,500	$0·45
Minnesota	(b) 126,000	63,000	0·50	(f)	....	....
New York:						
Ulster County	1,184,007	1,117,066	0·50	3,000,000	1,650,000	0·55
Onondaga County	141,623			(f)	....	....
Schoharie County	62,702			(f)	....	....
Erie County	663,800			700,000	315,000	0·45
Other counties	182,000	....	....	....	....	....
Ohio	(c) 104,000	62,400	0·60	(f)	....	....
Pennsylvania	942,384	376,954	0·40	800,000	320,000	0·40
Virginia	(d)	....	....	(f)	37,500	0·50
West Virginia	(d)	....	....	100,000	45,000	0·45
Wisconsin	481,020	182,788	0·38	(f)	....	....
Other States (a)	80,357	65,089	0·81	(f)	....	....
Total	7,084,823	$3,056,278	$0·43	(g) 9,083,759	$4,087,692	$0·45

(a) Includes Georgia, Tennessee, West Virginia, Texas and Nebraska. (b) Includes North Dakota. (c) Includes Virginia and West Virginia. (d) Included in Ohio. (e) Compiled by R. W. Lesley. (f) Not separately reported. (g) Preliminary statistics of U. S. Geological Survey.

SLAG CEMENT.—The output of slag cement in 1902 was 109,435 short tons, valued at $465,099, as compared with 54,536 short tons (equivalent to 272,689 bbl. of 400 lb.), valued at $198,151 in 1901. The production and value increased markedly in sympathy with the highly satisfactory condition in the Portland cement trade during the latter half of 1902. The distinction made by the Board of Engineers, U. S. A., that "Steel Portland Cement" cannot be substituted for Portland cement in Government work where the specifications call for the latter, but is to be classed as puzzolana slag cement, has been accepted by most of the slag cement manufacturers; and efforts are being made to push the sale of slag cements only for those uses to which they are particularly adapted. A greatly increased production should result in 1903 unless the state of the iron market is too good to permit attention being paid to the utilization of by-products. The review of the slag cement and slag brick industries of the United States during 1902 is given by Mr. E. C. Eckel, later in this section.

CEMENT PRODUCTION, IMPORTS, EXPORTS AND CONSUMPTION IN THE UNITED STATES. (IN BARRELS OF 300 LB.)

Year.	Production.				Imports.		Exports. (*b*)		Consumption.	
	Natural Hydraulic.	Portland. (*a*)	Total Barrels.	Value.	Barrels.	Value.	Barrels	Value.	Barrels.	Value.
1898......	8,161,078	4,989,664	13,150,742	$10,228,822	2,685,092	$2,624,228	70,892	$98,121	15,764,942	$12,749,929
1899......	9,686,447	8,067,161	17,753,608	15,860,731	2,810,951	2,858,286	147,029	218,457	20,417,580	18,505,560
1900......	9,177,222	11,309,052	20,486,274	15,393,109	3,182,245	3,330,445	186,586	289,186	23,481,933	18,434,368
1901......	7,084,823	12,983,914	20,068,738	15,588,638	1,239,856	1,305,692	384,280	752,057	20,590,442	16,142,273
1902......	9,083,759	17,082,175	26,165,934	22,028,248	2,659,721	2,581,883	432,189	575,268	28,402,466	24,029,863

(*a*) Includes slag cement. (*b*) Includes re-exports of foreign.

IMPORTS OF CEMENT INTO THE UNITED STATES ACCORDING TO SOURCE.

Year.	Belgium.		Canada.		France.		Germany.	
	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.
1898..........	133,806	$800,949	955	$8,852	3,459	$22,224	206,983	$1,394,551
1899..........	124,880	747,448	880	8,868	3,130	22,262	238,799	1,698,722
1900..........	165,258	1,001,122	903	9,396	6,542	47,798	281,110	1,722,104
1901..........	60,636	377,517	1,218	12,180	2,854	20,481	112,119	804,710
1902..........	123,159	724,090	722	8,223	2,984	24,705	251,853	1,692,684

Year.	United Kingdom.		Other Countries.		Total Imports.		Exports. (*a*)	
	Short Tons.	Value.	Short Tons.	Value.	Short Tons	Value.	Short Tons.	Value.
1898	47,212	$333,405	10,350	$64,247	402,764	$2,624,228	10,633	$98,121
1899	39,927	309,614	14,112	76,872	421,643	2,858,286	22,054	218,457
1900	53,584	416,937	19,939	133,093	477,337	3,330,445	27,988	289,186
1901	7,478	58,570	5,177	32,294	188,978	1,305,692	83,525	752,057
1902..........	15,817	105,294	4,422	26,887	398,958	2,581,883	74,683	575,268

(*a*) Estimated from number of barrels reported at 1 bbl.=400 lb. Includes re-exports of foreign.

THE CEMENT INDUSTRY IN THE UNITED STATES DURING 1902.

BY CHARLES F. MCKENNA.

PORTLAND CEMENT.—No other branch of the mineral industry in the United States has ever furnished more striking figures of rapid yet healthy growth than those encountered in the study of the manufacture of Portland cement. Economists have marveled at the continued steady expansion in the production of pig iron, which has shown a 100% increase in a decade; but there is more cause to wonder at the leaps and bounds in the rate of the annual production of Portland cement, which was measured 10 years ago by a few thousand barrels, and by millions of barrels at the present time. The Portland cement industry, which was already well established in 1894 with 24 operative factories, has grown 2,606% in eight years, the factories have increased three-fold in number and some of the larger ones eight-fold in capacity. The annual rate of increase, which is shown by the subjoined table, is of great interest.

RATE OF INCREASE IN THE ANNUAL PRODUCTION OF PORTLAND CEMENT IN THE UNITED STATES. (*a*)

Year.	Production.	Rate of Increase over Previous Year.	Rate of Increase Referred to 1894.	Year.	Production.	Rate of Increase over Previous Year.	Rate of Increase Referred to 1894.
	Bbl. of 400 lb.	%	%		Bbl. of 400 lb.	%	%
1894....	611,229	....	....	1899....	5,805,620	62·0	1,176·3
1895....	749,059	22·5	22·5	1900....	7,991,639	37·6	1,204·6
1896....	1,577,283	110·5	158·0	1901....	12,711,225	49·8	2,000·0
1897....	2,480,908	54·0	297·7	1902....	16,535,000	30·0	2,606·2
1898....	3,584,586	47·4	486·5				

(*a*) 1894–1901, from THE MINERAL INDUSTRY, Vols. IV. to X. inclusive: 1902, estimated by Charles F. McKenna.

It is the general belief that the rate of increase will be larger in 1903 than that shown for 1902, due to the construction of new mills of which a few will begin operation early in 1903. The condition of the industry classified by States during 1901 and 1902 is best shown by the statistical table given at the beginning of this section.

The total consumption of Portland cement in the United States during 1901 and 1902 is shown in the subjoined table (barrels of 380 lb.):

Year.	Production.	Imports. (*a*)	Exports. (*a*)	Consumption.
1901	12,711,225	894,150	373,984	13,231,441
1902....................................	16,535,000	1,945,490	340,821	18,139,669

(*a*) Includes Roman and other natural hydraulic cement.

The reports of delinquent companies which are now being received indicate a very large increase in the production during 1903, due to the contemplated extension of works already established as well as those at new sites. This continued increase in the quantities of Portland cement annually produced, which is almost in geometric progression, has resulted from increased number of uses and consequent larger demand. The consideration whether or not these increments can continue is of vital importance to all interested in the industry. The information published in the technical journals indicates that there is much hope for the continuing growth, as engineers and technologists seem to be following a fad in suggesting and considering this excellent hydraulic material for positions entirely novel, and for combinations and interweavings with other materials until the list of its applications becomes greatly expanded. Admitting that many of these suggestions will not be justified by necessity, economy, or structural strength, there should still remain a reasonable number whose success will be followed by rapid adoption at the hands of enthusiastic advocates. For the future, the manufacturers must carefully study these new uses, and come in closer relation to the consumer of the material. With all the advance that has been made in engineering practice with concrete there yet remains much to be determined in the study of the ways in which the cement, the water, the aggregates, and the finished concrete shall be treated. Failures and discredit of this material are more often traced to ignorance of these factors than to defective qualities of the cement. Since it is the foreman concreter and the laborer who have most to do with these factors it is obvious that systematic instruction furnished to them would quickly prove its value. It is probable that if manufacturers to-day were not pressed to supply orders, but were rather seeking trade, the effort would take the form of supporting traveling schools of concreting. The influence of the good workmanship thus taught would spread from railroad engineering and municipal engineering to farm engineering, house building, and other fields of activity where the economy of cement, its mode of treatment, and its successful applications have not yet been developed to their full values.

The testing of Portland cement, which has given rise to much friction in the past between manufacturers and consumers, has become better understood and great good has resulted from its application both in the factory and at the site of use. The Committee on Cement Testing of the American Society of Civil Engineers is entitled to much credit for its work in this field, and its report published during the year 1902 is a model of simplicity when it is considered how the subject might have been overburdened with confusing details, which would have discouraged many an earnest experimenter and inspector. The Committee on Cement Testing of the American Section of the International Association of Testing Materials is now co-operating with the committee of the American Society of Civil Engineers, and the investigation of the sufficiency and value of its findings will have the joint support of both societies.

The technology of Portland cement during 1902, while recording no striking invention or improvement, affords many evidences of advance both in the efficiency of apparatus and in better plan and disposition in the works. The rotary kiln is absolutely triumphant, and attention is being concentrated not upon efforts to replace it with any other type, but upon improvements in the details of form and arrangement of burner, selection and care of brick lining, regulation of blast, control of draft, and many minutiæ incident to uninterrupted operation. Undoubtedly the year 1902 can record a general increase of yield per kiln as a result of such attention, and both fuel consumption and labor cost have been reduced to some extent. Heat economies are studied, and a few works are reported to have been successful in utilizing the heat of the flue gases for feed-water heating. The saving of the heat of the clinker also is practiced in some types of clinker coolers, but apparatus of this character must commend itself for simplicity before an attempt to make such a minor saving is warranted. The mechanical engineer also is advancing the art of cement manufacture, and trade rivalry among the promoters of milling machinery is undoubtedly a favorable influence. The battle between the advocates of the Griffin mill and those of the ball and tube mill has continued, and it is believed that improvements have been made on both, so that a continuation of the contest may be expected. A few new works have been designed in which the ball and tube mills are used to grind the raw material and Griffin mills to grind the clinker

—a practice which is recommended by some engineers when the materials are diverse and a thorough mixing consequently becomes absolutely essential. Advance is being made in the steam power plants of mills, in electrical equipment, in the driving and carrying mechanisms, and in every feature open to the genius of the mechanical engineer.

The crisis in the coal trade which supervened in the summer of 1902 produced a powerful effect upon the technology not yet fully perceived. The cement manufacturer now realizes that coal is a very important factor of the total cost of manufacture, and information is being sought which will enable him to ascertain the economic values of the coal used and to learn the attendant economics of its use.

With regard to the price of Portland cement during 1902 peculiar features are to be recorded. At the opening of the year a feeling of nervousness manifested itself among the manufacturers which was more pronounced than any before experienced. The large stocks accumulating in certain mills appeared to some to be a menace, while the lack of room for this accumulation at other mills appeared to others as an additional menace. Reports of large increases in producing units by resourceful companies drove the small manufacturers into a panic, and agents of importers relaxed their efforts and ordered but little from abroad. The lowest prices ever known in the history of the cement business were reported and contracts of great magnitude were made. Suddenly upon the disappearance of winter and its effects, an unexpectedly large demand arose. Prices improved in April, grew strong in May, and in June hardly an important producer felt able, or at least warranted in taking contracts. The enormous demand for cement which began in June and lasted until the end of the year, surpassed even the large increase in the total production, thereby creating an unprecedented shortage of supply of amazing proportions, which created immediately a demand for any grade of Portland cement. The importers were not long in starting large shipments to the United States, and in August and September imported cement was being shipped by the fastest ocean liners regardless of the high freight charges. At the end of the year almost no stocks were on hand in the American mills. Prices during December, 1901, and January, 1902, could be fairly stated to have been 90@95c. a barrel, f. o. b. at the mill whereas in July and August $1·60@$1·75 were the ruling prices, followed by no marked fall during the remainder of the year, and both demand and inquiries continued good to the close.

The outlook for the Portland cement industry in the United States, particularly in the near future, may be judged from the fact that in 1902 approximately 375 kilns were in operation, a number which will be increased to 500 during 1903. But, as noted in the table given at the introduction of this review the rate of increase for 1902 over 1901 was only 30%, while 50% increases had been recorded for several years directly preceding. This failure to keep abreast of the demand produced a shortage of probably 5,000,000 bbl., which left for 1903 a splendid legacy of orders and prospects. The amount of heavy construction planned or contracted for in the near future in the large cities of the country promises to afford a very great source of demand. In addition, the American manufacturer still has the opportunity to develop the export trade almost from the very beginning. It would seem that there will be nothing but success for the manufacturer who looks well to the economies, and it seems also as if assurance can be given the user that plentiful supplies will be available.

NATURAL HYDRAULIC CEMENT.—The changing influences of the natural cement products upon the market for Portland cement continued as slight as they have been for several years. This variety of hydraulic material holds its own, but appears to make no progress. At the beginning of 1902 a consolidation of more than 75% of the Rosendale natural cement plants at Rondout, N. Y., was consummated. The production during 1902 of natural cements in this district approximated 2,350,000 bbls. of 300 lb. each. The total production of natural hydraulic cement in the United States during 1902 would be difficult to gauge accurately since the factories are many in number, small in size and much scattered, but it may be stated tentatively at 10,000,000 bbl. Natural cement is produced also at certain mills in Pennsylvania, and mixtures of this product are made with Portland cement. These mixed quantities, however, are not included in the statistics given in the table showing the production of Portland cement in the United States.

SLAG CEMENT AND SLAG BRICK MANUFACTURE DURING 1902.

BY EDWIN C. ECKEL.

THE present paper is supplementary to the detailed discussion of the slag-cement industry contained in Vol. X. of THE MINERAL INDUSTRY, and gives a résumé of progress made during the past year. In addition, however, to supplementary data relative to the slag-cement industry, the manufacture of slag bricks and slag blocks is discussed in some detail. These industries were not treated in the article cited, and at present it seems probable that they will soon attain considerable commercial importance in the United States.

Slag Cement.—During the past year the slag-cement industry of the United States has been in a very prosperous condition, the production for 1902 largely exceeding that for 1901, while the average value per barrel showed a slight increase. The report of the board of army engineers on slag cements, while having temporarily a depressing effect on the industry, has doubtless resulted in permanent good. Several plants manufacturing a puzzolana cement from slag have adopted the policy of frankly announcing both the methods of manufacture and the known defects of the material for certain uses, relying on its equally well-known value for other uses to accomplish its sale. An extensive correspondence with municipal engineers, which was carried on by me during 1902, shows that those who have experimented with slag-cement for such work as foundations, sub-pavements, etc., regard it with favor, and permit its use in public works.

Three new slag-cement plants at various points in Pennsylvania were planned or were under construction during 1902. Only one of these, however, was completed in time to commence operations before the close of the year. This plant, erected by the Stewart Iron Co., and located at Sharon, Pa., commenced producing in December, but this early start was made to test its economic and mechanical efficiency, rather than as the opening of an active campaign. Early in 1903, operations were recommenced, and the plant has since been operated steadily. The slag used is selected from that made by the Stewart Iron Co. furnaces, and has the following average composition: Silica, 32·72%; alumina, 12·95%; iron, 2·51%; lime, 47·67%; magnesia, 2·71%; sulphur, 1·44%. After granulation, the slag is elevated and fed to three Ruggles-Coles dryers. The lime is burned, slaked and mixed with the dried slag in a Broughton mixer, and the mixture is finally reduced in tube mills. The finished cement has the following composition: Silica, 27·33%; alumina, 11·61%; iron, 2·43%; lime, 55·83%; magnesia, 1·93%; sulphur, 0·87%.

The process followed at the slag-cement plant of the Société Française des Hauts Fourneaux de Champigneulles, Department of Yonne, France, deserves notice. It may be regarded as a method for regulating (principally, of course, accelerating) the set of slag cements, but it is in reality somewhat more than this, as the following brief description will show. Slag of the usual composition is granulated. The granulated slag is not, however, dried as in ordinary practice: but is mixed while still wet with slaked lime. If an ordinary lime be used, the proportions are 25 to 30 parts lime to 75 to 70 parts slag; if hydraulic lime be employed, the proportions are 35 to 40 parts lime to 65 to 60 parts slag. The mixture is stirred up with water until of the consistency of a thick paste, and after grinding is formed into bricks and allowed to harden for several days. At the end of this time the bricks are broken into lumps and burned at a dark or bright red heat, according to the rapidity of set desired, and then finally reduced to powder. This process gives a very rapid setting cement. If it is too rapid, the set is retarded to any desired degree by mixing with the cement a greater or less proportion of dry powdered granulated slag and slaked lime. It will be noted that this process is intermediate between the methods used in manufacturing ordinary slag cements, and that adopted in Portland cement manufacture. In fact if the mixing and guiding of the materials were carried on more carefully, and the burning accomplished at a higher temperature, the product would undoubtedly be a Portland cement.

Slag Bricks.—In a previous article[1] I have made a distinction between the terms "slag-bricks" and "slag-blocks." The distinction seems of value and will be restated here. The term "slag-bricks" is applied to those bricks, tiles, etc., made by mixing slaked lime with crushed or granulated slag, molding the mixture by hand or in a brick machine, and drying the product. The term "slag-blocks," on the other hand, refers to the blocks made by pouring molten slag into a mold.

In Europe the manufacture of slag bricks is an important industry, though it has not come extensively into practice in this country. It is usually carried on in connection with the manufacture of slag cement, in which case the only additional requirements are a few machines and considerable floor space. The processes of manufacture may be briefly stated as follows: Slags of approximately the same type as those used in the manufacture of slag cement[2] are granulated, dried and finely ground. The following analyses of slags used in the manufacture of slag brick at various plants are fairly representative; No. 4, however, is peculiarly low in lime, requiring the addition of considerably more slaked lime than usual, and giving a brick that dries and hardens with more than average slowness. Sufficient slaked lime is added to the slag to bring the total lime (CaO) content of the mixture up to about 55%, and the materials are carefully and thoroughly mixed. If the slaked lime has been added in the form of paste, the material is ready for the brick machine. If, however, the slaked lime was a dry powder, it will be necessary to add a small quantity of water to the mixture, in order that it may be sufficiently plastic to form good bricks. On issuing from the brick machine, the bricks are placed on racks to dry, either in the open air or in a drying house. In from 6 to 10 days' time, according to

	(1)	(2)	(3)	(4)	(5)
Silica (SiO_2)	22·5	25·8	27·0	33·0	35·0
Alumina)Al_2O_3)	14·0	17·8	19·8	18·67	15·0
Iron oxide (Fe)	3·8	1·5	1·7	1·0	1·1
Manganese oxide (MnO)	·0	·0	0·1	4·25	0·3
Lime (CaO)	51·0	51·5	51·5	40·0	45·0
Magnesia (MgO)	1·4	0·4	2·5	2·33	Trace.
Sulphur (S)	0·8	1·8	1·8	1·33	0·4

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[1] THE MINERAL INDUSTRY, Vol. X., pp. 84-95, 1902.

[2] *Engineering News*, Vol. XLIX., pp. 384, 385, 1903.

composition and weather conditions, they are sufficiently firm to bear transportation, and are then ready for market.

Slag bricks thus made are light in color, varying from light to dark gray. They weigh less than clay bricks of equal size; require less mortar in laying up; and are equal or superior to clay bricks in crushing strength.

At several plants, pipes and other articles are made from the same mixture as that used for slag brick, the plastic material being forced into iron molds by rammers. These pipes seem to be satisfactory either as water or sewer pipe.

Slag Blocks.—"Slag blocks," as the term is used in the present paper, are made by pouring molten slag into molds. The molds may naturally be of any desired form, so that the slag block can be shaped like a common brick, a tile, or a massive block. Slag blocks are made somewhat extensively in the Lehigh Valley, and have been used as paving material, notably in Philadelphia. They are very durable, but objectionable because of their slipperiness. This difficulty has been overcome in practice in the Middlesboro district, England, by casting the blocks in a double-size mold encircled by a projection, which results in a groove encircling the slag block. The two halves of the block after cooling are split apart with a chisel, and the rough fracture-surface of each is laid uppermost in paving.

In ordinary practice, slag blocks are cast in iron molds, with the top uncovered. This favors rapid cooling, and therefore requires little floor space for storage of the cooling blocks. In the best practice, however, blocks are cast in sand, or occasionally in iron molds, which are covered immediately after pouring with a thick layer of sand. This treatment allows the slag to cool very slowly, giving a tough, dense, and resistant block. More floor space for storage, however, is required than in the first method.

THE MECHANICAL EQUIPMENT OF A MODERN PORTLAND CEMENT PLANT.

BY F. H. LEWIS.

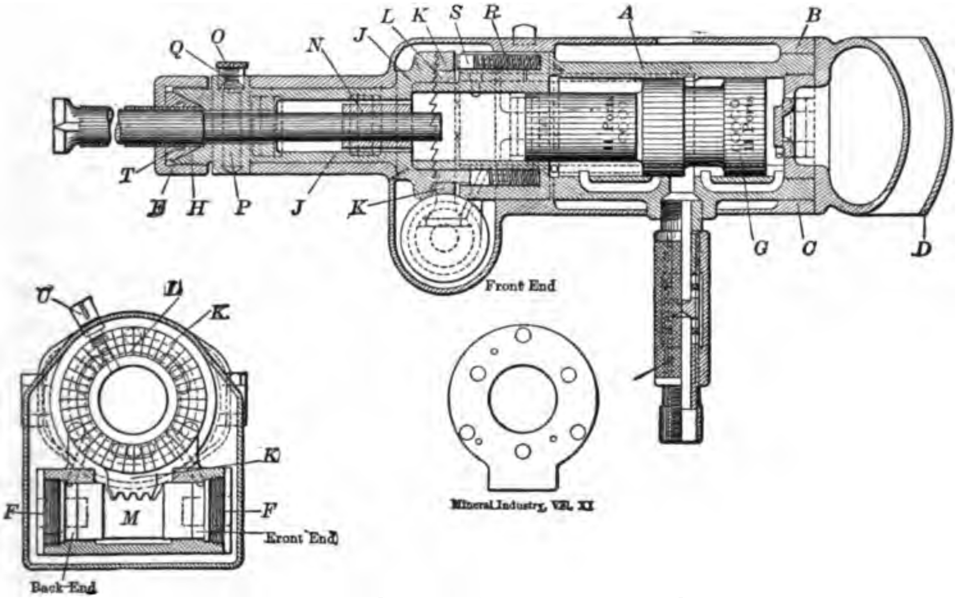
THE Portland cement industry in America had its beginning in 1875. At that time a small plant was started near Allentown, Pa., by David O. Saylor, employing as the raw materials the so-called cement rock of that section of Pennsylvania which had previously been used in the manufacture of natural cement, and which was brought up to the proper composition for Portland cement by the addition of pure limestone. An exhibit of this cement was made at the Centennial Exposition in Philadelphia in 1876. Saylor was thus the originator of the enormous industry which has developed in this section of Pennsylvania, and in similar rock deposits in western New Jersey since that time. About the same date (1875) Thomas Millen started the manufacture of Portland cement at South Bend, Ind., using the wet process, the raw materials being the wet marls and clays of that section. This factory was afterward abandoned for a new location in New York State, and for twenty years the growth of the industry by the wet way in America was extremely slow. Since 1897, however, there have been an extraordinary number of factories built in the marl sections of Ohio, Indiana and Michigan, making Portland cement by the wet method. Yet it is to be noted that while David Saylor's enterprise has been growing since its inception, and is now a very large plant, none of the original marl plants has expanded by natural development to large industries. The great establishments in the marl regions are all of them new enterprises and not developments from small beginnings.

During the first 20 years of its existence, the cement industry made slow progress, the total product in the United States in 1895 being but 750,000 bbl., 85% of this being produced in Pennsylvania and New Jersey. Since that date, however, the growth of the industry in all sections of the country has been extraordinarily rapid, the total product for the year 1902 being over 16,000,000 bbl. But in spite of this extraordinary growth the proportion manufactured at the point where the industry first began, that is, in the so-called cement rock section of eastern Pennsylvania and western New Jersey, is still 65% as compared with the total production by the wet way of about 15%.

It is probable that there is no place in the world where raw materials of equal quality are found in such abundance as they are in this great Pennsylvania cement section. This district has not only set the pace in manufacturing for the entire country, but the genius of its manufacturers has developed much the greater part of the improvements in manufacturing. The rotary kiln was developed here, as was the method of burning by powdered coal, with all the successful methods of cooling, storing and grinding clinker. These are the features which have developed into a distinctive American practice and have given a basis on which to establish a successful industry.

With expensive labor and comparatively cheap power, the American manufacturer in competing with the European product has been compelled to follow the same lines as those which have been successful in the American iron and steel industry, which is now pre-eminent, that is, the substitution of mechanical devices for hand labor at all points of the process. Indeed, this feature has been more important in establishing an American Portland cement industry than it has been in iron and steel, for the reason that the product is a bulk product, selling per ton at from one-half to one-third the price of pig iron. The cement manufacturer makes but one product and his profits, if any are earned, must come from the sale of this product. There are practically no by-products. If the cement is produced at satisfactory cost the industry is profitable; if not, it is unprofitable. There is no such thing as recouping losses from one line of manufacture by profits on another.

Quarrying.—In producing cement by the dry process the quarrying of the stone is much the largest element in labor cost, and in most instances it is impossible to reduce the labor item excepting fractionally. In the largest plants there has been some use of the steam shovel for loading cars. This is only applicable, however, to certain cases and to the larger enterprises. In general quarries are fitted up with air drills, employ high explosives, and use for the first reduction of the material the large gyratory crushers. The larger the opening of the crusher the less sledging and quarry work required; and as the sledging is very generally the largest item in the quarry cost the size of the crusher is of importance. Recently a very valuable drill for block holing has been developed. This is a pneumatic drill, similar in type to the pneumatic riveting hammers. It will drill holes ten or twelve inches deep at the rate of one inch per minute. When the materials are hard it constitutes one of the most valuable additions to a quarry outfit that has been developed in recent years. Fig. 1 illustrates one of the drills.



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A Cylinder.
B Front Housing.
C Back Housing.
D Grip Handle.
E Lock Nut.
F Rotating Cylinder Cap.
G Piston.
H Blow Tube Clamp.
J Chuck.
K Ratchet.
L Ratchet Pawl.
M Rotating Piston.
N Chuck Bushing.
O Drill Bit Key Lock
P Drill Bit Key.
Q Drill Bit Lock Spring.
R Ratchet Spring.
S Ratchet Pin.
T Blow Tube Clamp Spring.
U Ratchet Regulator.
V Wrench.

FIG. 1.—CHICAGO ROCK DRILL.

These drills are small, readily transported, and by using two or three of them, all the large stone can be broken up with a very small amount of sledging.

A considerable variety of practice has developed in handling the stone between the quarry and the mill. With pit quarries adjacent to the mill the ordinary method is a system of skips running on overhead rope tramways. These have the advantage of lifting and carrying by the same power. A number of these tramways are in use in Pennsylvania carrying stone quite economically. In open face quarries various types of side and end dump cars are used, usually of 3·5 ft. gauge or less, a narrow gauge being desirable for dump cars.

In many cases a crusher outfit in the quarry offers advantages; where practicable and when the handling of the mix will permit, it should always be used. The advantage derived from crushing material at once arises from the fact that it is much more easily handled in the subsequent processes. In some cases, however, as in a number of plants in the Lehigh Valley, this becomes impracticable because the required limestone is purchased from quarries at a distance, and is delivered by rail in standard gauge equipment. Under such circumstances it is generally necessary to handle both stones in bulk at the plant. When both raw materials are found at the factory site the advantage of crushing them at once and handling them through a system of bins and pockets is considerable. It is even a question whether it would not be economical to buy crushed stone instead of lump stone when it is purchased at a distance. The advantage of this would arise from the ease and accuracy with which the mix could be made and sent together through the subsequent processes of reduction.

The size of the quarry, its distance from the mill, its elevation above or below the level of the mill, and the character of the raw materials, all must be considered in determining the methods of quarrying to be used, but in any and every case the largest mechanical installation which is practicable will prove to be the most economical. In this way some type of steam shovel will prove advantageous for handling large quantities of material. The installation of air compressors for drilling will prove more economical than using steam direct, the loss of power from the condensation of steam being much greater than the loss of power in compressing the air. In order to economize still more when using air, some form of reheater for heating the air in the supply pipes at the quarry adds considerably to the efficiency of pneumatic power, and is especially advantageous in the winter time. Cold air in cold weather causes considerable trouble in freezing the supply pipes and the valves on drills. A simple pipe coil installed in some type of furnace will reheat the air satisfactorily.

The cost of quarrying varies considerably, and in this respect the Pennsylvania manufacturers have the advantage over the majority of plants using dry raw materials. The Pennsylvania cement rock is a soft shale, easily blasted, easily sledged, easily handled by the steam shovel, and readily and rapidly broken in crushing machinery. It is handled under favorable conditions in Pennsylvania and New Jersey at a cost varying from 18 to 30c. per ton as compared with the cost of handling the harder limestones varying from 30 to 50c. per ton. Offsetting this advantage in some measure, however, is the comparatively high cost of limestone required to bring the Pennsylvania cement rocks to a normal composition. As mentioned above, the major part of this limestone is transported by rail from a distance and delivered at a cost of from $0·85 to $1·25 per ton. In recent years large plants employing limestone and shale have been built in Virginia, Indiana, Missouri and in West Virginia. Plants employing hard limestone and softer clays have been built in New York, Illinois and Michigan. In the majority of these plants the two raw materials are found in close proximity to each other and adjacent to the factory, and the high cost of limestone is offset by the low cost of shale, as compared with the conditions in Pennsylvania. The underlying principle in this matter is that Pennsylvania and New Jersey deposits are below the normal in lime and must be brought up in the mix by the addition of limestone, while in the cases just cited the limestone is the major ingredient and must be brought to normal figures in the mix by the addition of clay rock. The economy in Pennsylvania plants is in handling the cement rock, while the expensive feature is the lime rock. In the other districts the conditions are reversed.

Reduction of Raw Materials.—The system of gradual reduction has been adopted in all modern plants. The first reduction as in quarrying is through the crusher. This is by far the cheapest part of the reduction process, and admits of considerable development. The type of crusher universally employed for hard materials is the gyratory crusher, a machine developed by American manufacturers, possessing considerable advantages in output and in the character of the product over the old type of oscillating toggle joint machines. Probably the most complete arrangement where both the materials are hard is to crush one of them, at least, in the quarry, handling it through a system of bins and pockets over scales. The cars containing the larger ingredient in lump form pass under these pockets, are weighed on the scales, and the smaller ingredient is added by weight to form the mix. These cars are dumped into a crusher and the materials crushed together, the smaller ingredient being in this way recrushed and thoroughly mixed with the larger. This crusher discharges onto an elevator or a belt, as may prove most convenient, which carries the crushed ingredients to a screen, the tailings being returned to the crusher or to an auxiliary crusher, the latter probably being preferable since it can be of smaller size, and will not choke the large machine with too much small material. This method of crushing insures a uniform size of product which readily passes through the bins and chutes and through the mill feeds.

In Fig. 2 is shown a very complete installation for crushing and separating as described above, the tailings being returned to a smaller machine. The elevator is of the continuous bucket type carried on a rubber belt. This constitutes the most satisfactory type of elevator for raw material, especially for elevators handling lump material to considerable heights. A system of belts handling crushed stone from a crushing installation as described is shown in Fig. 3. It will be observed that the belt carries the crushed stone to the top of the stone house and deposits it in a series of tanks. These tanks discharge at the bottom onto belt conveyors passing through an arch in the foundation and again carrying the stone forward to the bins or to the dryers, (Fig. 4). The complete installation mentioned above handles stone entirely by mechanical means from the

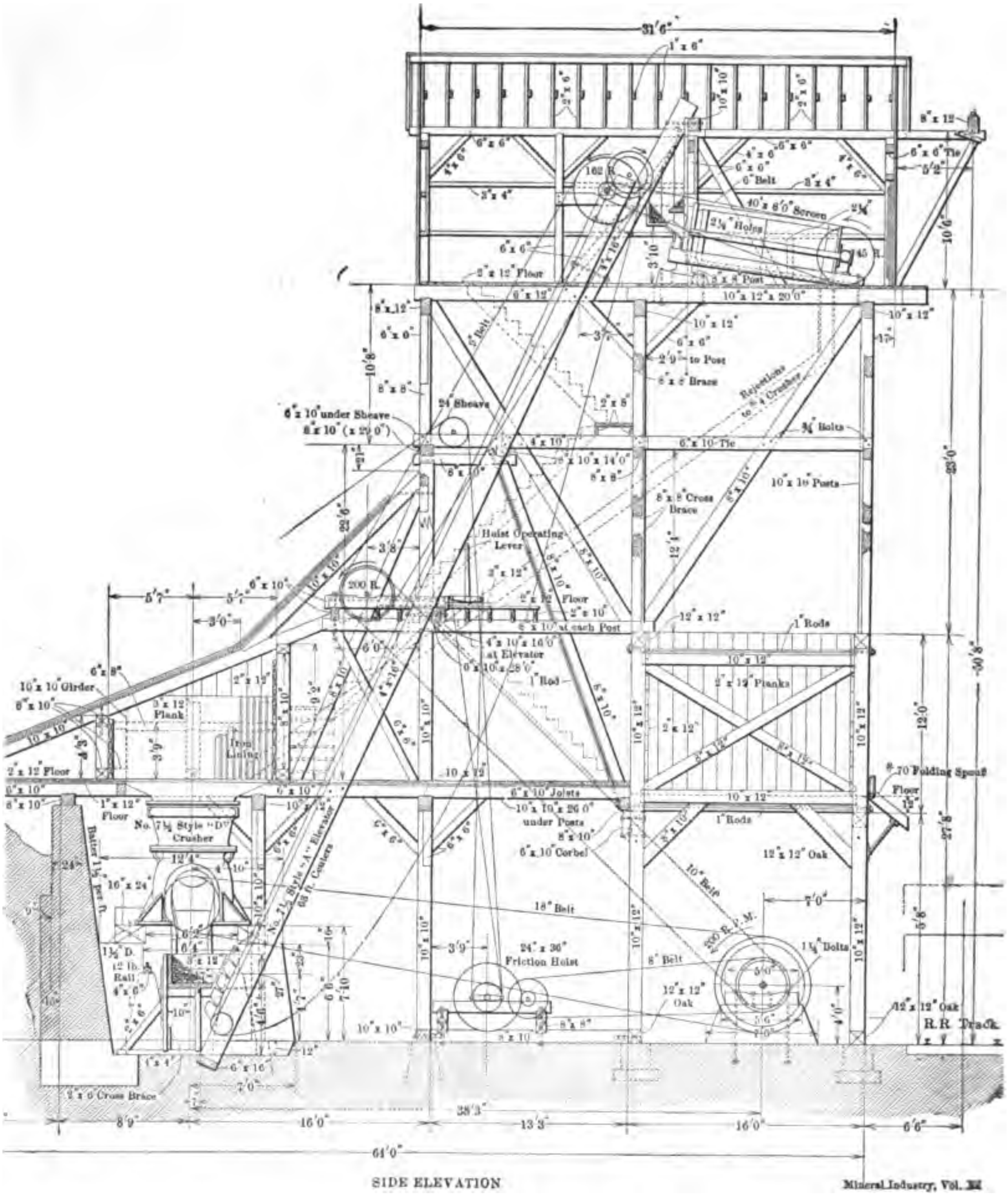
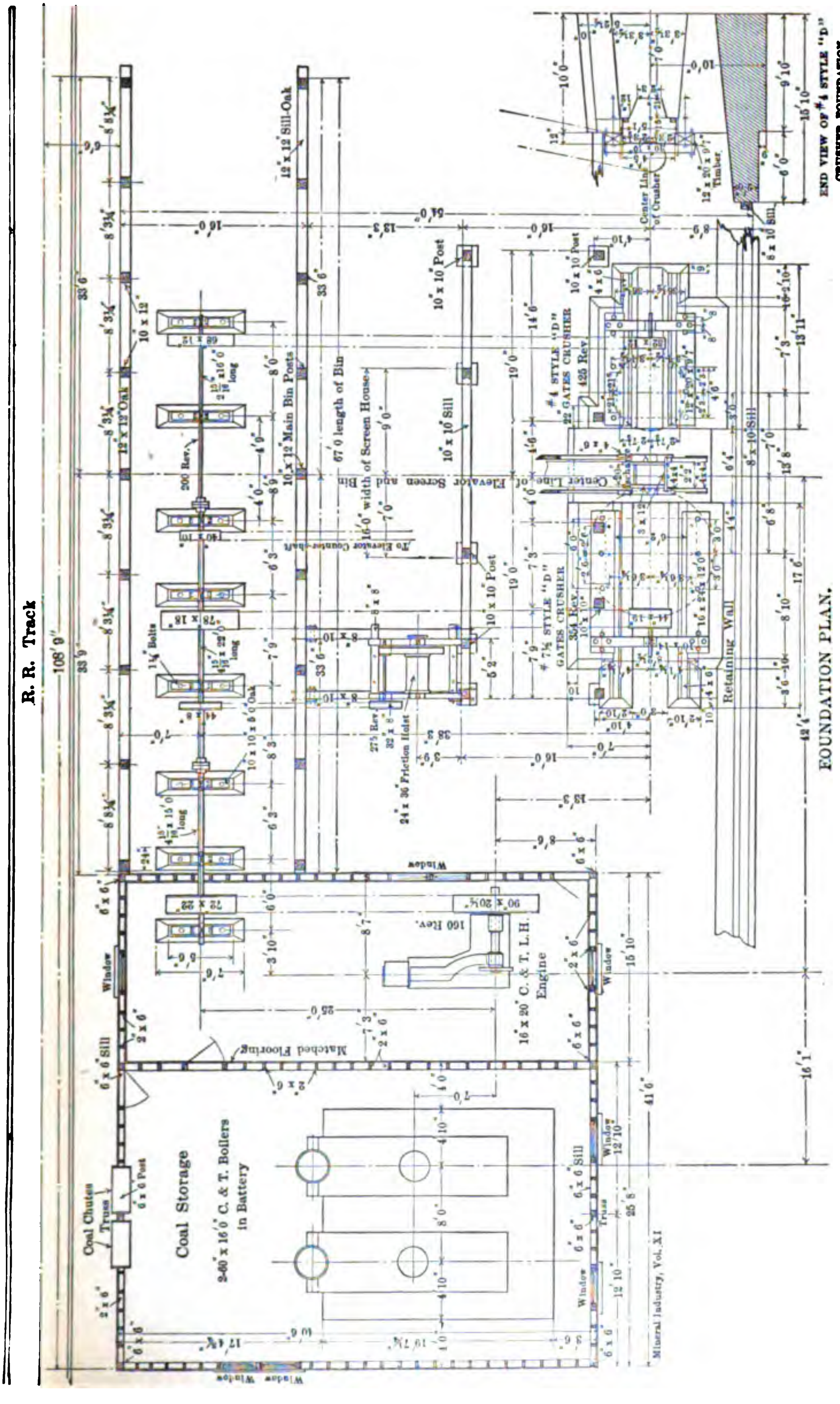


FIG. 2.—CRUSHING PLANT OF LEHIGH PORTLAND CEMENT CO., MITCHELL, IND.



FOUNDATION PLAN.

END VIEW OF #4 STYLE "D" CRUSHER FOUNDATION

FIG. 2. CRUSHING PLANT OF LEHIGH PORTLAND CEMENT CO., MITCHELL, IND.

time it leave the quarry at a very considerable saving of labor and cost. With such a plant the separation of the stone by screening after it leaves the crusher is essential because large flat slabs in the mass of the material will always make trouble by the choking of bins and chutes.

For handling the stone, or indeed for handling any lump material, a belt conveyor has proved to be by far the most satisfactory mechanical device. Its cost is very high, but it has great efficiency, and as all parts are visible and accessible at all times it is easily repaired, seldom getting out of order seriously or in a way which cannot be overhauled in the course of an hour or two. Properly installed the best types of belt conveyors will handle crushed stone up inclines as high as 25°. By means of movable trippers the material may be deposited at any point over large areas, or by means of fixed trippers it can be made to deposit at any one of a series of points.

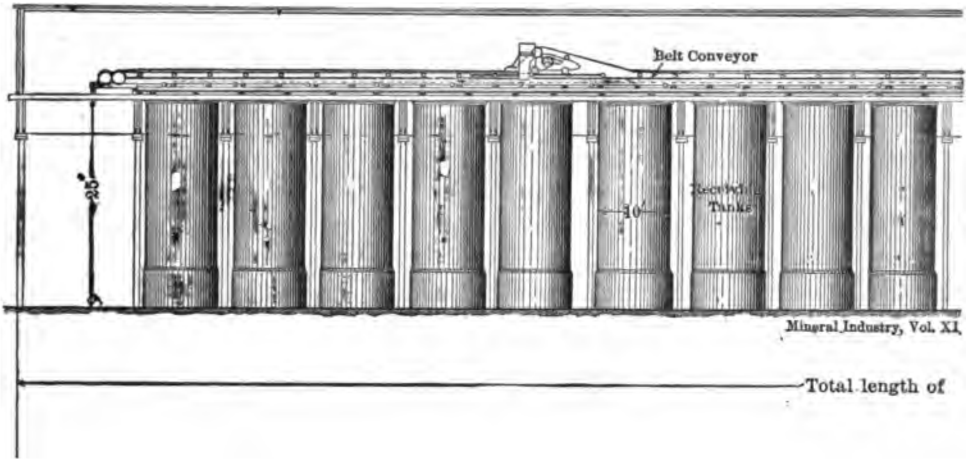
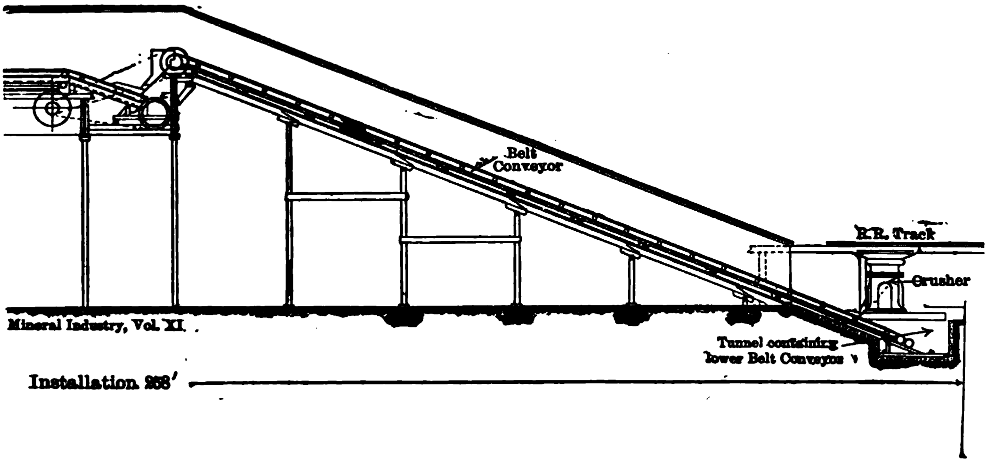


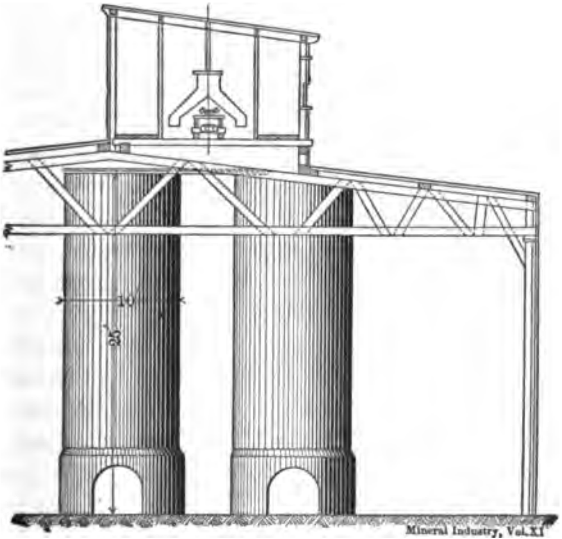
FIG. 3.—BELT CONVEYORS

For cement machinery it is necessary that all the moving parts should be thoroughly well constructed and of heavy type. The only difficulty which has been experienced with belt conveyors has been due to the use of light fixtures such as are used satisfactorily in handling grain. An equipment of this kind is poor economy. First class belt conveyors installed in place vary in cost from about $8 a running foot for narrow conveyors up to $25 or $30 for the large sizes, the average cost for a 14-in. conveyor being about $10 or $11, and for a 16-in. conveyor from $12 to $15 per linear foot measured between centers of head and tail pulleys. In the installation shown in Fig. 3 the overhead belt can either carry the material forward directly to dryers or deliver it to the storage tanks as shown on the drawing, or by means of suitable trippers a part can be carried forward to the dryers and the remainder discharged into storage tanks.

The installation of belt conveyors for handling stone in many cases has not been well considered. A belt conveyor necessarily wears much faster in the center than at the sides; hence a belt that is unnecessarily wide costs more to install, is too narrow receives the stone badly from the chutes and trippers, or requires such small chutes that they are liable to choke up. It is essential in every case to determine, first the size of belt absolutely necessary to carry the required quantity of stone, and then to make it wide enough to handle material of the size which is delivered to it without choking the chutes or spilling the stone at the point where it is received on the belt. A 12-in. belt will carry 40 tons of stone an hour, a 14-in. over 60 tons and a 16-in. belt will carry 75 tons or more an hour, and the larger belts proportionately larger tonnage. A 16-in. belt, therefore, is large enough to carry in 10 hours the stone required for a 10-kiln plant, and if this stone is crushed so that it will all pass a 3-in. ring it will be handled without and is worthless as soon as the center is worn out. On the other hand, a belt which



AND STONE HOUSE.



SECTION THROUGH STONE HOUSE.

FIG. 4.—CROSS SECTION (ENLARGED) OF STONE HOUSE.

difficulty at the chutes. On the other hand a 12-in. belt should not be used even for a small plant, unless the crushing is done to 2 in. or 2·5 in. size. The proper speed for belts carrying stone is from 300 to 400 linear feet per minute. At this speed, with properly adjusted chutes, the material will take the belt quietly and without rolling except when the quantity delivered is very small. The best form of chute is the wooden box made up of baffle plates discharging the stone with the motion of the belt. In all cases where trippers are used or where the material is discharged from one belt to another moving at right angles, a difference in height of 6 or 7 ft. should be provided for satisfactory chutes. Some excessively wide belts up to 24 and 30 in. in width have been used, but the necessity for such belts is not apparent, and they cannot be put in with any due regard for economy, either of first cost or of operation.

Grinding Raw Materials.—The old practice in grinding raw materials was almost entirely by the use of mill stones similar to those used in grinding grain. These stones were siliceous stones, largely the product of French quarries, and generally known as French buhr stones. Usually the material after crushing was still further reduced, either by means of rolls or smaller crushers. After passing through the buhr stones some system of separation became necessary, and a great variety of devices for this purpose were used. Of the different types of inclined screens some were simply screens set at an angle, others had a swinging motion imparted mechanically, others were revolving screens. A great variety of air separators was devised, and they are still on the market. It is an open question whether separators of this type could not be used to a greater extent in modern plants than they now are.

The method of grinding by buhr stones is expensive for several reasons. The dressing of the stones requires skilled mechanics, and has to be done frequently. Mills of this type are small units, yielding small output, and the grinding which is done by them is not as fine as that done by the later types of machines. On the whole, however, they were well adapted to the days when plants were small. Their cost was not great, the loss of one mill at any time was not serious since its output was small. It is evidently better with a small plant to have small units than to have large ones. The loss of one mill out of a dozen makes little difference in output, but if the grinding were all done in two units, the loss of one for repairs would cut down the output one-half.

The present practice in America runs along two lines. In one case the system of grinding by ball and pebble mills is adopted, and in the other some type of centrifugal mill like the Huntington or Griffin mills. By either of these systems the entire grinding can be done without auxiliary machinery; the ball mill will take quite large stone, and after passing the ball and pebble mills it will be reduced to fineness suitable for calcination. Similarly, mills of the Griffin type will take the product of a crusher and reduce it to the proper fineness without auxiliary machinery. Most of the earlier installations of these mills were made in this way. In later practice, however, considerable advantage has been derived by a system of gradual reduction. A ball mill will dispose of stone of any size that will pass the feed hopper. But it will grind a much larger output if the material delivered to it is reduced to a uniform size of 2·5 in. or less. It has been found that the Griffin mill practice can be very much improved by passing material through a roll crusher or through a pair of crushers in tandem with the separator between, and these are features of the present modern practice. It is a question whether considerable advantage could not be obtained by a separation at each stage of reduction, that is, after material passes the roll crusher and after it passes the ball or Griffin mills; but no extensive practice of this kind has yet been developed.

The first step in the reduction of raw materials is to dry them. The old buhr stone practice would handle damp materials or even wet materials satisfactorily. More modern mills will not do this, and it is necessary to dry them thoroughly in the stone house. The type of dryer which is almost universally employed is a revolving drum mounted on trunnions set at an inclination; the drum receives the stone at one end and discharges it at the other. The inclination of the dryer varies from 0·5 in. to 1 ft. to 1 in. to 1 ft., and a speed of from 2 to 15 r. p. m. In size these dryers vary from 4 ft. in diameter by 40 ft. long up to 6 ft. by 60 ft. long. Some styles of patented dryers have a diameter greater than 6 ft., with comparatively short length. Excluding the patented machines, the ordinary dryer is simply a steel cylinder with T irons riveted longitudinally at intervals of about 2 ft. around the periphery. These T irons act as buckets to carry the material up to the top of the dryers and discharge it through the hot gases coming from the furnace at the lower end. A later type of dryer is divided into four compartments by steel plates crossing through the center. One obvious advantage of this dryer is the fact that it balances better and requires less horse power to drive it than the other type. This is due to the fact that the material is distributed through four compartments instead of being carried largely on one side of the drum. Either of these dryers answers the purpose very well. An ordinary furnace is provided at the lower end with a flue bridge permitting the dried stone to fall out either at the back or at one side. A stack for taking off the spent gases is set at the upper end of the dryer. In the patented dryers sold by the Cummer Co. and Ruggles-Coles Co. the furnace is located at the upper end and the gases pass under the shell and return to a stack at the front end. both these dryers having induced draft by means of fans. With a dryer of sufficient size and length, running at slow speed, the ordinary type of dryer answers extremely well. The 4-ft. dryer 40 ft. long will easily dry enough raw material to make 40 bbl. of cement per hour and a 5-ft. diameter, 50-ft. dryer will easily handle the material for 60 bbl. (Illustrations of dryers are given on page 115.)

The more thorough the drying of material, the more readily it grinds in the modern type of mills. In either the Griffin or Huntington mills or in the ball and pebble mills, the tendency of all damp or wet material is to ball up, choke the screens and greatly impede the grinding. The difference in output between thoroughly dry material and material which is only slightly damp is quite considerable.

The ordinary method of feeding dryers is by means of a belt conveyor or a continuous bucket elevator, receiving material generally from a crusher charged by manual labor. This gives more or less intermittent feed, and a great improvement in drying and capacity is attained by running material to a suitable

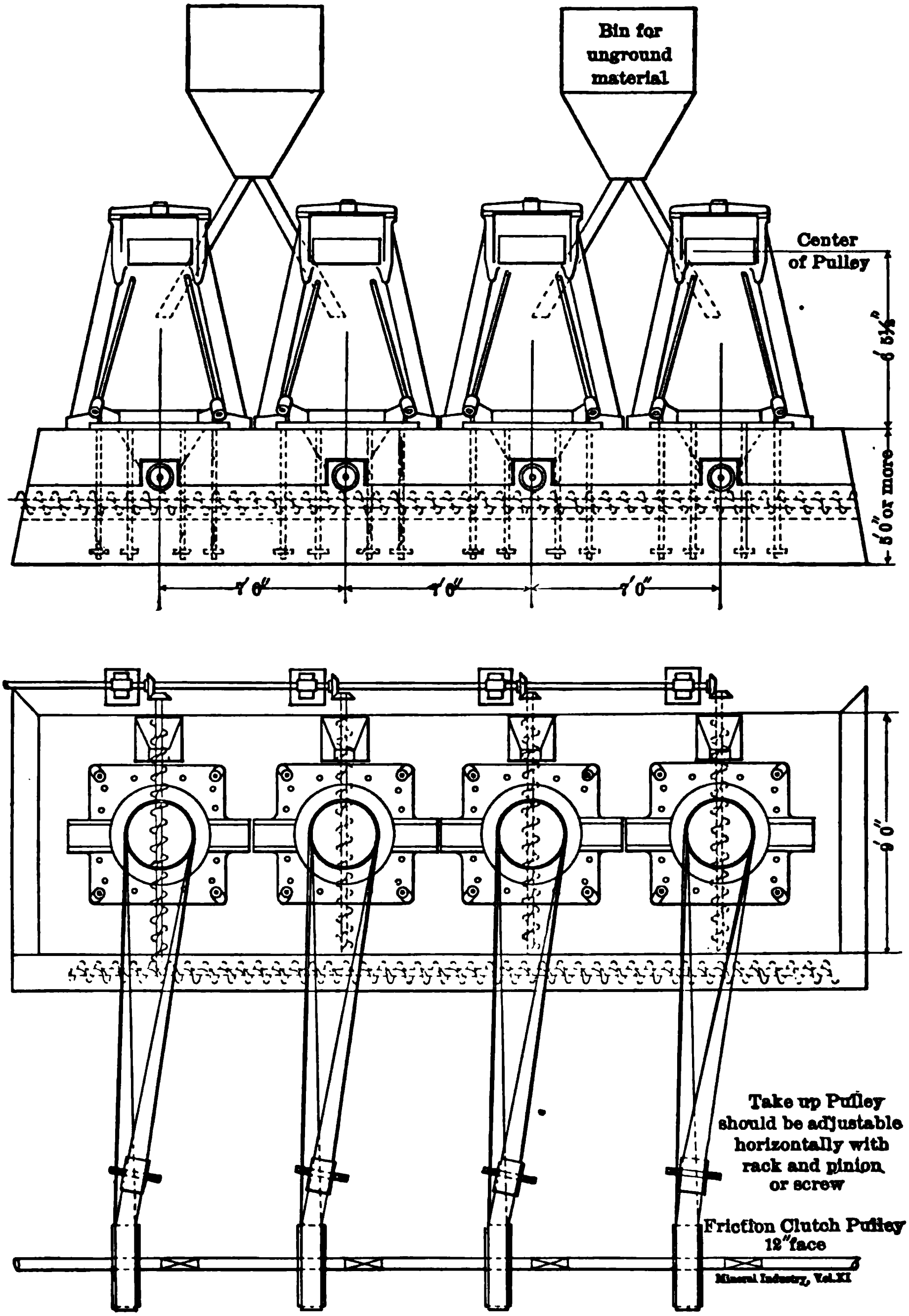
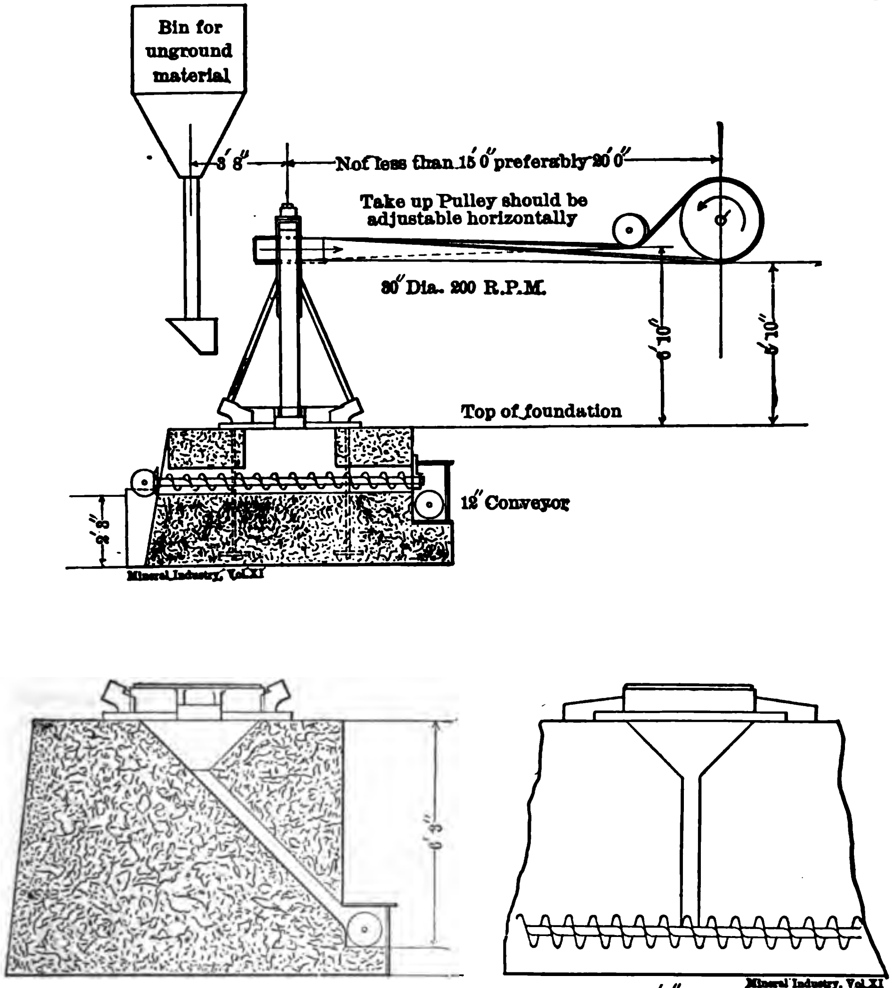


FIG. 5.—ARRANGEMENT OF GRIFFIN MILLS.

tank at the rear of the dryer and feeding it by some form of mechanical feed—either a percussion type or a revolving table under a spout—or by any simple mechanical means that can supply a uniform feed which can be varied at will. It ordinarily requires from 4 to 5 lb. of coal per barrel of cement to dry the stone.



If circumstances will permit the bottom of main conveyor to be 6' 8" below top of mill foundation, the cross conveyors may be omitted and the mills discharge directly into the main conveyor by inclined shutes, formed in the foundation, as shown above.

FIG. 6.—DETAILS OF GRIFFIN MILL.

Mill Layout.—In Figs. 5 and 6 is shown a typical Griffin mill installation in plan and elevation. These figures show the 30-in. mill driven at 200 r. p. m., fed from a suitable bin and discharging either to a conveyor directly under the mill or by gravity to a conveyor running in front of the entire battery. These mills are spaced 7 ft. from centers, making a very compact arrangement. The details of the mill itself are familiar to all readers of cement literature and need not be dwelt on here.

A new type of ball mill introduced two years ago and known as the Kominuter is illustrated in Fig. 7. This mill differs from the ordinary type of ball mill in having a peripheral discharge. The material is fed to it just as it is to a ball mill through a suitable nave adjacent to the shaft at one end of the mill. It can only get out of the mill, however, at the forward end through a series of openings in the periphery of the shell. This makes it necessary for the material to pass from one end of the mill to the other before it can reach the screens. In the regular type of ball mill, the material passes to the screens freely at all points of the periphery across the mill. The advantage gained by the Kominuter, due to this difference, is that with the same output the material will necessarily be finer ground. Passing out of the peripheral discharge of the Kominuter, the ground raw material falls upon an inner screen set at an angle with the mill and must return over this screen to the feed end of the mill, passing in this way over

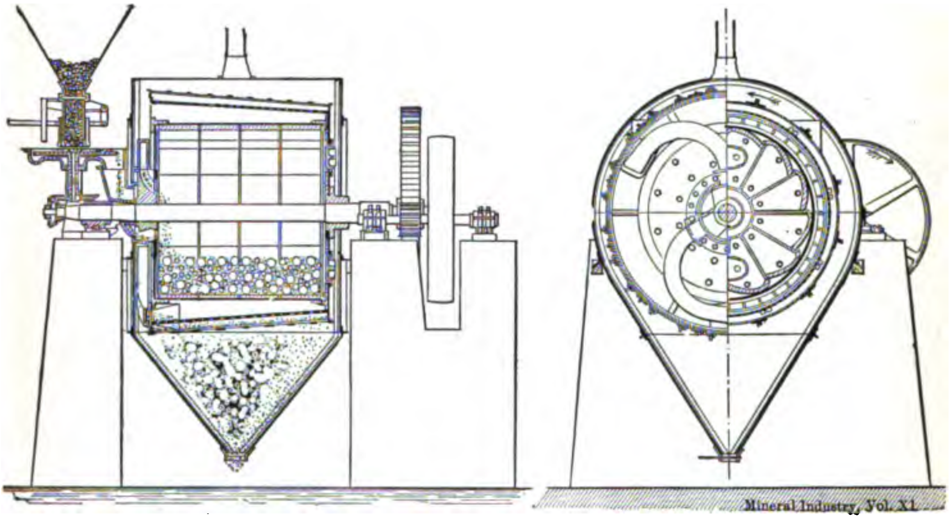

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FIG. 7.—KOMINUTER BALL MILL.

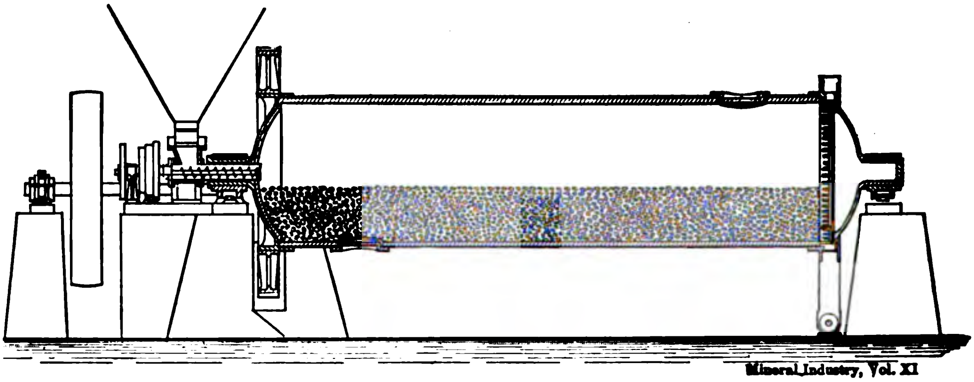
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FIG. 8.—TUBE MILL.

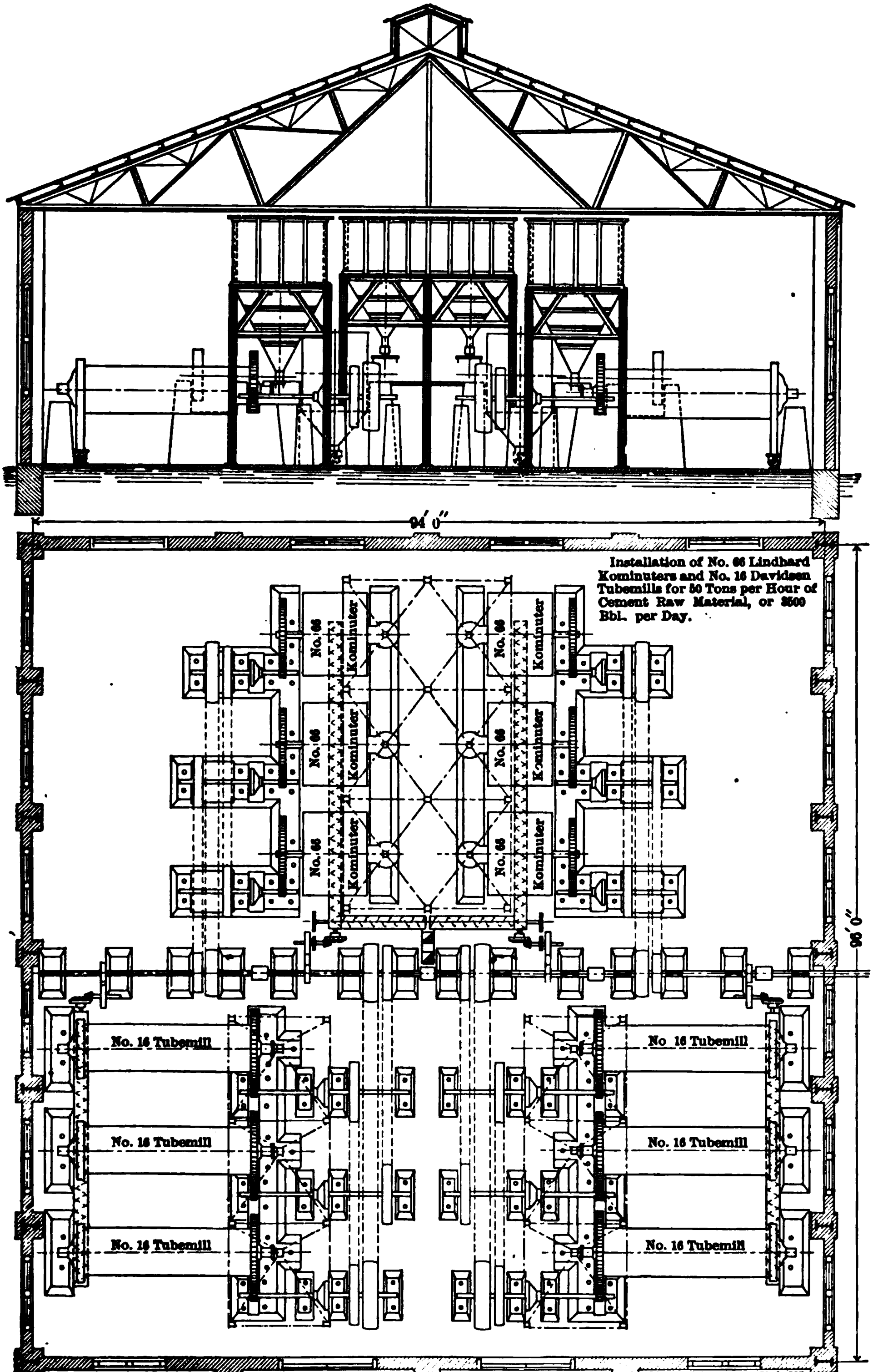

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FIG. 9.—PLAN AND VERTICAL SECTION OF A 50-TON PLANT FOR CRUSHING RAW MATERIALS.

the entire screen before the coarser particles are returned. The return arms are shown in Fig. 7. By means of these arms the material which the screens reject is returned to the mill at the same point where the original feed enters. Ordinarily the Kominuter is equipped with double screens and provided with three return arms. It can be arranged so that one of these return arms takes the tailings from the inner screens and two of them take the tailings from the outer screens, or vice versa. Or the inner screens can be entirely omitted and all three return arms used to return the tailings from the outer screens. A large number

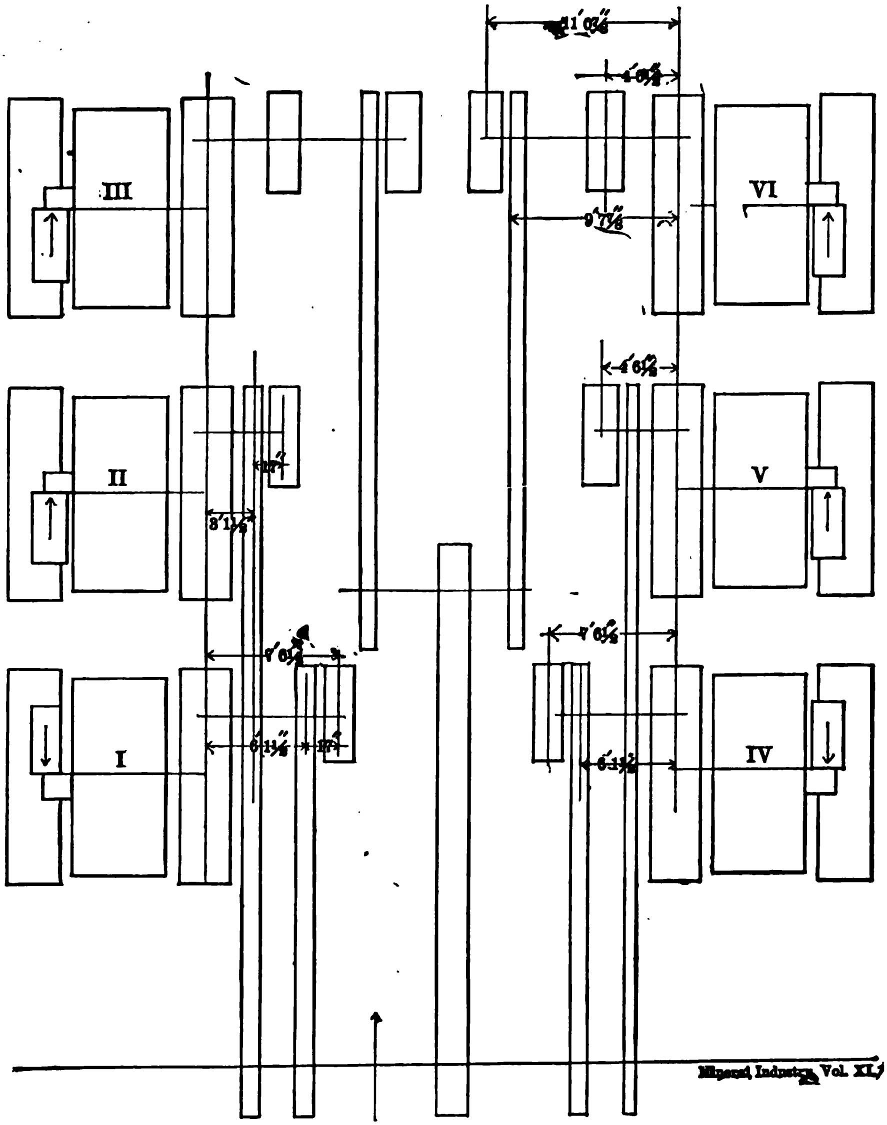

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FIG. 10.—ARRANGEMENT OF MODERN BALL AND PEBBLE MILL.

of these machines have been sold for cement plants within the last two years. As now built they are the largest mills of this character on the market, carrying 40 to 50% more balls than the largest type of regular ball mill.

In Fig. 8 is shown a section of the tube mill made by F. L. Smidth & Co., the same firm that manufactures the Kominuter. This particular tube mill also has a peripheral discharge. The principle of this mill, and, in fact, all of them, is simply the grinding of material by means of attrition with a large body of flint pebbles, reducing the material between the pebbles and in contact with the lining.

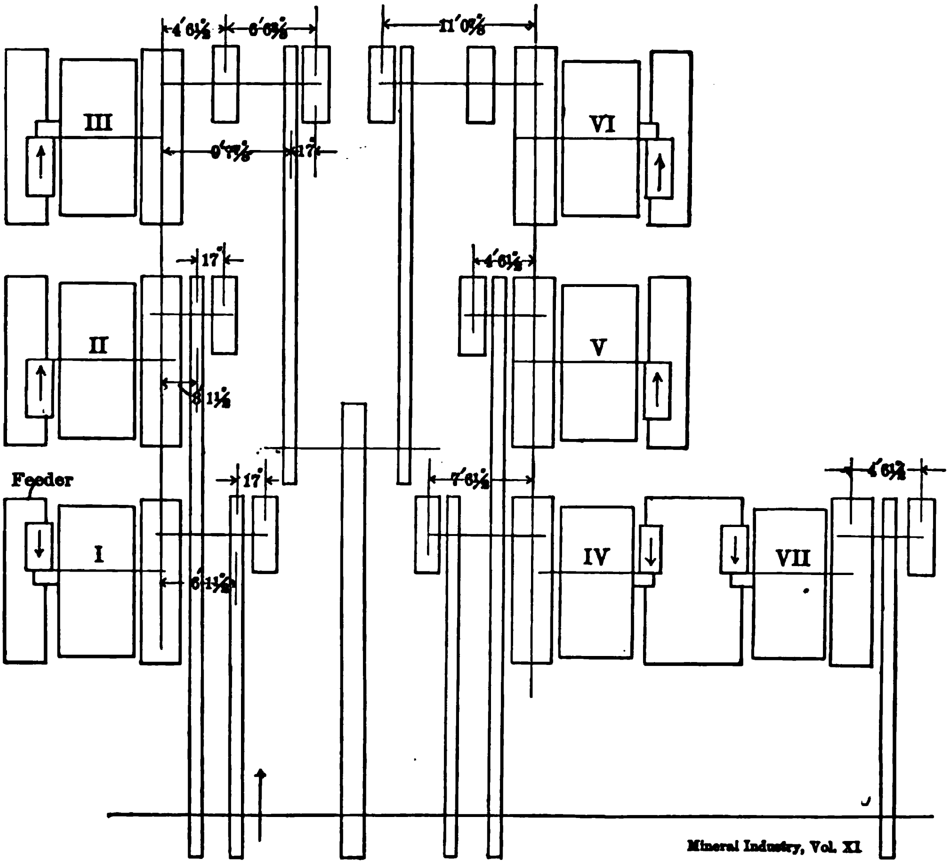

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FIG. 11.—ARRANGEMENT OF MODERN BALL AND PEBBLE MILL.

The pebbles are the well-known Iceland flint pebbles, and the lining is silex blocks cemented to the shell.

For simplicity of construction, ease of repairs, regularity and quality of output, the pebble mills commend themselves especially for the manufacture of Portland cement. Outside of the feed devices the mechanical parts are extremely few and a lining well put in will last from one to three years. It takes about 80 H. P. to drive a mill of this type which will yield ordinarily between 15 and 20 bbl. per hour either of raw material or clinker.

A complete installation of Kominuters and pebble mills with their feed boxes and the main conveyor systems to carry away the product is shown in Fig. 9. This plan shows a battery of six Kominuters making first reduction of material for a battery of six tube mills. In both batteries there are two large pulleys on the line shaft and two small ones. The middle and the long drive mills are driven direct from the line shaft, while the short drive mill is driven from the counter shaft of the long drive mill. All the pulleys on the line shaft are plain pulleys. Each mill shaft is provided with a clutch cut-off coupling making it possible to throw out any mill without shutting down the line shaft or disturbing operations in any of the other mills.

In Figs. 10 to 13 are shown typical layouts of ball and pebble mills as used in recent modern plants, with their drives from the line shaft of the mill. The illustrations do not require any detailed explanation.

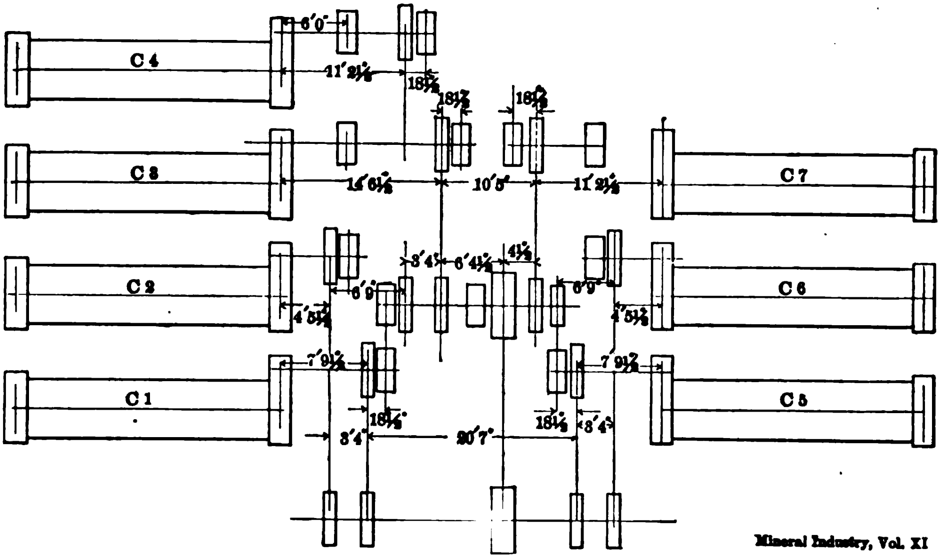

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FIG. 12.—ARRANGEMENT OF MODERN BALL AND PEBBLE MILL.

In all grinding of dry raw material, the finer the grinding the better the product. This is axiomatic, but it has a practical bearing from the fact that the finer the raw material is ground, the smaller the clinker and the easier it is to grind. There is a practicable limit to all things, however, and it is found that a fineness of 80% passing through a 200-mesh sieve will give an entirely satisfactory products in both respects, that is, the cement will be homogeneous, and the clinker will be small and readily ground.

Kiln Practice.—For dry materials two types of kilns are used. One the cylindrical kiln of uniform diameter, the other, the taper kiln reduced in diameter at the chimney end. The general arrangement of the second type is shown in Figs. 14 and 15. This kiln has a diameter of 60 in. at the chimney end and 66 in. at the discharge end and a length of 60 ft. It is supported on trunnions on two points, is turned by a train of gears, uses powdered coal and cools the clinker by an air blast in a suitable cooler. The inclination of the kiln is 0·75 in. to 1 ft. It may be regarded as a standard kiln for dry raw materials. A large number of kilns having the same general arrangement are in use in the Lehigh Valley in Pennsylvania. The arrangement in plan is shown in Fig. 14, which illustrates a group of four kilns. The cylindrical kiln, which has met with most favor, is 72 in. outside diameter, 60 ft. long, supported at two points on trunnions and is revolved by a train of gears. This kiln is more readily lined than the other kiln and seems to give about as satisfactory results, but theoretically the taper kiln should give greater fuel economy. A cylindrical kiln in plan and elevation is shown in Figs. 16 and 17.

Kilns both longer and shorter than the kilns described have been used. Within recent years new kilns have been built having a length of 45 ft., and in a new plant erected in New Jersey, kilns 10 ft. in diameter by 130 ft. long have been put up. The advantages in yield, however, are not apparent. With the short kiln the economy of coal must be lacking, since it is necessary to maintain a very high heat in order to make the clinker in the limited length. With a very large unit such as a 10-ft. kiln 130 ft. long, mentioned above, the length is unnecessarily great, requiring an unnecessary amount of power to drive the kiln and the unit is too large in any case except, perhaps, in a plant of extraordinary size.

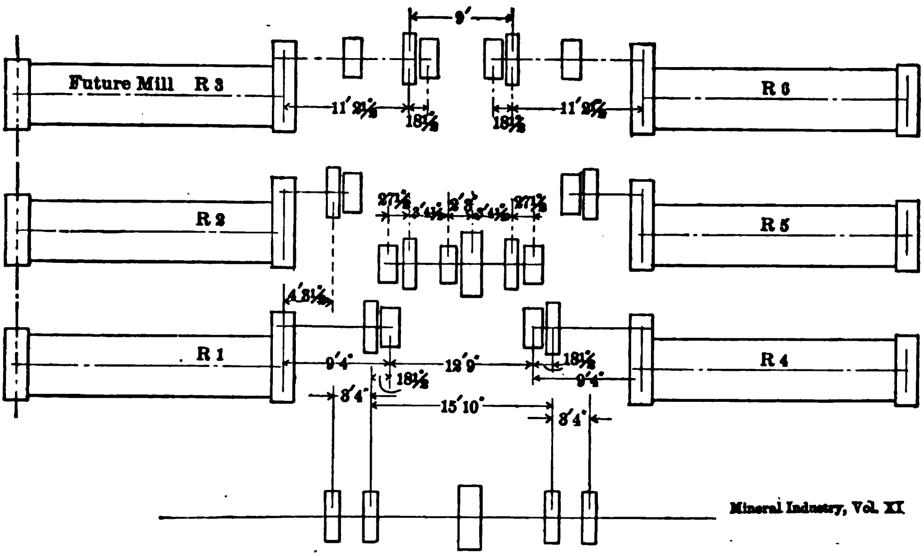

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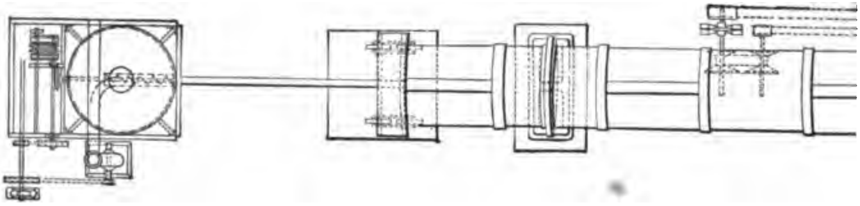
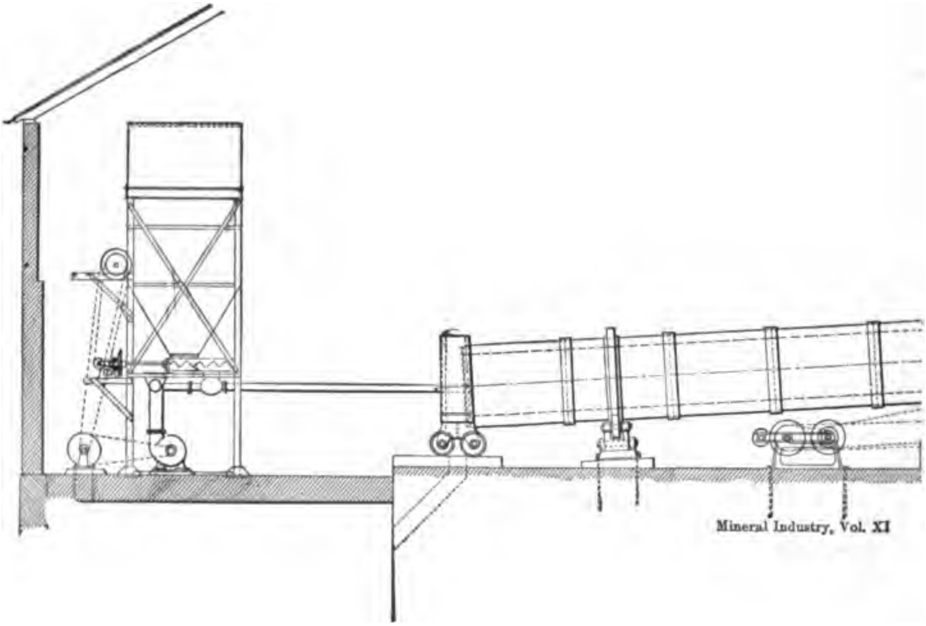
FIG. 13.—ARRANGEMENT OF MODERN BALL AND PEBBLE MILL.

In the standard kilns burning powdered coal the consumption of coal per barrel of cement is variously given by different parties from 80 lb. of coal per barrel of cement up to 140 lb., a fair mean performance being about 110 lb. The finer the coal is ground, the more effective it is in the kilns, and in general the larger





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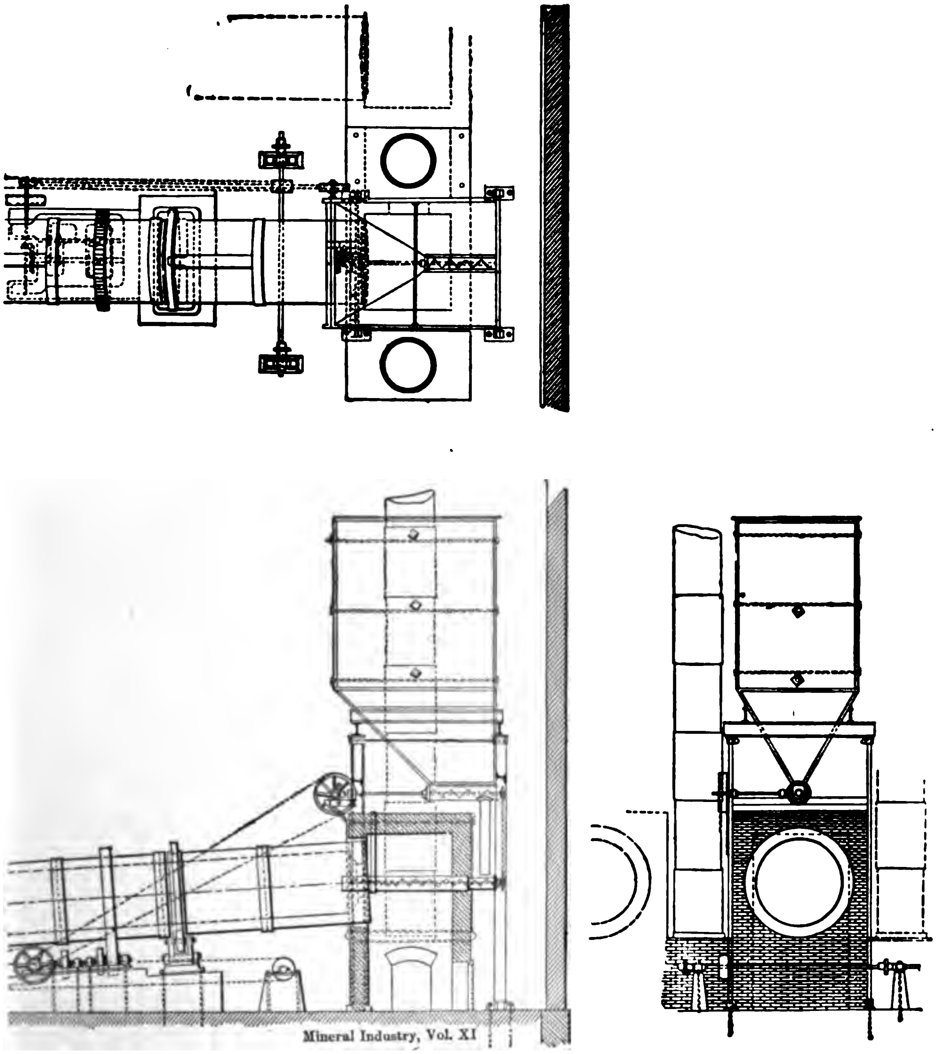
FIGS. 16 AND 17.—CYLINDRICAL



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KILN (PLAN AND ELEVATION).

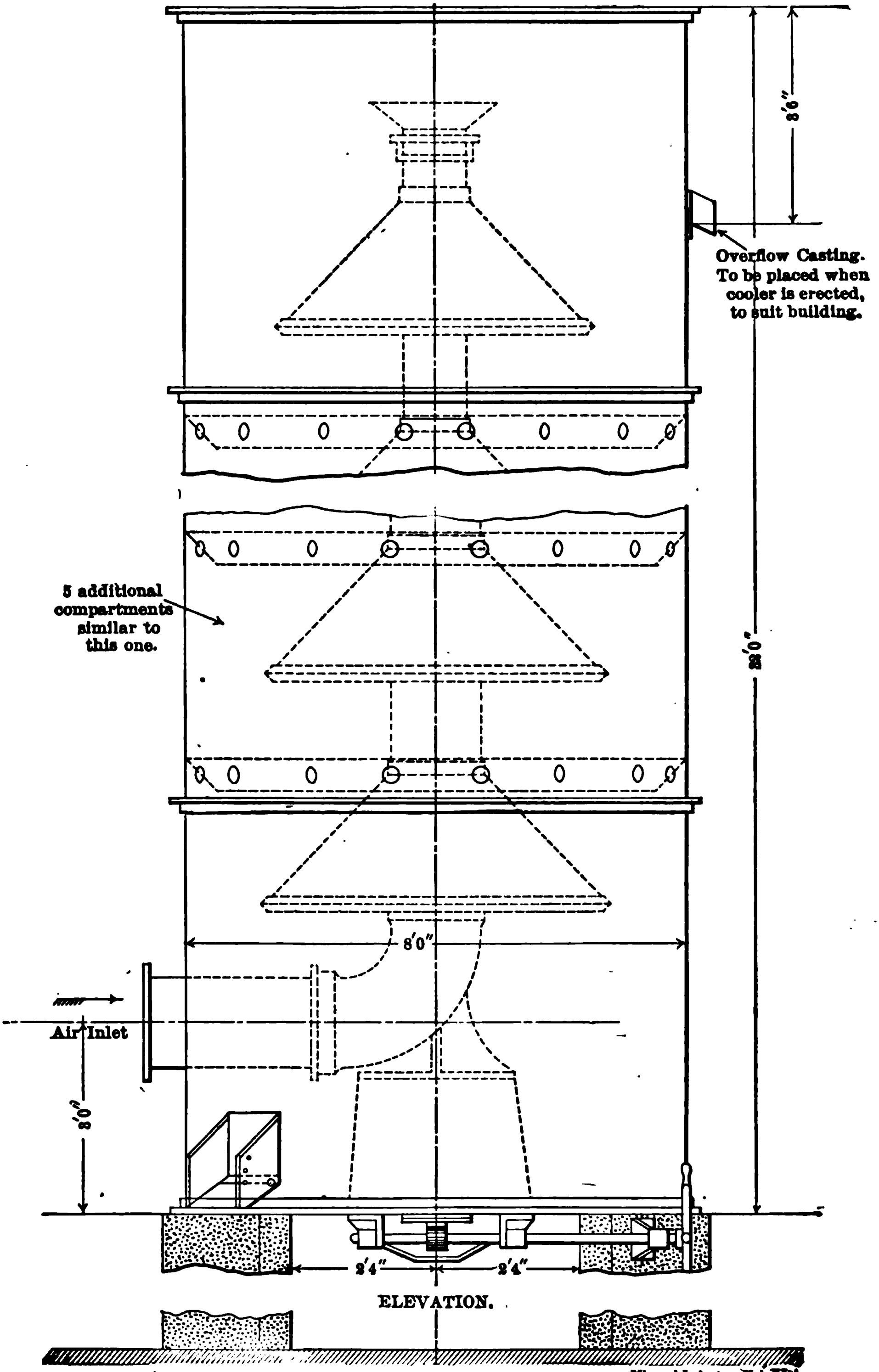

FIG. 18.—CLINKER COOLER.

the output the smaller the coal consumption. A 6-ft. kiln will yield in cement from 7 to 10 bbl. of clinker per hour, 8·5 bbl. being a very good average performance.

The most difficult problem in rotary kiln practice has been the handling of the clinker. A great variety of devices have been experimented with for this purpose. In nearly all plants it is customary now to wet the clinker by a water spray to reduce the temperature, and to complete the cooling by means of an air blast blown through the clinker in a suitably constructed tower. In Figs. 18 and 19 is shown a clinker cooler tower of this type. By referring to Fig. 14 a tower of this kind will be seen as a part of the general arrangement of the kiln building. A bucket elevator carries the hot clinker to the top of the clinker cooler tower. In the tower the height of the clinker is maintained up to or above the top of the air blast pipe. The air in the pipe is discharged under the mantles shown in Fig. 19, and passes freely to the clinker between the mantles and the shell of the tower. The hot clinker deposited at the top of the tower is discharged at the bottom, and all of it must thus pass from the top to the bottom with a continuous blast of air passing through it. A cooler tower such as is shown in the illustration will readily cool 500 bbl. per day of water-sprayed clinker to 97°F. or below. It is probably the most effective and most satisfactory device which has been used for this purpose. The tower has a suitable overflow at the top so that the hot clinker can be carried to some suitable point in case the cooler is overcharged. The material at the bottom can either be drawn from side outlets or from bottom outlets discharging on a belt conveyor.

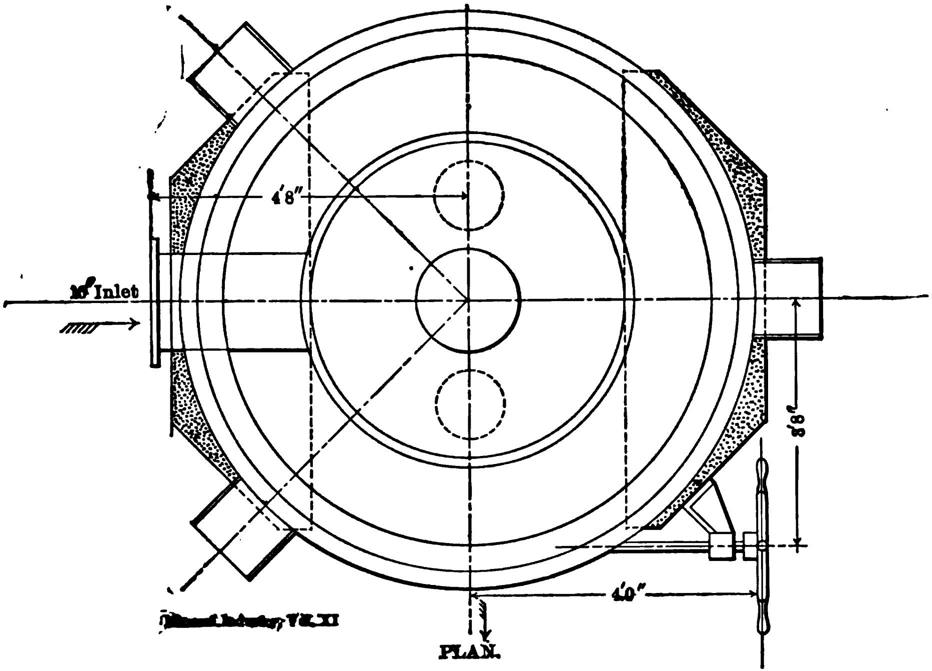

FIG. 19.—CLINKER COOLER.

A tower of this description will cool the clinker so that it can be readily and safely handled and ground. The fact has developed incidentally, however, that clinker which has been thoroughly cooled during a period of from 1 to 10 days grinds much more readily than the clinker discharged from a cooler at 97°F. within 6 or 8 hours after it has left the kilns. This fact has developed by reason of the occasional necessity for accumulating clinker due to the breakdowns in clinker mills, or for any reason which has made it impracticable to grind the clinker at once. In several recent plants, therefore, advantage is being taken of this fact, and, instead of running the clinker direct from the coolers to the mill, it is carried first to a suitable building where it can be stored and seasoned. It is found that clinker treated in this way will grind from 20 to 50% more rapidly in ball and pebble mills than fresh clinker. If this claim is established. it will evidently justify large expenditures for clinker storage facilities. The cost of the clinker storage building might be even greater than the cost of the mills required to grind the hard, fresh clinker, but as it would take very little power to operate a clinker storage building as compared with a large amount of power to operate mills, the clinker storage system more than justifies itself. Hard burnt, fresh clinker will often scratch glass, and is extremely hard to break up. Well sprayed with water and stored for some days it breaks up very readily, and has lost a good deal of the sharp cutting quality of fresh clinker.

Wet Raw Materials.—The handling, grinding and burning of wet raw materials differs in many important particulars from similar operations with dry raw materials. After passing the kilns, however, the processes are essentially the same and can be treated under one heading. For this reason the present article deals briefly with wet raw materials under the present heading up to the time they are clinkered.

It cannot be said that any practice has been established in the handling of wet raw materials. The reason for this arises from the great diversity in the character of these wet raw materials. In some cases the lime and clay rocks are both soft, homogeneous materials, free from sand, shells or any hard particles. Such conditions are, however, comparatively rare in this country, the majority of the wet raw materials containing either shells, sand or some form of gritty material which must be reduced as well as mixed. In the first case a simple mixture is required which can be accomplished in some form of wash mill or tank in which the two materials can be stirred together in the presence of a proper quantity of water. In the other cases it is necessary to do more or less wet grinding. Owing to the presence of the water, this wet grinding is difficult to accomplish. An ordinary pebble mill will not do it because the pebbles lose so much in gravity by being immersed in water. Steel balls have been substituted for pebbles with a satisfactory result. In each particular case, however, the problem has to be solved to suit the materials. The aim of all plants manufacturing Portland cement from wet raw materials is to get them into a homogeneous mixture, finely ground, and with a minimum of water.

Undoubtedly, when materials can be brought to a finely divided state. and to an intimate mixture in the presence of water, no better mix of Portland cement could be desired. But the practical difficulties of doing this, with a very large proportion of the raw materials available, are considerable, and in several recent plants the effort has been made to use wet materials by the dry way. This, of course, makes expensive drying, but as the fuel costs in the kilns is greatly reduced, and the yield considerably increased the proposition has these points in its favor. A wet mix will ordinarily contain 60 to 65% of water, which means that 1,500 to 1,600 lb. of material must be introduced into the kiln to yield 380 lb. of clinker. This constitutes the great disadvantage of the wet way for the rotary kiln practice. Evidently the lower the percentage of water the less the fuel consumed in the kilns and the larger the kiln output, so that no effort has been spared to devise means of keeping the percentage of water as low as possible. It is claimed that it has been successfully reduced to 40%, but this statement does not seem to be well established.

Operating entirely by the wet way the most successful recent results in rotary kilns have been obtained by increasing the length of the kilns. A kiln 60 ft. long, using dry raw materials will readily produce 200 bbl. of clinker per day with a fuel consumption of 120 lb. per barrel. Operating on wet raw materials perhaps 100 bbl. per day with a fuel consumption exceeding 200 lb. of coal per bbl. In later construction, however, kilns using wet materials have been extended to 100 and even to 110 ft. in length with excellent results. It is claimed that the output has been increased to 150 bbl. per day for a 6-ft. kiln and sometimes more, and the fuel consumption has been reduced 33%. In the rotary kiln installations in Germany in recent years, the practice has all followed these lines. The kilns have been 24 to 32 m. in length with a diameter of 2 m. The resultant economy claimed is very considerable.

Grinding Clinker.—Clinker grinding in American practice follows the same lines as the grinding of raw materials. The reduction is performed either by some form of centrifugal mill with auxiliary crushing machinery ahead of it or by ball and pebble mills in battery. In either case the output per grinding unit is about the same as on raw materials, but the wear and tear on machinery is much greater. The attrition of fresh burnt clinker on either wearing or bearing surfaces is almost equal to emery. Girder plates of ball mills, linings of pebble mills, gudgeons of conveyors and other wearing parts last only from one-third to one-half as long as similar parts in raw material mills. Hence for repairs and renewals it is necessary to have more spare mills and more repair parts in stock. As indicated above in discussing kiln practice, these conditions, however, are considerably ameliorated when seasoned clinker can be used. Portland cement, whether in powder or in clinker, is a sensitive chemical compound, reacting with moisture or water to form new and more stable compounds. The effect of water on clinker is necessarily much less than on cement in powder as it is superficial. But as the clinker is porous and spongy, the water and moisture do attack surfaces throughout the mass, and in the course of a week or more the clinker becomes brittle and friable and loses much of its sharp cutting qualities. The result of such treatment is therefore much to the advantage of clinker mills both in output and repairs. Under any conditions clinker grinding is difficult and expensive, perhaps the most difficult and the most expensive reduction required in any manufacturing process. The tendency of recent specifications has been to increase steadily the expense of this feature of cement manufacturing. The standard fineness for Portland cement was formerly 95% passing a 50-mesh sieve or 85% passing a 100-mesh sieve. This represents good practice abroad to-day. But in American specifications the tendency has been to push these requirements for fineness up to 90%, 92%, and even in a few instances to 95% passing a 100-mesh sieve. The practical advantages of this excessive fineness are not apparent, while the increased cost of manufacturing both in power, equipment required and repairs are considerable. It is true that the material rejected by a 50-mesh screen is probably inert, and so is a part of that rejected by the 100-mesh. But as it has been repeatedly demonstrated that 35% or 40% of absolutely inert material such as sand, ragstone, cinders or limestone can be ground with cement with comparatively small effect to its strength or its capacity to carry sand in mortars, the argument for excessive fineness is weak. In speed it is the last knot, or the last mile per hour which costs in power, and a limit may be reached which can only be surpassed at a cost which is prohibitive. Precisely the same thing occurs in grinding. The difference in output between a mill grinding 88% fine, and one grinding 95% fine is often 100%. And for any specification requiring over 90% fine it becomes necessary for the manufacturer to consider carefully ways and means of accomplishing the result. The readiest expedient is to raise the percentage of lime in the cement. The higher the content of lime in a cement mix the more refractory it is in the kiln. A high lime clinker is, therefore, softer, less vitrified, less "clinkered," in fact, than a lower lime clinker, and it is in consequence more readily ground. Within limits such clinker produces satisfactory cement for most purposes. Yet while each increase in the content of lime renders the clinker so much easier to grind, it must be borne in mind that the cement is so much higher in tensile strength, so much slower in set, so much nearer the limit where unsoundness may be manifested sooner or later.

Mechanical separation, either by screens or by air, suggests itself as a remedy, but it seems to be a fact that rotary kiln clinker does not lend itself readily to such treatment. At all events no considerable practice has developed along these lines, and cement grinding is for the most part simple mechanical reduction, as here indicated.

Coal Grinding.—Coal for cement kilns must be gas coal having over 30% volatile matter. The high grade steam coals with low volatile matter and high percentage of fixed carbon do not ignite readily enough and burn too far back in the kiln. It is claimed that a homogeneous mixture of gas coal and steam coal will give good results, and this is quite possible. The portion of gas coal igniting freely should burn the steam coal with it, and perhaps even with advantage over gas coal alone. The point is, however, that the presence of high-grade gas coal is always dangerous, as it is subject to spontaneous combustion. By slow oxidation it gradually becomes heated until it smoulders or bursts into flames. In a finely powdered condition this tendency is much more marked than in the lump coal. Spontaneous combustion results very readily, and more or less fire in the coal mill and storage tanks is to be expected, must be provided for and the necessary precautions must always be in evidence to handle the coal without danger. These precautions are based on one important fact, namely, that while combustion is readily started in powdered coal, flame or explosion requires free access of air. When suspended as dust in air either in a building or in a tank, powdered coal can explode with results similar to dynamite. When in a stream blown into the air, a spark will cause it to burst into flame, or if air is blown into the smouldering mass, flame will quickly result and perhaps explosion. Without free access of air powdered coal only smoulders, and is not an object of danger.

The necessary precautions to be taken in handling powdered coal may be stated as follows: 1. No torch, lantern, arc light or electric motor should ever be allowed in the coal mill when in operation. 2. From the time grinding begins until the powdered coal is fed to the kilns it should always be kept from free access of air. Elevator legs, conveyors and tanks should be closed in metal boxes. 3. In feeding the kilns the minimum quantity of air required to carry the coal should be used, and the blast device should put no back pressure of air upon storage tanks. With these precautions flame or explosion should be impossible, and the smouldering fires which will occur can be readily subdued.

As in handling raw materials, coal must first be dried, and for this purpose a special dryer is required. The patented Cummer dryer shown in Fig. 20, answers very well. A type of dryer which has been much used is shown in Fig. 21. This dryer is a revolving steel shell, and the products of combustion from the furnace pass under the shell and return around it. The discharge end of the dryer is either left open or can be hooded. Owing to the inflammable nature of the material in the dryer, it is desirable to have at hand a bag of common salt and several packages of sodium carbonate. These compounds thrown on the fire will generate gases which will smother flames.

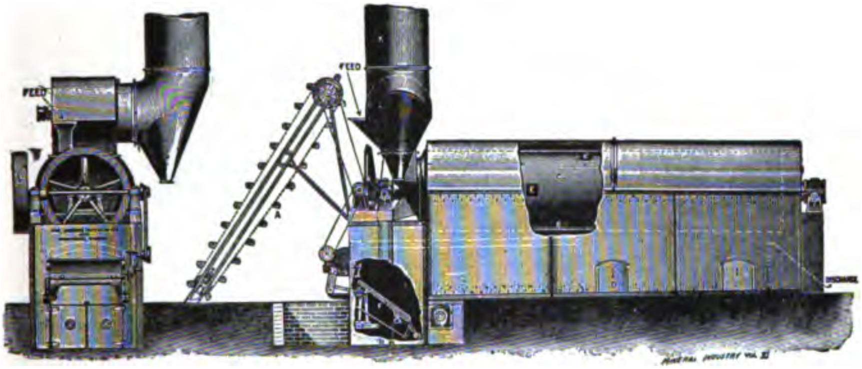

FIG. 20.—CUMMER DRYER.

The first step in grinding is usually to break the lumps by a toothed roll cracker, then reduce it further by roll crusher, and finish in Griffin or pebble mills. A ball mill with coarse screens or with outer screens omitted can be used in place of a roll crusher, and has large capacity. A general plan of the machinery used in the coal grinding building is shown in Fig. 22.

It follows from what has been said concerning the inflammability of coal, that no method of wind separation should be used. It provides exactly the conditions most favorable to explosion. A disastrous explosion of this kind occurred in

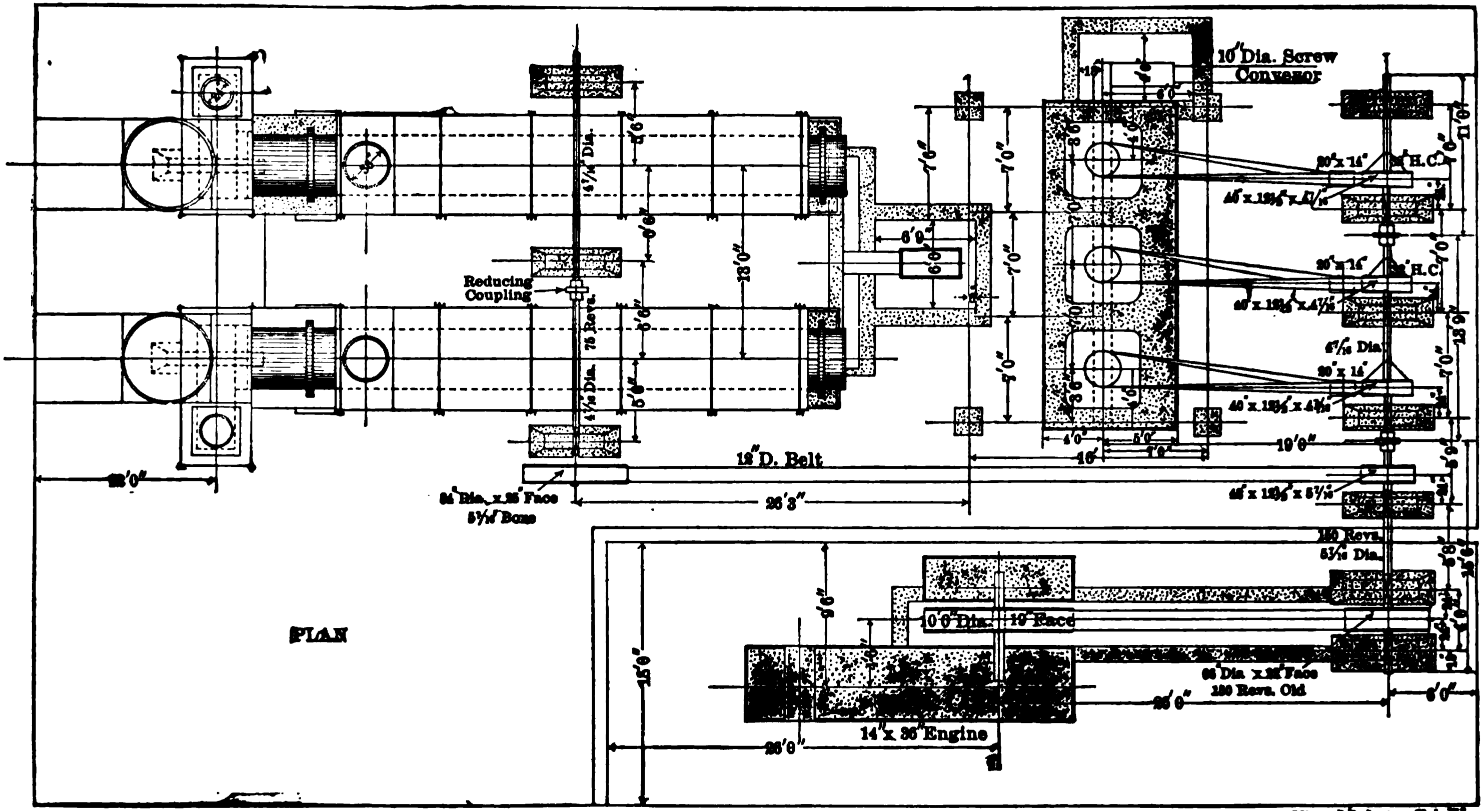

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FIG. 22.—GENERAL PLAN OF MACHINERY IN COAL GRINDING BUILDING.

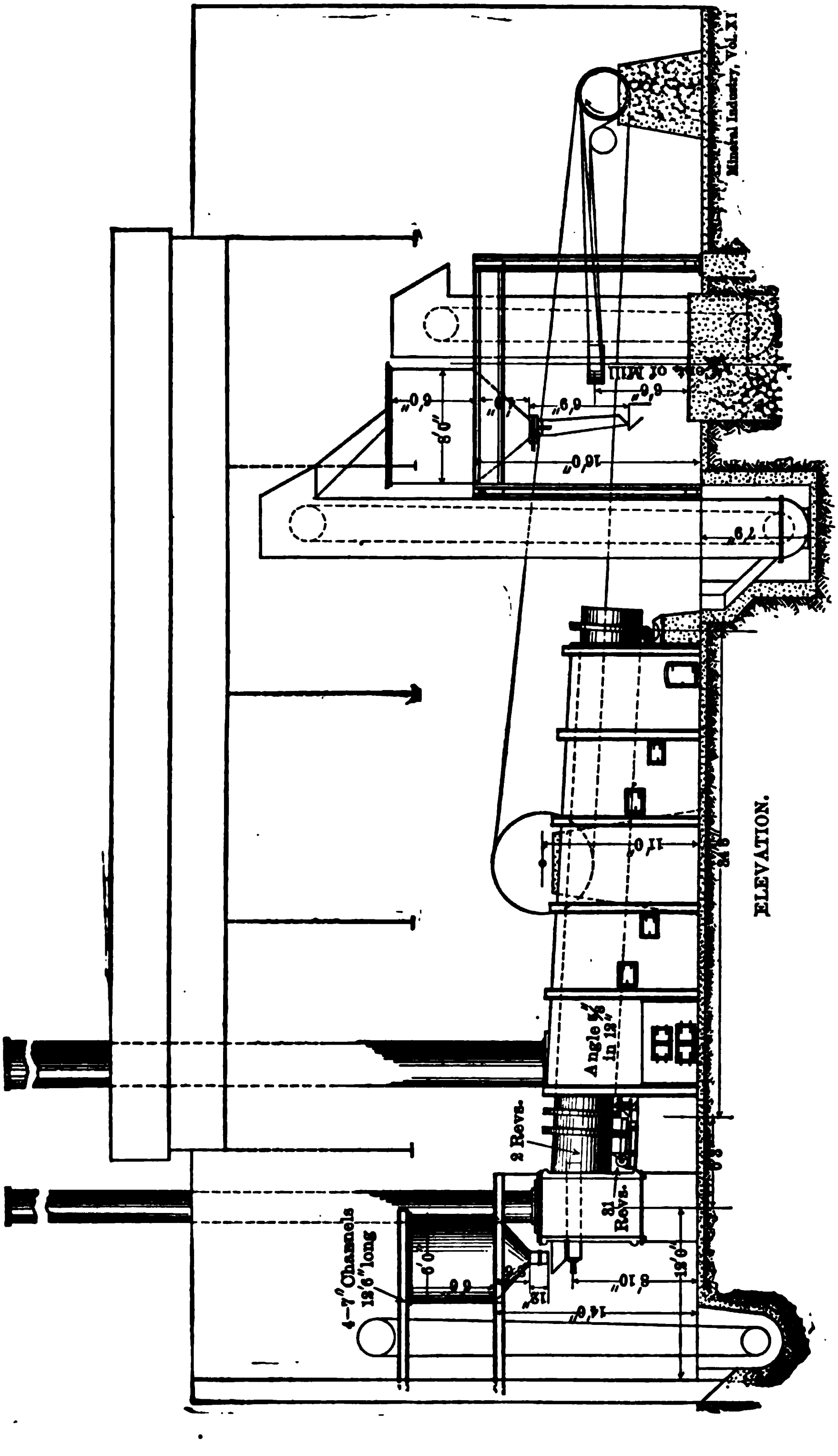

FIG. 23.—SIDE ELEVATION OF MACHINERY IN COAL GRINDING BUILDING.

1903 at a plant in New Jersey where a system of air separation had been installed.

Packing and Shipping.—When ground from clinker which is entirely cold, cement powder on leaving the mills has a temperature between 125° and 150°F. The increase above normal atmospheric temperature is due entirely to the friction of the grinding process. If the clinker is not cold, the cement powder leaves the mills at still higher temperatures. The problem of storing cement in bulk so as to remove this heat has received a great deal of attention with very small results. If it could be accomplished a considerable advantage to the product would result. Cement in bulk undoubtedly does season and cool somewhat, but in masses of 1,000 bbl. and upward the process is slow. The best opinion, therefore, favors seasoning the clinker, rather than the cement, and this feature is receiving the most attention.

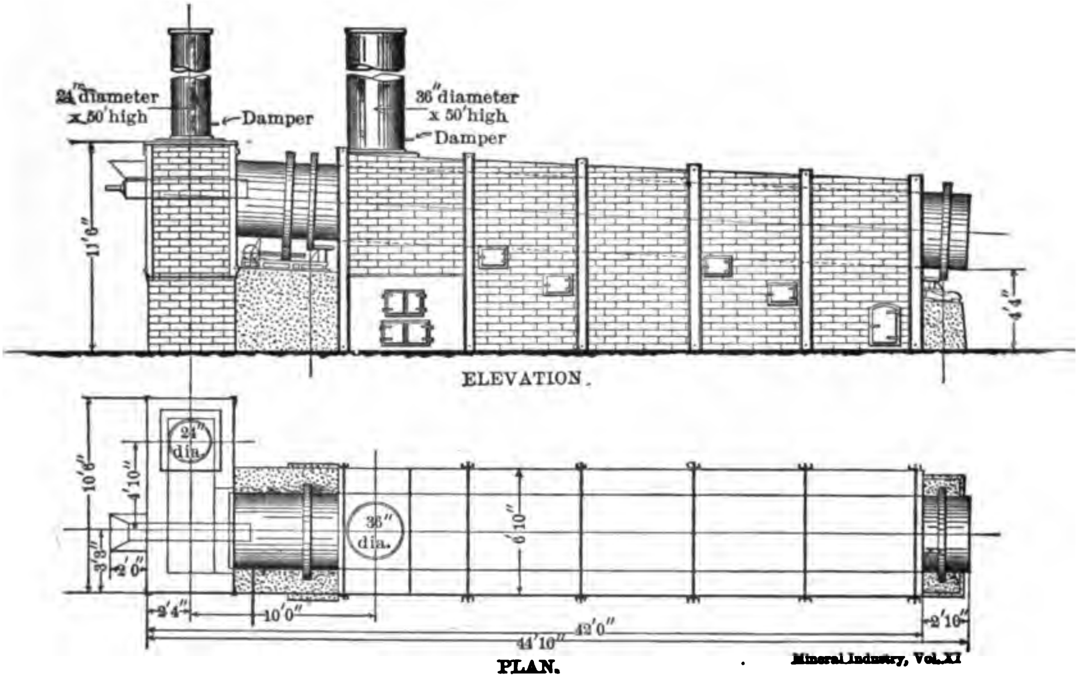

FIG. 21.—COAL DRYER.

The heat of the cement, its avidity for water and its weight prove destructive to barrels, and no material is harder on this kind of package. The present standard cement barrel has 28·5 in. cylinder, sawed staves 0·4375 ($\frac{7}{16}$) in. thick sawed with 0·625 ($\frac{5}{8}$) in. bilge. The head is 16 in. in diameter and 0·5 in. thick. Eight elm hoops are usually used, though for heavy service two more hoops are added of metal or elm. Such a barrel weighs from 20 to 24 lb.

The ordinary cement stock house is a hot and dusty place. Barrel packing is done mechanically by a variety of machines, all on the principle of a revolving nave pressing the cement into place as it issues from the bin. Bag packing, which is by far the largest in amount, is done by a spout from a bin. The spout is equipped with a suitable slide, and the bags set on a pair of sculls.

A variety of automatic bag packing machines are on the market. Their value is not yet proven nor have mechanical means for handling the cement in bins found much favor. Different types of tunnels, cross conveyors, self-emptying tanks, etc., have been worked out on paper, but the cement stock house to-day is almost everywhere a cellular system of bins, each holding from 1,000 to 2,000 bbl. of cement. Packing rooms are located at the center, at the ends or at both points and conveyors in the floor of passages or aisles along the front of the bins carry the cement from bins to packing rooms. Shovels, hoes and wheelbarrows are the implements used to get the cement from the bins into the conveyors. The reason that cement is not handled here mechanically is that the increased cost of a stock house thus equipped is not justified by the saving effected in handling. The first cost of extensive conveyor systems with tunnels, etc., is great, and the repairs and renewals are a serious item.

In conclusion it may be said that American practice has dealt fairly well with the problems encountered between the quarries and the stock house. Between the point of origin and the point of shipment, large output and a minimum of labor are the rule, which features are the essential ones for success in any manufacture under American conditions. It is possible that quarry and stock house work may later be successfully developed along the same lines. In the meantime it may be conceded that no industry could grow twenty fold in eight years without a correct method, nor could an industry advance in this short time from comparative insignificance to the first place among the nations of the world without genius to guide its development.

CHROMIUM AND CHROME ORE.

By Joseph Struthers and Henry Fisher.

The output of domestic chrome ore in the United States is but a small fraction of the total consumption, the great bulk of which is supplied from Turkey. While chromite occurs in California and North Carolina, the combined cost of mining, treatment and transportation to Eastern chemical works is greater than the cost of the ore abroad plus the ocean freight to the seaboard works, and as there is no duty on the ore, the development of the mines in the United States is necessarily hindered. During 1902 the chrome ore mines in California contributed the entire domestic output of 315 long tons, valued at $4,725, as compared with 498 long tons, valued at $7,740 in 1901. The value of chrome ore varies with the content of Cr_2O_3 and silica. The standard ore is 50% Cr_2O_3, and the price is increased from 75c. to $1 per long ton for every unit of Cr_2O_3 above 50. While no fixed premium or penalty is given for the silica content, ores containing small quantities of this component command higher prices. The average price of the domestic chrome ore sold during 1902 averaged $15 per long ton. The imports of chrome ore during 1902 amounted to 39,570 long tons, valued at $582,597, as compared with 20,112 long tons, valued at $363,108 in 1901.

Despite the increased use of ferrotitanium and ferrotungsten for purposes previously filled by ferrochromium, the production of the last-named alloy showed no decrease during 1902 as compared with 1901, the Willson Aluminum Co., with mills at Kanawha Falls, W. Va., and Holcombs Rock, Va., reporting an output of 1,200 long tons of ferrochromium for each year. There has been no radical change in the technology of chrome ore and chromium compounds during the past year (details of which are given in The Mineral Industry, Vols. IX. and X.), although the use of chrome-steel rails is noteworthy. The Pennsylvania Railroad is experimenting with chrome-steel rails at a portion of the road subjected to the extreme service of heavy trains and sharp curves. The alloy used in the manufacture of the rails consists of Cr 50% and Ti 7%, and the percentage of chromium in the finished rail is said to be within the limits of 0·75% and 1%. The Baltimore Chrome Works has been reported sold for $1,000,000 to the Kalion Chemical Co., of Philadelphia. This company supplies the greater part of the potassium chromate and bichromate salts used in tanning and dyeing in the United States, its output being manufactured from ore imported from Turkey.

PRODUCTION, IMPORTS AND CONSUMPTION OF CHROME ORE IN THE UNITED STATES.

Year.	Production.			Imports.			Consumption.	
	Quantity. Long Tons.	Value Per Ton.	Value.	Quantity. Long Tons.	Value Per Ton.	Value.	Quantity. Long Tons.	Value.
1898..........	100	$10·00	$1,000	16,304	$16·70	$272,234	16,404	$273,234
1899..........	100	10·00	1,000	15,798	18·03	284,825	15,898	285,825
1900..........	*Nil.*	*Nil.*	*Nil.*	17,542	17·39	305,001	17,542	305,001
1901..........	498	15·54	7,740	20,112	18·05	363,108	20,480	368,898
1902..........	315	15·00	4,725	39,570	14·73	583,597	39,885	587,322

California.—The production of chrome ore in California during 1902 was 315 long tons, valued at the mine at $4,725, as compared with 498 long tons ($7,740) in 1901. In both years the material was sold in the crude condition. The entire output during 1902 was derived from the Shotgun Creek mine at Sims, Shasta County. Other chrome ore mines are: Evans & Dougherty, Dunsmuir, Siskiyou County; Black Diamond, Glenn County; San Luis Chrome Concentrating Works, San Luis Obispo County; Tehama Consolidated Chrome Co., Tehama County; Mendenhall, Alameda County; and the San Francisco and San Joaquin Coal Co. The Shotgun Creek is favorably located adjacent to the railroad; the other mines were inoperative during 1902 as the additional cost of haulage to the railroads did not admit of profitable working.

THE WORLD'S PRODUCTION OF CHROME ORE. (*a*) (IN METRIC TONS.)

Year.	Bosnia.	Canada.	Greece.	New Caledonia (*b*)	New-found-land.	New South Wales.	Norway.	Russia.	Turkey. (*b*)	United States.
1897......	396	2,893	563	9,054	3,084	3,433	*Nil.*	13,483	11,551	152
1898......	458	1,833	1,367	14,300	657	2,145	*Nil.*	15,467	(*c*)	102
1899......	200	1,796	4,386	12,480	717	5,327	41	19,146	*d* 4,538	102
1900......	100	2,118	5,600	10,474	*Nil.*	3,338	165	(*c*)	*e* 9,749	*Nil.*
1901......	(*c*)	1,159	4,580	17,451	*Nil.*	2,523	(*c*)	(*c*)	*f* 40,972	506

(*a*) From the official statistics of the respective countries, except for the United States, which are our own (*b*) Exports. (*c*) Statistics not yet published. (*d*) Exports from Salonica and Smyrna. (*e*) Exports from Salonica and Kossovo. (*f*) Exports from European and Asiatic provinces.

Canada.—The production of chrome ore during 1902—reported as exports during that year—amounted to 816 metric tons, valued at $12,400, as compared with 1,159 metric tons, valued at $16,744 during 1901. The deposits of chrome ore in Coleraine, Province of Quebec, continue to furnish most of the product, one small mine being worked for crude ore, and another for supplying a concentrating mill. According to Mr. J. Obalski, 900 long tons of high-grade material, valued at $13,500, were shipped, of which 550 tons were in lumps and 350 tons in concentrated form. A reorganization of the two companies owning concentrating mills has taken place. The success of the Wilfley table has led to its adoption in preference to jigs. The usual jigging or other gravity method of separation has been combined with magnetic concentration which has resulted in raising the quantity of chromium oxide in the concentrates several per cent. above the results obtained from either process alone, and as 50% Cr_2O_3 is in most cases the critical commercial point, the extra expense of the combined method of treatment will doubtless be more than offset by the increased values obtained. There was no production of chrome ore in Newfoundland during 1901. A quantity of 83 tons of ferrochromium was shipped from Buckingham, where this product is manufactured.

Greece.—The production of chrome ore in Greece in 1902 amounted to 11,680 metric tons, valued at $140,160, as compared with 4,580 metric tons, valued at $47,770 in 1901. The chrome ore exported from the magnesia district in 1902 amounted to 10,750 tons, valued at $40,310, as compared with 4,750 tons, valued at $16,310 in 1901.

New Caledonia.—The production of chrome ore in 1902 was 10,281 metric tons (value not stated), as compared with 17,451 metric tons, valued at $189,200 in 1901. At Baige N'go where the greater bulk of the New Caledonian chrome ore has been mined of late years, some of the mines have been closed on account of the poorness of the ore, and the production of the remaining mines has been considerably reduced. One or two mines have been opened recently at Nehoue in the Gomen district on the northwest coast, from which good results are expected. A combination of chrome interests among important chrome mine owners is projected, and should it take place an increased output of this ore may be expected in the near future. The mines in question are far in the interior, and the cost of transportation is large. Two French mining companies owning about 40,000 hectares (1 hectare=2·471 acres) have combined to form the Société de Chrome, capitalized at 3,800,000 fr. The company is developing three mines, one in the South Bay, the second in Plum, and the third on Mt. Thiébaghi. The ores contain from 50 to 56% Cr_2O_3. The deposit at Thiébaghi is leased to another company, which contracts to mine a minimum of 10,000 tons, and to pay a royalty of 15 fr. per ton. The mines on the South Bay are said to be especially rich. A railroad is projected to connect the South Bay with the best port of New Caledonia. A large quantity of ore has already been obtained from the Plum mine, and when the necessary arrangements have been made, it will undoubtedly continue to yield a large output. Unsorted chrome ore is worth from 45 to 50 fr. per ton at the mine, and from 54 to 56 fr. at the port of Noumea. A premium of 2·5 fr. per ton is allowed for each unit of Cr_2O_3 above 50%.

New South Wales.—The exports of chrome ore from New South Wales during 1902 were valued at £1,740, a large decrease when compared with 2,483 long tons, valued at £7,774 in 1901; almost the entire output was mined at Gobarralong. At the chromite deposit at Bowling Alley Point in the Nundle division, the ore occurs in pockets in serpentine and is similar in characteristics to the Gundagai ore. A few tons which were assayed at Sydney were reported to contain 47% Cr_2O_3. The great distance of the deposit from the railway rendered the profitable treatment of the ore very uncertain, although if a proper method of ore concentration were installed the deposit might be operated successfully.

New Zealand.—The exports of chrome ore produced by the miners near Croixelles Harbor, during 1900 amounted to 28 tons, valued at $550; there was no production in 1901.

Norway.—The most important deposits of chromium ore are at Röros, but during 1901 the mines suffered from a strike which lasted from March until the close of the year.

Turkey.—The exports of chrome ore from Turkey from March 14, 1901, to March 13, 1902 (Turkish year 1317), were 38,752 tons, as compared with 40,972 tons for the previous year. Of this total the European provinces Salonica, Kossovo, and Monastir produced 11,650 tons, and the Asia Minor provinces Aidin, Konia, Adana, Angora, Broussa, and Daghardi produced 27,102 tons. The principal ore deposits are near Salonica, Broussa and Macri. A rich deposit which has not been exploited exists at Denislie, the ore assaying 56% Cr_2O_3. The Broussa mines have been developed recently, most of the output being shipped to the United States. The Daghardi mine, which has a yearly output of from 12,000 to 15,000 tons of from 51 to 55% chrome ore, exports about two-thirds of its output to the United Kingdom, the balance being divided about equally between America and Germany. The entire output of the Cozbelen mine is exported to the United Kingdom. There are three chrome mines in the Province of Broussa, the Anteram, Cozlondja, and Miran, which together produce from 6,000 to 7,000 tons of ore annually. The concessions from these three mines, as well as the Cozbelen and Bozbelen mine, are held by the English firm of Paterson & Co., at Smyrna. The Bozbelen mine exports about 1,500 tons of ore yearly. The Turkish Government taxes chrome ore 20% and imposes a customs charge of 1%. The total cost at the coast is $8·75 for Macri ore, and $11·74 for Broussa ore. For the past two years the Government has granted no new mining concessions, and permits the shipment of only 2,000 tons of ore from a new mine; when this quantity of ore has been mined a new permit to continue working must be obtained.

TECHNOLOGY.

For notes on methods of analysis and former German practice in the manufacture of ferrochromium and chrome steel, and alloys of chromium with iron and steel, reference should be made to THE MINERAL INDUSTRY, Vols VIII., IX., and X.

Composition of Metallic Chromium.—The specimens of chromium prepared by the alumino-thermic method when examined by T. Doring[1] gave the following analyses:—

Chromium.	Iron.	Aluminum.	Silicon.
%	%	%	%
97·41	1·88	0·16	0·73
97·95	1·00	0·12	0·69
93·67	1·90	0·21	0·86

These samples, containing also varying quantities of Mn, S, As, P, and Cr_2O_3, were soluble in concentrated HCl with evolution of hydrogen, also in dilute acid when the solution was heated, the action being most rapid with the sample containing the largest quantity of impurities. The $CrCl_2$ first produced was changed to $CrCl_3$, the reaction being complete when the temperature of the

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[1] *Journal fuer praktische Chemie*, 66, 14 and 15, 1902.

solution reached 20°C., but was incomplete at 100°C. This change is due to the catalytic action of SiO_2, produced by the solution of the silicon contained in the chromium, in the presence of HCl, and does not take place when the acid is absent.

Duty on Ferrochrome.—According to a decision of the Board of General Appraisers ferrochromium is dutiable at the rate of $4 per ton by its similitude to ferromanganese, and is not dutiable as a metal unwrought.

Chrome Solutions for Tanning Leather.—Chromium compounds[2] for tanning leather were used as early as 1856, but early experiments were not successful as the tannage was not permanent. The discovery of sodium thiosulphate to make the tanning permanent was due to W. Zahn who patented his process in the United States on June 28, 1888. The process consists in dipping the skin in a solution of a chromium salt, acidified with HCl, and then into a solution of $Na_2S_2O_3$ or $NaHSO_3$ acidified with HCl or H_2SO_4. For tanning 100 lb. of skin, 4 to 5 lb. $K_2Cr_2O_7$, 2·5 to 4·5 lb. HCl, 8 to 10 lb. $Na_2S_2O_3$ and 0 to 1·5 lb. H_2SO_4 are required. A number of electric processes for tanning skins with chromium salts have been patented in the United States.

The Use of Hydrazine Sulphate in Analytical Methods.—W. Herz[3] recommends the use of hydrazine sulphate in the estimation of chromates. On adding an excess of solid hydrazine sulphate and gently warming, the chromate is reduced in a few minutes, and on the addition of ammonia the chromium is precipitated as chromium hydrate.

The Allgemeine Thermitgesellschaft at Essen, using the Goldschmidt process, manufactures carbon-free chromium containing from 98 to 99% Cr, which is utilized in steel works to make hardened tool steel, of a chromium content amounting to from 5 to 7%; occasionally tungsten also is added. Carbon-free chromium is extensively used also for making chrome steel of a smaller chromium content to be utilized chiefly in the manufacture of cannon, locomotive bolts and rivets.

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[2] Twelfth Census of the United States, 1900, Vol. X., Part IV., p. 588.

[3] *Berichte*, 35, 4, 949.

CLAY.

The production of clay products in the United States during 1901 increased considerably over the output of the preceding year, the aggregate value being $87,747,727, as compared with $78,704,678 in 1900. The value of the output in 1902 probably showed little, if any, gain, although complete statistics are not available at this time. The chief cause of the increased output in 1901 was the great prosperity in the building trades, which was reflected in the very large increase in the production of building brick. The drain tile trade, however, suffered materially from the drought in the central West. At the beginning of the season the demand was so great that almost a brick famine resulted in many places, manufacturers frequently being compelled to refuse further orders. Despite the increased demand for bricks lower prices ruled, which resulted ultimately to the benefit of the trade, as thereby considerable competition was prevented, both for the present and for the future. The number of firms reporting brick and tile products during 1901 was 5,887.

The production of clay and clay materials in the United States is summarized in the following table, which is compiled from statistics collected by the United States Geological Survey:—

PRODUCTION OF BRICK AND CLAY WARES IN 1900 AND 1901.

Kind.	1900.			1901.		
	No. of M.	Value.	Per M.	No. of M.	Value.	Per M.
Common brick	7,500,868	$39,195,918	$5·23	8,088,579	$45,508,066	
Front brick	455,771	4,601,686	10·09	415,448	4,799,787	
Fire brick (*a*)	372,885	5,823,268	15·64		9,870,421	
Paving and vitrified brick	724,870	6,508,442	8·97		5,494,184	
Other clay building material (*b*)		5,530,369		(*f*)		
Sewer pipe and drain tile		*e* 8,550,000			6,786,969	
Crude clay, stoneware and misc. man'f'res (*c*)		*e* 8,500,000			15,443,890	
Totals		$78,704,678			$87,747,727	

(*a*) Not including silica brick. (*b*) Including terra cotta lumber, hollow building tile or blocks, roofing tile, floor tile and all other clay building material. (*c*) Including the value of common stoneware and various miscellaneous clay manufactures and crude clay used in pottery, for laying fire brick, in paper making, as burnt clay railway ballast, for the manufacture of gas retorts, glass pots, zinc retorts, etc. (*e*) Estimated. (*f*) Included under crude clay, etc.

The collection of these statistics is attended with many difficulties. In no other branch of the mineral industry except that of stone is the number of producers so large and so widely distributed. Most of them operate on a small scale, and as but little outlay of time and capital is required to open a brickyard,

PRODUCTION OF BRICK AND CLAY BUILDING MATERIAL IN THE UNITED STATES IN 1900. (IN THOUSANDS.)

States.	Building Brick. Common.		Building Brick. Front.		Fire Brick. Alumina.		Paving Brick.		Other Clay Building Material.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Value.
Alabama	50,700	$294,060	....	....	e 6,760	$141,960	....	....	e $1,000
Arizona (e)	10,000	70,000	125	$1,750	....	....	....	....	....
Arkansas	45,000	281,250	e 5,000	55,000	....	....	....	....	....
California (e)	130,000	650,000	3,000	60,000	....	....	....	....	....
Colorado	42,520	245,960	21,296	222,818	2,092	35,563	1,338	$13,381	734
Connecticut	141,381	709,408	7,000	63,000	....	....	....	....	65,000
Delaware	13,650	87,019	2,625	26,250	....	....	....	....	....
Dist. of Columbia	90,000	760,000	3,150	56,400	....	....	....	....	....
Florida	35,120	210,000	....	....	....	....	....	....	....
Georgia	199,043	977,960	4,874	58,469	e 2,200	26,400	4,861	17,043	e 65,000
Idaho	18,107	129,804	....	....	....	....	....	....	....
Illinois	476,350	2,581,817	17,008	87,856	9,519	81,078	190,156	1,639,191	784,743
Indiana	392,320	2,126,374	15,123	133,351	3,762	37,622	65,921	602,321	e 350,000
Indian Territory	4,000	20,000	500	5,000	....	....	....	....	....
Iowa	244,804	1,494,893	11,409	101,287	206	2,361	30,002	220,455	60,526
Kansas (e)	50,000	300,000	8,000	60,000	700	6,300	30,000	240,000	....
Kentucky	128,641	666,456	6,500	39,000	28,000	290,000	3,000	18,000	130,000
Louisiana	114,285	838,915	9,600	76,800	....	....	5,000	30,000	5,000
Maine	115,000	618,700	2,325	18,800	....	....	150	1,200	....
Maryland	233,517	1,451,479	9,614	204,791	6,495	101,888	144	1,299	60,000
Massachusetts	305,415	1,578,478	75,850	918,700	6,000	95,000	....	....	75,000
Michigan	204,081	960,254	3,858	26,758	....	....	4,000	36,000	e 3,000
Minnesota	211,623	1,074,715	9,234	92,525	114	2,286	....	....	31,544
Mississippi	48,164	263,110	712	5,435	....	....	5,176	31,059	....
Missouri	225,000	867,500	20,000	125,000	14,594	179,607	24,721	197,903	e 300,000
Montana	43,013	240,444	78	1,163	2,000	50,000	350	15,000	....
Nebraska	108,512	648,227	3,810	30,476	....	....	5,714	40,524	....
New Hampshire	63,484	335,273	6,490	67,850	1,180	23,600	944	8,496	....
New Jersey	355,047	1,485,028	35,000	600,000	30,000	600,000	300	3,000	e 2,000,000
New Mexico	2,000	14,000	1,300	10,400	250	2,500	....	....	....
New York	1,120,000	4,849,600	30,000	240,000	e 20,000	400,000	35,000	420,000	650,000
North Carolina	102,060	516,537	206	2,057	57	1,143	100	800	1,500
North Dakota	42,196	257,550	1,083	11,875	350	6,300	1,500	35,000	300
Ohio	522,949	3,082,783	66,359	129,896	105,779	2,114,582	e 200,000	1,800,000	e 375,000
Oklahoma	12,581	84,279	....	....	....	....	....	....	....
Oregon	14,732	104,539	183	5,238	5	84	....	....	....
Pennsylvania	797,681	5,246,237	61,998	663,946	100,774	1,606,218	68,887	589,881	e 500,000
Rhode Island (e)	40,000	210,000	1,500	13,500	....	....	5,000	45,000	15,000
South Carolina	142,837	652,781	904	9,047	e 600	6,000	500	2,500	....
South Dakota	16,286	131,571	157	5,143	....	....	150	1,500	....
Tennessee	126,768	650,963	3,048	30,479	48	481	e 12,000	170,000	e 2,000
Texas	141,340	833,032	5,799	63,143	500	7,500	2,767	24,800	....
Utah	40,903	227,645	5,607	60,587	....	....	....	....	....
Vermont	42,257	194,827	14,571	65,571	....	....	....	....	....
Virginia	77,398	430,017	1,290	15,382	....	....	1,346	12,789	e 45,000
Washington	61,234	471,682	3,400	68,000	....	....	350	6,300	....
West Virginia	23,012	116,417	1,750	21,000	e 400	4,800	e 25,000	220,000	e 5,000
Wisconsin	122,727	755,794	4,460	33,630	....	....	....	....	....
Wyoming	e 300	2,700	....	....	....	....	....	....	....
Totals	7,500,868	$39,196,913	455,771	$4,601,686	372,385	$5,828,263	724,870	$6,508,442	$5,580,369

its abandonment is of no serious consideration. The list of producers consequently is subject to continuous revision. A further difficulty arises from the fact that some concerns do not keep any records of their work, and are therefore not in position to furnish accurate reports.

The production of brick and clay building material by States in 1900 and 1901 is presented in the above tables, in which the columns "common brick" include only the ordinary red brick that is used generally in building. Under "front brick" we have grouped pressed brick of all colors. Under "fire brick," however, only what is properly termed alumina brick is included. Such silica brick as Dinas brick, which is also properly called "fire brick" or "refractory brick," being omitted, because it is not a clay product. "Other clay material" includes fancy or ornamental and enameled brick, roofing tile, terra cotta, terra cotta lumber, floor tile, hollow building blocks, etc. All the clay material other

PRODUCTION OF BRICK AND CLAY BUILDING MATERIAL IN THE UNITED STATES IN 1901. (IN THOUSANDS.)

States.	Building Brick. Common.		Building Brick. Front.		Fire Brick. Alumina.	Paving Brick.	Sewer Pipe.	Other Clay Building Material.	Total Value.
	Quantity.	Value.	Quantity.	Value.	Value.	Value.	Value.	Value. (*e*)	
	Thous.		Thous.						
Alabama	128,914	$742,691	795	$6,990	$132,783	(*a*)	....	*f* $1,800	$928,429
Arizona	13,533	92,986	....	....	....	....	....	....	92,986
Arkansas	56,501	368,359	1,205	11,570	13,580	(*a*)	....	*f* 950	395,858
California	146,522	943,250	3,787	86,425	87,665	(*a*)	$285,599	*f* 279,692	1,735,721
Colorado	116,160	760,867	16,563	196,147	292,269	(*a*)	(*a*)	*f* 170,965	1,568,167
Connecticut and Rhode Island	160,606	822,079	(*a*)	(*a*)	(*a*)	....	....	*f* 109,500	1,039,709
Delaware	15,963	126,092	(*a*)	(*a*)	....	....	....	(*f*)	131,164
Dist. of Columbia	23,175	179,184	(*a*)	(*a*)	....	....	95,000	*f* 134,652	311,129
Florida	32,253	185,759	(*a*)	(*a*)	....	....	(*a*)	3,015	190,674
Georgia	222,111	1,182,553	5,325	55,700	35,000	(*a*)	151,500	*f* 85,460	1,527,853
Idaho	8,391	66,514	(*a*)	(*a*)	....	....	....	*f* 272	68,328
Illinois	930,561	5,188,654	19,241	204,980	212,510	$899,454	348,716	*f* 2,040,851	8,960,041
Indiana	315,966	1,624,133	27,293	234,775	51,526	320,221	253,626	1,400,402	3,935,083
Indian Territory	17,603	110,774	(*a*)	(*a*)	(*a*)	....	....	....	117,224
Iowa	249,318	1,611,040	8,785	88,164	1,810	241,108	54,500	714,583	2,711,305
Kansas	108,365	555,928	5,495	50,340	(*a*)	312,994	(*a*)	*f* 43,300	981,020
Kentucky	115,977	621,756	2,486	16,535	377,741	(*a*)	100,705	*f* 29,498	1,374,846
Louisiana	94,981	560,375	(*a*)	(*a*)	....	....	....	*f* 27,220	612,595
Maine	69,819	407,354	2,530	22,350	(*a*)	(*a*)	(*a*)	3,830	734,678
Maryland	113,457	676,708	5,772	76,792	342,055	(*a*)	(*a*)	*f* 82,811	1,272,175
Massachusetts	170,455	1,060,493	6,950	98,892	57,945	....	....	*f* 211,911	1,589,469
Michigan	215,836	1,095,254	9,476	64,031	....	(*a*)	(*a*)	*f* 101,489	1,497,169
Minnesota	157,727	852,303	5,506	55,016	(*a*)	....	(*a*)	*f* 43,089	1,256,752
Mississippi	76,716	443,939	650	6,455	....	....	....	(*f*)	451,694
Missouri	276,821	1,595,031	26,301	298,158	620,116	225,247	788,513	818,701	4,409,906
Montana	51,739	357,210	1,248	18,432	152,650	....	(*a*)	*f* 2,539	539,221
Nebraska	109,060	668,863	6,806	85,260	....	28,150	....	11,700	806,473
Nevada	2,020	16,425	(*a*)	(*a*)	....	....	....	....	17,625
New Hampshire	114,532	741,589	(*a*)	(*a*)	(*a*)	....	....	....	765,964
New Jersey	351,886	1,675,746	29,239	473,138	780,327	22,024	(*a*)	*f* 2,510,092	5,781,805
New Mexico	9,885	72,045	(*a*)	(*a*)	....	(*a*)	....	(*f*)	81,345
New York	1,016,237	4,947,599	18,721	254,696	293,944	343,343	96,770	*f* 1,278,888	7,214,358
North Carolina	132,699	682,469	990	8,070	3,720	(*a*)	(*a*)	*f* 10,042	751,301
North Dakota	10,948	69,508	(*a*)	(*a*)	(*a*)	....	....	....	76,708
Ohio	489,275	2,725,512	69,405	612,718	1,287,059	1,443,537	2,735,703	*f* 2,709,601	11,526,424
Oklahoma	28,137	196,735	875	7,850	(*a*)	....	....	(*f*)	205,060
Oregon (*b*)	23,422	172,058	354	8,469	962	....	(*a*)	*f* 12,179	263,891
Pennsylvania	875,631	5,357,079	70,207	844,087	4,791,083	670,081	438,998	1,490,315	13,656,730
South Carolina	144,601	546,028	168	1,188	14,925	....	....	*f* 250	563,346
South Dakota	7,235	54,365	(*a*)	(*a*)	(*a*)	....	....	....	59,365
Tennessee	92,502	610,968	3,073	32,350	37,100	67,129	(*a*)	*f* 15,961	829,874
Texas	222,459	1,396,889	10,138	95,492	23,337	(*a*)	(*a*)	*f* 11,971	1,632,189
Utah	23,262	134,164	17,490	139,591	5,100	....	(*a*)	*f* 1,834	291,189
Vermont	11,872	61,554	....	....	....	....	....	16,000	77,554
Virginia	171,624	1,139,894	17,650	267,028	3,971	....	....	24,407	1,435,300
Washington	61,595	477,960	6,995	147,881	24,542	139,162	118,584	*f* 3,343	927,298
West Virginia	60,004	348,452	(*a*)	(*a*)	102,300	555,389	(*a*)	*f* 3,985	1,087,838
Wisconsin	187,173	1,151,838	6,527	54,374	(*a*)	(*a*)	....	*f* 26,232	1,234,144
Wyoming	2,960	24,050	(*c*)	(*c*)	....	....	....	4,900	28,950
Other States (*d*)	....	....	7,297	85,788	124,401	216,295	1,268,755	641,561	(*f*)
Total	8,038,579	$45,503,076	415,343	4,709,737	9,870,421	$5,484,134	$6,736,969	$15,443,390	$87,747,727
Per cent. of brick and tile products	....	51·86	....	5·37	11·25	6·25	7·68	....	100·00
Per cent. of total of clay products.	....	41·29	....	4·27	8·96	4·98	6·11	....	79·62

(*a*) Included in "Other States." (*b*) Includes Hawaii. (*c*) Value of front brick for Wyoming included in other clay building material. (*d*) Includes all products made by less than three producers in one State, in order that the operations of individual establishments may not be disclosed. (*e*) Fancy and ornamental brick, stove linings, drain tile, ornamental terra cotta, fireproofing, ordinary tile, including adobes, assayers' supplies, boiler and locomotive tile and tank blocks, building blocks, burnt clay ballast, chemical brick, patent chimney brick, chimney pipe and tops, clay furnaces and retorts, conduit for underground wires, crucibles, cupola brick, fence posts and stubs, fire clay mortar, flue linings, frost-proof cellar brick, furnace mantels, gas logs and settings, glass-melting pots and glass-house furnace blocks, grave markers, hollow bricks, muffles, supports and slides, porous cups, runner brick, sidewalk tile, souvenirs, stone pumps, terra-cotta vases, vitrified sewer brick, wall coping, water pipe, and well brick and tile. (*f*) Partly included in "Other States."

than brick, which is now used so extensively in the construction of fireproof buildings is included under this classification. A slightly different classification has been adopted for 1901, which is fully explained in the individual headings of the columns and in the appended foot notes.

VALUE OF THE PRODUCTS OF CLAY IN THE UNITED STATES IN 1900 AND 1901.

State.	1900.			1901.		
	Brick and Tile.	Pottery.	Total.	Brick and Tile.	Pottery.	Total.
Alabama	$692,431	$20,296	$712,727	$928,429	$18,362	$946,791
Arizona	112,727	....	112,787	92,986	....	92,986
Arkansas	354,732	26,280	381,012	395,858	11,405	407,263
California	1,351,611	24,387	1,375,998	1,735,721	33,434	1,769,155
Colorado	1,182,575	a 17,944	1,200,519	1,568,107	26,700	1,594,867
Connecticut and Rhode Island	1,038,722	61,250	1,099,972	1,039,709	k 91,200	1,130,909
Delaware	156,274	....	156,274	131,164	....	131.164
District of Columbia	278,060	10,878	288,938	311,129	12,879	324,008
Florida	140,604	(b)	140,604	190,674	(b)	190,674
Georgia	1,168,835	b 24,383	1,193,218	1,527,853	17,230	1,545,083
Hawaii	....	....	....	(l)	....	(l)
Idaho	49,882	(a)	49,882	68,328	....	68,328
Illinois	6,932,086	776,773	7,708,859	8,960,041	682,449	9,642,490
Indiana	3,532,450	c 325,900	3,858,350	3,885,083	581,371	4,466,454
Indian Territory	30,238	....	30,238	117,224	....	117,224
Iowa	2,254,662	36,589	2,291,251	2,711,305	26,520	2,737,825
Kansas	1,002,689	14,061	1,016,750	961,020	(m)	961,020
Kentucky	1,349,827	131,497	1,481,324	1,374,846	139,697	1,514,543
Louisiana	503,394	4,300	507,694	612,595	3,108	615,703
Maine	724,984	(d)	724,984	734,678	(m)	734,678
Maryland	1,275,239	436,617	1,711,856	1,272,175	333,480	1,605,655
Massachusetts	1,594,377	d 288,724	1,883,101	1,589,469	281,368	1,870,837
Michigan	1,147,378	34,317	1,181,695	1,497,169	44,865	1,542,034
Minnesota	1,103,302	e 293,395	1,396,697	1,256,552	292,095	1,548,647
Mississippi	558,916	14,452	573,368	451,694	4,779	456,473
Missouri	3,665,093	71,474	3,736,567	4,409,906	64,647	4,474,553
Montana	350,489	(a)	350.489	539,221	(m)	539,221
Nebraska	683,958	....	683.958	806,473	....	806,473
Nevada	9,580	....	9,580	17,625	....	17,625
New Hampshire	485,013	(f)	485,013	765,964	(m)	765,964
New Jersey	5,664,772	f 5,263,651	10,928,423	5,781,805	5,900,073	11,681,878
New Mexico	41,898	....	41,898	81,345	....	81,345
New York	6,495,281	g 1,165,325	7,660,606	7,214,358	1,077,360	8,291,718
North Carolina	797,112	18,863	815,975	751,801	20,037	771,838
North Dakota	92,399	....	92,399	76,708	....	76,708
Ohio	9,731,305	h 8,573,323	18,304,628	11,526,424	10,048,561	21,574,985
Oklahoma	164,457	....	164,457	205,060	....	205,060
Oregon	264,095	17,290	281,385	n 263,891	(m)	n 263,891
Pennsylvania	12,000,875	1,390,873	13,391,748	13,656,730	1,665,012	15,321,742
Rhode Island	(i)	....	....	(i)	....	(i)
South Carolina	693,703	17,633	711,336	563,346	11,872	575,218
South Dakota	43,440	....	43,440	59,365	....	59,365
Tennessee	865,923	49,655	915,578	829,874	64,093	893,967
Texas	1,083,553	87,464	1,171,017	1,632,189	91,186	1,723,375
Utah	227,621	6,600	234,221	291,189	(m)	291,189
Vermont	121,041	....	121,041	77,554	....	77,554
Virginia	1,302,085	3,110	1,305,195	1,435,300	4,047	1,439,347
Washington	616,029	9,430	625,459	927,298	17,500	944,798
West Virginia	1,384,924	631,841	2,016,765	1,087,838	858,642	1,946,480
Wisconsin	1,072,179	(e)	1,072,179	1,234,144	13,400	1,247,544
Wyoming	21,500	....	21,500	28,950	....	28,950
Other States	....	....	....	....	o 76,488	o 76,488
Total	$76,413,775	$19,798,570	$96,212,345	$87,747,727	$22,463,860	$110,211,580
Per cent. of total	79·42	20·58	100·00	79·62	20·38	100·07

(*a*) Value of the pottery products of Idaho and Montana is included with that of Colorado. (*b*) Value of the pottery products of Florida is included with that of Georgia. (*c*) Porcelain electrical supplies for Indiana included in New York. (*d*) Value of the pottery products of Maine is included with that of Massachusetts. (*e*) Value of the pottery products of Wisconsin is included with that of Minnesota. (*f*) Value of pottery products of New Hampshire is included with that of New Jersey. (*g*) Includes porcelain electrical supplies for Indiana and china for Ohio. (*h*) China for Ohio included in New York. (*i*) Included with Connecticut. (*k*) Produced by Connecticut alone. (*l*) Included in Oregon. (*m*) Included in "Other States." (*n*) Includes Hawaii. (*o*) Comprising pottery totals for the following States: Florida, Kansas, Maine, Montana, New Hampshire, Oregon and Utah. This total could not be distributed among the States to which it belongs without disclosing the operations of individual establishments.

As an exponent of the increasing use of burned clay products as a building material may be cited the number of building permits issued, together with the buildings erected under these permits in 42 of the principal cities of the United States for the past two years. In 1900 there were 68,417 permits affecting buildings valued at $241,516,585, as compared with 85,571 permits affecting buildings valued at $372,173,631 in 1901, an increase in number of 25% and of over 50% in value.

Review of the Literature of Clays and Clay Products in 1902.

By Heinrich Ries.

Clay Deposits.—Glass-pot clays have been obtained in the United States from St. Louis, Mo., and to a small extent in Pennsylvania, and have partially replaced foreign glass-pot clays. Their chemical composition and physical properties, as well as similar properties of foreign clays have been described by H. Ries.[1]

Colorado.—The manufacture of brick from both shale and clay has attained to considerable importance in the vicinity of Boulder.[2]

Missouri.—The well-known St. Louis glass-pot clays have been made the subject of an exhaustive physical and chemical study by O. Muhlhauser.[3]

North Carolina.—A recent development of kaolin near Bryson City, Swayne County, is described by C. A. Crane.[4] The composition of the kaolin is as follows: SiO_2, 46·47%; Al_2O_3, 35·87%; Fe_2O_3, 1·27%; CaO, 1·75%; MgO, 0·79%; SO_3, 0·19%; H_2O, 2·72%; combined H_2O, 10·95%.

Washington.—Plastic materials occur at several localities in this State.[5] They are used for the manufacture of brick, drain tile, sewer pipe, terra cotta, etc. The different types recognized are glacial clays, residual clays and clay shales. Of these, the first mentioned are irregular in their occurrence, while the second are found only in non-glaciated regions.

Austria.—Kaolins are found in Carboniferous rocks near Pilsen, Bohemia, and, according to C. V. Purkyne,[6] have resulted from the decomposition of an arkose, yielding a product whose composition is SiO_2, 85·60%; Al_2O_3, 8·85%; Fe_2O_3, 0·70%; CaO, 0·78%; MgO, 0·19%; alkalies, 0·62%; loss on ignition, 3·58%.

Canada.—An occurrence of brick clay has been described[7] from near Sault Sainte Marie, Ontario. The clay has the following composition: SiO_2, 60·28%; Al_2O_3, 15·73%; Fe_2O_3, 4·76%; CaO, 5%; MgO, 4·59%; loss, 7·17%.

France.—In the vicinity of Rouen, the clay working industry includes the manufacture of bricks, roofing tiles, porcelain and fayence.[8]

Germany.—F. Kovar and A. Haskoveck[9] describe the occurrence of beds of fire clay in the Quader sandstone at Vranova, near Kunstadt. Two varieties are found, a white and dark clay—the former analyzing: SiO_2, 52·42%; TiO_2, trace; Al_2O_3, 33·56%; Fe_2O_3, 1·17%; CaO, 0·77%; MgO, 0·77%; alkalies, 1·21%; loss on ignition, 10·84%.

Russia.—A series of kaolins and pottery clays from the department of Kiew have been described by C. Zemiatschensky,[10] and a number of chemical analyses given. Pottery[11] is manufactured at many localities in Russia, but, owing to

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[1] *Mineral Resources*, United States Geological Survey, 1901 (published as a separate pamphlet).

[2] *Clayworker*, Vol. XXXVIII., p. 226, 1902.

[3] *Zeitschrift fuer angewandte Chemie*, 1902, Vol. VII.

[4] *Clayworker*, Vol. XXXVII., p. 428, 1902.

[5] *Annual Report*, Washington Geological Survey, Vol. I., p. 178, 1902.

[6] *Casopis pro prunysl cagmicky*, 1901.

[7] *Report of the Bureau of Mines*, Ontario, 1902, p. 96.

[8] *United States Consular Report*, June, 1902, p. 266.

[9] *Journal of the Society of Chemical Industry*, Vol. LXXXII., p. 81.

[10] *Berichte und Forschungen zur keramische Industrie in Russland*, VI., pp. 208–228.

[11] *Thonindustrie Zeitung*, Vol. XXVI., p. 1998, 1902.

poor transportation facilities, the market is very limited, and at most localities pottery is made only in a small way for local or domestic use. The region around Nizhni Novgorod is an important one. In some districts lack of clay and fuel gives serious trouble.

PROPERTIES OF CLAYS.—*Softening Temperature.*—E. Cramer[12] discusses his method of testing the softening temperature of fire clays by making small bars and noting the temperature at which these bend when supported at two points. He finds that the clays which burn to a dense body at comparatively low temperatures are not necessarily those which soften first; that, in fact, porous kaolins may soften at an earlier point than the dense-burning clays. Experiments to determine the effect of adding finely powdered sand to the bars showed that it did not affect all clays alike, tending to soften some and to stiffen others when burned to the same temperature.

Dehydration.—In experiments to determine the temperature of dehydration of calcareous clays and kaolin, W. M. Kennedy[13] finds that the water of hydration of the kaolin passes off between 450° and 600°C., and in a mixture of 70 parts of Florida kaolin and 30 parts of whiting he found that the loss which occurred between the two temperature points above mentioned agreed with kaolin, and represented the period of dehydration. On further heating from 600° to 725°C. the expulsion of volatile matter was almost as rapid as that of the water. Another rapid loss occurred between 850° and 900°C. Holding the clay at a temperature of 725°C. did not seem to hasten the dehydration.

Plasticity.—A rather unique explanation of this peculiar property is given by E. Linder.[14] He explains it partly by supposing that the particles are of extreme fineness, and further considers that weathering produces very long or round particles, the former giving greater contact surface, and thereby increasing the surface tension and the plasticity. He believes that if clays have rounded particles they will burn dense only at high temperatures, while in those clays whose particles are elongated the reverse occurs.

Permeability.—An interesting series of experiments has been made by W. Spring,[15] who finds that clay when under pressure and confined so that it cannot expand on wetting is nearly impervious to water; under such conditions it will only soak up enough water to fill the pores. The percentage of water thus absorbed may range from as low as 3·37% in glass-pot clays, to 24·56% in some loams. Wet clay under pressure will part with its water, even though the mass be entirely surrounded by that liquid.

Composition.—Mackler[16] discovered that the presence of magnesia in clays results in the formation of a dense body at a relatively low kiln temperature, and that this material exerts quite a different effect from that exerted by lime. He found that clays containing magnesia do not vitrify and shrink so suddenly as do the calcareous clays, nor does the magnesia exert as strong a bleaching action on the iron of the bricks as the lime does. The effect of adding magnesia

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[12] *Thonindustrie Zeitung*, Vol. XXVI., p. 1067.
[13] *Transactions of the American Ceramic Society*, Vol. IV., p. 146.
[14] *Thonindustrie Zeitung*, Vol. XXXVI., p. 888.
[15] *Annales de la Société géologique de Belgique*, Vol. XXVIII., 1901.
[16] *Thonindustrie Zeitung*, Vol. XXVI., p. 705.

to kaolin was to cause the material to burn dense at cone No. 1, whereas otherwise it would not assume the same density until cone No. 16. He suggests the possibility of using magnesia in pottery bodies as a substitute for lime or feldspar.

Mechanical Analyses.—Kavalowski[17] describes an apparatus for the mechanical analysis of clays, consisting of a pear-shaped receptacle with a wide mouth and a cork containing three openings. The first opening is for the outlet of air, while the receptacle is being filled, the second is for the water inlet tube, and the third for the water outlet tube. The latter can be moved up and down so that its lower end may stand at any level in the receptacle. The disintegrated sample to be analyzed and some water are placed in the bottom of the receptacle with the lower end of the outlet tube raised to near the top. Water is then allowed to run in and to pass off through the outlet tube until it becomes clear. The outlet tube is then pushed further into the receptacle so that its lower end is about the middle or in the zone in which the fine sand particles remain suspended during the passage of the water through the tube, and these are then drained off. Finally the outlet tube is pushed still farther into the receptacle and the sand carried off through it. To separate the coarse sizes of sand the residue is put inside of a small egg-shaped sieve, outside of which are two other sieves. The meshes of the inner sieve are 5 sq. mm., those of the next sieve 1 sq. mm., and of the outer sieve 0·5 sq. mm. These sieves are then suspended by a string in the stream of running water, and the grains of sand are washed toward the outer sieve, where the finest are caught while the coarsest grains are retained in the inner sieve.

Chemical Analyses.—A. Sedeck[18] discusses the methods for the rational analyses of clay.

PYROMETERS.—J. Salt[19] believes that the irregular working of Seger cones is often due to improper implacement in the kiln.

MANUFACTURE OF ZINC RETORTS.—The manufacture of zinc retorts and requirements of the raw materials, as well as their properties are exhaustively discussed by O. Muhlhauser.[20]

POTTERY GLAZES.—The formation of crystalline glazes is considered by many to be due to the deposition during firing of willemite crystals from saturated alkali-zinc glazes, and therefore it is looked upon as a kind of devitrification, but others ascribe this phenomenon to the presence of titanic acid in these glazes. E. K. Bris[21] after a series of tests on zinkiferous glazes with and without titanic acid, finds that those free from titanium form crystals only sparingly in the thicker portions of the glazed layer, whereas a difference of 1% of rutile at once increases the dimensions of crystals. In some experiments made by R. H. Jones[22] the conclusion is reached that it is impossible to produce a crimson glaze in which lead is the only flux, and that a better color and brighter surface are

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[17] *Thonindustrie Zeitung*, Vol. XXVI., 546 (abstract from *Stein und Mörtel*).

[18] *Journal of the Society of Chemical Industry*, Vol. XXV., p. 90.

[19] *Ceramique*, Vol. IV., p. 189.

[20] *Zeitschrift fuer angewandte Chemie*, 1903, No. 7.

[21] *Sprechsaal*, Vol. XXXV.. p. 133.

[22] *Transactions of North Staffordshire Ceramic Society*, Vol. I., p. 37, 1901–02.

obtained with strongly alkaline glazes when lead is excluded. He also describes the effect of the addition of whiting to clear alkaline glaze and the production of crimson with the combination of tin oxide, lime and chrome. The occurrence of a golden yellow sheen on lead glazes, due to the formation of small lustrous yellow crystals, is believed by L. Thiriot[23] to be traceable to the high proportion of lead oxide to silica in the glaze (about 1 : 1), when quartz sand is used. A low temperature and gradual cooling also aids the formation of these crystals. A solid-colored glaze consisting of crude or burned pyrite, to which is added some clay, sand, ground glass and other substances, is used in many parts of Germany[24] for interlocking and shingle tiles. The air-dried ware is dipped in the glaze and then set in the kiln. According to M. Heim[25] the tendency of some stoneware glazes to deposit sediment can sometimes be remedied by the addition of crude plastic clay and kaolin, white lead, or chalk to the mass before it received its final grinding. It may also be prevented by increasing the density of the liquid portion of the glaze with gum, dextrin, syrup, milk, blood, borax, boric acid, or acetic acid. The sediment, however, hardens sometimes, and can only be redistributed by regrinding, but successive treatment of this kind works injury to the glaze. W. P. Rix[26] describes the conditions necessary to successful glazing, stating that the temperature must not be lower than 1,200°C., and that the body material should be highly siliceous. L. E. Barringer[27] also takes up the question of the relation between the constitution of the clay and its ability to take a good salt glaze, and finds that clays with a wide molecular ratio of alumina to silica, *viz.*: from 1 : 4·6 to 1 : 2·5 can be treated in this manner. He also states that soluble salts up to 3% may be present in a clay without seriously interfering with salt glazing when conducted at cone No. 8. S. Geisjbeek[28] claims that he was not able to find any good natural engobe clays in the United States, but that a good engobe could be made by adding flint and spar to some of our domestic clays.

Bodies.—Mica, when ground exceedingly fine, is found by R. L. Stull[29] to exert a fluxing action upon kaolin at temperatures below cone No. 5. He claims also that it is plastic if ground fine enough, and that it vitrifies sufficiently to produce a non-absorbent body below the temperature of cone No. 4.

PORCELAIN.—A. S. Watts[30] is of the opinion that every porcelain showing a high resistance test contains moderately large quantities of Al_2O_3 and SiO_2, but not over 1% Al_2O_3 and 6·2% SiO_2 should be used. He found that no specimens below 0·8% Al_2O_3 and 4·2% SiO_2 were safe, owing to their very narrow vitrification limits. He believes that the ideal porcelain for electrical purposes may be vitrified at any point between Nos. 6 and 12.

E. Mayer[31] points out the need of finer grinding of the American pottery materials, and finds that the English ground flint is considerably finer than the American ground flint. H. E. Wood[32] states that the employment of bone

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[23] *Sprechsaal*. 35 [32], 1210–11.

[24] *Ceramische Rundschau*. 1902.

[25] *Sprechsaal*, Vol. XXXV., p. 1337.

[26] *Transactions of North Staffordshire Ceramic Society*, Vol. I., p. 26, 1901–02.

[27] *Transactions of the American Ceramic Society*, Vol IV., p. 211.

[28] *Ibid*., Vol IV., p. 48.

[29] *Ibid.*, Vol. IV., p. 255.

[30] *Ibid.*, Vol. IV., p. 86.

[31] *Ibid.*, Vol. IV., p. 25.

[32] *Transactions of North Staffordshire Ceramic Society*, Vol. I., 1901–02, p. 21.

in English china dates from the middle of the eighteenth century. The author believes that the bone remains as calcium phosphate throughout the firing, and dissolves in the silicates without affecting their translucency, but that it increases the whiteness and lightness of the body, and furthermore that being present as an unalterable body, it is a safeguard against overfiring, and hence prevents distortion and blistering, as well as crazing.

TILES.—H. Richardo[33] considers the use of enameled tiles for saving or reflecting light and for decoration. He reviews also the history of their use in early times.

BRICK.—Kuehn[34] considers that face brick should not absorb more than 5% of water, and that a transverse test is applicable in cases where brick are laid projecting from the wall and are to support loads. Bricks with lime pebbles are to be rejected, and the same is true of bricks containing pyrite nodules. A face brick should invariably be proof to the action of the weather, and sulphates contained in the clay should be rendered harmless by the action of barium. Buff brick should be burned especially hard in order to prevent the formation of the green efflorescence due to vanadium. The destruction of brickwork has been noticed at several places in Italy, and, according to A. Cajo,[35] is due to the presence of incrustations of alkaline sulphates in some instances, and magnesium sulphate in others. In some cases a portion of the alkaline compounds was traceable to alkaline sulphides in the clay, and a further quantity to the sulphur in the lignite used for firing the kilns. As a result, it is suggested that it would be desirable to set a maximum limit for the presence of such impurities in bricks. Two tests were suggested: (1) Determination of sulphur trioxide. One kilo of the powdered sample of brick is extracted by boiling, filtered, and the solution tested. (2) Direct test for the influence of sulphates. Prismatic samples of the brick 6×6×12 cm. are treated in a copper vessel with a saturated solution of sodium sulphate by boiling for half an hour and are then exposed to a current of air until incrustation appears. This is repeated forty times, after which the residue is dried at 100°C. and weighed.

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[33] *Journal of the Society of Arts*, Jan. 24, 1902.

[34] *Thonindustrie Zeitung*, Vol. XXVI., p. 290.

[35] *Ibid.*, Vol. XXVI., p. 115.

COAL AND COKE.

THE continued industrial prosperity of the United States during 1902 caused the production of coal to exceed the enormous total registered in 1901. The total production of anthracite and bituminous coal amounted to 299,823,254 short tons, as compared with 293,298,516 short tons in 1901. Had it not been for the protracted strike in the anthracite region of Pennsylvania, the production in 1902 would have attained to still larger proportions. The total production of coal in the chief countries of the world during 1901 was 787,179,967 metric tons, against 766,935,262 metric tons in 1900.

TOTAL PRODUCTION OF COAL IN THE UNITED STATES. (IN TONS OF 2,000 LB.)

States.	1901.			1902.		
	Tons.	Value at Mine.		Tons.	Value at Mine.	
		Total.	Per Ton		Total.	Per Ton.
Bituminous:						
Alabama	9,099,052	$10,000,892	$1·10	10,329,479	$12,498,669	$1·21
Arkansas	1,816,136	2,068,613	1·14	2,125,700	2,338,270	1·10
California	151,079	394,106	2·61	88,460	248,622	2·81
Colorado (*e*)	5,635,435	6,248,151	1·11	7,455,156	8,349,768	1·12
Georgia	354,825	426,685	1·20	*e* 375,000	450,000	1·20
Illinois	27,331,552	28,163,937	1·03	30,031,300	28,289,485	0·94
Indiana	6,918,225	7,016,143	1·01	8,300,000	7,885,000	0·95
Indian Territory	2,421,781	3,915,268	1·62	2,741,797	4,386,875	1·60
Iowa	5,617,499	7,822,605	1·39	5,407,144	7,908,004	1·46
Kansas	4,900,528	5,991,599	1·22	5,229,767	7,321,674	1·40
Kentucky	5,469,986	5,213,076	0·95	6,429,419	6,107,948	0·95
Maryland	5,113,127	5,046,491	0·99	5,525,785	6,225,639	1·13
Michigan	1,241,241	1,753,064	1·24	869,228	1,173,458	1·35
Missouri	3,802,088	4,707,164	1·24	4,067,166	5,324,788	1·31
Montana	1,396,081	2,009,316	1·44	1,707,109	2,389,953	1·40
New Mexico (*d*)	1,084,257	1,540,357	1·42	1,090,373	1,537,426	1·41
North Dakota (*b*)	166,601	214,151	1·29	296,800	371,000	1·25
Ohio	20,943,807	20,928,158	1·00	23,929,267	24,843,608	1·08
Oregon	69,011	173,646	2·52	*e* 60,000	150,000	2·50
Pennsylvania	82,305,946	81,397,586	0·99	98,946,203	106,861,899	1·08
Tennessee	3,633,290	4,067,389	1·12	4,232,332	5,278,921	1·25
Texas (*c*)	1,107,953	1,907,024	1·72	*e* 850,000	1,360,000	1·60
Utah	1,322,614	1,666,082	1·26	1,641,436	2,068,209	1·26
Virginia	2,725,873	2,353,989	0·96	3,070,104	3,223,609	1·05
Washington (*d*)	2,578,217	4,271,076	1·66	2,690,789	5,300,854	1·97
West Virginia	24,068,402	20,848,184	0·87	26,162,173	27,208,660	1·04
Wyoming	4,485,374	6,060,462	1·33	4,720,000	6,472,000	1·35
Total bituminous { Sh. tons	225,759,980	$236,305,214	$1·05	258,371,987	$285,574,339	1·11
Total bituminous { Met. tons	204,808,110	....	1·15	234,398 529	....	1·22
Cannel:						
Kentucky { Sh. tons	(*g*)	....	......	(*g*)	....	......
Kentucky { Met. tons	(*g*)	....	......	(*g*)	....	......
Anthracite:						
Colorado	64,580	$193,740	$3·00	67,767	$203,301	$3·00
New Mexico	2,289	6,295	2·75	42,571	117,070	2·75
Pennsylvania	67,471,667	112,504,020	1·67	41,340,929	82,681,858	(*f*) 2·00
Total anthracite { Sh. tons	67,538,536	$112,704,055	$1·67	41,451,267	$83,002,229	$2·00
Total anthracite { Met. tons	61,270,558	....	1·84	37,604,343	....	2·20
Grand total coal { Sh. tons	293,298,516	$349,009,269	$1·19	299,823,254	$368,576,568	1·23
Grand total coal { Met. tons	266,078,668	....	1·31	271,997,872	....	1·35

(*a*) Fiscal year. (*b*) All lignite. (*c*) One-third lignite. (*d*) One-half lignite. (*e*) Estimated. (*f*) Estimated; owing to the protracted strike in the Pennsylvania anthracite region and the abnormal conditions which resulted in the trade, the value of anthracite at the mine can be fixed only approximately. (*g*) Included in bituminous.

Ohio.—The production of coal showed an increase of about 14% in 1902, the figures being 23,929,267 against 20,943,807 in 1901. The large increase was due primarily to the strong demand for coal resulting from the decreased supply furnished by Pennsylvania.

Pennsylvania.—The production in 1902 amounted to 98,946,203 short tons of bituminous coal, and 41,340,929 short tons of anthracite coal, as compared with 82,305,946 short tons of bituminous and 67,471,667 short tons of anthracite coal for 1901. The output of anthracite showed a large falling off, owing to the long strike among the miners.

West Virginia.—The production of coal in 1902 was 26,162,173 short tons as compared with 24,068,402 short tons in 1901, the increase being nearly 10%.

Other States.—Large increases in production were recorded in Alabama, Colorado, Illinois, Tennessee, Virginia and Wyoming. Iowa, alone of the important coal producing states, failed to increase its output in 1902.

TOTAL PRODUCTION OF COKE IN THE UNITED STATES. (IN TONS OF 2,000 LB.)

States.	1901.			1902.		
	Tons.	Value at Oven.		Tons.	Value at Oven.	
		Total.	Per Ton.		Total.	Per Ton.
Alabama	2,148,911	$6,062,616	$2·82	2,210,785	$6,858,278	$3·10
Colorado	671,303	1,626,279	2·42	*e* 750,000	1,875,000	2·50
Georgia and North Carolina	54,550	154,625	2·83	*e* 55,000	156,750	2·85
Indiana	....	....	....	*Nil.*	....	....
Indian Territory	37,374	154,834	4·14	49,279	197,116	4·00
Kansas	7,138	15,079	2·11	*e* 10,000	21,000	2.10
Kentucky	100,285	208,015	2·07	126,559	272,101	2·15
Missouri	4,749	9,968	2·10	*e* 5,000	10,500	2·10
Montana	57,004	337,881	5·93	55,050	316,549	5·75
New Mexico	41,648	118,368	2·84	26,012	58,207	2·25
Ohio	108,774	299,430	2·75	*e* 150,000	412.500	2·75
Pennsylvania (*c*)	14,355,917	27,066,361	1·89	14,941,091	31,077,869	2·08
Tennessee	404,017	952,782	2·36	555.188	1,709,745	3·08
Utah	....	(*d*)	(*d*)	187,765	551,060	4·00
Virginia	907,130	1,483,670	1·64	978,848	1,761,026	1·80
Washington	49,197	239,028	4·86	40,569	202,845	2·00
West Virginia (*b*)	2,283,700	4,110,011	1·80	2,249,744	4.189,529	1·84
Other States....(*f*)	564,191	1,607,476	2·85	*e* 750,000	2,250,000	3·00
Total coke { Short tons	21,795,883	$44,445,923	$2·04	23,090,842	$51,864,575	$2·25
Total coke { Metric tons	19,773,095	....	2·25	20,947,421	....	2·48

(*a*) Fiscal year. (*b*) Includes 40,537 tons made in Wisconsin in 1899, and 37,486 tons made in 1900; also, 53,973 tons made in Virginia in 1899, and 64,740 tons in 1900. (*c*) Includes 4,800 tons made in Wisconsin in 1900. (*d*) Included in Colorado. (*e*) Estimated. (*f*) Includes Massachusetts, Illinois, Michigan, Wisconsin, New York and Wyoming.

IMPORTS OF COAL AND COKE INTO THE UNITED STATES. (IN LONG TONS.)

Year.	Coal.					Coke.		
	Anthracite.	Bituminous	Totals.			Long Tons.	Metric Tons	Value.
	Long Tons.	Long Tons.	Long Tons.	Metric Tons	Value.			
1898	3,149	1,270,557	1,273,706	1,294,085	$3,578,181	41,135	41,844	$142,334
1899	61	1,400,461	1,400,522	1,422,930	3,882,675	27,855	28,301	142,504
1900	118	1,909,258	1,909,376	1,939,926	5,020,102	103,175	104,826	371,341
1901	286	1,919,962	1,920,248	1,950,972	5,293,273	72,729	73,883	266,078
1902	73,006	2,478,375	2,551,381	2,592,208	7,339,791	107,437	109,156	423,774

EXPORTS OF COAL AND COKE OF DOMESTIC PRODUCTION. (IN LONG TONS.)

Year.	Anthracite.		Bituminous.		Totals.		Coke.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1898	1,350,948	$5.712,985	3,152,457	$6,699,248	4,503,405	$12,412,233	199,562	$600,931
1899	1,707.796	7,140,100	4,044,354	8,573,276	5,752,150	15,713,376	280,196	858,856
1900	1,654.610	7,092,489	6,262,909	14,431,590	7,917,519	21.524,079	376,999	1,358,968
1901	1,993,807	8,987,147	5,390,086	13,085,763	7,383,393	22,022,910	384,330	1,516,898
1902	907,977	4,301,946	5,218,969	13,927,068	6,126,946	18,229,009	392,491	1,785,188

PRODUCTION AND CONSUMPTION OF COAL IN THE UNITED STATES. (IN LONG TONS.)

Year.	Production.	Imports.	Total Supply.	Exports.		Consumption.	
				Domestic.	Foreign.	Tons.	Metric Tons.
1898	194,940,967	1,273,706	196,214,673	4,508,405	2,890	191,708,378	194,775,712
1899	225,103,024	1,400,522	226,503,546	5,752,150	6,806	220,744,590	224,276,508
1900	239,567,351	1,909,376	241,476,727	7,917,519	6,740	233,552,468	237,289,307
1901	261,873,675	1,920,248	263,793,923	7,383,393	3,808	256,406,727	260,509,235
1902	267,699,334	2,551,381	270,250,715	6,126,946	7,581	264,116,188	268,342,047

Exports and Imports.—There was a decrease in the exports of coal during 1902, the figures being 6,126,946 tons for 1902, as compared with 7,383,393 tons in 1901. The imports increased from 1,920,248 tons in 1901, to 2,551,381 tons in 1902. Both imports and exports are given in the subjoined table:—

UNITED STATES EXPORTS AND IMPORTS OF COAL CLASSIFIED AS TO COUNTRIES.

Country.	Exports.			Imports. (*a*)		
	1900.	1901.	1902.	1900.	1901.	1902.
Australasia	*Nil.*	*Nil.*	*Nil.*	254,188	351,105	324,543
Canada	5,422,493	5,080,963	4,468,593	1,484,576	1,488,531	1,678,919
Central and South America	223,795	291,816	181,004	....	....	....
Europe	635,237	589,576	186,695	118,987	77,339	456,936
Hawaii and Philippine Islands	96,870	71,718	67,673	*Nil.*	*Nil.*	*Nil.*
Japan	*Nil.*	*Nil.*	*Nil.*	9,045	11,068	9,556
Mexico	664,036	551,448	537,708	41,826	19,702	8,087
West Indies	760,879	735,389	679,988	*Nil.*	*Nil.*	*Nil.*
Others	114,209	62,483	5,285	1,141	22,217	382
Totals	7,917,519	7,383,393	6,126,946	1,909,258	1,919,962	2,478,875

(*a*) Does not include anthracite coal.

PRODUCTION OF COAL IN THE CHIEF COUNTRIES OF THE WORLD.

The total production of coal in the world during 1901 was 787,179,967 metric tons, against 766,935,262 metric tons in 1900, an increase of 40,385,224 metric tons during the year. Detailed statistics may be found in the subjoined table:—

COAL PRODUCTION OF THE CHIEF COUNTRIES OF THE WORLD. (IN METRIC TONS.)

Year.	Africa.	Australasia.						Austria-Hungary	Belgium.	Canada.		France.
		New South Wales.	New Zealand.	Queensland.	Tasmania	Victoria.	Western Australia			British Colu'bia & Territories	N. Bruns-w'k, Nova Scotia.	
1897	2,008,174	4,453,728	854,164	864,142	48,210	240,063	*Nil.*	35,939,416	21,492,446	1,167,153	2,267,581	30,798,000
1898	*a*2,550,485	4,781,551	921,546	414,461	49,902	246,845	330	37,786,962	22,088,335	1,454,452	2,330,890	32,356,107
1899	*a* 239,443	4,670,580	990,838	501,913	43,803	266,578	55,208	38,738,872	22,072,068	1,601,833	2,866,144	32,862,712
1900	759,362	5,595,879	1,111,860	505,252	51,549	215,052	120,805	39,027,929	23,462,817	1,791,826	3,296,822	33,404,298
1901	1,388,205	6,063,921	1,247,280	547,624	46,165	212,678	119,721	40,746,704	22,213,410	1,861,248	3,788,168	32,325,302

Yr.	Germany	India.	Italy.	Japan.	Russia.	Spain. (*f*)	Sweden	United Kingdom.	United States.	All Other Countries	Totals.
1897	120,474,485	4,128,187	314,222	5,647,751	11 208,738	2,019,000	224,343	205,364,010	182,216,466	*e*2,000,000	633,215,229
1898	127,958,550	4,678,640	341,327	6,651,208	12,307,450	2,466,800	236 277	205,287,388	198,071,199	*e*2,500,000	665,480,705
1899	135,844,419	5,016,055	388,534	6,721,798	14,274,361	2,600,279	239,344	223,616,279	228,717,579	*e*2,500,000	724,828,145
1900	149,788,256	6,216,822	479,896	7,429,457	14,759,866	2,582,972	252,820	228,772,886	243,414,164	*e*2,500,000	766,935,262
1901	152,628,931	6,742,176	425,614	8,945,939	16,156,038	2,651,857	271,509	222,614,981	266,078,668	*e*2,500,000	787,179,967

(*a*) Includes estimate of 50,000 tons as the output of the Orange Free State and Transvaal, for which no statistics are available. (*e*) Estimated. (*f*) Not including lignite.

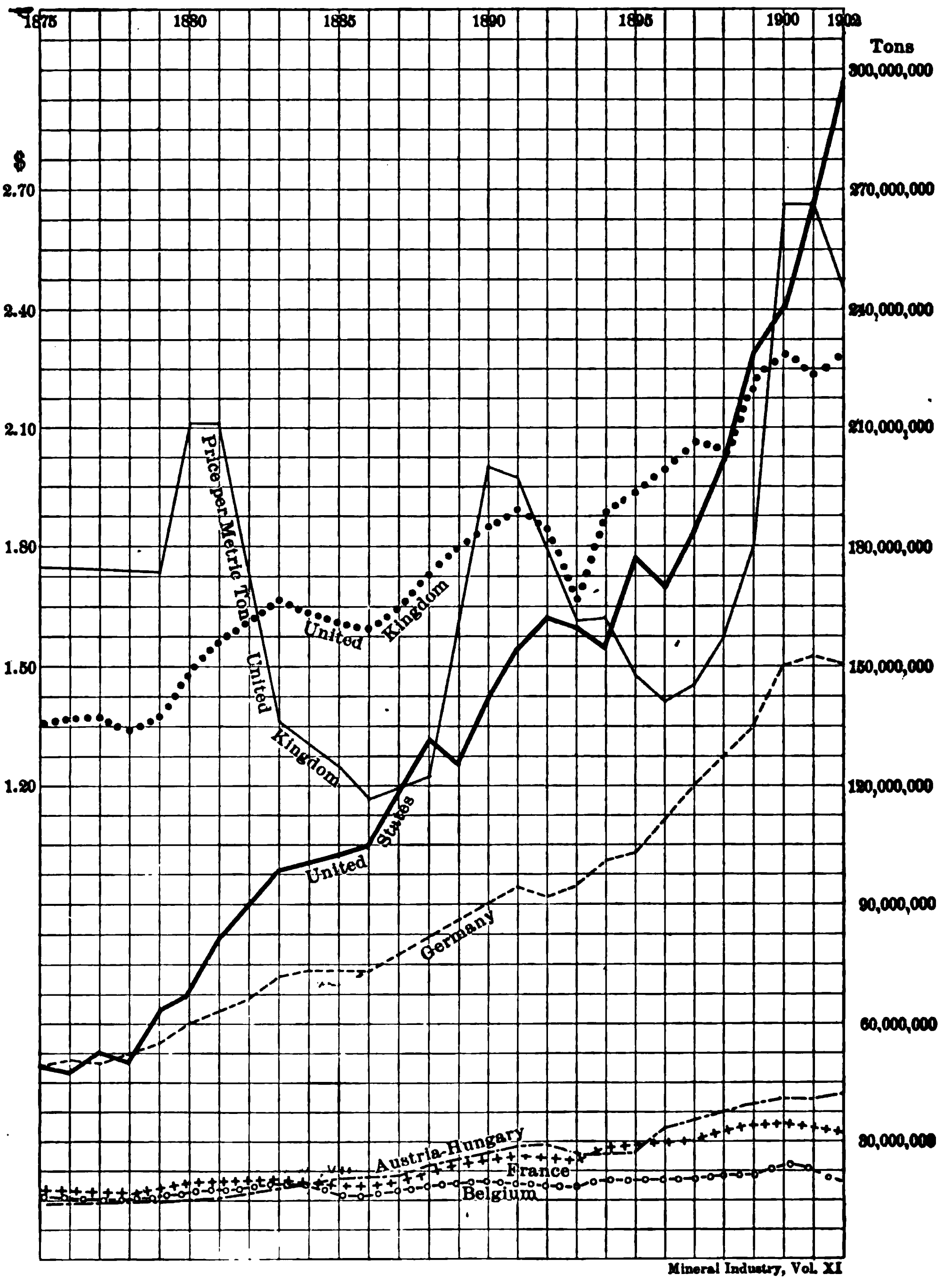
Africa.—Coal is produced in Natal, Cape Colony, the Transvaal and Orange River Colonies. Natal in 1901 produced 569,200 long tons coal, valued at £549,439, as compared with 241,330 long tons, valued at £241,330 in 1900. The output was mined at the collieries of Indwe, Cyphergat, Sterkstroom and Molteno. Cape Colony produced 205,810 long tons, valued at £180,413, as compared with 198,451 long tons, valued at £152,581 in 1900, and the Transvaal produced 809,898 metric tons coal in 1901, as compared with 514,171 metric tons in 1900. According to the report of the Transvaal Mines Department, the output of coal for the year 1902 was 1,910,947 long tons, valued at £637,640, as compared with 797,144 tons, valued at £329,113 for the previous year. This coal was produced by fourteen mines, the bulk of the coal coming from the Springs-Brakpan area, which contributed 61·5% of the total tonnage.

Australasia.—The production of coal in New South Wales in 1902 was 5,942,011 long tons, valued at £2,206,578, and the coke was valued at £89,605; the exports of coal were 3,104,735 long tons, valued at £1,528,121. The output of coal in Queensland in 1902 was 501,531 long tons, valued at £172,286. The output in Victoria was 225,164 long tons, valued at £155,850, and the output in Western Australia was 140,884 long tons, valued at £86,188.

Canada.—The production of coal in Canada during 1902 was 6,930,287 metric tons, valued at $15,538,611, as compared with 5,649,917 metric tons, valued at $12,005,565 in 1901, an increase of 1,280,370 metric tons and $3,533,046 for the year. The production of coke also showed a large increase, being 459,463 metric tons, valued at $1,558,930 in 1902, as compared with 339,043 metric tons, valued at $1,228,225 in 1901. The exports of coal during 1902 were 1,648,852 metric tons, valued at $4,867,088, the exports of coke, 52,873 metric tons, valued at $184,499, the imports of anthracite and bituminous coal, 4,892,096 metric tons, valued at $13,307,838 and the imports of coke, 242,416 metric tons, valued at $842,815. In 1902, Nova Scotia produced 4,366,869 long tons of coal, as compared with 3,625,365 long tons in 1901, 3,217,559 tons being mined in Cape Breton County. The sales of Nova Scotia coal in 1902 amounted to 3,898,626 long tons, the exports of coal to the United States were 751,382 long tons. The Dominion Coal Co. during 1902, produced 2,952,758 tons. Coal is also mined on the Pacific Coast. It is generally of a bituminous nature, and is mined at collieries at Nanaimo, Wellington and Comox on Vancouver Island. Both anthracite and bituminous coal are found on Queen Charlotte Islands. The Crow's Nest Pass Coal Co., of British Columbia, in 1902 produced 223,501 tons of coal and 107,837 tons of coke, the small output being due to an explosion which crippled their principal mine, followed by a strike of the miners. The output of the Vancouver Island collieries amounted to 1,173,893 tons of coal.

China.—The Kaiping coal mine in Chi-li Province, near the Gulf of Pechihle, which was operated since 1878 by a Chinese company, was sold in 1900 to a British syndicate, the Chinese Engineering & Mining Co., Ltd. The field extends for 23 miles along the Tientsin-Newchwang Railway, and is connected both by railway and canal with the port of Tongu. The cost of coolie labor at the mines is 10 to 15c. per day, native labor 12 to 20c., and skilled mechanics 24 to 36c. The company intends to ship coal to Western America.

Europe.—The production of coal in the United Kingdom during 1902 amounted to 227,178,140 long tons, as compared with 219,037,240 long tons in 1901, an increase of 8,140,900 long tons during the year, the greatest individual



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THE PRODUCTION OF COAL IN THE PRINCIPAL COUNTRIES OF THE WORLD IN METRIC TONS.

increase being Scotland. The coal exported in 1902 amounted to 43,160,143 long tons, against 41,877,081 long tons in 1901, an increase of 1,283,062 long tons. The output in France in 1902 was 30,196,994 metric tons, as compared with 33,404,298 tons in 1901, the decrease being due to the strike of miners at the beginning of the winter. Of this total the Valenciennes coal fields contributed 18,363,791 tons, while nearly the whole of the lignite was obtained from the Bouches du Rhone and the Var. The output of coal in the German Empire and Luxemburg in 1902 was 107,436,334 metric tons bituminous and 43,000,476 metric tons brown coal, a total of 150,436,810, as compared with 108,539,444 metric tons bituminous and 44,479,970 metric tons brown coal, a total of 153,019,414 tons in 1901. The exports of coal, including lignite, during 1902 were 16,122,907 metric tons, as compared with 15,287,984 metric tons in 1901, while the imports of the same products were 14,307,668 metric tons in 1902, as compared with 14,406,331 metric tons in 1901. The exports of coke in 1902 were 2,182,383 metric tons, as compared with 2,096,931 tons in 1901, and the imports in 1902 were 362,488 tons, as compared with 400,197 tons in 1901. In Southern Russia for the year ending Aug. 31, 1902, the output of bituminous coal amounted to 10,668,622 tons, as compared with 11,774,272 tons in 1901, the output of coke 1,832,760 for the same period in 1902, as compared with 2,065,845 in 1901.

India.—The output of coal for the year 1902 was 6,849,249 long tons, as compared with 6,635,727 long tons in 1901, the great bulk of which was produced in Bengal. Of a total of 142,491 persons engaged in mining, 85,361, or 60%, were engaged in coal mining. The best coal, known as the Gondwana coal, is found in large quantities at shallow depths and in thick seams in Bengal, Central Provinces, Central India and Hyderabad. The output is largely exported, Ceylon being the chief market. Coal has been discovered in Banganapalli State in the Kurnool district. The new coal field is of considerable area, and the coal seems to be similar to the coal from the Singareni mines farther north.

Japan.—The exports of coal in 1902 were valued at $8,635,209, as compared with $8,771,137 in 1901. The imports in 1902 were valued at $649,187, as compared with $1,271,067 in 1901. The exports of coal during 1901 from the ports of Shimonoseki and Moji, in the consular district of Shimonoseki, amounted to £1,141,725, of which £425,796 were exported to China. In 1901 there were 73 coal mines in North Formosa, 42 of which with an area of over 3 sq. miles were in operation at the close of the year, the total output being 62,547 tons. The mines are in the Kelung district, and are for the most part surface workings. The coal is exported from Tamsui, and is shipped mainly to China. Although the coal is brittle, it has great heating power and leaves but little ash when burned. A poorer grade of coal carrying a large quantity of sulphur is also found. The Takasima coal mines owned and worked by the Mitsu Bishi Co. are located on the islands of Hasima, Nakanosima, Takasima and Yokosima, near the entrance to Nasaki harbor.

Mexico.—The Mexican Coal & Coke Co., operating at Las Esperanzas, State of Coahuila, produced in 1902, 2,000 tons of coal and from 200 to 300 tons of coke per day. It is reported that preparations are being made to open new mines and to put in new coke ovens, and it is expected the coke output will be increased to 500 tons daily. The company, which owns 30,000 acres of coal, has 2,000 men on its pay-roll. Its nearness to Monterey gives the company a market for its coal. The San Marcial coal mines, in the State of Sonora, are being developed so as to produce 150 to 200 tons of coal per diem. A railway is being constructed from the Sonora Railway to the mines, and it is proposed to ship coal to the interior in the summer of 1903.

South America.—The imports of coal into Chile are shown in the following table, reported in long tons, for which we are indebted to the courtesy of Jackson Bros., of Valparaiso:—

Year.	Steam Coal.						Smelting Coal.		
	Hartly.	Orrell.	Other Classes.	Australian.	North American	Total.	English.	Australian.	Total.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1898............	134,177	8,591	100,480	270.085	10,608	523,941	8,599	42,763	51,362
1899............	125,042	7,633	151,825	307,119	3,200	594,319	24,078	43,277	67,350
1900............	88,655	10,341	121,284	356,859	35,600	612.739	15,657	46,350	62,007
1901............	110,280	6,804	217,080	442,380	33,150	809,644	25,868	55,099	80.967
1902............	122,965	5,876	255,883	345,154	34,887	764,765	10,570	54,273	64,843

THE ANTHRACITE COAL TRADE IN 1902.

BY SAMUEL SANFORD.

THE year 1902 will always be known as the year of the great strike, which greatly curtailed shipments for about five months, caused a loss of fully $26,000,000 in gross earnings to railroad companies and of $25,000,000 in wages to mine employees, and gave rise to much inconvenience and even distress. From its start in May, the strike was the controlling factor in the trade.

There were few important transfers of coal properties during the year, and there were no material changes in the general policies of the coal carrying railroads. The Delaware & Hudson Co. turned over to the Erie Railroad its tidewater shipments on a sales contract and also transferred to that road its business at Buffalo. The resignation of President Walter of the Lehigh Railroad, owing to dissatisfactions on the part of certain stockholders with his policy of putting the road's earnings into substantial improvements, was an outcome of the strike. In March, Geo. A. Holden retired as general sales agent of the Delaware, Lackawanna & Western; his retirement marking the final reorganization of the road under Mr. Truesdale, and the end of the long Sloan and Holden regime. The most important event of the year was not made known till the spring of 1903. The banking house of Kuhn, Loeb & Co. purchased in open market almost a controlling interest in the Reading Co. The stocks bought were first and second preferred and common, the largest purchases, relative to the total issue of each class, being in second preferred. It is not known just why Kuhn, Loeb & Co. made the purchases. Possibly the object was to prevent the Wabash Railroad from getting control of the Reading and thus making trouble for the Pennsylvania Railroad. Possibly J. P. Morgan, thinking his control of the

Reading through the voting trust, secure, did not think that any outside interest would try to get control—or possibly he was willing to sell his holdings at a profit. The fact remains that Kuhn, Loeb & Co. bought the stock, and the Pennsylvania Railroad afterward transferred part to the Baltimore & Ohio Railroad and part to the Lake Shore. By acquiring its large interest in Reading the Pennsylvania took a leading position among the anthracite railroads. The house of J. P. Morgan & Co., it is said, disposed of nearly all the Reading stock it held.

Trade by Months.—As the floods in December of the preceding year had greatly reduced output, the demand at the opening of 1902 was strong. The regular f. o. b. prices New York Harbor shipping ports were: Broken $4, egg $4·25, stove and chestnut $4·50, while the steam sizes were in demand at $3 for pea, $2·50 for buckwheat and $2 for rice. Cold weather during much of February stimulated consumption, but by March 1, the prospect of lower prices affected buying. On March 5, however, disastrous floods, the worst in 40 years, almost caused a complete suspension of shipments from the Lackawanna, Wyoming and Lehigh regions for several days, the Susquehanna River rising 32 ft. at Wilkesbarre. Great damage was done to the tracks of the Central Railroad of New Jersey and of the Lehigh Valley along the Lehigh River, while in the Schuylkill and Lehigh regions many collieries were flooded, some of which were not pumped out for months. The total damage to railroads and mines was probably not less than $5,000,000. On April 1, the principal companies announced that the f. o. b. New York Harbor shipping port, prices for April would be: Broken $3·75 and egg, stove and chestnut $4. Egg was thus put on a parity with stove and the differential on broken was reduced to 25c. in accord with practice in the West. Owing to the prospects of a strike at the mines which stimulated buying, the shipments for April were the largest on record. The monthly advance of 10c. a ton on May 1, did not affect buying, and the outlook favored a strong market that would continue well into the summer.

The unexpected action of the Hazleton Convention on May 12, however, practically stopped mining at once, though a few washeries kept at work. Sales agents at New York refused to take new orders and began to sell what coal they had to regular customers only, in order to stop speculators from getting control of the supplies. Nevertheless retailers in New York City advanced prices $1 per ton, while in other cities retail prices rose 25c. and 50c. By the middle of June, dealers at New York owing to limited storage capacity were running short and were buying coal from yards beyond Cape Cod, whither it had gone in April or May. Prepared sizes were selling for $10 per ton at retail, and cargo lots of pea coal sold up to $5·50. By the end of the month, over $6 was paid for pea coal at New York, and $9 for broken, the latter size being greatly needed by the elevated railroad. Bituminous coal wherever possible, was substituted for anthracite in hotels, restaurants and public buildings, and gas and oil were used for domestic purposes as never before. At some cities, for instance Buffalo, wholesale prices advanced but little.

By the opening of August, supplies all over the country were getting low, and in the whole anthracite region, but seven collieries and some twenty washeries were busy. At Lake Superior ports most docks were bare, and at Missouri and Mississippi River points dealers were trying to get Colorado anthracite and Arkansas semi-anthracite. Prices in Eastern cities showed wide variation according to the supplies available, though egg and broken were practically out of the market, the Manhattan Elevated Railroad taking all of these sizes it could get, even at points as far away as Albany and Boston. Speculative coal bought up by jobbers, was offered wholesale alongside New York Harbor at these prices: Stove $8·45, chestnut $8·35, pea $7, buckwheat $4·40, rice, $3. Supplies continued to get scarcer, and prices rose. By September 10, prepared sizes at Chicago sold for $11 and $12 at retail and $10 and $11 at wholesale, with visible supplies down to 15,000 tons. Retailers at New York were restricting deliveries to one ton or less, and getting $12 and $13 a ton. At Boston the retail price was $10. Baltimore and some other points along the seaboard, as well as Lake Superior ports, were out of anthracite.

Prices continue to advance, and by the opening of October, that section of the country north of Virginia was experiencing the worst shortage in anthracite since that coal came into general use, as shown by these retail prices: St. Paul $12, Kansas City $12, Saginaw, Mich., $12, Chicago $15 @ $16, Springfield, Mass., $16, Boston $20, Providence $20, New York $18 @ $25, with some sales as high as $27, Philadelphia $15 @ $20, Richmond, Va., $10. At New York, steam coal often of poor quality sold for: Pea $10, buckwheat $8, rice $6. By the middle of October the strike was virtually over, prices had fallen, and sales agents were overwhelmed with orders. The Philadelphia & Reading Coal & Iron Co. announced on October 5 that to cover the expenses due to the strike its regular winter prices would be advanced 50c. per ton on January 1, making its f. o. b. New York Harbor quotations: Broken $4·75, egg, stove and chestnut $5. Other companies followed the Reading. Fortunately, the weather during October and November was very mild, and with actual consumption under normal, the public did not suffer, though demand was far in excess of supply and speculative coal sold at a premium. By November 20, prices f. o. b. Chicago were: Broken $6·25, egg, stove and chestnut $6·50. In the East retail prices at Philadelphia had fallen to $7 and $9, and at Boston and Narragansett Bay ports to $9. At New York Harbor, where the nominal retail price was $6·50 speculative coal sold as high as $10 for prompt delivery. Some lots of very poor washery coal, steam sizes, sold at discounts.

Early in December, a cold wave with lower temperatures than for a corresponding date in thirty years stimulated demand and hindered coatswise shipments. Retail prices at New York rose to $7·50 and at Boston to $12, and remained there to the end of the year. It is important to note that during the strike some of the railroad coal companies managed to get a little coal for certain concerns which had to burn anthracite and this coal was sold at the regular list price, though prices in the open market were twice as high. The difference between list and speculative prices after the strike was marked, and it is almost impossible to say what were average selling prices at tidewater during the last half of the year.

THE SEABOARD BITUMINOUS COAL TRADE IN 1902.

BY SAMUEL SANFORD.

THE bituminous coal trade of the Atlantic seaboard during 1902 was controlled as never before by the railroads. Stockholders in the Pennsylvania Railroad are reported to hold large interests in three other roads shipping bituminous coal to tidewater from the West Virginia and Pennsylvania fields, and these roads have a territorial policy by which certain coals, to avoid long car hauls, are sent to certain markets. Industrial activity in 1900 and 1901 taxed the carrying capacity of railroads all over the country, and it is possible that in 1902 the Pennsylvania and allied railroads were unable to give the service demanded by coal shippers. There was a serious strike in West Virginia, otherwise production was very heavy. The great shortage in fuel over the northeastern section of the United States due to the anthracite strike affected bituminous prices, and it is still a question whether or not the railroads could have moved to tidewater a heavier tonnage of soft coal; some people contend that had the bituminous coal roads done their best, prices during the coal strike and later would not have reached extreme figures.

Of transfers of coal lands in West Virginia and Pennsylvania there were many, the two most important being the acquisition by the Goulds of the holdings of the Davis Coal & Coke Co., including its mines and the West Virginia Central Railroad from the mines to Cumberland. The Goulds also acquired the Western Maryland Road, owned largely by the City of Baltimore, running from Baltimore to Hagerstown, and by these roads will run a line from Pittsburg to Baltimore, making the Wabash a factor in the trade. The railroad will not have a particularly well situated line, but it will open a large coal field, and is likely to have much influence. In Pennsylvania, a number of mines and companies holding coal lands were consolidated as the Summerset Coal Co. later acquired by Baltimore & Ohio interests. This consolidation was largely speculative, and was probably made to enable the promoters to get favorable terms by having the Wabash compete with the Baltimore & Ohio.

Trade by Months.—Though the year opened with coal selling at a premium, by the middle of January conditions had improved, and prices were about normal —that is, $2·65 and $2·85 for Clearfield grades f. o. b. New York Harbor shipping ports. The best grades such as Georges Creek, were out of the market, and practically remained out of the market throughout the year. At a meeting of the Bituminous Association at Philadelphia in February the members favored continuing old prices for new contracts. The floods in March affected traffic and Clearfield sold f. o. b. at New York Harbor ports for $3·50 for spot. Car supply, which had been poor, improved subsequently to about 75% of the demand, and by April 20, prices for poorer Clearfield fell to $2·55 f. o. b. New York Harbor. The strike of the anthracite miners on May 12, was immediately followed by the bituminous railroads cutting car supply, which had been about 75% of the demand, to 50% of some shippers' needs. This and the fear that the anthracite strike might spread to bituminous mines frightened the trade, and Clearfield sold up to $3·50 f. o. b. New York Harbor. Though car supply improved to 90% of demand, the

Pocahontas and New River miners were preparing to go out, and the market soon became speculative. The output fell off about 80% when the Virginia and West Virginia miners stopped work on June 7. By June 25, speculative prices rose to $4·85 for the better grades of Clearfield f. o. b. New York Harbor. When the men began to return to work in July and transportation and car supply were fairly adequate, speculative prices dropped to $3·25, and there was complaint of an apparent connection between speculative prices and variations in car supply and transportation. By the middle of August, some Pittsburg coal was arriving at tidewater, and a few large blocks of Nova Scotia coals had been taken for delivery at points east of Cape Cod. At New York Harbor prices for Clearfield fell to less than $3 per ton. By the end of the month, the strike in the Pocahontas district and at most of the New River mines shipping to tidewater, was practically over, but car supply became poorer and transportation slower and Clearfield grades advanced to $3·55 f. o. b. New York Harbor. Then a serious car shortage began to develop, the market became suddenly nervous and speculative prices jumped, the Pennsylvania Railroad getting the blame. Bituminous coal supplanted anthracite in hotels and public buildings, and to some extent for domestic purposes; the New York, New Haven & Hartford Railroad unable to get coal on its contract with the Davis Coal & Coke Co., because of the dispute between the Pennsylvania and Wabash roads, was buying in the open market; yet car supply on the Pennsylvania fell off, transportation was poor and less than a normal tonnage of bituminous coal was arriving at shipping ports. Prices by September 25, were $6·35 at New York Harbor and as high as $8·50 f. o. b. at points beyond Cape Cod. Early in October, in some cases as high as $9 per ton was paid for Clearfield grades f. o. b. New York Harbor ports, the railroads were seizing coal in transmit, and many manufacturing concerns were closing down. In the East the situation had been relieved by imports of Canadian coal and purchases of Scotch, English and Welsh coals. By October 5, however, the anthracite strike was virtually over, and the market much quieter, Clearfield grades selling (in a few days) from $8 to below $6 at New York Harbor, and falling later to $4. Some English and Scotch coal was arriving at North Atlantic ports, some of it being offered at below $7 per ton f. o. b. New York. During October, car supply continued poor and transportation irregular with demand strong and prices rose to $6·25 by November 30, but with improved car supply dropped to $5·50 f. o. b. New York Harbor for Clearfield. Then car supply fell to 35% of the demand, cold weather and storms increased buying and interrupted coastwise shipments. In December, speculative prices jumped to $7·25 per ton f. o. b. New York Harbor and $10 at points beyond Cape Cod; while at Philadelphia before the end of the month, bituminous coal was selling for $7, or for more than the price of prepared sizes of anthracite.

RECENT DEVELOPMENTS IN THE ANTHRACITE COAL TRADE.

BY SAMUEL SANFORD.

THE anthracite coal trade during the last few years has attracted much attention. A great wave of industrial prosperity, the crest of which is perhaps passed, has lifted the trade from the level to which it fell in the years following the panic of 1893, and also enabled financiers to try to give it such support that it may not fall back to its old level when the wave of prosperity has passed. The public, though in a general way cognizant of their efforts, has apparently no clear idea of the problems those now in control of the trade have to solve. Two strikes of the anthracite miners have given an opportunity for newspapers of the baser sort to indulge in all sorts of abuse of the mining and railroad companies, to advocate confiscation of the mines, etc., thus expressing a natural anger at having to pay higher prices for coal, but little desire or even willingness to learn the facts or to look at the situation from more than one view point.

This article will not take up except incidentally the matters discussed so ably in the report of the Anthracite Strike Commission. Neither will it take up the early growth of the industry, the splendid achievements of its pioneers,—men like Josiah White,—nor trace the growth of large companies previous to 1860, the insecure prosperity of the industry during the Civil War and in the period of inflation following, the rule of trade unionism under the Mollie Maguires, or the ambitious plans and utter failure of the brilliant president of the Philadelphia & Reading Railroad—Franklin M. Gowen—since these have been discussed by the late R. P. Rothwell in his article on the "Evolution of the Anthracite Coal Trade," in THE MINERAL INDUSTRY, Vol. IV. That trenchant article, in its keen analysis of the weaknesses of the trade and their steady development, is perhaps one of the best short presentations of the evolution of a great industry ever written. The present article aims simply to give a review of what has been done in the trade during the past seven years, to show why recent attempts to put the industry on a profitable basis may prove successful, to point out the present tendencies in the trade and to indicate its probable future.

Mr. Rothwell summarized the evolution of the trade up to 1896 as follows: "From the very beginning of the industry there has always been more money invested in it than reasonable profits on a normal business could pay interest on. There has been an overproduction of both coal and railroads. Investments in anthracite lands and in railroads to reach them, as in other things, have generally been on the crests of waves of inflation when all valuations were exorbitant. Under the influence of enthusiastic, oversanguine and not always disinterested or even honest men, unnecessary lands were purchased and unnecessary roads were built because in 'boom' times it was comparatively easy for these men to raise capital on stocks and bonds. When the reaction from each of these periods of inflation arrived, and it was difficult to cover losses by increasing indebtedness, the real condition of the industry became more or less apparent, but instead of scaling down the excessive indebtedness the usual course has been to increase it by making new debts on still more onerous terms to provide temporary relief.

"The final outcome of this magnificent industry has been that with few and temporary exceptions, there has never been any profit in the mining of anthracite. It is shown in the history of the trade, and it is needless to multiply the proofs of it. Millions have been made from the royalties on coal by fortunate landowners, both individuals and companies. Fortunes have been amassed in the transportation and in the marketing of coal, and immense sums have been realized in salaries, commissions, and in various other ways connected with and dependent on the producing of coal. But it must be admitted that in the actual business of mining coal and selling it at the colliery, there has rarely been any profit over a series of years. The country at large has been the chief beneficiary of the anthracite fields of Pennsylvania. No other industry in all this broad land, nor in all the world, has ever created such magnificent results in material prosperity as has the anthracite trade of Pennsylvania."

At the close of 1895 the trade was in a bad way. Attempts in previous years to restrict production to market needs and keep prices high enough to give a fair profit had failed, and the 1895 attempt was a worse failure than most of its predecessors. The sales agents in New York City at monthly conferences estimated what the market would take, but the output regularly exceeded the estimates, so that by November even the pretence of restriction was abandoned, every company being free to get out as much as it chose. The net result for the year was a record-breaking output, sold at prices which could have hardly been satisfactory. Conditions during 1896 were also unsatisfactory, though the railroads maintained prices fairly well and kept output in sight of market needs; but the country had not recovered from the effects of the panic of 1893 and people managed to get along with much less coal than the directing minds of the anthracite trade apparently thought possible, and at the end of the year the companies again had large unsold stocks on hand. At the opening of 1897 the producers resolved to restrict production still more, and for the first half of the year succeeded fairly well, but shipments though cut to below the figures of 1896, were still too much for the market. The sales agents' monthly estimates of what the market would take in 1896 made a total of 42,344,222 tons, while the actual shipments from the mines were 43,177,400; in 1897 the estimated tonnage needed was 38,159,200 tons, the shipments 41,204,800 tons. During much of 1898 the trade was demoralized. Anthracite prices did not reach the 1879 average—$3·30 for stove size f. o. b. New York Harbor—but by the end of the year were very low. In 1899 prosperity came to the anthracite as to other industries, and came quickly. Since 1899 strikes have interrupted production in two years, resulting in abnormal conditions, and the continued prosperity of the country has maintained demand.

During May, June and July, 1898, many mines in the Lackawanna and Wyoming regions worked but 5 days a month. The miners were dissatisfied, and the organizers of the United Mine Workers found ready listeners when they began to preach trade unionism in a region where trade unions had lost nearly all power after the defeat of the Knights of Labor in 1887. The independent mining companies,—those mining companies not controlled by a railroad,—were complaining that freight rates were too high, that the railroad companies were altogether too arbitrary in restricing car supply, though in the demoralized state of the market it was utterly impossible for the coal companies to dispose of all the coal the independent producers wished to sell, and plans of all kinds, some good, some utterly visionary were under discussion. The upshot of the matter was that the independent operators, most of whom were members of the Anthracite Operators' Association, became most thoroughly dissatisfied with conditions, and a number of those in the Wyoming and Lackawanna regions took up the project of a new railroad to run from near Pittston, Pa., to Belvidere, reaching tide-water at New York Harbor. It was incorporated in 1898 as the New York, Wyoming & Western Railroad, with a capital of $1,000,000. T. H. Watkins, of Simpson & Watkins, T. L. Jones and T. C. Fuller were the executive committee. According to the promoters about $750,000 of the capital stock was subscribed, and operators not under contract to existing railroads pledged a tonnage of between 2,000,000 and 3,000,000 tons annually, the Simpson & Watkins tonnage alone being 1,150,000 tons. The company had surveyors in the field in 1899 and purchased or took an option on 7,000 tons of steel rails. The existing railroads naturally did not look with favor on the project, and the company had trouble in locating a right of way. In fact it is still a matter of doubt if the company could have secured a right of way to all the collieries it proposed to reach.

According to Mr. Baer, then counsel for the Reading Co., Mr. Watkins had a theory in 1898 that it was possible to get up a company to consolidate the selling agencies of the principal anthracite companies. Among the stockholders in the firm of Simpson & Watkins were certain New York men, who it is currently believed included representatives of the Vanderbilts. These gentlemen were much opposed to Simpson & Watkins going into the construction of a rival railroad, while not seriously believing that the road was planned wholly in good faith. When a syndicate was formed to buy the collieries, Mr. Watkins outlined his plan of a central purchasing and selling agency. The various railroad companies already in the field agreed to finance the new company, by a purchase of the stock in the future. To purchase the stock of the various collieries the charter of the Temple Iron Co. was secured. This company had a small anthracite blast furnace at Temple, Pa., and employed about 150 men. It was capitalized at $240,000, Mr. Baer owning one-fifth of the stock. The Company's Pennsylvania charter antedated 1874, and was very liberal indeed, even empowering the company to build railroads, transport, mine, buy and sell coal, iron ore and other minerals, etc. By Mr. Baer's advice the stock of the company was increased to $2,000,000, and bonds were issued as the Pennsylvania law permitted. The stock was deposited in a voting trust, and the railroads guaranteed the payment of the bonds.

The railroad companies agreed to purchase the stock when called upon by the trustees, the call being optional in 1904 and absolute in 1907. Subsequently Mr. Baer discovered that the scheme of a central agency was altogether undesirable; possibly it had features which would have aroused public protest and legal action. He, therefore, refused to make the Temple Iron Co. the selling agent of the Reading Co., and the other railway presidents followed his example. Mr. Watkins resigned as president of the Temple Iron Co., and Mr. Baer succeeded him. The Temple Iron Co., however, continued, and still continues, to operate the collieries it acquired. The presidents of the railroads guaranteeing the stock and bonds of the company were made directors because they were most directly interested. They control a majority of the stock. The railroads guarantee the debt on a basis of the average percentage of the total shipments of coal from the anthracite fields each handled during several years prior to 1898; this being deemed the most satisfactory basis. It may be noted in passing that there are other men than Mr. Baer who believe that the interest of Simpson & Watkins in a projected railroad was largely a pretext to get better terms for their property. Certain it is that they received a very good price indeed.

The New York, Lake Erie & Western Railroad was reorganized as the Erie Railway in 1895. It had a shipping arrangement with the Delaware & Hudson Canal Co., but its own coal lands were in the northern part of the Lackawanna region, and its subsidiary Hillside Coal & Iron Co. was not a very important producer. The stock of the Erie Railway, except a few shares of common stock, was deposited in a voting trust; the three trustees, one of whom was J. P. Morgan, were to hold the stock until 1900 and thereafter, until a cash dividend of 4% had been paid on the first preferred stock.

In 1898 Mr. Morgan made the Erie Railroad a much more important factor in the anthracite trade by taking over the New York, Susquehanna & Western Railroad, which had been completed to the anthracite fields in 1894, after considerable litigation over rights of way, etc., with existing lines. The road was to take the tonnage of a number of independent operators about Scranton, who had pledged their tonnage on contracts calling for 50% of the tide-water selling price. The New York, Susquehanna & Western Railroad handled the output of the Jermyn collieries, and of several other companies, and in 1897 handled as an initial road 1,400,000 tons of coal. The Erie Railway paid for it by issuing stock, and exchanging nine-tenths of a share of its stock for one of New York, Susquehanna & Western.

Most of the independent operators were shipping under contracts by which they turned over their coal at the breaker to a coal and iron company controlled by a railroad company, receiving therefore 60% of the average selling price of the prepared sizes of free burning white-ash coal, f. o. b. New York Harbor during the preceding month. It is to be noted that the coal and iron company bought the coal outright at the breaker, and the 60% of the tide-water selling price was simply a measure of value. The coal of an independent operator bought under one of these contracts might be shipped to some nearby point, or to Chicago, Duluth or St. Louis, and the price which the railroad company received for it would then have nothing to do with the New York Harbor price. The sales contracts, therefore, were not shipping contracts, but purchase contracts pure and simple. However, many independent operators were much dissatisfied at the restrictions the railroads often put on output by short car supply, the railroads being hampered by the poor market in 1896, 1897 and 1898, and these operators, or some of them, projected another railroad to tide-water. This road was incorporated in 1899 as the Delaware Valley & Kingston, and was to run from Lackawaxen to Kingston along the Delaware & Hudson Canal, which the Delaware & Hudson Canal Co. had just abandoned as unprofitable after some 70 years of use. A large part of the tonnage to be shipped over the proposed road was to come from the mines of the Pennsylvania Coal Co., one of the few large concerns in the anthracite regions to pay good dividends over a long term of years. This company owned its coal lands, therefore paid no royalties. It had bought the lands at a time when lands were cheap, and its operations had been carefully managed. The company had its own railroad, the Erie & Wyoming Valley Railroad, running from Hawley to Scranton, and this road was to be part of the projected Delaware Valley & Kingston Railroad. The construction of the new road was vigorously opposed by the Erie Railroad, which had been hauling for something like 30 years the output of the Pennsylvania Coal Co.'s mines from the terminus of the Erie & Wyoming Valley Railroad. The Erie Railroad naturally objected to losing the haul of something like 1,000,000 tons of coal a year, and bitterly fought every step in the New York and the Pennsylvania courts. This litigation delayed construction, if construction had been seriously intended, on the road, and finally in 1900 the Erie bought the property of the Pennsylvania Coal Co. and of the Delaware Valley & Kingston Railroad. The purchase was made through J. P. Morgan & Co., which bought up the shares of the Pennsylvania Coal Co., paying therefore $32,000,000, and afterward transferred the shares to the Hillside Coal & Iron Co. controlled by the Erie Railroad, taking payment in Erie Railroad bonds and receiving a commission of $1,500,000 on the deal. As the Pennsylvania Coal Co. was now out of it, and as the market for anthracite had greatly improved, the other independent operators lost interest in a new railroad, and finally abandoned the project when they made new sales contracts in 1901, by which they sold their coal at the breaker at 65% of the tide-water price. The new contracts, however, were to last during the life of the mine.

When the Delaware & Hudson Canal Co. abandoned its canal from Honesdale to Rondout in 1899, it turned over its Eastern shipments to the Erie Railroad, which hauled the coal from Honesdale to tide-water at a very low freight rate, reported to have been about 0·3c. per ton-mile, in strong contrast with the usual charge of about 0·8c. from the anthracite mines to tide-water. At present the Delaware & Hudson sells much of its coal to the Hillside Coal & Iron Co. on a contract calling for 65% of the average tide-water price.

The Philadelphia & Reading Railroad was reorganized in 1896 as the final outcome of Mr. McLeod's attempt in 1892 to control the anthracite trade. His plan was to unite the railroads by leasing several and securing a majority in the boards of directors of the others. The plan also included the purchase by the railroad of all the coal produced on the line of the road at 60% of the price realized at New York harbor, and if any independent wished to sell his own coal he was to be brought to terms by an advance in freights. Mr. McLeod was in some ways an abler railroad executive than Mr. Gowen, and his plan did not rest on oversanguine estimates. It failed from external reasons. (1) The attempt to extend the Reading's control was at a time of falling values and contracting credit, making the task of raising sufficient funds very difficult. (2) Mr. McLeod wrongly supposed that a great market could be secured by an all-rail route to New England. In endeavoring to secure New England connections Mr. McLeod incurred the displeasure of stockholders in the New York, New Haven &

Hartford Railroad, and thereby brought quick destruction on himself and his plans. Mr. McLeod's attempt was premature, but in the main soundly planned.

After the foreclosure in 1896 the capital stock of both the Philadelphia & Reading Railway, successor of the Philadelphia & Reading Railroad, and of the Philadelphia & Reading Coal & Iron Co. were acquired by the Reading Co., a Pennsylvania corporation. All the stock except 2,000 shares of common stock was deposited in a voting trust, with J. P. Morgan, F. P. Olcott and C. S. W. Packard as voting trustees, to be held until January 1, 1902, and thereafter until the first preferred stock should receive a 4% dividend for two consecutive years.

Speaking of the Reading Railroad, Mr. Rothwell has said: "There is no competitor in market so dangerous as a concern obliged to force its output and sell its product regardless of consequences, because while running it can get extensions of credit and can borrow money to carry it over to those better times which are always looming up on the horizon of every sanguine financier. The condition of unstable equilibrium, in which the finances of a number of the coal roads and companies have always been, could not withstand the additional burden which would be brought upon it by such demoralized markets as would result from the frantic struggles of a bankrupt competitor. Hence the companies have unwillingly been forced to hold together in an effort to support the market price of coal. Since the weakest financially, and consequently the most dangerous of the coal roads, is that which has the greatest natural advantages and elements of strength, it is evident that the controlling factor in this struggle lies not in natural advantages but in pre-eminent ability to borrow money. There is no doubt that if the Reading had abundant capital it would promptly take a very much larger proportion of the trade than it has, and would practically dictate to all its competitors or absorb them."

In reorganizing the Reading, Mr. Morgan and the men he represented were of course taking up a project out of which they expected to make money. Probably they, like Mr. Gowen and Mr. McLeod, saw the possibilities of the Reading system and of the anthracite coal trade; possessed of ample resources, all they needed to do was to take full advantage of the first rise of the next wave of industrial prosperity. The anthracite companies had wandered in the wilderness of mismanagement long enough and were looking for a Moses to lead them out. Consequently the house of J. P. Morgan & Co. met with no serious resistance in its plans, and public opinion was not aroused till later.

In January, 1901, the Philadelphia & Reading Railway took over 145,000 shares (a majority) of the stock of the Central Railroad of New Jersey for $23,200,000. J. P. Morgan & Co. bought the shares and charged a commission. The purchase gave the Reading a more direct entrance to New York, and also enabled Morgan interests to extend their holdings of coal lands, as the Central Railroad of New Jersey controls the Lehigh & Wilkes Barre Coal Co., which has collieries in the Wyoming Valley and in the Lehigh region. New York business of the Reading had gone over Central tracks for 30 miles, and the Reading hauled considerable bituminous coal to Allentown, Pa., whence the Central hauled it to New York.

A previous transfer of the Central Railroad of New Jersey to the Reading Co.

by lease, under the McLeod régime, had been set aside by the New Jersey courts. Purchase of stocks in the open market is, however, a different proposition, and the Reading Co. undoubtedly violated no law in getting control. The lines of the Reading and of the Central Railroad of New Jersey from the anthracite fields to tide-water are not parallel, and thus the Reading Co. does not violate that clause of the Pennsylvania constitution of 1874, which forbids the consolidation of parallel and competing railways.

The Lehigh Valley Railroad owns the capital stock of the Lehigh Valley Coal Co., that has mines in the Wyoming and Lehigh regions, and has long been an important factor in the anthracite trade. The railroad, once a magnificent property, got into financial straits by building its own line from the coal regions to Buffalo, completed in 1892. In 1895 the railroad officials applied to J. P. Morgan for aid, and he advanced a large sum, taking as security the stock of the Packard estate, about one-third of the total capitalization of the company, and securing an option to purchase it.

This stock was deposited in a voting trust and held thus several years, but in 1900 Mr. Morgan exercised his rights under his option and bought the stock. The Lehigh Valley securities are held by many stockholders, and purchase of control in the open market would have been expensive, and perhaps not desirable. The Packard estate stock was the largest block easily procurable. Mr. Morgan, it is said, turned the stock over to the Erie, the Reading and the Delaware, Lackawanna & Western, dividing it between them; the railroads paid for it by an exchange of stock, and Mr. Morgan got his commission, it is generally believed, in some of the Packard stock.

Of the coal mining concerns not directly owned by railroads in the Lehigh region the largest are the Cross Creek Coal Co. (Coxe estate), and the Lehigh Coal & Navigation Co. The Cross Creek Co. owns the Delaware, Susquehanna & Schuylkill Railroad that connects with the Lehigh Valley, and runs its own cars and locomotives to tide-water over Lehigh Valley tracks. The Lehigh Coal & Navigation Co. years ago leased its railroad lines in the Panther Creek Valley for 999 years to the Central Railroad of New Jersey.

Of the chief coal carrying roads, the Delaware, Lackawanna & Western Railroad enjoys many advantages. Incorporated in 1853, its Pennsylvania charter gives it the right to mine, transport and sell coal. It has properties around Scranton, near Plymouth and back of Nanticoke. Some of these are leased at high royalties, but many were bought years ago at low prices, consequently the road has not been burdened with a great coal land indebtedness, and as the road has been managed very conservatively it has paid dividends when some of its competitors were undergoing reorganization, or were on the verge of bankruptcy. Being thus financially independent, the road under the administration of Messrs. Samuel Sloan and E. B. Holden acted independently in the matter of marketing its output. Its officials aimed to make a profit in their own way regardless of other roads. The stock of the company was largely held by Mr. Sloan, by the Taylor estate and by the New York Central Railroad, or stockholders in that road. After the Vanderbilts and others became interested in Mr. Morgan's plans to put the anthracite trade on a more profitable basis there was a change in the policy of the Delaware, Lackawanna & Western Railroad. Early in 1899 Mr. Samuel Sloan, the venerable president of the road, resigned, and was succeeded by Mr. W. H. Truesdale, who had shown high ability as a railroad manager. His coming was followed by many changes in the officials, some of whom had held their places for years, by a more open attitude of the directors toward the stockholders, and apparently by a changed policy regarding output and prices.

The New York, Ontario & Western Railroad, when it built a 54-mile branch to Scranton in 1890, had no direct control of anthracite mines, and its contracts with individual operators did not insure tonnage. To insure tonnage it did what other railroads had done, advanced money to operators to open mines, and later bought a majority of the stock of the Elkhill Coal & Iron Co. and of the Scranton Coal Co., and advanced money to these companies to buy mines, including those of the Lackawanna Iron & Steel Co. In this way between 1898 and 1901 it secured indirectly over 80% of the producing capacity of the mines it reaches. The stock of the New York, Ontario & Western is largely held in England, and its directors though willing enough to support any policy that would increase the road's earnings, have always acted rather independently. The Vanderbilts are believed to own stock in the road, which ships to New York harbor from Cornwall over the tracks of the West Shore, a Vanderbilt line.

The Pennsylvania Railroad has been interested in anthracite through its subsidiary Susquehanna Coal Co. with mines near Nanticoke in the Wyoming region, and through the Union Coal Co. and the Mineral Hill Railroad & Mining Co., with mines in the western part of the Schuylkill region. The company has always given attention to hauling bituminous coal, and has had little to do with any attempt to restrict the production or uphold the price of anthracite. When Mr. Morgan started to control the anthracite situation he met with little or no opposition from the Pennsylvania, and the opinion prevailed that Mr. Morgan and the Vanderbilt roads were to take care of anthracite, and the Pennsylvania Co. was to look out for bituminous trade. After the Pennsylvania Railroad had secured large interests in the stocks of the Norfolk & Western, Chesapeake & Ohio, and Baltimore & Ohio (in 1899), there was no apparent change in the Pennsylvania's attitude until 1902. In the spring of 1903 the announcement was made that the banking house of Kuhn, Loeb & Co. had purchased in open market almost a controlling interest in the Reading Co., 1,300,000 shares out of 2,800,000, mostly first preferred stock. Why this purchase was made is a matter of doubt. Possibly it was an outcome of the fight between the Pennsylvania and Wabash systems, Mr. Morgan having no objection to selling out his Reading holdings at a profit and the Pennsylvania and the Vanderbilt railroads wishing to keep the Wabash from getting control of the Reading. The stock acquired by Pennsylvania and Vanderbilt interests was taken over by the Baltimore & Ohio Railroad, a Maryland corporation, for the Pennsylvania Railroad and by the Lake Shore Railroad for the Vanderbilts. Thus conflict with that clause of the Pennsylvania constitution forbidding the consolidation of competing lines was avoided. At the same time J. P. Morgan & Co. increased their holdings of Erie.

The house of J. P. Morgan & Co. having secured a commanding position in the

SHIPMENTS FROM THE ANTHRACITE REGIONS (TONS OF 2,240 LB.) AND PERCENTAGE OF COAL HANDLED BY EACH ROAD AS AN INITIAL LINE.

Coal Roads.	1895.		1896.		1897.	
	Shipments.	Per Cent.	Shipments.	Per Cent.	Shipments.	Per Cent.
Philadelphia & Reading	9,905,059	21·28	9,019,533	20·89	8,395.411	20·2
Central of New Jersey	5,388,194	11·58	4,999,008	11·58	4,730,860	11·4
Lehigh Valley	7,360,454	16·82	6,749,128	15·63	6,425,237	15·4
Del., Lack & Western	6,129,261	13·17	5,627,533	13·03	5,696,684	13·7
Delaware & Hudson	4,347,843	9·35	4,152,278	9·02	5,646,853	13·5
Pennsylvania R.R.	5,025,645	10·80	4,752,120	11·16	....	....
Pennsylvania Coal Co.	1,746,833	3·76	1,728,972	4·05	1,777,841	4·3
Erie	1,820,038	3·91	1,718,262	3·98	....	....
N. Y., Ontario & Western	1,424,407	3·07	1,821,895	3·06	....	....
Del., Susq. & Schuylkill	1,905,784	4·10	1,698,684	3·93	....	....
N. Y., Susq. & Western	1,493,244	3·21	1,410,080	3·27	....	....
Total	46,511,476	100·00	48,177,485	100·00	41,637,864	100·00

Coal Roads.	1898.		1899.		1900.	
	Shipments.	Per Cent.	Shipments.	Per Cent.	Shipments.	Per Cent.
Philadelphia & Reading	8,219,814	19·6	9,683,508	21·21	9.338,516	....
Central of New Jersey	4,626,386	11·0	5,392,550	11·31	5,309,856	....
Lehigh Valley	6,885,577	16·5	7,588,932	16·62	6.909,442	....
Del., Lack. & Western	5,795,540	13·8	....	....	6,018,849	....
Delaware & Hudson	5,613,186	13·4	....	....	3,973,859	....
Pennsylvania R.R.	....	....	....	....	5,169,947	....
Pennsylvania Coal Co.	1,854,515	4·4	....	....	....	....
Erie	....	....	....	....	5,165,070	....
N. Y., Ont. & Western	....	....	....	....	1,658.457	....
Del., Susq. & Schuylkill	....	....	....	....	1,568,488	....
Total	41,879,751	100·00	47,665,203	100·00	45,107,484	100·00

In the year 1886-1896 the highest and lowest percentages handled by the railroads were: Reading, highest 21·84, lowest 20·30; the Lehigh Valley, highest 21·12, lowest 13·86; Central of New Jersey, highest 17·10, lowest 11·58; Delaware, Lackawanna & Western, highest 18·42, lowest 13·08; Delaware & Hudson, highest 11·84, lowest 9·02; Pennsylvania Railroad, highest 13·57, lowest 9·28.

anthracite trade could put through any plan which seemed likely to benefit the railroads, make mining more profitable, and insure steadier work at the mines. As has been pointed out time and again, the anthracite trade has suffered not only from the persistent tendency of operators to mine and market more coal than the public could take at a profitable price, but also from irregular demand. Anthracite being a domestic fuel is most wanted in winter, while from April to September but little coal is required. A demand, heavy during a few months and then very light, has made the working time of miners correspondingly irregular, with the result that though wages have been high, yearly earnings have sometimes been woefully small. The wages have attracted many men to the field with the resulting conditions that the Anthracite Strike Commission discusses in its report.

As irregular work at the mines is more expensive than steady operation, the mining and railroad companies have sought to keep the mines running more steadily by storing coal during the slack months—June, July and August, long known as the time of "midsummer dullness." This, however, gave little relief to the independent operators since the railroad could hardly be expected to help an independent at the cost of rehandling his coal, and the companies themselves aside from the expense and waste in storing coal, according to Mr. Baer, 20c.

per ton for the Reading, have often found this stored coal a demoralizing factor in a weak market.

A new plan proposed in the spring of 1901 resembled somewhat a plan suggested years before which had failed for the same reason that caused the failure of so many other plans to make the trade profitable, the lack of good faith among officers of the companies. The new schedule of prices was on a basis of $4·50 per ton for stove and chestnut sizes of free-burning white ash coal f. o. b. New York harbor, with egg, $4·25 and broken $4. A discount of 50c. per ton was to be given on all coal delivered in April, 40c. in May, 30c. in June, and so on till basis prices were reached Sept. 1. In connection with this plan, a most excellent one for insuring a more even distribution of buying, and thereby steadier work at the collieries, the Reading undertook the reform of another abuse, by making prices the same to large and small dealers, and doing away with many commission sales agencies. This meant a saving in commissions, and the removal of the influence of the jobbers and speculators who by buying at discounts, perhaps of some relative connected with a coal company, had helped demoralize market conditions. It is to be noted that all the companies announced the same prices and the same discounts for the same grades of prepared sizes. This at first sight

CIRCULAR AND SELLING PRICES OF STOVE COAL F. O. B., NEW YORK HARBOR, BY MONTHS, 1895–1902.

Month.	1895.		1896.		1897.		1898.	
	Circular Price.	Selling Price.	Circular Price.	Selling Price.	Circular Price.	Selling Price.	Circular Price.	Selling Price.
January	$3·60	$3·36	$3·75	$3·28	$4·25	$3·87	$4·50	$3·74
February	3·60	3·28	3·75	3·24	4·25–4·10	3·91	4·00	3·84
March	3·60	3·15	3·75	3·44	4·25	3·92	4·00	3·88
April	3·35	3·05	3·75	3·55	4·25	3·93	4·00	3·68
May	3·35	3·00	4·00	3·60	4·25	3·95	4.00	3·91
June	3·35	2·87	4·00	3·66	4·25–4·10	3·97	4.00	3·91
July	3·35	2·80	4·25	3·81	4·50	3·99	4.00	3·85
August	3·35	2·75	4·25	3·90	4·50	4·01	4.00	3·80
September	3·55	3·10	4·50	3·98	4·50	4·03	4.00	3·72
October	3·87	3·28	4·50	4·06	4·50	4·00	4.25	3·64
November	4·00	3·40	4·50	4·14	4·50	3·91	4.25	3·60
December	4·00	3·28	4·50	3·97	4·50	3·78	4.25	3·56
Average	3·58	3·11	4·15	3·72	4·37	3·94	4.10	3·75

Month.	1899.		1900.		1901.		1902.	
	Circular Price.	Selling Price.	Circular Price.	Selling Price.	Circular Price.	Selling Price.	Circular Price.	Selling Price.
January	$4·25	$3·54	$4·40	$4·02	$4·00	$4·48	$4·50	$4·50
February	4·25	3·57	4·40	3·96	4·50	4·42	4·50	4·48
March	4·25	3·56	4·40	3·84	4·50	4·28	4·50	4·48
April	4·25	3·62	3·90	3·72	4·00	3·90	4·00	3·99
May	3·75	3·64	3·90	3·71	4·10	4·01	4·10	4·10
June	3·75	3·66	3·90	3·70	4·20	4·12	4·20	4·20
July	4·00	3·72	4·25	3·69	4·30	4·23	4·30	....
August	4·00	3·75	4·25	3·78	4·40	4·34	4·40	....
September	4·00	3·83	4·25	3·84	4·50	4·40	4·50	....
October	4·25	3·93	4·25	4·28	4·50	4·45	4·50	....
November	4·25	3·97	4·50	4·41	4·50	4·47	5·00	5·00
December	4·25	4·03	4·50	4·44	4·50	4·48	5·00	5·00
Average	4·10	3·73	4·24	3·88	4·37	4·32	4·46	....

The above table shows quite plainly the wide divergencies between list quotations and the actual selling prices in the year prior to 1900. It will be seen that the strike of September, 1900, brought selling prices up to quotations. During the long strike of 1902, the companies nominally adhered to regular quotations, but had little coal to sell after June, and the f. o. b. price given is that of "speculative" coal—coal sold by independent operators or brought to New York from other markets.

looks like a combination in restraint of trade, a violation of the Sherman act, and certain newspapers have actively denounced the plan. Mr. Baer, however, has publicly said that he announces what prices the Reading Co. will ask for its coal, and the presidents of the other companies follow his lead. He said that the president of another company would be foolish to sell for less with demand as active as it has been for the past two years. This is, of course, so, but back of this is the fact that several of the anthracite railroads are owned by interests that act in harmony, and those that are not have no desire to fight. In conclusion it should be said of this sales system that it has yet to stand the test of years of depression.

Taking the roads as they are to-day, therefore, we find the Pennsylvania Railroad owning stock in the Norfolk & Western, the Chesapeake & Ohio, and Baltimore & Ohio railroads, which with it transport 90% of all the bituminous coal reaching the Atlantic seaboard. The Reading Co. owns 53% of the stock of the Central Railroad of New Jersey, and with the Erie, the Delaware, Lackawanna & Western, and the Pennsylvania owns a large amount of Lehigh Valley Railroad stock. A controlling interest in the first preferred stock of the Reading Railroad is held by the Baltimore & Ohio Railroad, controlled by the Pennsylvania Railroad, and by the Lake Shore Railroad, a Vanderbilt road. The Vanderbilts have large holdings in the Delaware, Lackawanna & Western, and possibly also in Delaware & Hudson Co., while the output of the Delaware & Hudson is largely handled by the Erie, a Morgan railroad. Recently there have been many transfers of railroad securities on the Stock Exchange, and it is not known what share of Lehigh Valley Railroad stock has been secured by men interested in the Wabash system, but with Mr. Morgan, the Vanderbilts and the stockholders of the Pennsylvania Railroad acting in harmony to make the anthracite industry profitable, there is not going to be such recklessness in the management of the anthracite roads as there has been. There is little need of sales agents agreeing on prices, or of railroad presidents agreeing on outputs. The presidents are expected to make their properties pay, but, knowing the history of the trade and how the stocks of their companies are held, they are not likely to use extreme methods to sell coal or to secure new business. It is very doubtful if any action brought under the Sherman law, even accepting the most liberal interpretation given that law by the courts, would show that there was any combination in restraint of trade among the anthracite railroads. The independent operator has had his day, great corporations control the anthracite fields, and these companies compete for business to a certain extent. Mr. Baer has stated that he determines what price the Philadelphia & Reading Coal & Iron Co. shall ask for its coal at New York harbor. The presidents of the other railroads follow Mr. Baer's estimate because behind Mr. Baer and the other presidents are the directors and the stockholders. Thus, should some newspaper or politician succeed in having the suit brought against the Temple Iron Co., and should the contracts guaranteeing that company's stock be set aside, yet such action would affect the situation little. The railroads most interested would exercise the rights given them by Pennsylvania laws and the laws of the United States and buy the stock outright.

It is frequently said that the anthracite railroads habitually violate the new Constitution of the State of Pennsylvania, adopted in 1874. Article XVII. of the Constitution says, "No incorporated company doing business as common carrier in the State shall, directly or indirectly, engage in mining or manufacturing articles for transportation over its works." But this same Article XVII. makes no further provision for companies already chartered than to say that "no railroad, canal or other transportation company in existence at the time of the adoption of this article shall have the benefit of any future legislation by general or special laws, except on condition of complete acceptance of all the provisions of this article." The Pennsylvania courts have held that charters granted by the State are inviolate, and that the Constitution is not retroactive. Hence the prohibition does not apply to companies incorporated twenty or thirty years before, like the Delaware, Lackawanna & Western, or Delaware & Hudson, the latter a New York corporation. In the case of the Reading the situation is this: The mortgagee's committee that bid in the road at the foreclosure of 1896 secured the charter of the National Enterprise Co., incorporated in 1871, changed its name to the Reading Co., increased its capitalization, and transferred to it all the capital stock of the Philadelphia & Reading Railroad and the Philadelphia & Reading Coal & Iron Co. The reorganization of the railroad involved its recognition of the new Constitution, but the franchises of the Coal & Iron Co. were expressly excepted in the sale, since recognition of the Constitution would have taken from that company the right to hold over 10,000 acres of land. The Reading Co.'s charter antedates the new Constitution. Thus it happens that while the Philadelphia & Reading Railway has accepted the Constitution, the Reading Co. and the Philadelphia & Reading Coal & Iron Co. have not.

Further, it may be said that State laws have empowered railroad companies to purchase the stock of coal and iron companies, and, according to a ruling of the Supreme Court there is no limit on the amount of stock the railroad may own. The distinction between indirectly mining coal and controlling a coal mining company is a pretty fine one, but the Pennsylvania courts have made it.

Writing in 1896, Mr. Rothwell said: "The natural evolution of the industry has always been in the direction of the union of the business of mining and of transporting, and its concentration into fewer and fewer hands, and this tendency will undoubtedly continue. The financially strong will devour the weak, and the control of nearly all the coal lands and mines by the coal roads will lessen the chance of new roads being projected to secure this coveted tonnage. Agreements or devices to regulate prices will become less important as the concentration of interests goes on and as the available supply of anthracite diminishes."

The present condition of the industry shows that the time when agreements would be unnecessary was nearer than Mr. Rothwell supposed. Viewed in this light the evolution of the anthracite coal trade is not likely to be affected greatly by anti-trust legislation. Unless the United States is rushing pell mell into socialism, with State ownership of all mines, railroads, industrial establishments and land, the anthracite trade in the future, as in the past, will be governed by the working of that inexorable law that controls the growth of corporations or industries, as it controls the development of organisms—the law of the survival of the fittest. Since the evolution of the industry has been in the direction of the union of the business of mining and transporting and the consolidation of the transporting lines or the control of their policy by a common ownership of their stocks, it is idle to speculate on what might have happened had mining always been conducted by mining companies and the railroads remained strictly common carriers. Unrestricted competition among mining companies and transporting companies proved unprofitable years ago; no one having the good of the industry in mind advocates it now. Restricted competition will prevail in the future.

That present industrial conditions are but temporary every intelligent person knows. Business depression will follow prosperity as the trough of the wave follows the crest. Anthracite prices just now are influenced by a wide demand but the strongest financial support cannot, in times of depression, long maintain prices at an artificial level, and though anthracite coal, through increasing consumption from increased population and through the increased cost of production as mines go deeper and are exhausted, will undoubtedly sell at higher average prices than in the past, there is no reason to believe that present prices will be long maintained. Sooner or later they will fall, though probably not to the level of 1879, or even to the level of January, 1898. Ultimately, it is likely that present methods of marketing the fuel and the present wastes in its use will be superseded by the utilization of coal at the mines and the transmission of its energy as electricity.

BY-PRODUCT COKE OVENS.

BY F. SCHNIEWIND.[1]

THE development of the by-product coke oven in the United States is progressing satisfactorily, as is indicated by the subjoined table which gives the number of ovens of this type operative or in course of construction in the United States and Canada during 1902.

BY-PRODUCT COKE OVENS IN THE UNITED STATES AND CANADA IN 1902.

Company.	Location.	No. of Ovens.	Use of Coke.	Use of Gas.
Otto-Hoffmann ovens:				
Cambria Steel Co. (*a*)	Johnstown, Pa.	100	Blast furnace	Fuel.
Cambria Steel Co.	Johnstown, Pa.	160	Blast furnace	Fuel.
Pittsburg Gas & Coke Co	Glassport, Pa	120	Blast furnace and domestic	Illum. and fuel.
New England Gas & Coke Co.	Everett, Mass.	400	Domestic and locomotive	Illuminating.
Dominion Iron & Steel Co., Ltd	Sydney, C. B.	400	Blast furnace	Fuel.
Hamilton Otto Coke Co	Hamilton, O.	50	Foundry and domestic	Illuminating.
Lackawanna Iron & Steel Co	Lebanon, Pa.	232	Blast furnace	Fuel.
Lackawanna Iron and Steel Co. (*a*)	Buffalo, N. Y	564	Blast furnace	Fuel.
South Jersey Gas, Electric & Traction Co.	Camden, N. J	100	Foundry and domestic	Illuminating.
Maryland Steel Co.	Sparrows Point, Md	200	Blast furnace	Illum. and fuel.
Michigan Alkali Co	Wyandotte, Mich	15	Burning lime	Fuel.
Sharon Coke Co. *a*)	Sharon, Pa	212	Blast furnace	Fuel.
Zenith Furnace Co. (*a*)	Duluth, Minn	50	Blast furnace and foundry	Illuminating.
Semet-Solvay ovens:				
Solvay Process Co	Syracuse, N. Y.	30	Lime kilns	Fuel.
Semet-Solvay Co	Dunbar, Pa.	110	Blast furnace	Fuel.
National Tube Co	Benwood, W. Va.	120	Blast furnace	Fuel.
Semet-Sclvay Co.	Ensley, Ala	240	Blast furnace	Fuel.
People's Heat & Light Co	Halifax, N. S	10	Domestic	Illum. and fuel
Solvay Process Co.	Delray, Mich.	120	Lime kilns	Fuel.
Philadelphia Suburban Gas Co. (*a*)	Chester, Pa	40	Blast furnace	Illuminating.
Central Iron & Coal Co. (*a*)	Tuscaloosa, Ala.	80	Blast furnace	Fuel.
Pennsylvania Steel Co. (*a*)	Lebanon, Pa.	90	Blast furnace	Fuel.
Milwaukee Coke and Gas Co. (*a*)	Milwaukee, Wis.	80	Blast furnace and foundry	Illuminating.
Newton Chambers ovens	Pocahontas, Va.	60	Blast furnace	
Retort Coke ovens:				
Cleveland Furnace Co. (*a*)	Cleveland, O.	66	Blast furnace	Illum. and fuel.
Total		3,649		

(*a*) In course of construction.

The production of coke in 1901 from by-product ovens amounted to 1,179,900 tons, valued at $2,894,077, or about 5% of the total quantity of coke produced. The average yield per oven in 1901 was 1,000 tons of coke. The by-products included 12,659,150 gal. tar, 12,927,627 lb. ammonium sulphate and 2,537,510 gal. ammonia liquor, aggregating in value $1,029,876. The quantity of gas produced is estimated at 12,000,000,000 cu. ft., worth $3,000,000. From these statistics, the importance of this special branch of manufacture may be appreciated.

The number of ovens erected or in course of erection during 1902 was 3,649, as compared with 3,278 ovens in 1901. Of the former total, 2,603 ovens are of the Otto-Hoffmann type, and 920 are Semet-Solvay ovens. The tendency of the present time is to increase the capacity of the ovens, and the new ones of the United Coke & Gas Co., erected during the year, are 43 ft. 8 in. long, 6 ft. 6 in. high, and 17 in. wide. Of the 3,649 ovens referred to above, all are practically completed with the exception of the plant of the Lackawanna Steel Co., at Buffalo, N. Y., and the plant for the Zenith Furnace Co., at Duluth, Minn. The Semet-Solvay Co. is also increasing the size of its ovens, and five horizontal flues are now being used in the side walls instead of the three originally used.

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[1] Supplementing the article by F. Schniewind, on "The Manufacture of Coke in the United States with Special Reference to the Markets for By-Products," THE MINERAL INDUSTRY, Vol. X., pp. 185-174.

The application of a number of new pieces of apparatus has been described by Mr. C. G. Atwater in a paper read before the American Institute of Mining Engineers, New Haven meeting, October, 1902. At the Dominion Iron & Steel Co.'s plant at Sydney, Cape Breton, the coal used yields a brittle coke, and on this account the charge is first compressed into a solid cake before being charged into the oven. A rectangular mold with movable sides is used, and the coal compressed by means of power-driven rammers. Coke of better quality results from this treatment. A larger quantity of coal can be charged into the oven, an advantage, however, which is partly offset by the higher cost of the compression apparatus. There is a net increase of 30% in the quantity charged, but 20% more time is required to coke it, so that there is a net increase of 10% in the coke yield. This gain, however, is balanced by the cost of the installation and maintenance of the compressing plant and the condensing and ammonia apparatus required for the increased quantity of gas liquor due to the 8 or 10% water needed for the compression. The process has its greatest value in handling coals that cannot be successfully coked in other ways, but it is impracticable to use it in the case of swelling coals. In the oven illustrated in Fig. 1, designed by Mr. G. Hilgenstock, of C. Otto & Co., and known as the underfired oven, the regenerators are omitted, the gas firing being introduced at different points underneath the vertical flues instead of at one point at the end of the oven. This oven has the advantage of simplicity as well as a better distribution of the gas, and consequently more uniform heating. Dr. Schniewind has combined the advantage of improved heat distribution with the use of regenerators, and has designed the Schniewind or United-Otto oven, the essential points of difference between this

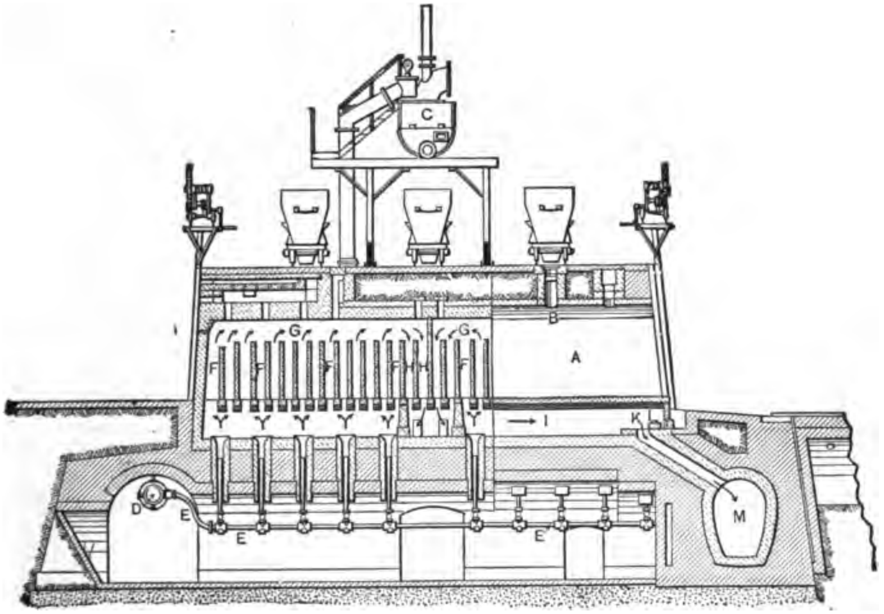

FIG. 1.—SECTION OF AN OTTO-HILGENSTOCK BY-PRODUCT COKE OVEN.

oven and the Otto-Hoffmann and Otto-Hilgenstock oven being summed up as follows: (1) The introduction of the underfired principle in connection with the use of regenerators; (2) the use of a columnar substructure instead of brick arches, admitting anchorage rods beneath the ovens to facilitate complete inspection while in operation; (3) the entire separation of the regenerative chambers from the frame work supporting the ovens. The Schniewind oven can be more easily watched, the heats can be better controlled, and the length can be increased from 33 to 43 ft. An 8-ton charge can be treated in place of a 6-ton one, with a corresponding decrease in the operating costs per ton of output.

Mr. E. A. Moore, of the United Coke & Gas Co., has designed a new form of quenching car, whereby the coke is cooled with a minimum amount of water, and its silvery luster preserved. The coke can be handled directly to the railroad cars. The car is covered, and receives the charge of coke directly from the oven, quenching it by water supplied to nozzles placed inside. The top and sides of the car are of cast-iron plates, so that the steam is confined and assists in the quenching operation. The bottom of the car is movable in order that the coke may be discharged from the car with ease.

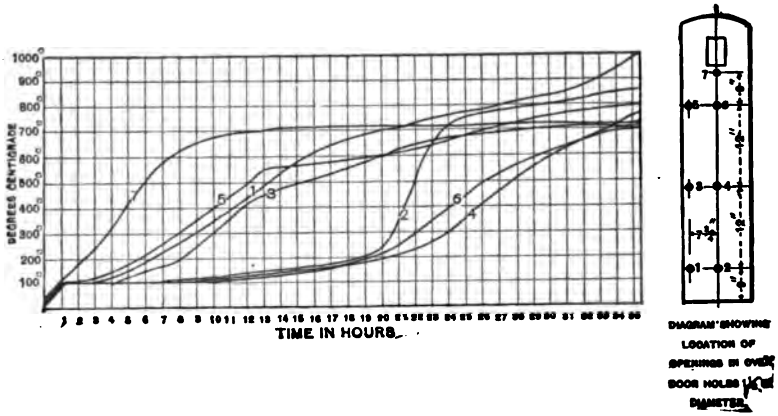

FIG. 2.—DIAGRAM SHOWING THE TEMPERATURE OF THE OVEN CHARGE AT DIFFERENT POINTS.

A series of tests was made at Sydney on the progress of coking in the oven. Holes were bored in the oven door at various points, as shown in Fig. 2, and temperatures were taken at intervals during the coking period. These temperatures were plotted by means of curves, as shown in Fig. 2, which group themselves into two classes, those very near the heating walls rising rapidly, and those in the middle of the oven charge remaining at a lower temperature, between 100° and 200°C., until some time has elapsed, when they rise rapidly as the coking becomes complete. The diagram shows that the gasification begins at the oven walls and that it proceeds gradually from the wall toward the center; also that the evolved gases pass upward along the wall and through the fissures in the coked portion. During the passage of the gas it has an opportunity to deposit a certain portion of its carbon in graphitic form, which accounts in part for the increased yield of the by-product oven over that of the beehive type. The same results were obtained by C. Otto & Co. when carrying out a similar series of tests, the curves in the two cases being almost identical.

The building of coke ovens in Germany in 1902 showed continued progress.

According to the annual report of the Chief Inspector of Alkali Works, etc., for the United Kingdom, several improvements have been made in the use of coke ovens of the Semet-Solvay type in the steel works. The washed fine coal, before being placed in the ovens, is molded into cakes by means of a compressor worked with coke-oven gas. One-fourth more coal can be charged into the oven, the time of charging is shortened, and a gain of 10% in the yield is obtained. A needle bath is also used to quench the cake of incandescent coke, by which the brightness of the resulting coke is increased. The time of carbonizing is now made more regular by controlling the draught by means of a fan connected with the flues. During 1902, five plants with 165 ovens have been constructed by the Otto-Hilgenstock Coke Oven Co., Ltd., the ovens all being of the Hilgenstock non-regenerative underfired type.

COPPER.

BY JOSEPH STRUTHERS, D. H. NEWLAND AND HENRY FISHER.

THE production of copper in the United States during 1902 amounted to 610,815,384 lb., as compared with 597,443,212 lb. in 1901, an increase of 13,372,172 lb. resulting from increased activity throughout all of the copper mining districts in the United States excepting Arizona and California.* The greatest increase was from the Michigan mines, followed by those in Montana. Detailed as to principal States, the production of copper during 1902 contrasted with that of 1901 was as follows: Montana 240,050,000 lb. as compared with 229,870,415 lb. in 1901; an increase of 10,179,585 lb.; Michigan 170,663,999 lb. as compared with 155,511,513 lb. in 1901; an increase of 15,152,486 lb.; Arizona 119,841,285 lb. as compared with 126,183,744 lb. in 1901, a decrease of 6,342,459 lb., and California 25,038,724 lb. as compared with 33,667,456 lb. in 1901, a decrease of 8,628,732 lb.

According to the reports of the American copper refiners, the quantity of copper refined electrolytically during 1902 was approximately 80% of the total production. The output of copper sulphate during 1902 was 48,763,538 lb. as compared with 78,004,257 lb. in 1901, a decrease of 29,240,719 lb. The average price of copper sulphate during 1902 was 4·16c. per lb. as compared with 4·1c. per lb. in 1901. Of the total production of copper sulphate during 1902, the quantity recovered as a by-product was 35,879,212 lb. as compared with 51,000,000 lb. so produced in 1901, while that produced direct from ore was 739,801 lb. as compared with 204,095 lb. in 1901.

The stock of copper on hand at the end of 1902 was 144,905,600 lb. as compared with 209,587,698 at the end of 1901.

The imports of copper during 1902, as reported by the smelting and refining companies and the United States Treasury Department were 161,551,040 lb. as compared with 176,472,369 lb. in 1901, while the exports during 1902 were 369,402,880 lb. as compared with 227,194,184 in 1901. As given in detail later in this section, the price of Lake copper during 1902 averaged 11·887c. per lb. as

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* The statistics of production do not include copper recovered in the form of copper sulphate.

compared with 16·53c. per lb. in 1901. The average price of electrolytic copper during 1902 was 11·626c. per lb. as compared with 16·12c. per lb. in 1901.

COPPER PRODUCTION IN THE UNITED STATES. (LB. OF FINE COPPER.)

States.	1899.		1900.		1901.		1902.	
	Pounds.	Long Tons.	Pounds.	Long Tons.	Pounds.	Long Tons.	Pounds.	Long Tons.
Arizona	125,377,758	55,972	115,403,846	51,520	126,183,744	56,332	119,841,285	53,500
California	23,915,486	10,677	29,639,987	13,232	33,667,456	15,030	*e* 25,038,724	11,178
Colorado	10,614,252	4,739	7,826,949	3,494	7,872,529	3,515	8,463,938	3,779
Michigan	155,845,786	69,574	144,227,340	64,387	155,511,513	69,425	*f* 170,663,999	76,189
Montana	237,953,951	106,229	254,460,713	113,599	229,870,415	102,621	240,050,000	107,165
Utah	9,310,344	4,156	18,504,726	8,261	20,116,979	8,981	*e* 23,939,901	10,688
Eastern and Southern States	3,804,617	1,698	6,918,122	3,088	6,860,039	3,063	*e* 13,599,047	6,011
All others	4,989,000	2,227	12,536,850	5,597	17,360,537	7,750	9,218,490	4,115
Copper in sulphate (*b*)	9,507,897	4,245	11,313,962	5,051	11,730,000	5,232	9,154,753	4,087
Total domestic production	581,319,091	259,517	600,832,505	268,229	609,173,212	271,949	619,970,137	276,772
Stock January 1	54,361,470	24,269	88,722,559	39,608	93,050,230	41,541	209,587,698	94,009
Imports bars, ingots, old, & ores *a*	94,568,050	42,218	103,805,793	46,342	176,472,369	78,782	161,551,040	72,121
Total supply	730,248,611	326,004	793,360,857	354,179	878,695,811	392,275	991,108,875	442,902
Deduct exports	249,923,941	*c* 111,573	352,731,143	157,469	227,194,184	101,426	369,402,880	164,912
Deduct consumption	391,602,111	174,822	347,579,484	155,169	440,913,929	196,837	477,792,000	213,300
Stock December 31	88,722,559	39,608	93,050,230	41,541	209,587,698	94,009	144,905,600	64,690

(*a*) This includes copper imported in low-grade Spanish and other pyrites chiefly for sulphur, and the copper imported from Canada in copper-nickel matte, in which the nickel is the metal of chief value: also the copper in certain gold and silver ores. These items, until 1898, did not appear in the United States statistics of imports. (*b*) Including only the copper in sulphate obtained as a by-product and by leaching copper ores. (*c*) Not including Mexican copper en route for Europe. (*e*) Preliminary estimate of the U. S. Geological Survey. (*f*) Probably includes a certain quantity of anode copper from Montana, which was refined at Lake Superior furnaces and reported as Lake copper.

REVIEW OF COPPER MINING IN THE UNITED STATES DURING 1902.

Alaska.—The copper deposits of the White, Tanana and Copper River districts were described by Alfred H. Brooks in the *Engineering and Mining Journal,* July 5, 1902. The occurrence of placer copper on the headwaters of White River was first definitely determined by Dr. C. W. Hayes in 1891, although the natives for a long time had drawn supplies of copper from this region. The deposits are contained in benches that owe their existence to rocky barriers through which the streams have eroded their courses. Nuggets weighing from 8 to 10 lb. are found. The source of copper may be traced to veins filling the joints of greenstone dikes that cut through limestones and schists. So far as observed, the veins are small and of no commercial importance. Along the Copper and Chitina rivers, the deposits are associated with greenstones and consist of native copper in stringers or filling cavities and sulphide in true fissure veins. On Stretna Creek there is a mineralized zone from 8 to 10 ft. in width carrying copper and iron sulphides. In the bed of Nugget Creek, a tributary of the Kuskulana, a mass of copper 8 ft. in length and from 3 to 5 ft. in width was found. Fissure veins carrying copper ores have been observed on the ridge between McCarty Creek and Kennicott Glacier. In the Prince William Sound region, copper prospects were opened up several years ago. The ores are chiefly sulphides occurring in fissure veins and mineralized zones. These deposits have the advantage of being located on tide-water and can be exploited without any great outlay of capital. The developments thus far made in the deposits of the interior are limited to a few prospect holes and cross-cuts. Exploitation on a commercial scale is dependent upon the construction of a railroad which it is thought would offer no serious difficulties.

Arizona.—(By James Douglas.)—The works of the Calumet and Arizona Co. at Douglas were started in November, 1902, with an output of from 20 to 25 tons of copper per day, which will be increased during 1903. The Shannon Co. in the Clifton district closed its smelters after a short campaign in order to supplement the works with a concentrator of 500 tons daily capacity; when operations are resumed the production of copper will probably amount to 300 tons per month. In Yavapai County the Val Verde Co. is active and is producing a copper matte rich in gold and silver. The Black Diamond Co., operating in the Dragoon Mountains, expects to start a 100-ton furnace early in 1903. The older companies are showing no symptoms of decay. The new Copper Queen works at Douglas should start during the present summer; they are designed to take custom ores of copper, gold and silver, as well as a slightly larger tonnage from the mines of the company. The works are to be supplied with large furnaces and good engines, and planned so as to handle large quantities of fuel and ore by machinery. The removal of the works to a distance of 28 miles from the mines was made to secure space for an enlarged and better designed smelter, water for high-class condensing engines, nearer proximity to fuel, a location more central to the mines of the Phelps-Dodge properties, and to facilitate the purchase of ores from Mexico and the Southwest. There is no intention of invading the market for lead, but the company will enrich the copper bullion with gold and silver. The completion of the El Paso & Southwestern Railroad, and the extension of the Nacosari Railroad into Sonora from Douglas, makes this town a favorable center for metallurgical works, which may hope to secure ores from Mexico and from the reopened mines of Tombstone. The latter are being revived by the Development Co. of America, and have been reached by a branch of the El Paso & Southwestern Railroad. Recent exploration in depth in the mines of the Old Dominion and the United Globe companies reveal sulphides in quantity of a grade that promises to give life to the mines, and, it is hoped, a better smelting mixture. The United Verde mines should show an increased production in 1903. During the past year this company earned net profits of $927,654. In the Clifton district the Arizona and Detroit companies are aiming rather at increased efficiency in operation and lower cost of production than at making more copper, assured as they are of the

COPPER PRODUCTION IN ARIZONA. (*a*) (POUNDS OF FINE COPPER.)

Mines.	1897.	1898.	1899.	1900.	1901.	1902.
Arizona Cop. Co....	13,727,911	18,169,096	19,072,709	19,697,086	20,535,800	30,821,842
Calumet & Arizona	....	....	....	....	....	2,066,647
Copper Queen.....	23,999,878	33,749,390	36,901,684	34,383,309	39,781,333	35,831,755
Detroit............	8,405,138	11,428,992	13,906,253	10,749,258	17,535,000	18,721,411
Old Dominion......	2,000,000	1,800,000	6,300,000	7,155,000	10,094,300	7,992,550
United Verde......	31,355,025	42,828,926	43,995,932	39,970,193	34,520,695	19,407,080
United Globe......	1,241,975	2,847,460	4,451,180	*Nil.*	830,100	*Nil.*
Other mines.......	290,000	*e* 500,000	*e* 750,000	*e* 3,450,000	*e* 2,886,516	*e* 5,000,000
Totals..........	81,019,922	110,823,864	125,377,758	115,403,846	126,183,744	119,841,285

(*a*) Reported by producers direct to THE MINERAL INDUSTRY. (*e*) Estimated.

long life of their mines, and believing in the future value of the metal. The Arizona Copper Co., Ltd., during the year ending Sept. 30, 1902, earned a net profit of £183,225 from the mines and £113,662 from the railroad, a total of £296,887. Payments for mine administration were £13,888; for railroad administration, £8,306; office, £2,506; interest, £25,718; reserve, £40,000; dividend on preference shares, £24,531, leaving a net balance of £181,938 in addition to the balance of £14,410 brought forward from the previous year. Out of the surplus, which amounted to £196,348, a dividend of £180,488 or 9s. 6d. per share was declared on the ordinary shares, and the sum of £15,860 carried forward to the following year. The total quantity of ore treated in the mill was 195,849 tons, yielding 28,806 tons of concentrates. The ore and concentrates smelted amounted to 54,849 tons, while the leaching plant handled 35,721 tons of tailings. The average yield of all copper ores treated was 3·37%, a decrease from the preceding year, which was due in part to the reduced output of first-class ores and in part to a slightly lower quality of the concentrating ores. In the Bisbee group of mines the most promising feature of the year's development has been the discovery of profitable sulphide ore bodies in the deeper limestones, in the property both of the Copper Queen and the Calumet & Arizona companies. The extension of the ore bodies over a large area has been proved.

California.—The Bully Hill mines in Shasta County have been consolidated with the properties of the Mount Shasta Gold Mines Corporation, and are to be operated under the latter title. These mines are situated about 25 miles northeast of Redding in the same geological district as the deposits owned by the Mountain Copper Co. The ore bodies are composed of pyrite and chalcopyrite, with chalcocite, bornite and traces of carbonates and native copper. One body of ore is said to have assayed 15% Cu, $8 in gold and 6 oz. silver per ton. The main group of mines is opened to a depth of 350 ft. by three tunnels with extensive drifts and cross-cuts. At the Bully Hill smelter, which began operations in 1901, a matte carrying from 35 to 55% Cu is produced. The matte is taken directly from the furnace to the converters, and the metal assaying 98% fine is shipped to the De La Mar refinery at Carteret, N. J. At the Shasta King mine, four miles east of Iron Mountain, development work has been actively carried on, exposing, it is reported, an enormous body of low-grade ore. The company has secured a smelter site near Kennet, and intends to erect a smelter of 500 tons capacity. According to the reports of the Mountain Copper Co., Ltd., the output of copper ore in 1902 was 139,903 tons, the quantity smelted at the Keswick works was 149,787 tons, which yielded 7,854 tons converter copper, and the output of fine copper was 8,739 tons. The sales of copper for delivery during the year were 7,822 tons, from which a profit of £117,846 was earned, while rents, interest and other sources of income increased the profits to £124,308. Out of the latter sum £14,304 were expended for exploratory work, administration, and general expenses at London, leaving a total net profit of £110.004. Debenture interest required £60,000, and the remainder, after payment of income tax and crediting a due portion to purchase price, was carried forward.

Idaho.—Owing to the lack of transportation facilities, operations in the Seven

Devils district during 1902 were limited practically to development work. The White Knob Copper Co. completed the construction of its smelting plant at Mackay, and it is expected that production will begin early in the present year. A large quantity of ore assaying about 9% Cu and $3 gold and silver per ton has been opened preparatory to an active campaign.

Michigan.—(By D. H. Newland.)—Despite the low prices of copper that prevailed during 1902, the mines on the Upper Peninsula made the largest output yet recorded. The increase over the preceding year amounted to about 10%, and was contributed in most part by the new mines, *viz.:* the Baltic, Trimountain, Champion, Isle Royale, Arcadian, and Mohawk, whose combined production exceeded 20,000,000 lb. The larger properties made no advance in respect to output, although improvements in both mines and mills materially strengthened their position for continued profitable working. It is expected that the output in 1903 will reach a still larger total, due to the more extended operations of the new producers. The production of all the mines during the past six years was as follows:—

COPPER PRODUCTION IN MICHIGAN. (POUNDS OF FINE COPPER.)

Mines.	1897.	1898.	1899.	1900.	1901.	1902.
Arcadian	*Nil.*	*Nil.*	500,000	*e* 800,000	*e* 1,000,000	*e* 500,000
Atlantic	5,109,663	4,377,399	4,675,882	4,930,149	4,666,889	4,949,368
Baltic	*Nil.*	42,766	608,570	1,735,060	2,641,432	6,285,819
Calumet & Hecla	88,378,966	94,103,000	98,002,137	81,403,041	82,519,676	81,248,739
Central	611,172	291,339	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Champion	....	....	....	....	....	4,165,784
Franklin	2,908,384	3,568,978	1,230,000	3,663,710	3,757,419	5,259,140
Isle Royale	*Nil.*	*Nil.*	*Nil.*	*Nil.*	2,171,955	3,569,748
Mass	24,061	*Nil.*	61,000	*Nil.*	*e* 800,000	2,345,805
National	28,959	18,441	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Osceola Consol'd	9,500,000	11,800,000	10,950,000	11,200,000	13,723,571	13,416,396
Quincy	16,924,618	16,354,061	14,301,182	14,116,551	20,540,720	18,988,491
Ridge	12,590	....	(*a*)	(*a*)	(*a*)	(*a*)
Tamarack	20,000,000	22,500,000	17,750,000	18,400,000	18,000,852	15,961,598
Trimountain	....	....	....	....	....	*e* 6,000,000
Wolverine	2,316,296	4,588,114	4,789,015	4,778,829	4,946,126	6,478,181
All other mines	25,000	*e* 25,000	2,983,000	3,200,000	738,828	1,500,000
Totals	145,839,749	156,669,098	155,845,786	144,227,340	155,507,465	170,663,999

(*a*) Consolidated with Mass. (*e*) Estimated.

In the subjoined table will be found the results obtained by ten leading mines, their capitalization, profits and itemized costs for the period 1898-1902. Similar information relating to previous years is included in THE MINERAL INDUSTRY, Vols. I., IX., and X.

CALUMET AND HECLA MINING CO.

Year.	Capital Paid In.	Real Estate. Amount Invested.	Personal Estate. Amount Invested.	Debts.	Credits.	Copper Produced Lbs.	Yield. (*b*) %	Average Price per lb. (*a*)	Estimated Receipts.	Dividends.
	$	$	$	$	$			$	$	$
1898	1,200,000	14,223,895	4,184,321	2,235,543	6,280,589	94,103,000	3·07	12·01	11,301,770	5,000,000
1899	1,200,000	14,032,991	7,215,716	2,298,467	1,669,622	98,002,137	....	16·92	15,788,162	10,000,000
1900	1,200,000	16,545,511	3,092,768	(*c*)	1,676,766	81,403,041	(*c*)	(*c*)	(*c*)	7,000,000
1901	1,200,000	(*c*)	(*c*)	(*c*)	(*c*)	82,519,676	(*c*)	(*c*)	(*c*)	4,500,000
1902	1,200,000	(*c*)	(*c*)	(*c*)	(*c*)	81,248,739	(*c*)	(*c*)	(*c*)	2,500,000

(*a*) Prices obtained by taking the average prices realized by the other leading mines, including Quincy, Tamarack, Atlantic and Wolverine. (*b*) Computed from the shipments of freight over the Hecla and Torch Lake Railroad. On this basis the yield in 1875 was 4·30%; in 1891, 3·13%; and in 1896, 3·09%. (*c*) Not given in report of the company.

ATLANTIC MINE.

Year.	Capital	Stamped.	Fine Copper Produced.	Yield.	Selling Price per Pound.	Total Receipts.	Cost of Ton of Ore Stamped.						Total Cost per Pound.	Total Cost per Ton, Milled.	Net Profit.	
							Mining.	Transport. to Mill.	Surface Expenses.	Stamping per Ton.	Improvements.	Smelting and Brokerage			Per Pound.	Per Ton, Milled.
	$	Tons.	Lbs.	%	Cts.	$	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$	Cts.	$
1898 ..	980,000	370,767	4,377,399	0·590	11·88	518,219·14	66·77	5·55	22·34	24·11	19·18	16·04	13·01	1·54	—1·18	—0·14
1899 ..	980,000	380,781	4,675,882	0·614	17·15	802,804·51	78·58	6·50	25·02	23·35	20·62	17·04	13·93	1·71	3·22	0·40
1900 ..	980,000	410,674	4,930,149	0·600	16·41	809,177·00	76·85	6·92	26·73	24·70	27·75	14·70	14·80	1·78	1·61	0·19
1901 ..	980,000	409,124	4,666,889	0·570	15·76	747,177·32	82·87	7·68	27.67	21·98	46·72	14·07	17·73	2·02	—1·97	—0·20
1902 ..	980.000	446,098	4,949,368	0·555	11·88	588,200 73	69·34	5·97	19·81	25·03	4·58	14·11	13·37	1·85	—1.59	—0·08

BALTIC MINE.

Year.	Capital	Stamped.	Fine Copper Produced.	Yield.	Selling Price per Pound.	Total Receipts.	Mining.	Transport. to Mill.	Surface Expenses.	Stamping per Ton.	Improvements.	Smelting and Brokerage	Total Cost per Pound.	Total Cost per Ton, Milled.	Net Profit Per Pound.	Net Profit Per Ton, Milled.
1899 ..	1,000,000	35.411	603,570	0·858	16·98	(k) 107,896	261·7	15·00	100·0	40·00	......	.....	.....	....	......	......
1900 ..	1,000,000	85,596	1,735,060	0·979	16·49	297,180	160·0	15·52	63·9	41·40	......	29·60	.....	....	......	......
1901 ..	1,000,000	114,708	2,641,432	1·150	16·43	442,551	171·3	14·99	53·13	41·08	391·0	33·57	.....	(m)	......	......
1902 ..	1,000,000	275,175	6,285,819	1·142	11·87	746,276·02	126·7	16·11	7·77	22·30	107·7	32·06	13·67	312	—1·80	—0·41

CHAMPION MINE.

Year.	Capital	Stamped.	Fine Copper Produced.	Yield.	Selling Price per Pound.	Total Receipts.	Mining.	Transport. to Mill.	Surface Expenses.	Stamping per Ton.	Improvements.	Smelting and Brokerage	Total Cost per Pound.	Total Cost per Ton, Milled.	Net Profit Per Pound.	Net Profit Per Ton, Milled.
1902 ..	2,500,000	120,485	4,165,784	1·73	11·88	(k) 492,553·36	(d)	(d)	(d)	(d)	579·22	52·21	27·92	965	—16·1	—5·57

FRANKLIN MINE.

Year.	Capital	Stamped.	Fine Copper Produced.	Yield.	Selling Price per Pound.	Total Receipts.	Mining.	Transport. to Mill.	Surface Expenses.	Stamping per Ton.	Improvements.	Smelting and Brokerage	Total Cost per Pound.	Total Cost per Ton, Milled.	Net Profit Per Pound.	Net Profit Per Ton, Milled.
1898 ..	2,000,000	116,696	2,628,702	1·12	12·07	(a) 817,917·63	(b) 177	(d)	(d)	51·02	(d)	34·29	9·39	2·11	2·68	0·61
1899 ..	2,000,000	89,789	1,230,000	0·68	16·48	202,647·81	(d)	(d)	(d)	32·30	(d)	32·28	(d)	(d)	(d)	(d)
1900 ..	2,000,000	268,571	3,668,710	0·68	16·20	594,252·36	172	(d)	(d)	30·34	0·04	23·79	17·90	2·41	—1·70	—0·27
1901 ..	2,300,000	313,552	3,757,419	0·88	16 69	828,045·94	123	(d)	24·75	25·75	1·00	16·42	15·92	2·59	0·77	0·12
1902 ..	2,300,000	315,687	5,259,140	0.83	11·88	632,717·37	127·2	(d)	7·23	28·81	1·31	24·34	11·42	1·89	0·46	0·08

ISLE ROYALE MINE.

Year.	Capital	Stamped.	Fine Copper Produced.	Yield.	Selling Price per Pound.	Total Receipts.	Mining.	Transport. to Mill.	Surface Expenses.	Stamping per Ton.	Improvements.	Smelting and Brokerage	Total Cost per Pound.	Total Cost per Ton, Milled.	Net Profit Per Pound.	Net Profit Per Ton, Milled.
1901 ..	2,000,000	185,175	2,171,955	0·585	(d)	281,269	120·0	5·50	3·90	24·91	(d)	32·00	32·57	1·86	(d)	(d)
1902 ..	2,000,000	263,672	3,569,748	0·675	11·91	500,775	98·8	5·07	2·35	26·43	7·1	19·20	13·45	1·59	—1·54	—0·29

OSCEOLA MINE.

Year.	Capital	Stamped.	Fine Copper Produced.	Yield.	Selling Price per Pound.	Total Receipts.	Mining.	Transport. to Mill.	Surface Expenses.	Stamping per Ton.	Improvements.	Smelting and Brokerage	Total Cost per Pound.	Total Cost per Ton, Milled.	Net Profit Per Pound.	Net Profit Per Ton, Milled.
1898 ..	2,325,000	505,008	11,800,000	1·168	(d)	1,549,820·12	(d)	(d)	(d)	28·94	18·10	(d)	9·98	2·33	3·15	0·74
1899 ..	2,328,750	546,326	10,950,000	1·002	(d)	1,791,471·01	(d)	(d)	(d)	26·30	18·29	(d)	11·48	2·30	4·92	0·98
1900 ..	2,397,500	683,066	11,200,000	0·819	(d)	2,136,253·02	(d)	(d)	(d)	27·20	27·68	(d)	13·92	2·28	5·15	0 85
1901 ..	2,397,500	798,207	13,723,571	0·865	13·90	1,984,437·14	157·0	(d)	(d)	26·575	60·95	(d)	14·64	2·53	0·005	0·09
1902 ..	2,406,750	836,400	13,416,396	0·802	11·78	1,594,453·76	137·0	(d)	(d)	21·735	10·20	(d)	10·55	1·79	0·007	0·12

QUINCY MINE.

Year.	Capital	Stamped.	Fine Copper Produced.	Yield.	Selling Price per Pound.	Total Receipts.	Mining.	Transport. to Mill.	Surface Expenses.	Stamping per Ton.	Improvements.	Smelting and Brokerage	Total Cost per Pound.	Total Cost per Ton, Milled.	Net Profit Per Pound.	Net Profit Per Ton, Milled.
1898 ..	1,450,000	543,592	16,354,061	1·54	12·14	(e) 1,986,116·81	(f) 165	(d)	(d)	(h) 22·28	39·59	34·23	8·17	2·39	(i) 3·97	(i) 1·16
1899 ..	1,450,000	559,164	14,301,182	1·27	17·18	2,450,178·66	181	(d)	(d)	(h) 22·19	72·39	27·50	10·96	2·81	6·17	1·58
1900 ..	1,450,000	558,723	14,116,551	1·26	16·67	2,353,416·59	208	(d)	(d)	(d)	108·3	28·17	13·63	3·44	3·04	0·77
1901 ..	1,450,000	886,266	20,540,720	1·19	16·02	3,399,574·80	181	(d)	(d)	(d)	18·87	23·28	9·61	2·23	6·94	1·61
1902 ..	1,450,000	958,019	18,988,491	0·99	11·99	2,275,819·25	155	(d)	(d)	(d)	10·09	19·50	9·02	1.79	2·97	0·59

TAMARACK MINES.

Year.	Capital	Stamped.	Fine Copper Produced.	Yield.	Selling Price per Pound.	Total Receipts.	Mining.	Transport. to Mill.	Surface Expenses.	Stamping per Ton.	Improvements.	Smelting and Brokerage	Total Cost per Pound.	Total Cost per Ton, Milled.	Net Profit Per Pound.	Net Profit Per Ton, Milled.
1898 ..	1,500,000	670,832	22,500,000	(d)	(d)	2,381,888·95	179	(d)	(d)	22·40	(d)	(d)	(d)	(d)	(d)	(d)
1899 ..	1,500,000	681,090	17,750,000	1·40	(d)	2,952,098·91	(d)	(d)	(d)	22·73	63·49	(d)	12·46	3·50	4·17	1·17
1900 ..	1,500,000	685,422	18,400,000	1·47	(d)	3,299,077·26	(d)	(d)	(d)	31·48	(d)	(d)	11·41	3·36	6·52	1·92
1901 ..	1,500,000	626,905	18,000,852	1·48	14·22	2,627,954·35	244·0	(d)	(d)	24·95	44·87	(d)	11·67	3·35	(l) 4·48	(l) 1·28
1902 ..	1,500,000	658,720	15,961,528	1·21	11 87	1,941,907·26	230·0	7·28	(d)	23·30	23·50	23·65	11·90	2 88	(l) 1·24	(l) 0·30

WOLVERINE MINE.

Year.	Capital	Stamped.	Fine Copper Produced.	Yield.	Selling Price per Pound.	Total Receipts.	Mining.	Transport. to Mill.	Surface Expenses.	Stamping per Ton.	Improvements.	Smelting and Brokerage	Total Cost per Pound.	Total Cost per Ton, Milled.	Net Profit Per Pound.	Net Profit Per Ton, Milled.
(g) 1898 ..	600,000	130,089	3,470,927	1·33	11·48	(a) 399,368·77	119	(d)	23·51	36·63	47·42	33·33	9·73	2·60	1·70	0·45
1899 ..	600,000	184,799	4,700,373	1·27	14·35	675,859·08	100	(d)	19·66	36·68	5·83	34·00	7·71	1·96	6·64	1·69
1900 ..	600,000	184,594	4,756,646	1·29	16·86	806,810·32	112	(d)	24·01	41·19	36·67	32·34	9·67	2·46	7·20	1·85
1901 ..	600,000	190,104	4,907,646	1·29	16·74	828,797·82	116	5·94	24·16	36·89	14·56	30·00	8·84	2·28	7·90	2·04
1902 ..	600,000	187,482	4,984,367	1·33	13·21	665,333·28	133·3	5·88	20·70	34·36	141·18	32·13	13·82	3·67	—0·61	- 0·13

(a) Sales of copper and interest. (b) Includes underground and surface expenses and costs of stamping. (c) Includes transportation to mill and surface expenses. (d) Not stated in the reports. (e) Not including interest. (f) Includes mining, transportation to mill, surface and stamping costs. (g) Fiscal year ending June 30. (h) Included under mining costs. (i) Exclusive of interest and income from real estate. (k) Not including assessments. (l) Not deducting extraordinary construction account from annual profits. (m) Not including taxes.

The Calumet & Hecla Mining Co. during 1902 continued making additions and improvements to its equipment, and this work will be carried on for some time to come. The Red Jacket shaft, which is bottomed in the conglomerate at a depth of 4,920 ft., is supplied with hoisting engines aggregating 8,000 H.P., and capable of raising over 2,000 tons of ore daily. A duplex air compressor with a capacity of 550 drills is to be installed. Shaft No. 4 has been carried to a depth of 6,900 ft. on the incline. The amygdaloid ore body was not worked, owing, it is said, to the low price of copper. Explorations from the Red Jacket shaft show that the conglomerate gradually decreases in copper tenor with depth. The electrolytic plant at Black Rock on the Niagara River was started during the year. The Osceola Consolidated Mining Co. has practically abandoned work at the Tamarack Junior mine, and hereafter will confine its operations to the Osceola, North Kearsarge, and South Kearsarge mines. The Osceola No. 5 shaft was idle for a large part of the year owing to a cave-in, which badly damaged the shaft timbers. A large amount of development work was done in the North Kearsarge and South Kearsarge mines, and extensive ore reserves have been made available. The Quincy Mining Co. completed the construction of the new coal dock and coal hoisting plant which will effect a considerable saving in the cost of fuel. A new warehouse for the storage of refined copper was erected at the smelting works. At the Tamarack mine the new No. 5 shaft, which is 4,938 ft. in depth, was operated for the first time in December, 1902. Seven levels have been opened from the shaft giving facilities for a large daily output of ore. Operations last year were restricted to some extent owing to the low prices of copper. The Wolverine Copper Mining Co. started its new mill on Traverse Bay in August. The mill has two steam stamps capable of handling daily about 1,000 tons of ore, or double the capacity of the old mill. This company produces copper at a very low cost so that it was able to maintain the regular dividend payments throughout 1902. The year's developments at the Baltic mine were highly satisfactory, the output of fine copper being more than double that for 1901. The new mill at Redridge was placed in commission, but was operated only at partial capacity, as two of the stamps were not ready until late in the year. When the four stamps are in operation the Baltic will rank well up in the list of Michigan mines. The Isle Royale Copper Co. started work in its new 3-stamp mill on Portage Lake, but one stamp only was operated during the latter half of the year in order to make possible a closer selection of ore. The Isle Royale and Portage lodes have proven to be "bunchy," and their successful exploitation requires large ore reserves with close selection of ground in accordance with the prices obtainable for copper. The Adventure Consolidated Copper Co. during 1902 received $70,791 from the sales of copper and $1,182 from the sales of silver, while the total income, including an assessment of $200,000, was $278,714. The total expenditures for mining and additions and improvements to the company's property amounted to $718,805, leaving a balance with that brought forward from the previous year of $69,571. Owing to delay in the equipment of the stamp mill the production of copper was much less than expected. The Mohawk Mining Co. in the past year received $104,417 from the sales of mohawkite and metallic copper, and $340,249 from assessments and other sources, making a total income of $444,666. The expenditures for mining were $185,697, for construction $260,374, and for office, freight and smelting charges, $17,362—total, $463,433. An assessment of $200,000 was levied to meet the indebtedness and for completing the equipment in course of installation. Although it was expected that the new mill would begin operations by the middle of the year, the first stamp was not started until December. The quantity of ore treated was 8,613 tons, which yielded 226,824 lb. copper, or an average of 26·34 lb. per ton. The Champion Copper Co. began operations in January, 1902, employing a single stamp in the Atlantic mill, with which 120,485 tons of ore averaging 34 lb. copper per ton were stamped. Three stamps in the new mill were placed in commission early in 1903, and when the full equipment of four stamps are in operation the capacity will average about 2,000 tons of ore per day. The mine has been opened by four large shafts, and sufficient ore is in sight to supply the mill for many years. Among the new companies organized during 1902 was the Copper Range Consolidated Co., which took over the Baltic Mining Co. and the Copper Range Co., issuing its shares in exchange for the shares of the two companies. At the same time 35,000 new shares of the Copper Range Consolidated Co. were sold at $40 per share for the purpose of providing funds to complete the equipments of the Baltic and Champion mines and to extend the Copper Range Railroad.

Montana.—(By W. H. Weed.)—There was no marked change in the copper mining industry during 1902. The numerous suits at law between the Amalgamated Copper Co. and the Heinze interests were still before the courts, and as a result production was entirely shut off from some properties, and greatly curtailed in others. The New Washoe smelter, at Anaconda, which went into commission early in 1902, handled 4,500 tons of ore a day, a business estimated at $60,000 daily. The old works of the Anaconda Co. are idle save the electrolytic refinery, which is refining the output of the New Washoe smelter. The Great Falls plant, which was completely overhauled during the latter part of 1901, started up again in January, 1902, and ran uninterruptedly. The Butte & Boston smelter at Butte was operated successfully, and while not considered as thoroughly modern as the larger plants of the Amalgamated Co., it probably

COPPER PRODUCTION IN MONTANA. (POUNDS OF FINE COPPER.)

Mines.	1896.	1897.	1898. (*d*)	1899.	1900.	1901.	1902.
Anaconda	125,350,693	131,471,127	107,214,059	107,914,857	(*f*)	*e* 101,850,224	*e* 75,000,000
Boston & Montana	60,250,000	60,000,000	62,000,000	79,000,000	66,200,000	*e* 58,028,746	*e* 75,000,000
Butte & Boston	4,500,000	....	7,000,000		16,950,000		*e* 10,000,000
Butte Reduction Works	4,225,647	7,883,795	9,685,068	10,049,629	12,455,772	17,969,663	*e* 19,400,000
Colorado Sm. & Mg. Co	9,090,680	8,911,578	7,657,938	9,572,155	11,453,940	*e* 7,465,260	*e* 10,000,000
Hecla Cons. Mining Co	312,445	215,431	121,039	155,719	131,494	108,671	54,718
Parrot	8,045,648	14,894,487	12,444,828	10,625,696	(*f*)	*e* 10,167,850	*e* 10,000,000
Montana Ore Purch'g Co	15,049,066	13,047,648	13,084,000	15,360,679	22,257,563	*e* 29,898,980	30,650,000
Other Mines	4,242,583	804,474	(*b*)	5,775,716	125,011,944	*e* 3,386,021	*e* 9,945,287
Totals	*a*228,958,164	*c*237,158,540	*c*216,979,334	237,953,951	254,460,713	229,870,415	240.050,000

(*a*) In addition to 818,531 lb. of Canadian copper smelted by the Montana Ore Purchasing Co. and deducted in the above table, there was also deducted 1,000,000 lb. more of foreign copper estimated as having been included in the aggregate of the above returns, leaving the net amount 225,958,164 lb. (*b*) Included in reports of smelters itemized above. (*c*) Totals reported by E. B. Braden. (*d*) The individual reports include some copper derived outside of Montana, wherefore their sum exceeds the total as given. (*e*) Estimated. (*f*) Included under "Other Mines."

can show as good, if not a better economic record for the year. The matte produced by the Colorado smelter and the Butte Reduction Works is being converted at the New Washoe plant. In August a fire destroyed the reverberatory department of the Butte Reduction works, but it was rebuilt and again in operation in October. The fire did not necessitate the closing of the other departments of the works. The smelter owned by the Montana Ore Purchasing Co. continued in active operation, although a fire on August 28 completely destroyed the company's concentrator, which was the means of curtailing the output of the smelter itself. The concentrator was not rebuilt, but instead the management leased the uncompleted concentrator at Basin owned by the Basin & Bay State Mining Co. This plant has been put in working order, the Montana Ore Purchasing Co. sending its crude ore to Basin, and returning the concentrates to the smelter at Butte to be treated. During the year Mr. Heinze merged the Montana Ore Purchasing Co. and auxiliary companies into the United Copper Co., with an authorized capital of $80,000,000 divided into 50,000 common shares, all of $100 par value. Of the common stock 300,000 shares have been reserved in the treasury. Early in the summer the Speculator mine was closed by a court injunction, and remained idle during the remainder of the year. The Minnie Healey mine, which was operated by Mr. Heinze, was also closed by an injunction. The Pittsburg & Montana Copper Co., which succeeded the Farrel Copper Co., prosecuted development work by sinking two shafts to bedrock on the flat east of Meaderville. The completion of this work has been attended by unexpected difficulties. The depth to solid formation was found to be in the neighborhood of 700 ft., a goodly portion of the sinking being through quicksand. The net earnings of the principal copper mining companies during the fiscal year ending June 30, 1902, as reported to the assessors of Silver Bow County, were: Anaconda Copper Mining Co., $1,289,610; Boston & Montana Consolidated C. & S. Mining Co., $1,639,695; Montana Ore Purchasing Co., $600,000; Butte & Boston C. & S. Mining Co., $166,136; Colorado Smelting & Mining Co., $152,495; Parrot Silver & Copper Co., $577,617; Colusa-Parrot Mining & Smelting Co., $397,475. Outside of Butte the copper properties have not yet reached the productive stage. The Indian Queen, near Dillon, has shown large bodies of glance and chalcopyrite, but it is not yet a regular producer. The Basin Creek properties, in Jefferson County, have been worked throughout the year, and development work has been carried on in the copper properties near Helmville. The Sweet Grass Hills and Blackfoot Reserve properties are as yet in the prospect stage.

Nevada.—The property of the New York & Nevada Copper Co., in White Pine County, was actively developed, and construction work was begun on a 500-ton concentrator and smelting plant near Ely. The ore is chalcopyrite and chalcocite in a gangue of quartz porphyry and averages about 3% Cu. A tramway will be built to connect the mine and smelter. The Nevada Copper Co. and the Bell Mare Mining & Smelting Co., both operating in the Table Mountain district. were consolidated under the name of the Bell Mining & Reduction Co., which plans extensive developments.

New Jersey.—The reduction plant of the Arlington Copper Co., Ltd., erected at a cost of $250,000, was inactive during 1902, except for experimental runs.

New Mexico.—The Burro Mountain, San Andreas, Lordsburg and Black Range districts made good progress during 1902, and an increased output of copper ore was recorded in each of these mining centers. The Burro Mountains are situated in Grant County, about 15 miles southwest of Silver City. Mining has been conducted in the district on a small scale since 1875, but it is only in the last three years that the operations have assumed any marked importance. The main copper bearing area is about three miles long and two miles wide, with a general east and west strike. The prevailing rocks are granite and porphyry, which, by metamorphism and disturbance, have been thoroughly shattered and the seams mineralized with iron, manganese and copper oxides. In addition the country rock contains impregnations of malachite and azurite that constitute low-grade ore bodies. The low-grade ore is to be treated by lixiviation with sulphuric acid, for which a sufficient supply of water can be obtained from the deeper workings. New discoveries of copper ore were reported in the Sandia and Organ Mountains and in the Sacramentos.

North Carolina.—At the Gold Hill mine in Rowan County a 20-stamp mill was operated on copper-gold ores. The Union Copper Co. is reported to have discovered a large body of ore in the Randolph shaft, which assays about 10% Cu. A 10-stamp mill and a leaching process are to be installed at the Rowan mine.

South Dakota.—A small copper smelter is in course of erection near Hill City. The Central Black Hills Copper Co., which exploits a deposit of copper carbonate, has installed a leaching plant with crushers and six leaching tanks, and will produce cement copper.

Tennessee.—The two copper mining companies in the Ducktown district were active during 1902. The Tennessee Copper Co. completed its smelting plant, although only one of the two furnaces was in blast during the first five months of the year. The total quantity of ore smelted was 221,194 tons, which yielded 8,103,539 lb. fine copper, or about 35·5 lb. per ton. The receipts from copper sales were $760,450, and from other sources $2,647, making a total of $763,097, from which after deducting all working expenses, interest, depreciation, and other charges, there remained a profit of $231,109, or $1·32 per share on the outstanding stock. An issue of bonds to the amount of $5,000,000 was authorized to pay the floating debt and provide working capital. The results of the operations in both mining and smelting departments were highly satisfactory, and there is promise of increased activity in the immediate future. Developments underground added nearly 800,000 tons to the ore reserves, which at the close of the year were estimated at 2,050,000 tons. The smelting capacity is to be augmented by a third blast furnace, assuring an annual production of 10,000,000 lb. copper. A summary of the working costs per ton of ore during 1902 is as follows: mining, 84c.; crushing and sorting, 8·3c.; roasting, 34c.; railroad, 15·5c.; engineering and laboratory, 2·7c.; general expenses, 8·7c.; blast furnace, $1·05; converting, 21·7c.; refinery, 10c.; total, $2·90 per ton. The results obtained in blast furnace operations are described under copper metallurgy elsewhere in this volume. The Ducktown Sulphur, Copper & Iron Co., Ltd., in 1901 earned gross profits, including interest, of £24,488, from which the net profits after providing for interest on debentures and appropriating £3,000 to depreciation amounted to £14,761. An interim dividend of 5% was paid, and a further dividend of 5% on the ordinary shares and £9 18s. per share on the founders' shares was declared.

Utah.—The Bingham district formerly a producer of low-grade silver-lead ores is now the largest copper mining camp in the State. The Highland Boy shipped about 500 tons of ore per day, which were treated in its own furnaces. New developments in the mine have exposed large ore bodies in the limestones above the old workings so that the future of this company appears promising. The Bingham Consolidated mines produced about 250 tons of fluxing ore daily, which together with siliceous ores purchased in the open market was handled in the company's smelter. The United States Mining Co. has erected a complete smelting plant with three furnaces, and during the year treated daily about 300 tons of ore from Bingham mines mixed with siliceous ore from the Centennial mine at Tintic. This plant reduces the ore in a blast furnace without previous roasting, and produces converter matte with two smeltings. The company has large ore reserves, and will increase the output of copper during 1903. Work has been prosecuted on a number of other properties in the Bingham district with the result that two mines—the Boston Consolidated and the Yampa—have been brought to the productive stage warranting the erection of smelters. The Columbia Copper Co. operating in the main Bingham Cañon has steadily developed its mine, shipping the ore in the form of concentrates.

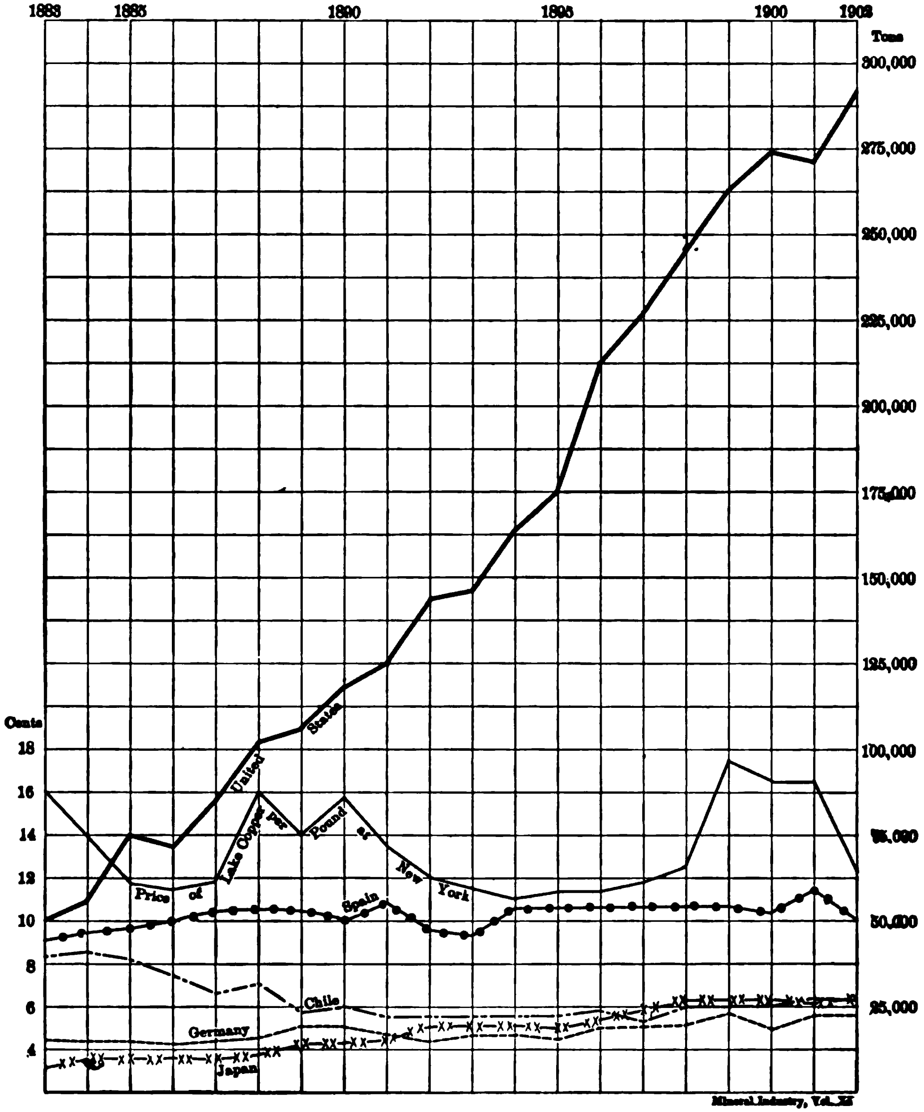
Wyoming.—(By Wilbur C. Knight.)—The progress in the copper mining industry has been of development rather than production, the greatest changes having been made in the Grand Encampment and the New Rambler camps. The North American Copper Co. purchased the Ferris-Haggerty mine, the new tramway that has been put in at a cost of over $250,000 to connect the mine with the smelter, the Grand Encampment smelter, and numerous other valuable rights. The purchase price was stated to be $1,000,000. The company has commenced extensive development at the mine, and is erecting a large concentrating plant. It is claimed that the Union Pacific Railroad will construct a branch into the camp. Other properties have been greatly developed during the year; to the southward the Pearl district has been opened up on the Colorado-Wyoming line. In the New Rambler district, early in the season, a new matting furnace was installed, which made several very successful runs. Later, an Eastern company purchased the Rambler mine and incorporated it for $2,000,000. The Laramie & Hahns Peak Railroad, now under construction, which is graded to a distance of about 25 miles southwest of Laramie, will pass within a few miles of this property. Several companies have opened very promising prospects near the New Rambler. The discovery of platinum and palladium in the Rambler vein was of more than ordinary interest, and, as far as is known, this property is the only producer of ore carrying these rare metals. From an average of many assays the covellite ore contains 3·5 oz. of platinum and palladium to the ton, sometimes being all palladium. Although about 2,000 tons of this ore was sold, nothing was paid for the precious metals contained. At Hartville, an old-time copper camp, some very rich ore bodies have been discovered.

Philippine Islands.—Copper deposits of considerable importance are found on the Island of Mindanao, in the region inhabited by the Moros. The natives, as well as the Chinese, have exploited the ores on a small scale with remunerative results. The ore obtained from small workings is pounded on anvil-shaped pieces of metal, and the crushed material is then run through rolls. These rolls are of stone or iron, and are turned by hand or by a water buffalo. In some places there are large furnaces for heating the rock, preparatory to crushing, and several smelting furnaces have been in operation, some of them owned by Germans. The native miners are said to be efficient workmen and can be obtained for a few cents a day. Gold and silver as well as copper are found in Mindanao.

By a recent enactment of Congress, the mineral deposits of the Philippines are to be thrown open to exploration and purchase by citizens of the United States, natives of the Philippines and Spaniards in the Philippines who have declared their intention of becoming citizens of the Islands. Claims for lode mining are limited for each individual to 1,000 ft. square; for placer mining to 20 acres; and for coal lands to 160 acres. Provision has been made for proper inspection and registration of the claims upon proof and payment of the fees prescribed, and the publication of notice in two newspapers of the Islands. A prescribed amount of work must be done upon the claims each year in order to hold them.

COPPER MINING IN FOREIGN COUNTRIES.

Australia.—Both the depressed condition of the copper market and the severe drought had an unfavorable influence upon mining operations, which under more normal conditions would have shown a greater expansion.



THE PRODUCTION OF COPPER IN THE PRINCIPAL COUNTRIES OF THE WORLD. (IN METRIC TONS.)

The output of fine copper in New South Wales during 1902 was valued at £308,923, against £413,902 in 1901, a decrease of £104,979. This State suffered from the long period of dry weather, which necessitated a partial or complete suspension of activity by most of the copper mines. In the Cobar district, the Great Cobar Copper Co. was the only concern that worked continuously through the year, and its activity was due to the fact that the company had entered into a contract for the supply of copper. For a time water was drawn to the mine by railway, a distance of 150 miles. The Lloyd, the Nymagee, and the Mt. Hope mines were closed down during a part of the year. The ore from the Cobar Chesney mine, in which 600 men were employed, was smelted in the furnaces of the Great Cobar Co.; about 4,500 tons of ore containing 3% copper and 1 dwt. gold per ton were shipped during 1902. A discovery of high-grade copper ore near Cowl Creek was reported.

The Queensland Copper Co., Ltd., for the 16 months ending July 31, 1902, reports an expenditure of £18,456, and an income of £14,277. From February to September inclusive, 3,707 tons of ore were smelted to matte, containing 0·35 oz. gold, 18 oz. silver per ton, and 50% Cu. Arrangements are being made to convert the matte into blister copper at the smelter. The Mount Perry mine has been opened, and work upon it is being rapidly done. Copper ores have been found near Mount Hector, on the eastern side of the Dawes Range, about 46 miles due south of Gladstone, Queensland. Development work is being prosecuted, but so far little is known as to the extent of the deposits. The ores are oxidized and carry gold and silver; a trial shipment assayed 5% Cu, 1·5 oz. gold

THE WORLD'S COPPER PRODUCTION, 1898—1902. (*a*).

Countries.	1898.		1899.		1900.		1901.		1902.	
	Tons of 2240 Lb.	Metric Tons.	Tons of 2240 Lb.	Metric Tons.	Tons of 2240 Lb.	Metric Tons.	Tons of 2240 Lb.	Metric Tons.	Tons of 2240 Lb.	Metric Tons.
Algeria	50	51	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Argentina	125	127	65	66	75	76	780	793	240	244
Australasia	18,000	18,288	20,750	21,082	23,000	23,368	30,875	31,371	28,640	29,098
Austria-Hungary	1,540	1,565	1,505	1,529	1,355	1,377	1,335	1,356	1,500	1,524
Bolivia	2,050	2,083	2,500	2,540	2.100	2,134	2,000	2,032	2,000	2,032
Canada	8,040	8,169	6,730	6.838	8,459	8,595	18,282	18,575	17,486	17,766
Cape of Good Hope										
Cape Company	4,660	4,785	4,140	4,206	4,420	4,491	4,000	4,064	2,750	2,794
Namaqua	2,400	2,438	2,350	2,388	2,300	2,337	2,400	2,439	1,700	1,727
Chile	24,850	25,248	25,000	25,400	25.604	26,016	30,805	31,299	28,930	29,393
Germany—Total	20,085	20,407	23,460	23,836	20,310	20,635	21,720	22,069	21,605	21,951
(Mansfeld)	(18,045)	(18,334)	(20,785)	(21,118)	(18,390)	(18,684)	(18,780)	(19,082)	(18,750)	(19,050)
Italy	3,039	3,088	2,965	3,012	2,753	2,797	3,000	3,048	3,370	3,424
Japan	25,175	25,578	28,310	28,763	27,840	28,285	27,475	27,916	29,775	30,251
Mexico—Total	15,668	15,919	19,005	19,310	22,119	22,473	33,818	33,948	40,000	40,640
(Boleo)	(9,436)	(9,587)	(10,222)	(10,386)	(11,119)	(11,297)	(10,783)	(10,956)	(10,785)	(10,958)
Newfoundland	2,407	2,446	2,956	3.003	2,883	2,929	2,756	2.800	2,586	2,627
Norway	3,615	3,673	3,610	3,668	3,935	3,998	3,375	3,429	4,565	4,638
Russia	6,000	6,096	7,210	7,325	8.000	8,128	8,000	8,129	7,580	7,701
Peru	3,040	3,089	5,165	5,248	8,220	8,351	9.520	9.673	8,000	8,128
Spain-Port.—Total	53,225	54,075	54,220	55,088	52,872	53,718	53,621	54,482	49,790	50,767
Rio Tinto	33,705	34,244	34,370	34,920	35,732	36,304	35,348	35.916	34,480	35,031
Tharsis	12,000	12,192	9,448	9,599	7,965	8,092	7,427	7,546	6,710	6,817
Mason & Barry	3,600	3,658	3,600	3,658	3,460	3,515	3,729	3,789	3,330	3,386
Sevilla	800	813	1,200	1,219	1,460	1,483	1,292	1,313	1,545	1,570
Sweden	480	488	520	528	450	457	450	457	455	462
Turkey	....	....	....	....	2,304	2,341	1,639	1,665	1,100	1,118
United Kingdom	640	650	637	647	765	777	532	541	600	610
United States	239,241	243,069	259,517	263,685	268,229	272,536	271,949	276,300	272,685	277,047
Totals	434,330	441,284	468,679	476,194	485,634	494,422	528,327	537,381	525,357	533,763

(*a*) The figures in this table are taken from the annual metal circular of Henry R. Merton & Co., except where returns have been received by THE MINERAL INDUSTRY direct from official sources.

and 2 oz. silver per ton. The mines and smelters at Mount Garnet in the Herberton district were operated intermittently, producing copper and silver valued at £164,267. Systematic prospecting was carried on at Chillagoe, and one smelter was started in October which produced copper and silver of a value of £22,519. In the Kangaroo Hills district smelting works have been erected, and the mines are undergoing rapid development. The ore is reported to assay 16% Cu, 15% Pb, and 49 oz. silver per ton. The total output of copper in the form of ore and matte in Queensland during 1902 was 3,784 long tons valued at £189,200.

In Western Australia there is only one district, the Mt. Malcolm, where operations are carried on systematically, and this is the only district in which the ore is reduced to matte, water-jacket furnaces being erected at the mines. The ore from the Murchison, Northampton, West Pilbarra, Phillips River, and other districts is exported for treatment. In the latter district only the high-grade ore can be exported, as the cost of treatment is considerable and the shipping facilities poor.

The Mount Lyell Mining & Railway Co. during the semester ending Sept. 30, 1902, treated 159,450 tons of ore from the Mount Lyell mine and 5,689 tons purchased from outside mines; the yield being 3,608 tons of blister copper which contained 3,608 tons of fine copper, 341,346 oz. silver, and 11,681 oz. gold. Out of the net profits of £45,348, the sum of £34,375 was paid in dividends, making a total disbursement on this account of £896,887. As compared with the results of the previous half year, the cost of producing blister copper per ton of ore shows a reduction from £1 1s. 3·2d. to 19s. 8·3d. Considerable exploration work was carried out at the Mount Lyell, South Tharsis and Royal Tharsis mines, and the company increased its holdings by acquiring the leases formerly owned by the North Crown Lyell and the Central Lyell companies. The last-named property adjoins blocks 13 and 14 of the original Mount Lyell leases and contains the downward extension of the main ore body. The company's present contract with the Baltimore Copper Smelting & Rolling Co. for refining the blister copper was extended for a period of three years. The North Mount Lyell mine during the year ending June 30, 1902, produced 61,728 tons of ore, the larger part of which was sold to the Mount Lyell Mining & Railway Co. and realized £188,620. Satisfactory progress was made in the erection of the company's smelting works at Crotly. The Mount Lyell Blocks mine during the same period produced 5,066 tons of ore, valued at £21,200 and the Lyell Tharsis mine 13,197 tons of ore. Operations at the latter mine were temporarily suspended owing to the low price of copper.

Argentina.—In the Calamuchita district, 60 miles southwest of Cordoba City, the Rosario Co. is operating a 36-in. blast furnace on ore yielding from 5 to 6% Cu. The matte which contains about 65% Cu is exported. The Famatima Development Corporation. Ltd., capitalized at £400,000, is operating mines in the Mexicana spur of the Famatima range. There are 14 lodes averaging 4 ft. in width and two miles long. The ore contains silver and gold as well as copper. and 30-ton samples show values from £7 15s. to £22 10s. per ton. An aërial tramway 25 miles long is being constructed to connect the mines with the smelter at Chilecito. The Upolongos mine in the Mexicana district has been operated for many years and yields ore assaying 15·3% Cu, which is reduced to 65% matte and shipped to Europe. The Carranza-Lafone Copper Smelting Corporation of London, capitalized at $3,000,000, has acquired the mines and smelters in the Capillitas and Atajo districts. The construction of a modern smelting plant is proposed.

Bolivia.—The exports of *barilla* (native copper) from the port of Mollendo in 1902 was 3,498,117 kg., which practically represented the entire output of this country, as the ore exported from Antofagasta amounted to only 12 tons.

Brazil.—The Bahia Exploration Co. has acquired copper claims 50 miles west of Jaguarary, which are said to carry from 2 to 40% Cu.

Canada.—(By Samuel S. Fowler.)—The copper deposits of British Columbia are widely scattered, generally occurring in the igneous rocks and their derivatives, which are extensively developed throughout the southern part of the Province. The important mines are found at three general centers, *viz.:* Rossland, in the southwest corner of West Kootenay; the Boundary portion of Yale district; and the southern part of the mainland coast, including Vancouver and other islands. All of the copper occurs as chalcopyrite, with pyrite and pyrrhotite, and carries more or less value in gold and silver. The total output of copper for 1902 was 14,818 short tons derived from the following localities: Rossland and vicinity, 5,834 tons; Boundary, 7,478 tons; coast, 1,248 tons; other districts, 258 tons. The Rossland mines increased their output over 1901 when serious labor troubles interfered with mining operations. All of the Rossland ores are smelted to matte, either at Northport, Wash., or at Trail, B. C., in both instances the matte being converted elsewhere. At Trail a considerable quantity of the Rossland low-grade ore is used as a "dry" ore in lead furnaces. Experiments in preliminary concentration have been tried extensively on these low-grade ores, and with apparent success. I believe that successful commercial results may be looked for during 1903. The Le Roi Mining Co., Ltd., during the fiscal year ending June 30, 1902, mined and shipped to the Northport smelter 155,765 dry tons of ore, averaging 1·53% Cu, 0·373 oz. gold and 0·71 oz. silver per ton, or a total value of $11·70 per ton. In addition there were shipped 14,333 tons of ore from the dump valued at $10·29 per ton. The year's sales of matte amounted to £385,521, while the stocks of ore and matte on hand were valued at £218,571. The costs of mining were £124,201, and of smelting £387,967. At the close of the year there was a debit balance of £46,551—an unfavorable showing which was due to the overestimation of the stocks of metal on hand, the losses of copper, new work and improvements. The Le Roi No. 2, Ltd., in the year ending Sept. 30, 1902, shipped 63,262 dry tons of ore containing 3,001,027 lb. copper, 32,435 oz. gold and 82,548 oz. silver, with a gross value of $1,068,916 or $16·89 per ton. The costs of mining were $5·02 per ton and of smelting $7·87 per ton, making the total cost of realization $12·89 per ton. The profits of the year's operations were $224,935, out of which an interim dividend of 5% was paid. In the Boundary district, near Phœnix, are the mines of the Granby Co., the "B. C." Co. and the Snowshoe Co., and near Greenwood, the mines of the British Columbia Copper Co. and the Montreal & Boston Copper Co. The operations of these companies, as well as of those in Rossland, were hampered seriously by strikes at the coal mines upon which they depend for cheap coke supplies, and the copper output was therefore much less than it would have been under more favorable conditions. The copper deposits in the Boundary district are usually of large size and of self-fluxing composition, and although yielding extremely low values they can, with possibly one or two exceptions, be worked at a profit. The Granby Co. is engaged in the construction of two new furnaces which will bring its capacity up to about 2,100 tons daily. The plant is equipped with converters and handles the matte of the two other smelters, so that the entire shipment from the Boundary district is in the form of metal. Mining and smelting operations in this vicinity are greatly facilitated by the supply of electric current from the power plant at Cascade, B. C. From the generating station lines extend to the Granby smelter and to Phœnix, a distance of 22 miles. The Hall Mining & Smelting Co. in the Nelson district, during the year ending June 30, 1902, mined and treated 22,661 tons of ore for a yield of £66,179. The copper furnace treated 22,936 tons of ore from the Silver King mine and 2,558 tons purchased from other mines. The results of operations in all departments show a net loss for the year of £5,946. In the Coast districts much activity was manifested during the year, smelting facilities being provided by the Northwestern Smelting & Refining Co., at Crofton, V. I., and others. Unfortunately one of the largest mines became legally involved, and on this account the copper output from the Coast mines was 310 tons less than in 1901. This part of the Province appears to have a particularly bright future, due to its many good copper prospects.

The output of copper-nickel ore in Ontario in 1902 was 265,538 tons, of which 233,388 tons were smelted yielding 38,023 tons of matte. The copper content of the matte was 4,066 tons, valued at $616,763.

Copper mining has been carried on as usual at Capelton by the Nichols & Eustis companies, with an output of 32,938 tons, valued at the mine at $121,170. A quantity of 12,152 tons has been shipped to the United States, while the balance remains in Canada for use at the chemical works of Capelton. The Ascot mine has been worked during the year for development purposes, with a small output of good grade ore. The King & Norton's mines have also been a little developed, and the old Ballarat mine, in Melbourne, has been pumped out for examination purposes. During the year, there was talk of establishing a custom smelter in Sherbrooke or its vicinity, and if a sufficient supply of ore could be obtained to support it several old mines would be re-opened and new ones started, having then a ready market for their output, big or small. The district around Sherbrooke is rich enough in copper ore to encourage such an enterprise. A new discovery of high-grade copper ore has been made near Matane, in the county of this name. The ore found is mostly bornite with some chalcopyrite. Native copper is also found in small quantity. A local company is presently sinking down with a small steam plan, and it claims to be satisfied with the results.

Cuba.—There have been no notable developments in copper mining during

1902. The copper resources of Cuba are described in THE MINERAL INDUSTRY, Vols. IX. and X.

Italy.—(By Giovanni Aichino.)—The only important centers of copper mining at the present time are Massa Marittima, Tuscany, and eastern Liguria. The once famous mines of Montecatini are now nearly exhausted. The largest producers in the Massa Marittima district are the "Bocchegiano," the "Fernice Massetana" and the "Capanne Vecchie." Of these the first named is located on a quartz vein enclosed between Permian and Tertiary schists and averaging about 6 m. in thickness. During the period 1895-1901, this mine produced 257,332 tons of ore (pyrite and pyrrhotite) which gave an average yield of 3·68% Cu and 28·15% S. Of the total product 30,300 tons were classed as first grade, assaying 10·67% Cu and 31·97% S; 48,040 tons as second grade, assaying 3·44% Cu and 40·48% S; and 178,992 tons as third grade, assaying 2·67% Cu and 24·19% S. The Fernice Massetana and Capanne Vecchie mines also exploit a quartz vein carrying pyrite and pyrrhotite, which ranges from a few centimeters to 20 m. in thickness. The ore is sorted into first grade (11%Cu) and second grade (3% Cu). The richest ore from these mines is roasted and treated by the Bessemer process at Leghorn, while the poorer grades are heap-roasted at the mines and subjected to the leaching process with the precipitation of the copper by iron. The deposits in eastern Liguria call for no special discussion, as their product at present is mostly pyrite. The Etruscan Copper Estates Co. is developing mines at Campiglia which were worked by the Etrurians; the company's directors are very sanguine as to the future, but competent engineers who have examined the property are much less confident.

Mexico.—(By James W. Malcolmson. See also under the sections "Lead" and "Gold and Silver" elsewhere in this volume.)—The advance of Mexico as a producer of copper has been very marked during the past few years, principally owing to the developments of mines in the State of Sonora. In 1897 Mexico produced 11,370 metric tons of metallic copper, 10,170 tons of which were from the Boleo mine in Lower California. In 1902, 40,000 tons were produced, the production of the Boleo mine being 10,958 tons. A great amount of development has taken place along the lines of the railroads, due to the establishment and the growth of the custom smelting industry. In these smelters copper as a vehicle for the concentration of silver and gold seems to be steadily displacing lead. It is probable that recent improvements in the metallurgy of copper, and the opening of large deposits will increase considerably the quantity of the precious metals so handled in 1903.

Along the extension of the Mexican Central Railroad now building, between Guadalajara and Colima, a very important and almost virgin copper-gold country is being rendered accessible, and the Kansas City, Mexico & Orient Railroad now building between Chihuahua City and the United States-Mexican frontier will open up a large field of copper ores low in silver and gold values.

In addition to the above a fair quantity of copper is produced as a secondary product in the mining of gold and silver ores, notably at Viesca, Quinteras; Piedras Verdes; La Bufa; The Lustre Mining Co., Inde.; Cushing & Walkup's mines, Durango; Dolores in Matehuala; Santa Fe Chapas; Bolaños; Barranca de Cobre, etc.

Sonora.—The completion of the Nacosari and Cananea copper smelting plants, the building of two smelters—the Copper Queen, and the Calumet & Arizona—at Douglas, Arizona, on the northern frontier, mark a new era in the history of mining in the State of Sonora. At least one of these smelters will be a custom smelter and will purchase gold and silver ores in addition to those of copper. The extension of railroads from these smelters into the heretofore undeveloped mining camps in the southeastern part of Sonora is now within measurable distance.

The Greene Consolidated mines at La Cananea now produce daily approximately 1,000 tons of ore, assaying 7% Cu. The ore reserves opened up by exploration work during 1902 have been phenomenal, and there is more ore in sight at present than at any previous time, although extraction has been maintained at a high level throughout the year. The Cananea ore occurs as bonanzas, the ore bodies being an alteration of limestone and quartzite and as a general rule carrying an excess of silica. Some of the ore bodies, especially in the Oversight mine, are exceptionally rich, assaying in large lots 25% Cu. A concentrator has just been installed with four jigs and 52 Wilfley tables capable of handling daily 600 tons of ore, which will produce 200 tons of concentrates. According to the official report of this company the production during the fiscal year ending July 31, 1902, was 26,665 short tons of copper matte, which contained 23,991,617 lb. copper and 194,609 oz. silver, and 3,862,880 lb. copper bullion containing 39,120 oz. silver and 342 oz. gold. The ore smelted comprised 142,968 tons copper ore and 52,855 tons iron ore, and the average yield was 9·8% Cu and 1·7 oz. silver per ton. The income for the year was $802,833, out of which $200,000 were paid in dividends, and $417,671 set aside for depreciation and legal requirements.

At the Moctezuma copper mine at Nacosari, 60 miles southeast of La Cananea, the ore is a mass of crushed porphyry on a fault plane, the interstices of which have been filled with copper and iron pyrites. All the ore is concentrated by jigs, the jig tailings being re-crushed and passed over Frue vanners. A concentration of 3 to 1 is effected. The sulphide concentrates are smelted without roasting and the resulting matte is Bessemerized in a converter having a very thick lining of low-grade gold-silver quartz mined from an adjacent property of the company. The Loomis-Pettibone fuel gas installation at this plant has given great satisfaction, the consumption of fuel being under 3 lb. of inferior cordwood per H.P. per hour. The Santo Niño copper mines near the Yaqui River, east of Minas Prietas, have received some attention during 1902, but their importance as producers of copper has probably been exaggerated.

Chihuahua.—On account of the decline in the price of copper, the mines and smelter of the Rio Tinto Mexicana Co. at Terrazas, have suspended operations, and work at the Magistral mines, west of the city of Chihuahua, has been carried forward on a very limited scale.

Durango.—Very large quantities of basic silver-copper ores have been opened up in the Descubridora copper mines, near Conejos, and the construction of the smelter is completed. After finishing the present contracted shipments of matte to the American Smelting & Refining Co., a Bessemer plant will be operated and converter bars produced. The Velardeña copper properties have been acquired by American Smelting & Refining Co. interests, and a railroad and concentrating plant is now under construction. The Promontorio, a copper-gold mine, has attracted considerable attention during the year; the ore bodies are large, and a concentrator and matte smelter is under construction. The Jimulco Copper Co. produces monthly 1,800 tons of ore assaying 0·2 oz. gold, 20 oz. silver per ton and from 9 to 10% copper. This property is in an almost entirely undeveloped region.

Zacatecas.—The Mazapil Copper Co. has maintained its high production, although somewhat handicapped by the scarcity of water. The Mazapil district produces approximately 7,000 tons of ore per month.

Guerrero.—A deposit of cupriferous pyrites has been opened up in Campo Morado on the Balsas River, near the terminus of the Mexican Central Railway; the ore lies on a contact between shale and igneous conglomerate, and assays 0·2 oz. gold, 6 oz. silver, 2% copper, 40% iron, 5% silica and 45% sulphur. Over a million tons are already demonstrated to be in sight in the large lens, and smaller lenses of higher grade ore have also been discovered.

Augascalientes.—The Copper mines of Tepezala, operated by M. Guggenheim Sons, have maintained a steady production of siliceous silver-copper pyrites.

Michoacan.—The operations of the Inguaran Copper Co. have not increased during the year. At Chirangangueo the Angang Copper Co. has opened up large bodies of copper pyrites, but the low price of copper has prevented very energetic operations.

Puebla.—The pyritic deposit of basic silver-gold zinky copper ore at Tezuitlan has been actively worked. The ore is now being smelted at the rate of 5,000 tons per month, converter bars being shipped.

Baja California.—The Boleo Copper Co. maintains its steady production, which is the remarkable feature of the operations of that company. The ore is a cuperiferous impregnation of eruptive breccia. The mine is famous for the "Boleos" or pockets of azurite, which are found at irregular intervals in the deposit, near the outcrop. During 1901, the Boleo Co. produced 10,956 metric tons copper from 275,635 tons of ore, the yield being 3·95%. The total operating profits were 1,206,502 fr., showing a large reduction from the previous year. For improvements and new machinery there was expended the sum of 1,744,235 fr., while 208,844 fr. were set aside on account of depreciation, and 1,191,925 fr. for amortization and reserve funds. The smelting works have been reconstructed with eight modern furnaces of 150-ton capacity, and two additional furnaces are in the course of erection. Under a new agreement the company's product of matte and bars is now shipped by rail from Guaymas to New Orleans where it is trans-shipped to steamers for Europe. The number of workmen on the company's rolls at the close of the year was 3,324.

Newfoundland.—The production of copper ore in Newfoundland in 1902 amounted to 71,482 tons, valued at $247,060, the metallic contents of which were estimated to be 2,586 tons of copper valued at $630,326. This copper ore was all exported, 35,947 tons going to Great Britain and 35,538 tons to the United States. The ore is smelted at the works of the Nichols Chemical Co., in the United States, and at those of the Cape Copper Co., in England. The report of the Cape Copper Co., Ltd., for the fiscal year ending Aug. 31, 1902, shows an income from operations at Tilt Cove of £75,176, and a net profit of £11,748. During the year the East mine produced 49,147 tons of ore, averaging 3·20% Cu, the South lode 9,417 tons, averaging 3·85% Cu, the North lode 7,119 tons, averaging 3·32% Cu, and the West mine 1,896 tons. Of the output, 23,388 tons were shipped to Swansea, Wales, 38,578 tons to New York, and 8,319 tons to Garston. The York Harbor property was sold in December, 1902, to an American company for $400,000.

Norway.—The Sulitjelma mine, according to reports, produced about 66,000 tons of copper ore and pyrite in 1902, and the Röros mine about 25,000 tons. The ore from these mines, averaging from 5 to 6% copper after roasting, is smelted in American water-jacket furnaces to matte carrying about 40% copper, and the latter is then treated by the converter process. The total cost of producing fine copper is about 6·8c. per pound. The sale of the Skjangli properties to American capitalists was reported. These properties are situated in the northern part of the Scandinavian peninsula on both sides of the Norway-Sweden boundary line, and contain low grade ore carrying small quantities of gold and silver. The properties are as yet undeveloped.

Portugal.—The report of Mason & Barry, Ltd., for the year 1902, states that the quantity of ore raised was 177,563 tons, while the shipments amounted to 405,111 tons. The net profits on working account were £90,495; the stocks of ore and copper precipitate at the close of the year were valued at £90,495.

Russia.—This country consumes annually about 22,000 tons copper, 14,000 tons being imported. About 90% of the domestic production was furnished by the Ural and Caucasus districts. Since the Trans-Siberian Railroad has been completed, the copper deposits of the district of Krasnojarsk in Central Siberia have been opened. A Russian-English corporation has been formed, which is reported to have received a concession from the Russian Government for the exploitation of an area of 1,200 acres, 110 miles from the Yenisei River and directly connected with the Trans-Siberian Railroad.

South Africa.—The report of the Cape Copper Co., Ltd., for the year ending April 30, 1902, for South Africa, and August 31, 1902, for London, shows a loss in the year's operations of £6,494, which with the balance brought forward from the previous year left a credit of £158,194. Out of this sum a dividend of £138,000 was paid, and the balance, after deducting income tax of £5,605, was carried forward to 1903. At Ookiep 14,691 tons of ore were smelted and at Nababiep 10,717 tons. Operations were hampered by incursions of the Boers, who inflicted much damage upon the mining and smelting machinery. The British South African Co. has granted mining concessions aggregating 560 square miles in northern Rhodesia to the Northern Copper Co., who in turn have conceded 500 square miles to the Rhodesia Copper Co. The area covered by these grants has been partially explored with the result that many promising prospects have been located, some of which bear evidence of having been worked in ancient times

Assays of ore from various localities range from 2·5 to 50% Cu. Development work has been undertaken on an extensive scale, and the Rhodesia Railway, Ltd., has arranged to extend a line to the territory from Victoria Falls.

Spain.—The Rio Tinto Co., Ltd., during 1902, realized on sales of copper and other items, including balance carried forward from 1901, a total of £1,129,662. Of this sum the following amounts were set aside: for a fixed charge on pyrites and overburden account, £19,053; the redemption of the 4% bonds, £68,440; plant out of use and charged off, £1,100; credited to reserve fund, £50,000; credited to provident fund, £2,000; total, £198,306. Out of the balance, amounting to £912,304, interim dividends of 2s. 6d. on the preference shares, less income tax (total, £38,171), and 22s. 6d. on the ordinary shares, free of income tax (total, £365,625), were paid, and dividends of 2s. 6d. on the preference shares (total, £38,086), and 27s. 6d. on the ordinary shares (total, £446,875) were recommended, leaving a balance of £23,547 to be carried forward to 1903 revenue account. The total quantity of ore extracted during 1902 was 1,865,289 tons, with an average copper content of 2·517%. The pyrite ore invoiced to consumers in England, Germany and the United States amounted to 595,092 tons. The sulphur ore shipped was 117,704 tons. The pyrite shipped contained 12,819 tons of copper, which with the 21,659 tons extracted at the mines, made a total output for the year of 34,478 tons of copper. It was estimated that the reserve heaps at the mines contained 142,951 tons of fine copper, while the stocks at the company's works at Cwmavon, consisting of refined copper, copper in process, in precipitates and in matte, amounted to 4,217 tons. The Bessemer plant, erected in 1901, was in full operation throughout the year, and has caused a saving to the company both in freight charges and ore treatment. The output of the refinery at Cwmavon, Wales, was 20,583 tons copper. The Tharsis Copper & Sulphur Co., Ltd., during 1902 mined 342,692 long tons of ore, and produced 6,708 tons of fine copper. Nearly all of the ore was taken from the Catañas mine, as the Lagunazo and Tharsis workings have been practically exhausted. The exports of pyrite amounted to 382,053 long tons. The total gross profits of the year's operations were £251,268, from which the sum of £81,666 was charged off for cost of management, interest, depreciation, etc., leaving a balance, with the sum carried forward from the previous year, of £213,389, out of which dividends amounting to £187,500 were distributed, and the balance carried forward to the next year's account. A large amount of exploratory work was done in the Catañas mine, and sufficient ore opened up to assure the continuance of operations for many years. The company is seeking to acquire copper properties in other countries.

United Kingdom.—The Ovoca Copper Syndicate, Ltd., capitalized at £12,000, is preparing to develop the Cronebane mines at Ovoca, County Wicklow, Ireland. Samples of the ore assay from 0·05 to 26·82% Cu, and average about 2·99% Cu. A complete analysis of the ore gave the following results: Cu, 2·79%; Zn, 1·5%: Pb, 0·31%; Fe_2O_3 and Al_2O_3, 37·05%; S, 30·7%; SiO_2, 17·5%; CaO, 1%; As, CO_2, and H_2O, 9·15%; Au, 1 dwt. 6 gr. and Ag, 1 oz. 7 dwt. 12 gr. per long ton.

THE COPPER MARKETS IN 1902.

New York.—The course of the market during 1902 was very interesting in a good many respects and was again followed with marked attention on the part of those directly and indirectly connected with the industry, as well as by the general public. In view of the erratic policy pursued by one of the largest factors in forcing the output of its mines after having accumulated large stocks, and in selling its copper in a manner surprising and inexplicable to the more conservative business men in the trade, the impression gained firm footing that the policy inaugurated in December, 1901, was to be continued indefinitely, that is, to bring the price down to a very low level and keep it there at all hazards. There was comparatively slight resistance to this movement from Europe, where business throughout 1901 was rather disappointing, and traders there took full advantage of this carefully nursed specter, depressing prices long before our manufacturers awoke to the fact that a further heavy decline was imminent. However, the course of events made it apparent to the more experienced authorities in the trade on this side that in view of the very large consumption in the United States, the popular estimates of the available supplies were wildly inaccurate, all signs pointing to a rapid decline of the stocks on hand. It is true, production showed an increase, in spite of the prevailing low prices. A number of new mines have started active operation. On the other hand, all the copper consuming industries have been exceedingly busy throughout the year. The brass as well as sheet mills have taken heavy quantities of copper. The railroads had to replenish their rolling stock, which was acknowledged to be inadequate. The shipbuilding industry was very prosperous, and last but not least, enormous quantities have been sold for electrical purposes. The use of copper for traction purposes seems to have only just started, to say nothing of local extensions of electrical lines that are being, both in America and Europe, extended to longer distances and made to connect cities as well as points within cities. This is evidently only a forecast of the use of electricity for long distance travel, and experiments in that direction are continually being made on both sides of the Atlantic. At the beginning of the year the greatest uncertainty prevailed in the copper market, and it was evident that the retrograde movement which had commenced in November, 1901, had not yet terminated. Prices opened nominally for Lake at 12c., electrolytic at 11·75c., but very soon a further cut of 1c. was made, followed by quite large sales at the parity of 10·875c. and 10·625c., respectively, at which figures consumers at last operated freely, and speculators were not slow to take an interest in the markets, trying to contract for whatever they could lay their hands on. This enormous buying sufficed to put an end to the forced depression in prices which had been systematically worked for the two previous months, and the moment it was felt that prices had about reached bottom, consumers who had allowed their supplies to drop to the lowest ebb, purchased very largely, not only for prompt delivery, but also as far ahead as they possibly could. The interests which had been instrumental in forcing prices down were evidently unable to withstand the flood of orders pouring in from all sides. Quotations advanced quickly to 12·5c. for Lake and 12·25c. for electrolytic, ruling at these figures for several weeks. That this advance had been too rapid was evident, and as soon as some speculators tried to realize, the market commenced to ease off, and since that time there have been persistent efforts on the part of the largest operators to establish lower prices for copper wherever possible. During May Lake copper declined to 12·25c. and electrolytic to 12c., at which figures the market was fairly steady throughout June, but in July the coal strike caused manufacturers to proceed cautiously and to restrict purchases. Consequently, values suffered, and by the end of August had declined to 11·75c. for Lake and 11·5c. for electrolytic copper. September proved fairly steady, but in October the flat tendency of the Stock Exchange and the unsettled state of affairs in the coal regions, coupled with renewed efforts on the part of leading interests to establish a lower range of values, tended to influence the market adversely. With the exception of a short-lived upward movement toward the end of the month, dullness reigned supreme for a considerable time, prices dropping slowly, until 11·5c. for Lake and 11·25c. for electrolytic was quoted at the end of November. The settlement of the coal strike and a large inquiry from Europe, where business at last showed signs of improvement, and a good demand for home trade caused a buoyant feeling to prevail during December, to which prices quickly responded, the year closing with Lake selling at 11·75@12c.; electrolytic at 11·625@11·875c.; and casting copper at 11·5c. The tendency was, moreover, apparently to a further advance.

AVERAGE MONTHLY PRICES OF LAKE COPPER PER POUND IN NEW YORK.

Year.	Jan.	Feb.	Mar.	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1898	10·99	11·28	11·98	12·14	12·00	11·89	11·63	11·89	12·31	12·41	12·86	12·93	12·03
1899	14·75	18·00	17·54	18·48	18·25	17·93	18·33	18·50	18·46	17·76	16·93	16·40	17·61
1900	16·33	16·08	16·55	16·94	16·55	16·00	16·16	16·58	16·69	16·64	16·80	16·88	16·52
1901	16·77	16·90	16·94	16·94	16·94	16·90	16·51	16·50	16·54	16·60	16·63	14·39	16·55
1902	11·822	12·878	12·186	11·986	12·226	12·360	11·923	11·649	11·760	11·722	11·538	11·599	11·887

AVERAGE MONTHLY PRICES OF ELECTROLYTIC COPPER PER POUND IN NEW YORK.

Year.	Jan.	Feb.	Mar.	April	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1899	14·26	17·02	16·85	17·18	17·20	16·89	17·10	17·42	17·34	16·94	16·49	15·85	16·67
1900	15·58	15·78	16·29	16·76	16·34	15·75	15·97	16·35	16·44	16·37	16·40	16·31	16·19
1901	16·25	16·38	16·42	16·48	16·41	16·38	16·31	16·25	16·25	16·25	16·22	13·82	16·11
1902	11·053	12·178	11·882	11·618	11·856	12·110	11·771	11·404	11·490	11·449	11·288	11·480	11·696

London.—The year under review opened rather unpropitiously. While the visible supplies were light, amounting only to 22,051 tons, the effects of the disastrous break in December were still felt. Although the market had steadied itself a little, January opened with standard at £48 17s. 6d. for spot and £49 10s. for three months. There was a fair consumer's trade in tough and best selected, but as soon as the market began to rise, Americans became free sellers, with the apparent object of reducing the price. The European companies generally held out of the market. In February there was a gradual advance until as high as £57 was paid for standard. Another American bear onslaught followed, however, and prices were beaten down below £52. When this passed, the market showed renewed strength, rallying to £55 10s. spot and £56 three months; at this point some European companies made large sales of tough copper at £60.

Early in March the market was weaker, declining to £52 2s. 6d. for spot, with a backwardation of 5s. on futures, but some large purchases made by the British Government rather improved matters. Consumers also made some heavy purchases on the lower prices. The feature of the situation about this time was the large shipment of electrolytic copper from America made by the Amalgamated Co., in consequence of which the price of refined fell off, sales of that variety being made at very little above the quotation for standard.

In April there was a considerable speculative movement for the advance, which, however, failed in its object, owing to continued heavy offers from America. The market at this time, as well as earlier, was considerably puzzled by the tactics of the American producers, whose main object seemed to be to keep prices at the lowest possible level. In May there was a better demand from consumers, who generally required prompt delivery, showing that their needs were urgent. In June the conclusion of peace in the Transvaal was used as a bull point, but produced little effect, and later this was neutralized by the unfavorable influence of the King's illness. A considerable trade for the Continent sprung up, however, and large orders were placed for electrical work, buyers being tempted by the narrow margin between standard and electrolytic.

In July, heavy offers from the United States continued, and consumers were inclined to hold off, the reports from abroad indicating a further possible fall. The month closed with standard selling at £53 for spot and £53 5s. for three months. In August a temporary rise, caused by short covering, was neutralized by further reductions offered from New York, and prices slipped back to £51 5s. spot and £51 10s. for three months. The European producers were apparently tired of waiting, and offered metal much more freely than in the early part of the year. September opened uncertain, owing to the contradictory rumors as to Amalgamated policy, but some strength was lent to the market by the statement of stocks prepared by Dr. Ledoux and printed in the *Engineering and Mining Journal*. Contradictory rumors prevailed, however, but they did not prevent consumers from making extensive purchases. At the close of the month, however, it was found that manufacturers were generally stocked, and copper closed rather flat at about £51 15s. spot and £52, three months.

Many people looked for some recovery in October, but the heavy bear operation in Rio Tinto shares, which was engineered from Berlin, had an unfavorable effect on the metal market, and prices declined to £51 10s. for spot. At this level a considerable demand from consumers, whose stocks were again exhausted, improved the tone, and there was a hardening to between £52 and £53. November opened with the visible supplies reduced to the low figure of 16,657 tons. There was also a fair consumptive demand. Rumors from America of an increase in stocks received some belief, however, while the unfavorable condition of the stock markets and the unsatisfactory position of affairs in South Africa also affected trade, and the market closed flat at £49 12s. 6d. for spot, with about 5s. better for forward copper. The only support to the market at this time was from the copper sulphate trade, makers of that article purchasing rather heavily of Chile bars. This had the effect of improving the prices of tough and best selected.

December was a month of some excitement, prices opening flat, but early in the month renewed rumors of a working arrangement among American producers brought about a sharp advance of over £2. The break of the operation for the fall in Rio Tintos, marked by a very sharp advance in those shares, also helped the market. Unexpected assistance was derived from free purchases made by consumers at the advance. The year closed with a firm tendency, standard being quoted at £52 15s. to £52 17s. 6d. for spot, with some 10s. higher named for forward copper.

One feature in the market which was noted throughout the year was the persistent bearing of certain producing interests. It has happened very seldom indeed that sellers should thus work directly against their own apparent advantage, and the London market was for the most part thoroughly at sea as to the cause of this curious movement. It is also to be noted that Germany was a light buyer throughout the year, owing to continued depression in manufacturing interest there; while in France trade was nearly stationary at a dull level throughout the year.

AVERAGE MONTHLY PRICES OF STANDARD COPPER (G. M. B.'S) IN LONDON.

(In pounds sterling per long ton of 2,240 lb.)

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1901	71·78	71·17	69·54	69·61	69·60	68·83	67·60	66·34	65·97	64·11	64·51	52·34	66·79
1902	48·43	55·16	53·39	52·79	54·08	53·93	52·89	51·96	52·68	52·18	51·08	50·95	52·46

PROGRESS IN THE METALLURGY OF COPPER DURING 1902.

BY JOSEPH STRUTHERS AND D. H. NEWLAND.

THE following notes on the progress in the metallurgy of copper during 1902 have been abstracted chiefly from the technical literature of the year, in addition to information and criticism which have been obtained by direct correspondence or discussion with practical metallurgists.

Automatic Ore Sampling.—An illustrated description of automatic system of sampling at the smelter of the British Columbia Copper Co., at Greenwood, B. C., will be found in the "Review of the Progress in Ore Dressing during 1902," given elsewhere in this volume. The results of practice at this plant are fully discussed in THE MINERAL INDUSTRY, Vol. X., pp. 206-211.

Smelting Ore and Matte at Leadville and Robinson, Colo.[1]—The following data of furnace working at the Bi-metallic plant, Leadville, and at the plant of the Robinson Construction, Mining & Smelting Co., Robinson, have been prepared by Mr. C. H. Doolittle, referring to practice during the year 1900. At Leadville, the Bi-metallic plant was equipped with three furnaces having cross sectional areas at the tuyeres of 36×163 in., 36×176 in., and 36×215 in., respectively. The two smaller furnaces were used for concentrating the ore into a low-grade matte, and the largest one for concentrating the low-grade matte with the addition of oxidized siliceous ores to matte of a high-grade. Cold air was furnished by three No. 7 Root blowers, so connected to the furnaces that each furnace could have its individual blower, an arrangement which was found preferable. Two fans, one 9 ft., and one 6 ft. in diameter, were connected with the dust chamber, and the gases, after having traveled a distance of 300 ft., were forced through towers in which a water spray precipitated a large part of the fume, rich in lead and silver. The gases escaping from the towers were damp and were reduced to a temperature of 100° F., finally passing into the atmosphere through a wooden stack. The power was furnished by a 450-H.P. Corliss engine. The furnaces were operated so that the matte produced by the ore furnaces was just sufficient for the reconcentration furnace, and the slag from the reconcentration furnace, which had to be re-smelted, was not too burdensome for the ore furnaces, but still sufficient to keep an open charge in the ore furnaces. In this manner, the locking up of capital in large surpluses of low-grade matte and rich slag was avoided.

The analyses of the characteristic ores treated are given in the subjoined table:

Name of Mine.	Components of Ore.				
	SiO_2.	Fe.	CaO.	Zn.	Cu.
	%	%	%	%	%
Iron Silver	3	41	0	6	0·1
Ibex M. Co	20	28	0	6	2·7
New Monarch	28	18	0	11	3·5
Marian	8	33	0	1	0·5
Vinnie	28	28	0	9	3·0
Commodore	85	8	2	0	0·0
Centennial-Eureka	77	5	2	2	6·0

During March, 1900, the three furnaces were in continuous operation and treated 9,838 tons of ore containing Au 2,256 oz., Ag 159,811 oz., and Cu

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[1] *Engineering and Mining Journal*, April 11, 1903.

314,690 lb., which gives an average treatment for each furnace of 105·8 tons of ore per day. The matte shipped averaged Au 2·249 oz., Ag 146 oz., and Cu 14·328%, and the recovery of metals was Au 98·5%, Ag 95% and Cu 90%.

A charge for the ore furnace consisted of: Ore (sulphides) 2,600 lb.; lime rock, 250 lb.; bricked flue dust, 300 lb.; slag, 1,500 lb. and wet coke (containing 20% water) 325 lb.; total, 4,975 lb. The apparent fuel consumption was 12·5% on the ore charged, but by deducting the water from the wetted coke, the actual consumption was 10%.

The flue dust was bricked and fed in sufficient quantities to prevent an accumulation of this product. The slag was produced in the reconcentration furnace, and was fed in order to keep the charge of the ore smelting furnace in an open condition. Ordinarily, each of the ore furnaces averaged 120 tons of ore per day. Great care was necessary in feeding the furnace on account of the fine ore and the heating qualities due to the sulphur. A charge for the concentrating furnace consisted of: Matte, 1,000 lb.; siliceous ore, 600 lb.; lime rock, 100 lb. and wet coke, 125 lb.; total, 1,825 lb. The consumption of fuel (dry) was 16·7%. Taking the total quantity of ore treated during March—9,838 tons—and the actual quantity of fuel consumed—1,417 tons—gives a fuel consumption of 14·4% per ton of ore smelted.

During reconcentration the furnace was run with a cool top to avoid losses of precious metals by volatilization, the blast temperature being maintained at about 90°F. The physical condition of the ore was such that the charge would keep open without the addition of slag.

The chemical conditions differed from the practice at Leadville, in that copper appeared only as traces in the ores mined. In addition, only a small quantity of copper ore, containing not more than 4% Cu, was obtainable on the market, hence the collector of precious metals was practically an iron matte. A good saving was made for matte, due partly to the copper, and more especially to a heavy fall of matte. The specific gravity of the slag was lightened by a higher percentage of lime than at Leadville.

The price paid for matte was $9·45 freight and treatment, 95% of the silver, $19 per oz. for gold, and 6c. off New York quotation for copper. This condition necessitated a high concentration of 30 into 1 as a final shipping matte, which was accomplished by reconcentration.

The analyses of the ores treated are given in the subjoined table:—

Name of Mine.	Components of Ore.			
	SiO_2.	Fe.	CaO.	Cu.
	%	%	%	%
Washington	5	42	0	Tr.
Robinson	25	15	1	Tr.
Pride	64	12	3	4
Wintergreen	4	43	0	1

The iron was in the form of pyrite, FeS_2, except that from the Wintergreen mine, which was pyrrhotite, Fe_7S_8.

Contrary to the opinions of several metallurgists, the use of pyrrhotite in a raw state gave no trouble whatever, and as it carried 1% Cu, it was desirable to use it. A 24-hour run on ore smelting was as follows:—

	Tons.
Washington mine ore	7·60
Robinson mine ore	81·00
Wintergreen mine ore	36·98
Total ore	125·58
Lime rock	25·65
Slag	55·50
Total charge	206·73
Coke	16·50
Percent fuel on ore.	13·14

Slag assay and analysis were:

SiO_2	41·0%
FeO	30·8%
MnO	5·5%
CaO	17·0%
ZnO	4·0%
Ag	1·1 oz.
Total	98·3%

Analysis of re-smelting matte:

Ag	42·07 oz.
Cu	0·2%

A 24-hour run on reconcentration matte was:

	Tons.
Robinson mine ore	116·50
Pride mine ore	28·42
Total ore	144·92
Matte	121·52
Lime rock	21·90
Total charge	288·34
Coke	14·60
Percent fuel on ore	10·00

Analysis of matte:

Ag	200 oz.
Au	0·5 oz.
Cu	50·0%

The average fuel consumed during the time the smelter was in operation was 13·5%, being about 1% less than the fuel consumption at Leadville. After smelting 3,289 tons of ore the works were shut down. The quantity of flue dust produced was 2·5% of the ore treated. The cost of fuel and labor was $2 per ton of ore. Labor in this case does not include management, superintendence, etc.

The capacity of the ore furnace was 75 tons per day. The slag averaged SiO_2 36%, Fe 36%, CaO 7% and Zn 5%. A saving might have been made by the addition of a larger proportion of lime and less iron, but from a commercial standpoint, a $9 rate on a neutral basis on iron ore allowed a fair margin for the treatment of that class of ore. The average cost for the month showed $3·645 per ton of ore treated, including all expenses except new construction. The matte was shipped to the Philadelphia Smelting & Refining Co. at Pueblo and treated for $3·25 (freight and treatment), allowing $19·25 per oz. for gold, 95% of the silver, and 4c. off casting brand quotation for copper.

The Robinson Construction, Mining & Smelting Co. was equipped with one stack having a cross sectional area of 36×142 in. at the level of the tuyeres. A Loder hot blast apparatus was attached to the furnace consisting of a series of pipes carrying the air in a chamber through which the gases escaping from the furnace pass on their way to the dust chamber. The highest temperature of blast obtained was 200°F.

To the copper metallurgist the results shown by the data given above will undoubtedly seem small in tonnage, but the ores are similar to those handled by lead smelters and the tonnage is fully equal to that of the 42×146-in. lead furnace with a 20-ft. ore column and blast at a pressure of 3 lb. per sq. in.

All of the ores above enumerated carried lead and zinc, and notwithstanding the volatilization of the greater part of the lead the resultant matte contained about 3% of that metal.

Smelting Raw Sulphide Ores at Ducktown, Tenn.[2]—(By W. H. Freeland.)—The following facts and statistics of operations were obtained at the works of the Ducktown Sulphur, Copper & Iron Co., Ltd., at Isabella, Tenn., covering a period of several months. At first, little else than 6% matte, "breakouts" and "chills" resulted, but ultimately the efforts were successful, and the change in practice is to be permanently adopted. The smelting consists of two operations, carried out alternately in the same furnace: (1) The smelting of raw ore to a low-grade matte, about 20% Cu, and (2) the concentration of the low-grade matte to one containing about 50% Cu.

A Herreshoff furnace was used, having a total depth of 8·5 ft., with a cross sectional area at the tuyeres of 21·7 sq. ft. The forehearth, proving troublesome, was replaced by a water-cooled, blast-trapping spout and an ordinary brick-lined settler of 5 ft. × 4 ft. × 18 in. internal dimensions. A No. 6 Connersville blower, driven by a direct-connected engine, supplied the blast. Several campaigns of from two to six weeks were made without stopping the blast, the duration of time being limited only by the necessity of shutting down to wash out the silt from the furnace jacket, spout, etc. In a test run, hourly samples were taken of each constituent of the furnace charge, as well as of the slags and mattes produced. These were combined into daily samples and reduced to laboratory pulps, which, in turn, were combined in proportions corresponding to the daily tonnages. The final samples, thus representing reliable averages of the entire run, were carefully analyzed. During a 16·5 days' campaign there were treated 1,120 tons ore, 89 tons quartz, 162 tons slag, equaling a total burden of 1,371 tons, exclusive of 38 tons coke, the coke consumption being equivalent to 3·4% of the ore, or 2·77% of the total burden. The Ducktown ore is pyrrhotite, carrying less than 3% Cu, and no precious values. Full analyses of the ore, fluxes and coke charged, and the matte, slag and flue dust produced are given in the following table:—

DATA PERTAINING TO THE FIRST OPERATION (ORE SMELTING).

	Cu.	Fe.	S.	SiO_2.	CaO.	MgO.	ZnO.	Al_2O_3.	Mn.	C.	O, etc.	CO_2, etc.	Loss on Ignition.	Total
Materials smelted:	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Ore	2·744	36·519	24·848	18·548	7·294	2·672	2·556	0·911	0·77	......	......	*a*3·138	....	100
Quartz	......	1·45	0·32	96·79	0·23	Trace	......	0·32	Tr.	......	*b* 0·38	......	0·39	99·88
Slag (used on charge)....	0·73	39·20	1·75	30·90	8·51	2·71	2·88	1·90	0·85	......	*b*11·37	......	....	100·80
Coke	......	2·30	1·58	8·41	Trace	Trace	None	3·56	None.	83·86	*b* 1·00	......	....	100·71
Products:														
Matte	20·00	47·15	24·00	0·44	0·10	Trace	2·05	0·82	0·53	......	......	*a*4·91	....	100
Slag	0·37	38·84	1·74	33·60	8·24	3·44	1·54	1·50	0·80	(*b*) 10·88		......	....	99·95
Flue dust	2·20	30·80	16·51	23·92	4·45	1·38	2·98	1·94	0·56	(*a*) 15·26		.....	....	100

(*a*) By difference. (*b*) By calculation.

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[2] *Engineering and Mining Journal*, May 2, 1903.

The matte produced is represented by 396 hourly samples. Ignoring fractions, the variations in assays ranged from 11 to 32% Cu, averaging numerically for all the samples 21·18% Cu, which, however, corresponds practically to a range of from 16 to 26% Cu; the extremes beyond these limits being obtained during the blowing-in of the furnace and under other special conditions of working.

SYNTHESIS OF CHARGE AND ITS PRODUCTS (ORE SMELTING).

		Cu.	Fe.	S.	SiO_2.	CaO.	C.	MgO.	Zn.	Al_2O_3	Mn.	Difference. (a)
Charge.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
Ore	1000	27·44	365·19	248·48	185·48	72·94	......	26·72	25·56	9·11	7·70	31·38
Quartz	80	......	1·16	0·26	77·43	0·18	......	......	......	0·26	......	0·71
Slag	145	1·06	56·84	2·54	44·81	12·34	......	3·93	4·18	2·76	1·23	15·31
Coke	34	.....	0·78	0·54	2·86	......	28·51	......	......	1·21	......	0·10
Totals	1259	28·50	423·97	251·82	310·58	85·46	28·51	30·65	29·74	13·34	8·93	47·50
Deductions (as below)	428·95	25·10	65·75	235·88	6·69	1·26	28·51	0·35	15·68	1·50	0·78	47·50
Balance (+"O" to Fe, Zn and Mn)=Slag	938·24	3·40	358·22	15·94	303·89	84·20	......	30·30	14·11	11·84	8·15	..... "O" 108·19

DEDUCTIONS.

Products.												
Matte (20% Cu)	122·65	24·53	57·83	29·44	0·54	0·12	......	......	2·51	1·00	0·64	6·04
Flue dust recovered	25·71	0·57	7·92	4·24	6·15	1·14	......	0·35	0·77	0·50	0·14	3·93
Volatilized	280·59	......	......	202·20	......	......	28·51	......	12·35	......	.....	37·53
Totals (deducted above)	428·95	25·10	65·75	235·88	6·69	1·26	28·51	0·35	15·68	1·50	0·78	47·50

(a) Includes errors of analysis and undetermined CO_2 and O.

From the foregoing tonnages the average charge is readily calculated, and based on this and on the tabulated analyses, a synthesis of the charge and its products is constructed, which, if somewhat empirical, is nevertheless both interesting and useful. A comparison of the composition of the slag calculated from the materials charged and the results obtained by analyses varied but very little, the results being as follows (the calculated percentages being given in parentheses): Cu (0·36), 0·37%; Fe (38·183), 38·84%; S (1·70), 1·74%; SiO_2 (32·39), 32·60%; CaO (8·97), 8·24%; MgO (3·23), 3·44%; Zn (1·50), 1·54%; Al_2O_3 (1·26), 1·50%; Mn (0·87), 0·80%; O (11·54), 10·88%. Totals (1·00), 99·95%.

DATA PERTAINING TO THE SECOND OPERATION (MATTE CONCENTRATION).

	Cu.	Fe.	S.	SiO_2.	CaO.	MgO.	ZnO.	Al_2O_3	Mn.	C.	O. etc.	CO_2, etc.	Loss on Ignition.	Total
Materials smelted.	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Matte	20.00	47·15	24·00	0·44	0·10	Tr.	2·05	0·82	0·53	......	a 4·91	......	....	100
Ore	2·79	43·26	29·18	10·01	6·32	1·39	2·56	1·00	0·69	......	......	a 2·80	....	100
Laboratory samplings	2·45	31·07	14·84	22·66	5·71	2·03	2·05	1·15	0·75	a17·29	......	......	....	100
Quartz	......	1·45	0·32	96·79	0·23	Tr.	......	0·32	Tr.	......	b 0·38	......	0·30	99·88
Coke	......	2·30	1·58	8·41	Tr.	Tr.	None.	3·56	None.	83·86	b 1·00	......	....	100·71
Products.														
Matte	49·63	25·24	23·00	0·26	Tr.	Tr.	1·53	Tr.	0·39	......	......	......	....	100·05
Slag	0·60	43·99	1·19	33·72	2·03	0·57	2·12	2·16	0·50	(b) 12·86		......	....	99·74
Flue dust	2·49	24·79	8·91	31·43	3·31	1·18	3·81	3·93	0·30	(a) 19·85		......	....	100

(a) By difference. (b) By calculation.

The second operation, in which occurs the concentration of the 20% matte to one containing 50% Cu, occupied a few hours less than three days, and, in addition to the matte, 34 tons of raw ore and discarded samplings from the labor-

SYNTHESIS OF CHARGE AND ITS PRODUCTS (MATTE CONCENTRATION).

		Cu.	Fe.	S.	SiO_2.	CaO.	C.	MgO.	Zn.	Al_2O_3	Mn.	Difference. (*a*)
Charge.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
20% matte	1000	200·00	471·50	240·00	4·40	1·00	......	Tr.	20·50	8·20	5·30	49·10
Raw ore	170	4·74	73·54	49·60	17·02	10·74	......	2·36	4·35	1·70	1·17	4·78
Laboratory samplings	84	0·83	10·50	5·05	7·70	1·94	......	0·69	0·70	0·39	0·26	5·88
Slag	160	1·17	62·72	2·80	49·44	13·62	......	4·34	4·61	3·04	1·36	16·90
Quartz	330	......	4·78	1·06	319·41	0·76	......	Tr.	......	1·06	Tr.	2·93
Coke	95	......	2·19	1·50	7·99	Tr.	79·67	Tr.	......	3·38	......	0·27
Totals	1789	206·74	625·29	300·01	405·96	28·06	79·67	7·39	30·16	17·77	8·09	79·86
Deductions (as below)	763·86	199·61	104·33	285·86	4·81	0·40	79·67	0·14	6·60	0·47	1·61	79·86
Balance (+ "O" to Fe, Zn and Mn)=Slag	1182·18	7·13	520·96	14·15	401·15	27·66	......	7·25	23·56	17·30	6·48	"O" ......156·54
DEDUCTIONS.												
Matte (49·63%)	401·60	199·31	101·36	92·18	1·04	Tr.	......	Tr.	6·14	......	1·57	.....
Flue dust recovered	12	0·30	2·97	1·07	3·77	0·40	......	0·14	0·46	0·47	0·04	2·38
Volatilized	349·76	......	......	192·61	......	......	79·67	......	.....	.....	......	77·48
Totals	763·86	199·61	104·33	285·86	4·81	0·40	79·67	0·14	6·60	0·47	1·61	79·86

(*a*) Includes errors of analysis and undetermined CO_2 and O.

atory were smelted, the ore being added to the charge to keep the tenor of final matte from rising too high for comfortable running.

A comparison of the calculated and actual composition of the slags during the second operation is as follows (the calculated percentages being given in parentheses): Cu (0·60), 0·60%; Fe (44·07), 43·99%; S (1·20), 1·19%; SiO_2 (33·93), 33·72%; CaO (2·34), 2·03%; MgO (0·61), 0·57%; Zn (2·00), 2·12%; Al_2O_3 (1·46), 2·16%; Mn (0·55), 0·50%; O (13·24), 12·86%. Totals (100), 99·74%.

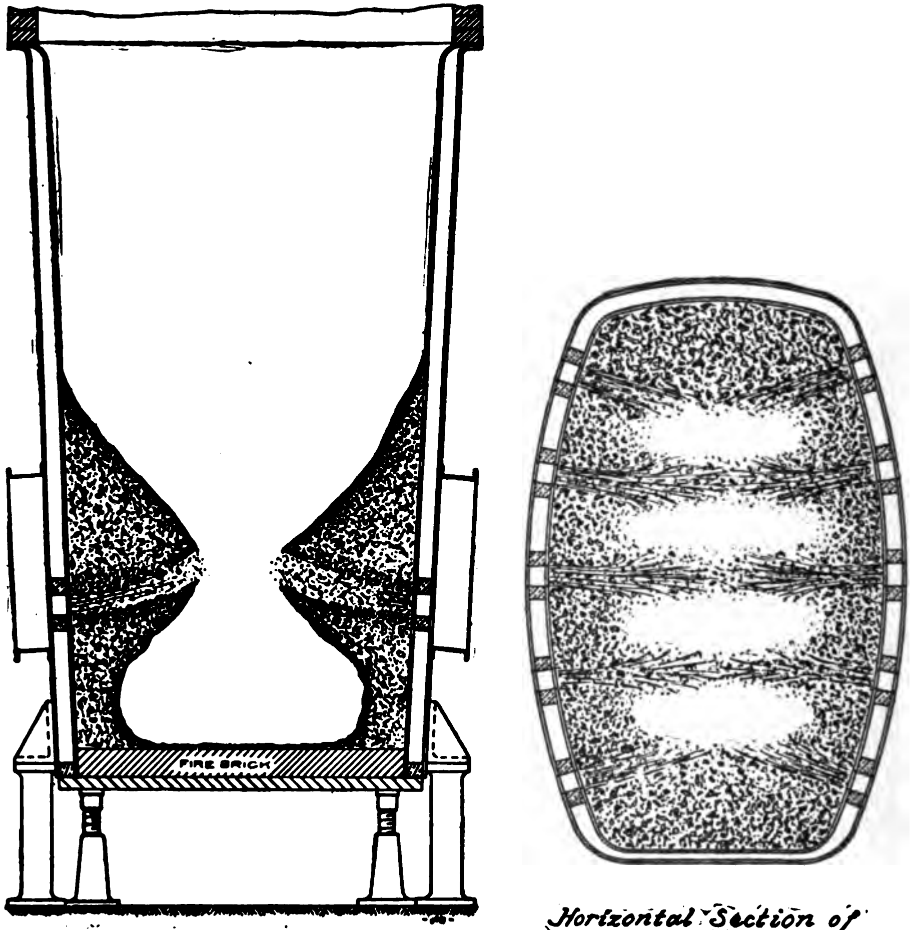
The average daily capacity of the furnace, including both operations, was 60 tons raw ore, or 115 tons of roasted ore. In the former case granulated slag was used throughout the test run, and a daily average equivalent to 80 tons raw ore, has been repeatedly attained when lump slag was available. Hot blast would probably increase the smelting capacity, but with a Herreshoff furnace of the dimensions of the one used, the additional tax for fuel, coal heavers and firemen was found to be economically prohibitive.

The average volume of the blast was 4,500 cu. ft. of air per minute at a pressure of 17 oz. per sq. in. Some incrustation forms around the furnace top, but not in sufficient quantity to be troublesome. At the region of the tuyeres, however, a porous friable accretion bridges the furnace from wall to wall. Light is rarely discernible on punching the tuyeres. It may seem unreasonable, but it is nevertheless true, that a bar has been driven through the furnace, entering a tuyere on one side, and withdrawn from the opposite tuyere by the naked hand.

It is my belief that this condition, alarming as it would seem in ordinary smelting practice, is essential to satisfactory concentration. The condition encountered in barring the tuyeres leaving no doubt that, for a certain area surrounding each tuyere, the furnace is bridged from wall to wall and the molten matte and slag must find its passage into the crucible through channels between the tuyeres. The vertical and horizontal sections of the furnace during the operation would probably appear as shown in Figs. 1 and 2, on the following page.

Granting the condition described, the effect is that the column of charge resting upon boshes and bridge, undergoes a partial roasting in its descent, and a rapid, fierce oxidation as it reaches and is held in the constricted channels. The charge sinks evenly and uniformly, rarely showing a hot top. The slags run hot and fluid; in fact, the furnace gives less trouble throughout than those smelting roasted ore.

The concentrations effected were 7·3 into 1 in the first operation, and 2·5 into 1 in the second, but these by no means represent the limits attainable. Contrary to the experience of many, the reconcentration of the first matte presents no difficulties at Ducktown. There is no limit within the range of matte to the second operation. A 6% matte may be brought up to a 50% one quite as successfully as an initial matte of higher grade.



Vertical Section of Furnace

Horizontal Section of Furnace.

Figs. 1 and 2.—Probable Vertical and Horizontal Sections of Furnace while in Operation.

Occasional samples of 70% matte have been assayed from the reconcentration of a 10% initial matte, but such conditions, if permitted to continue, would speedily result in a "chill," particularly with the scanty flow of a small furnace. The degree of concentration, whether in the first or in the second operation is, for the most part, proportionate to the speed at which the furnace is driven, and is controlled by the proportion of quartz in the charge, or the manipulation of the blast, or both. But on these seemingly simple measures hinge not only the grade of the matte, but the life of the campaign.

Calculating the percentage of coke on copper bearing burden only, the regular charge of 1,000 lb. ore carries 30 lb. coke, a quantity which is occasionally doubled for an hour, or perhaps two, on a shift. It is due to these causes that the average coke percentage on test run is raised from 3 to 3·4% in the first operation.

During the second operation, the coke averaged 8% on matte, etc. Calculating the coke of both operations back to the original ore, the total coke consumption is 4·4% thereof.

The losses of copper in the slag are 0·37% in the first, and 0·6% in the second operation. Calculating both to a basis of the slag of the first operation, the equivalent is 0·45% of copper, a loss that should claim the attention of all familiar with the high concentration of a low-grade ore, particularly where settler area is limited by a small matte flow.

The flue dust recovered from both operations (almost wholly confined to the first) was equivalent to 53 lb. per ton of original ore.

Despite the greatly reduced tonnage capacity per furnace, the economical result of raw ore smelting gave extremely satisfactory results.

New Copper and Lead Smelters at Salida, Colorado.—The new smelting plant of the Ohio & Colorado Smelting Co. at Salida, Colo., is designed to treat 600 tons of lead ores and 500 tons of copper ores daily. The ore bins have a capacity of 50,000 tons. The copper furnace building is 120×40 ft. and contains two furnaces of the ordinary type, 180×38 in., with flanged steel jackets. These furnaces will treat ores from various camps in Colorado and also the rich cupriferous slags from the lead furnaces at this plant, of which there are four.

Smelting Practice at Santa Fe, Mexico.—The special problems encountered in the smelting of a cuperiferous garnet ore are discussed by Henry F. Collins.[2a] The ore mixed with 10% of lime and from 1 to 2% of wood ashes, is briquetted and smelted in a furnace of standard type, except for an unusual angle of bosh. In the first campaign, the separation of matte from slag proved perfect. The slag averaged Cu 0·37%, gold 0·37 oz., and silver 0·85 oz. per ton. Of the copper in the ore 96·5% was recovered, of the gold 95·6% and of the silver 96%. The quantity of ore smelted was 1,808 tons, of which 706 tons were bricked middlings, 625 tons coarse garnet middlings, and 476 tons selected garnet ore. The average assay was Cu 8·58%, gold 0·677 oz, and silver 13·57 oz. per ton. The quantity of matte produced was 301,229 tons, which averaged Cu 50·5%, gold 3·9 oz., and silver 82·65 oz. per ton. The ratio of concentration was about 6 to 1. The average quantity of ore smelted per 24 hours was 62·36 tons. Of the ore charged, 34·6% was garnet sand, which had all passed a 5-mm. screen. As a rule, no trouble was experienced by the sifting down of this fine material. The average

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[2a] Abstract in the *Engineering and Mining Journal*, Nov. 15, 1902, of a paper read before the Institution of Mining and Metallurgy, Oct. 16, 1902.

composition of the slag was as follows: SiO_2 41·50%, Al_2O_3 8·42%, FeO 19·28%, CaO 29·23%, MgO 0 3%, Cu_2O 0·45%.

The Trail Smelter.—(Through the courtesy of W. H. Aldridge.)—This plant, known as the Canadian Smelting Works, situated at Trail, B. C., has a capacity of about 1,300 tons of copper and lead ores per day. It is operated by electrical power from a station on the Kootenay River, 30 miles distant. The current of 20,000 volts is transformed at the smelter to 550 volts, and used to drive 16 motors aggregating 1,000 H.P., besides a lighting plant which furnishes the smelter and the town of Trail. The ores are purchased from all parts of British Columbia and are of such varying character that great care must be exercised in handling and sampling. The copper-gold ores, which are furnished mostly by mines in the Rossland district, carry the chief values in gold, the tenor in copper being low. These ores are delivered at the smelter in 30-ton hopper bottom-dumping cars, which discharge directly into large receiving bins in front of the copper sampling mill. The ore is drawn from the bins into transfer cars, dumped into a No. 6 Gates crusher, having a capacity of 100 tons per hour, and crushed to 3-in. size; the ore is then elevated by a large bucket elevator to the first automatic Vezin sampler. This sampler takes 17 samples per minute, an amount equal to one-tenth of the entire lot. The sample from this machine is then crushed to 1·5 diameter by a No. 3 Gates crusher, after which it passes to No. 2 Vezin sampler, which takes 34 samples per minute, or one-fifth of the original sample, being one-fiftieth of the original lot. This sample is again reduced by crusher and rolls to 0·25 in., after which it passes to the third sampler, taking 42 samples per minute, and one-tenth of the second sample, or one-five-hundredth of the original lot. This sample is further rolled and divided by Jones riffles, until it weighs about 20 lb. It is then taken to the assay office for further crushing and reducing. The ore from the mill is either taken to the roasting yard and roasted in heaps of 3,000 tons each, or transferred direct to the blast furnace charge bins. There are three large copper furnaces, aggregating 900 tons capacity. The ores and fluxes are fed directly from cars into the furnaces, hand-feeding having been discontinued. As the plant is built on a sloping site, every advantage is gained by gravity, which reduces elevating and shoveling to a minimum, leaving nothing but final products to be elevated. All transferring and hauling is done by electrical locomotives of 10 H.P. each. A description of the methods used in handling and treating the lead ores will be found under "Lead," elsewhere in this volume.

The Granby Smelter.—The capacity of this plant is to be increased by the construction of two new furnaces—making six in all—which will enable it to handle 2,200 tons of ore daily, or about 800,000 tons per annum. The furnaces are to be of the standard type, built by the Allis-Chalmers Co., and will be supplied with automatic charging devices. New electrical equipment will also be installed to provide the extra power needed in the enlarged works.

New Copper Smelter at Crofton, B. C.—The construction of the copper smelting works at Crofton, Vancouver Island, was completed late in 1902. The plant is situated on Osborne Bay, about 40 miles by rail from Victoria, and is owned by the Northwestern Smelting & Refining Co. The furnace building, which is 73×45 ft., contains one ordinary water-jacket furnace of 350 tons daily capacity, one Garretson furnace of the same capacity and a small cupola furnace for remelting the matte. In the converter building there are two converters of 50 tons daily capacity, a 50-ton electric crane, and a hydraulic elevator. Ample facilities for sampling and assaying have also been provided.

Smelting Practice at Greenwood, B. C.—The furnace results obtained at the Greenwood smelter of the British Columbia Copper Co. are discussed by Mr. Paul Johnson,[3] who also makes some interesting observations and comparisons on blast furnace work in general. The furnace operated at Greenwood is 42×150 in. at the tuyeres, giving a sectional area of 43·7 sq. ft., and is supplied with a No. 7·5 Connersville blower, which furnishes 80 cu. ft. of air for each revolution, and averages 150 r. p. m., showing an average pressure at the furnace of about 14·15 oz. per sq. in. During 1901 this furnace gave a daily average output of 380·5 tons of ore, or 8·7 tons per sq. ft. of furnace area; the highest monthly run showed a daily average of 428·6 tons, or 9·8 tons per sq. ft. of furnace area, and the highest run for a single day was 460 tons, or 10·5 per sq. ft. of furnace area. For a period of six months the slags gave an average analysis as follows: SiO_2 39·8%, CaO 19·6%, Fe 23·6%, Cu 0·321%, while the mattes for the same period showed a daily average of 50·1% Cu. Thus the slags contained only 0·0064% Cu for every 10% Cu in the matte. With an average daily tonnage of 422·5 tons, which was maintained for several months, and with a staff of 47 men—including those employed at the blast furnace works proper, as well as sample mill crew, engineers, firemen, blacksmiths, masons, carpenters and foremen—an average of 9 tons of ore was handled for every man employed. Mr. Johnson advocates the use of ordinary blowers in copper smelting in preference to blowing engines on the ground of economy in first cost and cost of running, and the smaller percentage of flue dust produced. He favors also feeding by hand in preference to mechanical feeding, especially when dealing with refractory ores, and claims that with the former method, cleaner slags are made and a larger tonnage can be handled. An instance is cited where hand feeding, as compared with mechanical feeding, showed an average saving of 30c. per ton of ore from cleaner slags alone, which, with an average daily output of 350 tons, amounts to $105 per day.

Blast Furnace Capacity.—The relative capacity of furnaces of varying width, working on the same or different ores, has been discussed by Messrs. W. Randolph Van Liew,[4] William A. Heywood,[5] James W. Neill,[6] and George W. Metcalfe.[7] Mr. Van Liew, referring to blast furnace operations in Montana, compares the relative efficiency of two furnaces working on the same ores, the one furnace measuring 44×100 in. and the other 56×180 in. at the hearth. The 56-in. furnace was much higher from the tuyeres to the charging floor, but the burden on the tuyeres was kept as nearly as possible at the same height. This furnace was fed by charging cars while the 44-in. furnace was fed by charging wheelbarrows, dumping directly into the furnace. The slags produced were nearly of the same

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[3] *Engineering and Mining Journal*, Aug. 23, 1902.

[4] *Ibid.*, March 21, 1903.

[5] *Ibid.*, April 4, 1903. [6] *Ibid.*, April 4, 1903. [7] *Ibid.*, April 25, 1903.

composition, although those made by the larger furnace not uncommonly contained from 2 to 3% more of iron. A monthly average of the 44-in. furnace was about 215 tons per day, of the 56-in. furnace, 420 tons, with a range for the latter of from 400 to 500 tons. As the former had 30·5 sq. ft. of hearth area, its average was 7·06 tons per sq. ft. of hearth; the latter had 70 sq. ft. of area, and its average was 6 tons per sq. ft. of hearth. The 44-in. furnace required 19 oz. blast, the 56-in. furnace required 27 oz. blast and about 10% more fuel. A comparison of these results seems to show that the advantage lies with the narrower type of furnace, both in regard to the tonnage smelted per sq. ft. of hearth area and the economy of power for blast pressure. This conclusion is substantiated by the results obtained from a trial run with a still narrower type of furnace, measuring 35×122 in. at the tuyeres. This furnace showed a maximum capacity of 344 tons, or 11·25 tons per sq. ft. of hearth area, while consuming 7% coke.

Mr. William A. Heywood states that the two 56×180-in. furnaces of the Tennessee Copper Co. during a run of 28 days, smelted a total charge, not including coke, of 30,095 tons, or 1,074 tons per day for the two furnaces. The total ore smelted was 36,757 tons, and the coke used was 3,269 tons. The slags contained an average of 0·44 Cu. There were 54 men and boys employed in the blast furnace department per day of 24 hours, so that the charge smelted daily was about 20 tons for each person employed. Mr. Heywood is not in favor of using the factor of tonnage per sq. ft. of hearth area as a standard for gauging the efficiency of a furnace, and he states that the results on this basis throw the advantage to the smaller furnace without regard to the factor of economy. The best size of a furnace must be determined by actual experiment in each case, and tonnage is only one of the elements to be considered. Experience in copper as well as in iron smelting appears to indicate that the larger furnaces are the more economical.

Mr. James W. Neill expresses the opinion that the width of the furnace should conform to the physical conditions of the ore; that for coarse ore, which has been previously roasted, the width is limited only by the penetrating power of the blast, while fine material charged in a wide furnace results in a heavy mass, through which the blast penetrates only with difficulty. In such a case, "blowholes" are formed with the production of large quantities of flue dust and consequent losses.

The results reported by Mr. Metcalfe have reference to the new smelting plant of the Anaconda Copper Co. The furnaces as originally constructed were 56×180 in. at the tuyeres, 72×180 in. at the top of the jackets, and 18 ft. from tuyeres to charging floor. They are charged by hand dumping of coke barrows and mechanical dumping of large tram cars containing approximately 5,000 lb. each.

The materials used are Butte ores, coarse concentrates and briquettes of flue dust and slimes fluxed by converter slag and limestone. On first starting up considerable trouble was experienced from heavy crusts forming on the ends and sides of the jackets. Much of the end crusting was done away with by cutting off the end tuyeres—originally there were 12 tuyeres in front, 14 at the back, and 3 at each end—but the side crusts seemed to be due to improper distribution of the charge owing to the partial separation of the coarse and fine components while sliding from the car over a sloping charging plate and falling three or four feet into the furnace. The tendency was for the larger and heavier fragments to fall in the center, the finer materials remaining at the sides. The higher this drop the more pronounced the sorting action; and, as the natural expedient of keeping the furnaces full was found to make even worse crusts, the experiment was tried, in building two new furnaces, of making them respectively 3 ft. and 6 ft. lower than the original five furnaces. At the same time, as it was the intention to run with less depth of charge and lower blast pressure, the jackets were drawn in at the bottom so as to make these furnaces 48 in. instead of 56 in. wide.

The blast used on the original five furnaces was 28 to 30 oz., on the No. 6 (15 ft. deep) 26 oz. and on the No. 7 (12 ft. deep) 24 oz. Other blast pressures were used at times, but these were finally settled on as yielding the best results.

During a six weeks' run No. 7 furnace (12 ft. deep) averaged 352 tons of charge per day on 10·2% of coke, while the four furnaces of the original type in that time averaged 397 tons of charge per day on 9·8% coke. During this period a constant attempt was made to run No. 7 on the same charge and coke per unit as the other furnaces, but it invariably became crusted badly, and had to be put on a more fusible and ferruginous charge with a higher proportion of coke until the crusts were burned out. As expected, however, it made a higher matte than the others, which averaged 40·4% Cu. The average slag of all the furnaces assayed: Cu, 0·19%; SiO_2, 43·3%; FeO, 26·0%; CaO, 21·8%, and Al_2O_3, 8·0%.

During another six weeks' run No. 6 furnace (15 ft. deep) averaged 383 tons per day on 9·7% coke, while the four furnaces of the original type averaged 407 tons per day on 9·6% coke, all the furnaces being practically on the same charge. Furnace No. 6 made matte averaging 42·6% Cu, the average of the others being 39·7% Cu. The slags of all the furnaces averaged: Cu, 0·18%; SiO_2, 44·0%, FeO, 26·0%, CuO, 21·8%; Al_2O_3, 6·8%. During four of the six weeks of this latter experiment the jackets of No. 3 furnace were drawn in to make the size 48×180 in. at the tuyeres, though remaining as before 18 ft. in depth. During that time it averaged 397 tons per day on 9·3% coke, while the three unaltered 18-ft. furnaces averaged 409 tons on 9·6% coke. The matte from No. 6 averaged 0·5% less Cu than that from the 56×180-in. furnaces. Fed high and blown the same as the others this furnace would nearly keep up in tonnage, but it would make the lower grade of matte with less blast, even down to 20 oz., and fed low it still made 0·5% poorer matte, and, of course, fell still further behind in tonnage.

None of the changes seemed to have any appreciable effect in lessening the crusts in the upper part of the furnaces, although the 18-ft. furnace contracted to 48×180 in., at the tuyeres kept hotter and in better shape at the bottom. As the feeders became more accustomed to the system of charging, however, it has been possible to prevent the formation of such crusts as would seriously retard their running. In the experiments on No. 6 and No. 7 furnaces the differences in depth interefer somewhat with drawing, a conclusion as to the effect of the narrower width *per se;* while the results on No. 3, though showing a decided increase in tonnage per sq. ft. of hearth area, certainly do not indicate that the narrower width is in itself a commercial advantage in smelting such materials. The results with No. 6 which show a slightly decreased tonnage but an increased grade of matte, and a slightly decreased power expense owing to the lower blast pressure, may be held, however, to indicate a commercial advantage for the 48×180-in. furnace of 15 ft. depth in a plant where cost of converting is an important item.

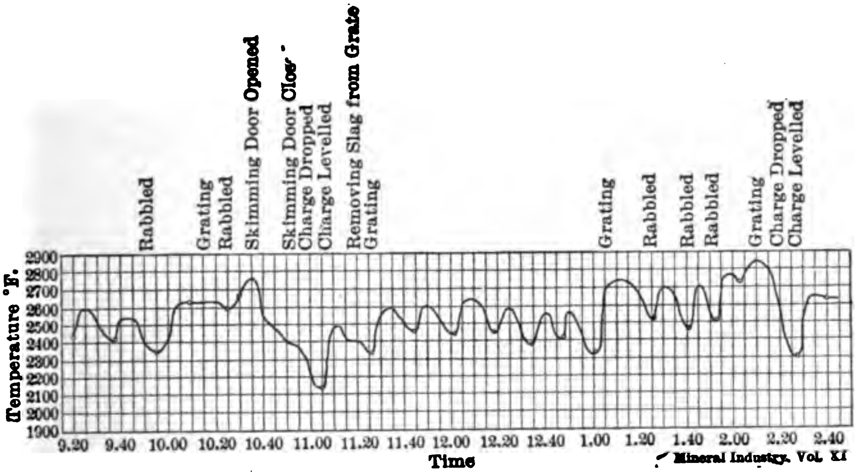
Reverberatory Furnaces for Smelting Copper.—(By E. P. Mathewson.)—Probably the largest installation of reverberatory furnaces built in recent years for the smelting of copper is that of the Washoe Copper Co., at Anaconda, Mont. The plant consists of 14 furnaces, originally 20×50 ft. hearth measurement, set)ack to back in two rows and housed in two steel buildings substantially built and well ventilated. Between these buildings is a chimney 225 ft. high, 20 ft. internal diameter, constructed of steel and lined with brick, the connections to the furnaces being made by four main flues. One feature of the original construction was an arrangement for pre-heating the air by the heat of the escaping gases and the heat radiated from the bottom of the hearth. The air was admitted first to a brick chamber built around the brick-lined steel pipe, which carried the waste gases to the main flue; thence the partially heated air passed beneath the bottom of the furnace in a narrow channel, passing from the front o the back four times before rising in a cast iron box to the top of the furnace; thence to a sheet steel box above the bridge wall, being finally admitted to mix with the gases from the fire box, through checker work in the roof above the bridge wall, the draft of the furnace being sufficient to draw in the hot air. In remodeling the furnaces this arrangement was omitted, as it was considered more important to retain the heat in the bottom of the furnaces than to use it for pre-heating the air furnished to the top of the charge, more rapid smelting being accomplished by keeping the matte in the furnace as hot as possible.

In building the plant, every convenience to facilitate the handling of materials was arranged for. The ashes from ash pits are sluiced away by waste water from the concentrating department, and the slags are granulated and washed away to the dump by the same means. The matte is tapped from time to time into large ladles holding 11 tons and drawn by compressed air locomotives to the converting department, where the still molten matte is dumped from ladle to converter to be blown to copper. The air necessary for the combustion of the fuel was forced under the grates by fans, the ash pit being closed by cast iron doors. Each furnace had an average daily smelting capacity of 100 tons of calcines. The fuel used was obtained from Diamondville, Wyo., and consisted of "run-of-mine" coal of the following composition: Water, 1·6%; volatile combustible, 38·7%; fixed carbon, 49·2%, and ash, 10·5%. This coal gives very satisfactory results under natural draft, but with forced draft, it does not act so well.

In the former practice, the time lost in grating the furnace averaged three hours per day per furnace, and during the grating (which occupied one-half hour at a time) the front of the furnace became cooled and the slag frequently set near the skimming-door. At the suggestion of Capt. W. M. Kelly, Furnace

No. 9 was remodeled on the lines of the best furnace at the old Anaconda works, and an extra large fire box was constructed in order to give every chance possible for the furnace to work without forced draft. The grates were ordinary bar iron with open ash pit. The flues were changed to permit of a more direct connection without sharp bends, and the down-takes for escaping gases were enlarged. The results obtained in the modified furnace were excellent at the start, and the good record has been satisfactorily maintained.

In consequence of the improvements in Furnace No. 9, the other furnaces were altered accordingly, and the work under the new conditions made a very excellent showing, as set forth by the following data: Average tonnage of calcines treated per furnace per day was: January, 1903, 106·6; February, 115·7 tons; March, 123·84 tons, and April, 133·53 tons. The fuel consumption averaged one ton of coal to three tons of calcines treated, and it may be stated that this good average will be still further improved. The total supply of coal delivered to the plant is charged up as weighed, and during the months under review (January to May, 1903) much of this coal was consumed in starting up new furnaces and in tapping out old ones. The best record for fuel consumption yet obtained on a single furnace is 1 ton of coal to 4·07 tons of calcines, the output of the furnace being 171 tons. Under the present conditions the furnaces carry an even heat and no time is lost in grating. The materials sent to the furnaces are carefully weighed in charge cars (20 tons to the charge) which are weighed back when empty each trip. The weighing and tramming are done by a set of men entirely separate from the furnace crew and under a separate foreman. The coal weights are checked monthly by the railroad car weights and check within 1·5% of the latter—the variation being overweight. All material for the furnaces is handled by compressed air locomotives and is loaded in hopper-bottom cars which discharge into the hoppers above the furnaces.



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Note: The time of stoking is indicated thus: o.

FIG. 3.—CHART SHOWING VARIATION OF TEMPERATURE DURING SMELTING.

Under the improved conditions of working, the aggregate cost of coal, labor and repairs has been reduced by more than $1,000 per day. The following details of furnace operations are of interest: Draft in Down-take=1·5 in. of water: Analysis of material charged.—Cu, 10·5%; SiO_2, 33·2%; FeO, 39·5%; S, 7·8%.

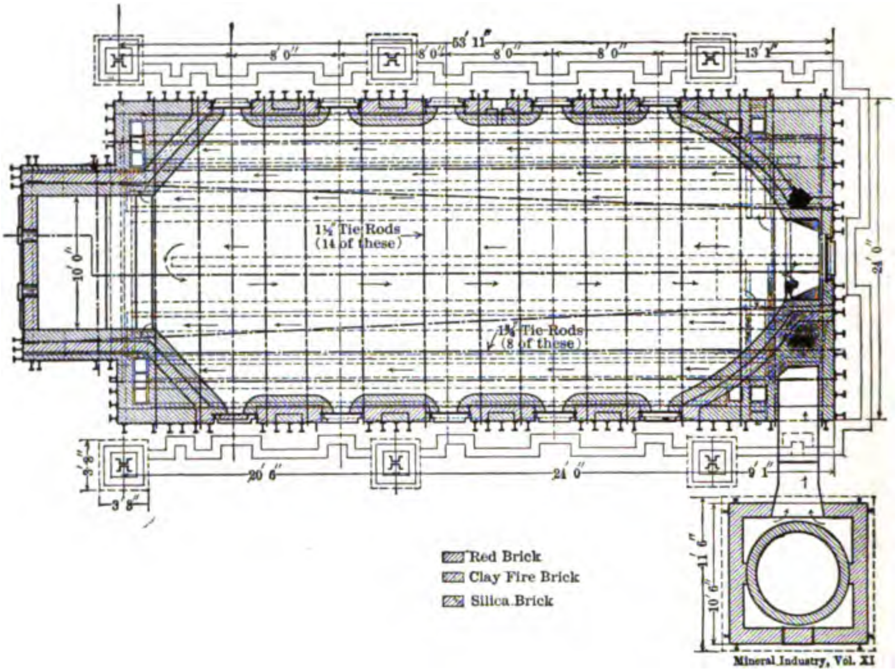

FIG. 4.—PLAN OF ORIGINAL FURNACE.

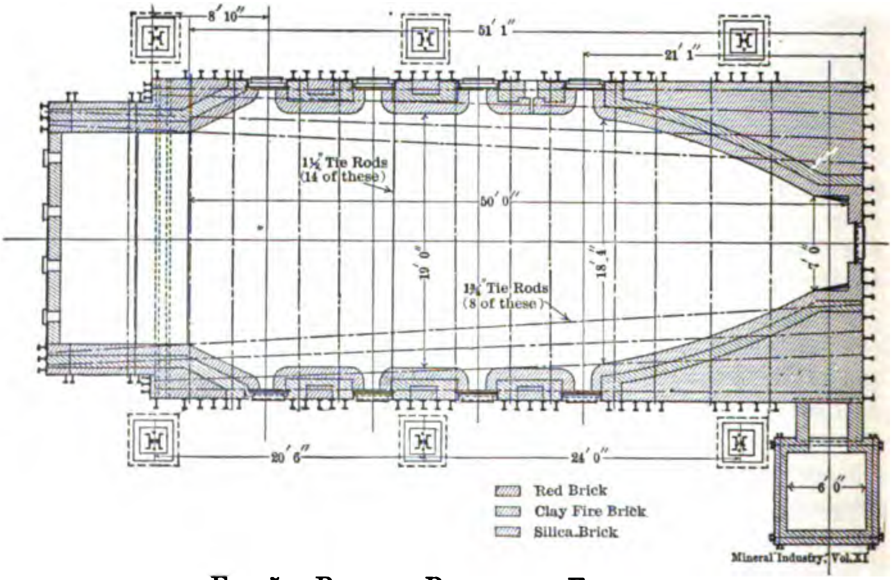

FIG. 5.—PLAN OF REMODELED FURNACE.

Analysis of slag produced.—Cu, 0·39%; SiO_2, 41·4%; FeO, 45·8%; and CaO, 3·1%. Copper content of matte produced, 47·44%.

During March, 1903, three of the old style furnaces were still in operation, which reduced the average tonnage. The modified furnace treated on the average 135 tons of calcines per day, and each of the old furnaces when remodeled will have a capacity of 140 tons per day, with fuel consumption of 1 ton of coal to 3·5 tons of calcines smelted. Another important change now being installed is the placing of a 300-H.P. Stirling boiler between each reverberatory furnace, and the main flue, the idea being to utilize the waste heat of the gases escaping from the furnaces. These boilers had been tried once before at the plant, but they were then installed in the same manner as for direct coal firing, and although the boilers themselves made excellent records, the output of the furnaces to which they were attached fell 20% below those that had no boilers. In the new setting, the idea has been to give free passage through the boiler, and ample

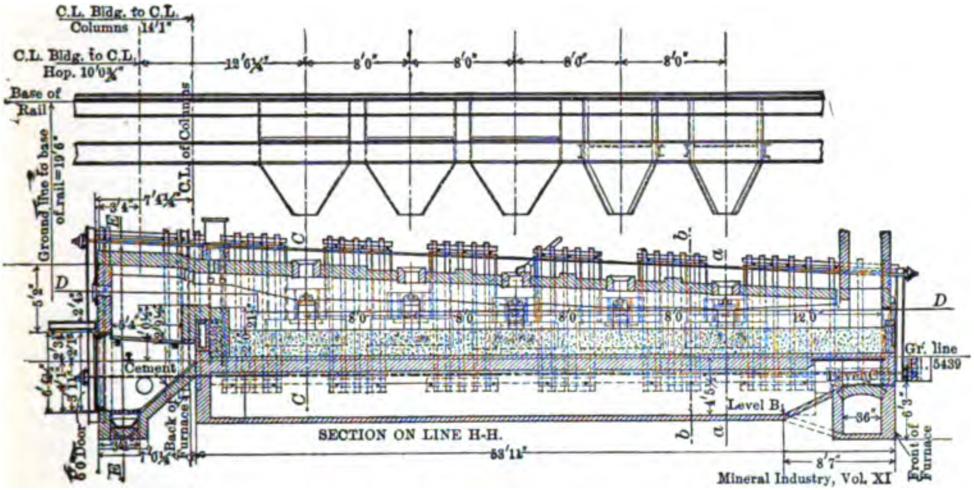

FIG. 6.—LONGITUDINAL SECTION OF ORIGINAL FURNACE.

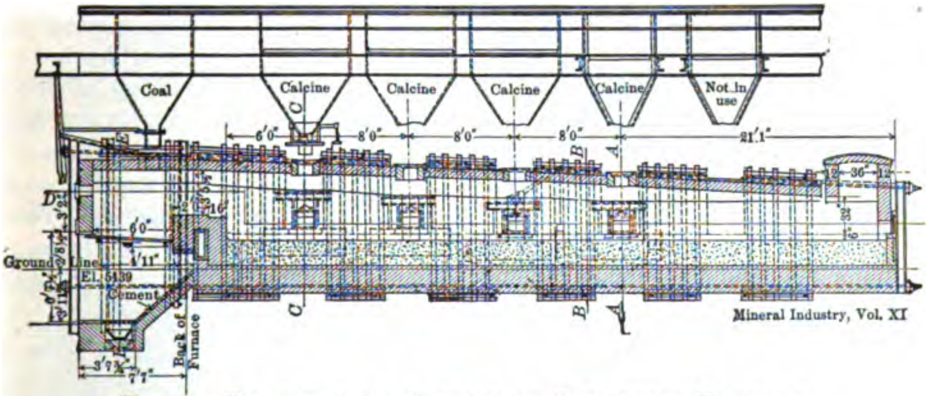

FIG. 7.—LONGITUDINAL SECTION OF REMODELED FURNACE.

down-take beyond, in order to facilitate the escape of gases as much as possible. Furnace No. 11, which was arranged in this manner, has given excellent results, the draft on each side of the boiler corresponding to 1·6 in. of water. The temperature of the gases at the inlet of the boiler was 2,380°F., while at the outlet it was 1,100°F. Allowing 34·5 lb. of water per horse power hour from and at 212°F., and feeding the water at 47·2°F., the boiler tested 340 H.P., which corresponded to a saving in coal alone of $70 per boiler per day. The steam pressure was 155·7 lb.

The chart (see Fig. 3) prepared by G. A. Hutchinson from readings of a Le Chatelier pyrometer, shows the variation in the temperature during the smelting of the 20-ton charge in Furnace No. 11. The changes made in the furnace are clearly shown in Figs. 4, 5, 6 and 7, from which it is noted that the improved furnace has a higher roof, and that the hearth, which is 19×49 ft. in area, is contracted toward the front of the furnace; in addition, a few minor changes have been made about the fire box, and the connections between the furnace and the main flue have been altered so as to provide a more direct passage for the exit of the furnace gases.

Cost and Profit in Pyritic Smelting of Low-Grade Copper Ores.—F. H. Prentiss[8] gives a number of tables and charts from which may be estimated the cost of producing copper by pyritic smelting. A series of 11 type copper ores are taken ranging in composition as follows: SiO_2, from 36 to 67%, Fe, from 7 to 22%, S from 10 to 25%, CaO 10% and Cu 3%, and the various smelting factors of quantity and cost of fuel, flux and labor, both for cold blast smelting and hot blast smelting, the loss of silver and copper and the power required have been calculated for each type.

Another set of tables is given which assumes a certain cost for mining and general expenses, and shows the profit per ton by direct smelting, the loss in concentration that would offset gain, and the extra profit made by using sulphides to reduce barren flux under concentration losses of 30, 25 and 20%. A diagrammatic chart has been prepared on which are plotted the type of ores with reference to silica content, the matting value in dollars per ton of ore, and the profit per ton derivable by smelting, as well as by concentration prior to smelting. From these data it is an easy matter to ascertain at once the relation of the process to be followed with reference to the composition of the ore. Other diagrammatic charts are given concerning the quantity of flux required per ton of each type ore and the quantity of slag resulting therefrom modified by the type of slag to be produced, also the cost of mining, and that of smelting with both hot blast and cold blast. Charts are also given showing the limit of concentrating and smelting and other factors of treatment under special conditions. Absolute factors cannot always be determined from these charts as it has been impracticable to include all the variables of smelting and concentration practice, yet they are interesting and valuable as the graphical presentation of complex problems facilitates greatly the study of the various factors involved.

Heated Blast in Copper Smelting.—C. A. Grabill[9] gives a few notes of the smelting of copper ores in the furnace of the Val Verde Copper Co. at Val Verde.

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[8] *Mining and Scientific Press*, May 10 to June 14, 1902.

[9] *Engineering and Mining Journal*, April 12, 1902.

The ore and concentrates were smelted in a round shaft furnace, 48 in. in diameter, having attached a Bretherton hot-blast stove. A daily average of 52,000 lb. of ore and 45,000 lb. of slag and flux (mostly slag) were treated with a fuel consumption of 4,950 lb. of ordinary coke from Colorado. The iron for the slag was derived entirely from sulphide ores and concentrates, the latter containing from 7 to 11% of arsenic. The lime necessary was fortunately available in a copper ore from the mines of the company. Calculations showed a daily combustion of 7,380 lb. of arsenic and 18,000 lb. of sulphur. A concentration of 12 to 1 was made in one operation with a practical elimination of all of the arsenic contained in the charge. On account of the stated economy of the Bretherton hot-blast stove, the fuel consumption was reduced to 4·6% calculated on the net quantity of ore smelted; the high efficiency being aided to some extent by running the furnace with a cool top and the utilization of the heat generated by the combustion of a part of the volatile sulphur and a part of the arsenic. The ores in the vicinity of Prescott are generally siliceous in character, a factor which aids materially in their treatment by pyritic or allied smelting.

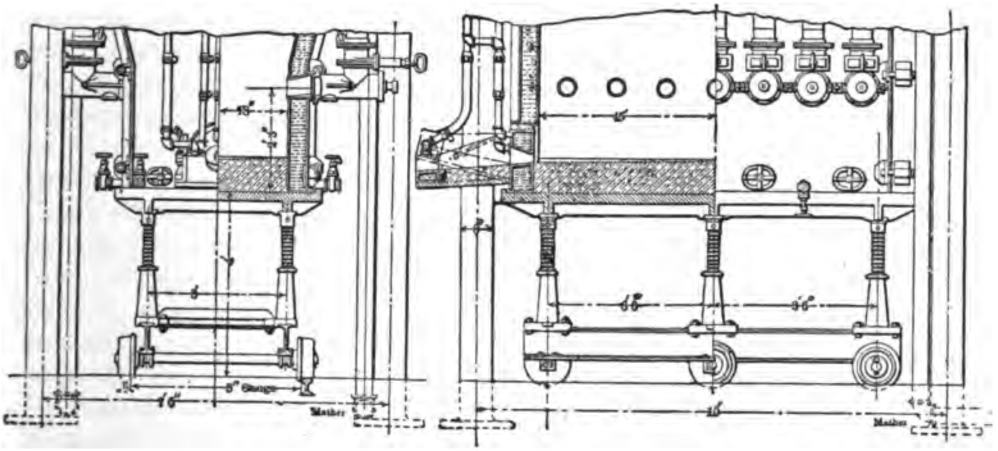

FIG. 8.—CROSS- AND LONGITUDINAL SECTION OF FURNACE, SHOWING THE TRUCK SUPPORT. (MATHER.)

The Herreshoff Roasting Furnace.—Mr. J. B. F. Herreshoff has patented[10] and arrangement of the shelves of his circular calcining furnace whereby the ore is passed toward the apertures of the shelves, and, in combination with spouts extending between the shelves, is directed in its passage from one shelf to the next shelf below in such a manner that it is protected from the influence of the draft through the furnace.

Furnace Construction.—H. A. Mather, in a paper read before the American Institute of Mining Engineers, 1902, described a truck support for furnace bottoms.

While this device is not new, it failed to be of practical utility until the upper and lower water-jackets were supported by hanging them from an I-beam frame,

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[10] United States Patent No. 729,170, May 26, 1903.

independently upheld by iron columns, instead of resting the entire weight of the structure on the bottom of the furnace, as in former construction. The Colorado Iron Works installed this device at two furnaces for the Westinghouse interests near Ely, Vt., and the furnace of the Grand Prize Copper Co., of Gila County, Ariz.

The jack-screw supports (Fig. 8) and the familiar iron bottom of former practice are retained as integral parts of this new furnace bottom. The jack-screws are supported on and bolted to two I-beams extending the length of the furnace and placed immediately beneath and parallel to its sides. These I-beams are bolted to and supported by three steel axles equipped with small flanged wheels, the whole constituting a carriage which runs freely on a track. The entire apparatus is movable or rigid at will, for the wheels are easily braced if the tension of the tightened jack-screws does not serve to hold it in position. The jack-screws have a play of 10 in., and the false bottom is 9 in. deep, including the firebrick cover.

The time occupied in cleaning and preparing a frozen furnace for active service is lengthened by the necessity of working in a confined place where the temperature is uncomfortably high and the débris must be removed from the bottom of the furnace before the false bottom of fire clay, coke-breeze, etc., can be repaired or replaced; furthermore, the superimposed bottom is almost invariably destroyed when the iron plate is pried from the supporting jack-screws, and no renewal is practicable until the plate is once more installed beneath the furnace. These disadvantages are for the most part removed by the use of the truck support. Working results have shown a reduction of at least 50% of the time lost by the freezing up of a furnace. The work of barring down and renewing the false bottom proceeds simultaneously.

The Garretson Furnace.—Oliver S. Garretson, assignor to Garretson Furnace Co., Pittsburg, Pa., has patented[11] a process of matte or pyrite smelting which consists in subjecting the molten matte to a converting or Bessemerizing blast underneath a column of material which contains a flux, removing the slag, and subjecting the slag to the action of a blast underneath a column of sulphur-bearing material.

The Treatment of Low-grade Siliceous Copper Ores.—(By Edward D. Peters.)[12] —The processes which appear economically applicable to the treatment of low grade siliceous copper ores are: (1) Direct smelting; (2) mechanical concentration, followed by the smelting of the concentrates and the lixiviation of the tailings; (3) lixiviation of the ore direct with a solution of ferrous chloride and salt; (4) lixiviation of the ore direct with hydrochloric and sulphuric acids, which are regenerated in the solution by the precipitation of the copper from a chloride solution by means of sulphurous acid; (5) lixiviation of the ore direct with sulphuric acid; and (6) the Rio Tinto method of gradual lixiviation in heaps.

1. Direct Smelting.—Wherever it is in any way practicable, the American met-

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[11] United States Patent No. 728,701, May 19, 1903.

[12] Abstracted in the *Engineering and Mining Journal*, June 6, 1903, from a paper and discussion, read before the Institution of Mining Engineers, Newcastle-upon-Tyne, England, May and December, 1902. Mr. Peters' paper is a contribution to the discussion of an article by Mr. E. J. Muir, in which the latter gave results of tests made upon an Australian siliceous copper ore. For the interpolations, given within parentheses, the Editor of the *Engineering and Mining Journal* is responsible, and not Dr. Peters. The discussion is reproduced because it concerns a practical subject and gives the views of an authority.

allurgist prefers smelting to any form of wet process. The perfect continuity of the operation, the ease and simplicity with which the unpulverized ore pursues its steady course from the mine to the blast-furnace, from the blast-furnace to the converter, and from the converter to the refinery, lend themselves to operations on a very large scale, and permit the substitution of mechanical appliances for hand labor to an extent unapproachable in any other method. Another great advantage of smelting is the almost complete recovery of the precious metals present, with but little extra cost. Direct smelting may also be used with ores containing a very considerable excess of silica, and a corresponding deficiency of iron in the ore. This was most clearly pointed out by Mr. F. R. Carpenter in the Deadwood & Delaware Smelter in S. D., who demonstrated conclusively that highly siliceous ores, containing a little pyrite, and with extremely expensive coke, could be smelted direct in the blast-furnace, with the production of slags containing 50% SiO_2, 30% CaO and MgO, and only 16% FeO. The lime and magnesia were added to the ore in the form of barren dolomite; 20 to 30 tons of ore produced 1 ton of matte; the slags were exceedingly clean, and the precious metals and copper (very little) that were contained in the ore, were almost entirely recovered in the matte.

The most interesting features of this unusual type of smelting are the fusibility of the very acid silicate of lime and magnesia with but little iron, and the high rate of matte concentration. The latter result is due to the very acid slag, which decomposes the pyrites present, carrying their iron contents into the slag as ferrous oxide. It is not always understood by blast furnace smelters that, other things being equal, an acid slag means a high grade matte, while a basic slag is accompanied with a low-grade matte. Mr. Peters has only gone into this detail in regard to the direct smelting of very siliceous ores in the blast-furnace in a raw state, in order to call the attention of metallurgists to possibilities that may solve certain difficult metallurgical problems. In the case of an absence of silver and gold in the ores, and the non-existence of limestone ores for fluxing purposes, with a high cost of fuel, the metallurgist would be compelled, most reluctantly, to give up the idea of direct smelting.

2. Mechanical Concentration, Followed by the Smelting of the Concentrates and the Lixiviation of the Tailings.—Mr. Peters has met with, or been cognizant of, so many difficulties and failures in attempting to concentrate low-grade, disseminated copper sulphide ores, that he has always advised exhaustive mill tests on a large scale before venturing to use this method. It is only suitable for exceptional ores and conditions. In reference to the results of tests quoted in this discussion by Mr. Muir, it is obvious that the results themselves are stronger arguments against the employment of this process than any that the writer could advance. (The experiments of Mr. J. J. Muir were made on an Australian ore containing Cu 3·94%, Fe 9·55%, SiO_2 50·15%, Al_2O_3 16·85%, S 19·51%, and alkalies undetermined. A concentration test yielded a product representing 7·277% of the original ore, but the assay gave only 11·12% Cu, with 28·40% Fe and 14·40% SiO_2. The tailings carried 3·37% Cu, so that the recovery was only 81% of the copper content.[13])

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[13] *Transactions of the Institution of Mining Engineers*, 1902, Vol. XXIII., pp. 520 and 521.

Without attempting to analyze his experiments in detail, Mr. Peters would simply point out that the results of Mr. Muir's concentrating tests show a saving in the concentrates amounting to about 20% of the original copper contained in the ore, and a loss of nearly 80% in the tailings. This, of course, means no concentration whatever, and there must be some reason, not apparent, why Mr. Muir attempted to concentrate at all.

If a portion of the copper in the ore were present in the shape of some mineral that would exercise an injurious effect upon the subsequent lixiviation, and if this mineral had a higher specific gravity than the remainder of the sulphides present, there might be some question of attempting to remove it by concentration. But, as the 20% of the copper that was removed by concentration had, as Mr. Peters understands, exactly the same chemical composition as the 80% left in the tailings, he fails to see the use of employing concentration; nor does he believe that these ores should be subjected to concentration. (It will be understood that Mr. Peters is referring solely to the ordinary methods of wet-concentration in making this statement, and that he is not expressing any opinion as to the results that might be obtained by one or two novel patented methods of which he has no personal experience.)

It seems to Mr. Peters most advantageous, therefore, to subject the entire mass of ore to lixiviation, rather than to complicate matters and increase expenditure by any preliminary concentration.

3. Lixiviation of the Ore Direct with a Solution of Ferrous Chloride and Salt (old Hunt & Douglas Method).—Considerable quantities of ore have been successfully worked by this process in the United States. The method depends upon the fact that copper oxide is decomposed by ferrous chloride solutions, forming insoluble ferric oxide, while the copper goes into solution as cuprous and cupric chlorides. It is precipitated in a very pure metallic form by iron, the ferrous chloride solution being thus also regenerated, and requiring only the addition of a little salt to fit it for further use. The consumption of metallic iron in this method is very small, since much of the copper is in solution as cuprous chloride. As the copper must be in an oxidized form in order to go into solution quickly and thoroughly, the ore will require a preliminary roasting of sufficient thoroughness to convert most of the copper present into oxide or sulphate. This means that the ore must be crushed dry, though not to nearly so fine a state as would be required for its concentration. Therefore, instead of wet-crushing followed by concentration, the writer would suggest dry-crushing followed by roasting.

It is impossible to make a comparison of the costs of these two different plans of operation without being accurately acquainted with the physical and chemical character of the ore under consideration. By the use of modern high-speed rolls of great diameter and weight, and of the automatic reverberatory roasting-furnaces so general in use in the United States and elsewhere, the cost of dry-crushing and roasting should not exceed the cost of wet-crushing and concentration, while the condition of the pulp for lixiviation is incomparably better when produced by the former treatment. Apart from the advantage gained by the coarser condition of the pulp, and the much lesser proportion of very fine powder, the ore undergoes a physical change in roasting, which makes it much like sand and gravel, and enables the solutions to permeate it with a completeness and rapidity that are quite surprising. The advantages thus gained will only be fully appreciated by those who have had experience in leaching the same ore, both before and after roasting. They are so great that, in several instances in this country, tailings are roasted previous to lixiviation, solely for the purpose of improving their physical condition, and of increasing the thoroughness and rapidity of the latter operation.

Mr. Peters desires to emphasize this dry-crushing and roasting as being, in his opinion, the most important step toward a successful leaching of these ores by the methods that he has called Nos. 3, 4 and 5.

4. Lixiviation of the Ore Direct, with Hydrochloric and Sulphuric Acids, which are Regenerated in the Solution by the Precipitation of the Copper from a Chloride Solution by Means of Sulphurous Acid (new Hunt & Douglas Method).—By this method the copper is precipitated from its chloride solution, by means of sulphurous acid gas, which throws down the copper as a very heavy white cuprous chloride, that settles almost instantaneously. Sulphuric and hydrochloric acids are generated in the solution, which only requires the addition of salt to make it ready for further use. One great advantage of this method is the rapid dissolving of the oxidized copper present by the strongly acid solution, which even attacks sulphides with considerable energy. Any lead and silver present remain undissolved. The ores require to be roasted, as in the previous process. A supply of pyrite is essential to the economical working of this method, and, of course, it is very advantageous if these pyritic ores contain some metal of value.

5. Lixiviation of the Ore Direct, with Sulphuric Acid.—Mr. Muir has already considered this method in his paper, though he confined it to the treatment of the tailings after concentration. Mr. Peters can only add that, if lixiviation is at all suited to the fine tailings and slimes from the concentrating process, it is still more feasible, and much more economical, when employed upon the coarsely crushed and roasted ore; and, that instead of taking 11 weeks for the extraction of the copper, it is probable that, with roasted ore an equally perfect extraction would be accomplished within 2 or 3 days.

(In this connection reference may be made to the process patented by Mr. James W. Neill. Sulphurous acid is used to leach the copper. This method was described in the *Engineering and Mining Journal,* May 30. 1901, from which the following is now quoted: The native copper oxides and carbonates are readily soluble in sulphurous acid with the formation of cuprous sulphite (Cu_2SO_3). This salt is insoluble in water, but soluble in water containing sulphurous acid, from which the copper can be precipitated by driving off the excess of sulphurous acid by heat. The precipitate is cupro-cupric sulphite ($CuSO_3$, $Cu_2SO_3+2H_2O$), and contains 49·1% Cu. This salt is a heavy, crystalline compound, of a dark red color, which settles readily from the solution, and can be washed by decantation, dried and reduced to metallic copper by fusing on the hearth of a reverberatory furnace. The process is suitable, both for sulphide and oxidized ores, the former being first roasted to expel the sulphur and convert the copper compounds into oxides, as sulphurous acid does not attack sulphides. The ideal ore is one carrying copper oxides or carbonates in a siliceous gangue; lime and magnesia are objectionable, as they dissolve in sulphurous acid and, while they do not materially interfere with the reactions, they consume a certain amount of sulphur and so increase the cost of the process.)

Sulphurous acid produced by roasting pyrite is the cheapest chemical procurable in the western country, and the plant is much simpler than that used in making sulphuric acid. A unit of copper converted into cuprous sulphite requires but half the sulphur that would be required to convert it into cupric sulphate. Cuprous sulphite is precipitated from the solution without the use of scrap iron, which is a great advantage in remote districts. In southern Utah, for instance, scrap would cost from $40 to $50 per ton, and from 2·5 to 3·5 lb. iron are required to precipitate 1 lb. of copper from sulphuric acid solutions, owing to the large amount of basic salts formed. Sulphurous acid dissolves very small amounts of other metals that may be in the ore, and the precipitated cuprocupric sulphite is practically pure and furnishes pure copper by a simple smelting operation.

6. The Rio Tinto Method of Gradual Lixiviation in Heaps.—Mr. Peters agrees with Mr. Eissler in having a strong leaning toward this process of slow, but inexpensive, lixiviation, in cases where the climate is suitable, and where the chemical and physical condition of the ore favors the gradual and persistent formation of sulphates. (In the Rio Tinto method the poor coarse ore is built up in the form of large conical heaps, 10 to 15 ft. high and about 20 to 30 ft. apart. A fire is then lighted in each of these and the mixed lump and fine ore is filled in between them. The gas produced by combustion mixes with the steam generated from the moistened mass and permeates the whole mass of 4,000,000 tons of ore. After burning slowly for a period of four to six months, water is turned on so as to dissolve out the copper sulphate. This percolation and leaching process continues for about five years, the liquor being caught below in dams or large reservoirs built of masonry, the copper being precipitated on scrap iron.[14])

At certain Portuguese mines, such as the San Domingo works, a slow process by weathering was formerly employed on pyrites containing copper. For this treatment the soft, more permeable ores are best adapted. Heaps, containing from 100,000 to 250,000 tons of material, are built up, their assay content ranging from 1·5 to 2% Cu. About 88% of the total copper is extracted in the course of six years, the remaining 12% being recoverable only by a long and unprofitable continuance of the same treatment. At San Domingo as much as 3,000,000 tons have been under treatment at a given period. Plenty of stone flues are distributed on the surface of the ground and the mineral is dumped over them. These flues are connected one with another longitudinally and transversely, and at intervals they communicate with the outer air by vertical stone shafts. The object of this arrangement is, of course, to provide a plentiful supply of air in order to prevent the heaps taking fire. This last is detrimental because the sintering of the material obstructs the subsequent leaching of the copper.

Before precipitating the copper it is necessary to reduce the ferric salts present

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[14] THE MINERAL INDUSTRY, Vol. II., p. 296.

in the solution. This is done by filtering the liquor through copper sulphide ores. The operation takes place in large dams, by a prolonged contact in the course of which the reduction takes place as presented by the formula:—

$$Cu_2S+5Fe_2(SO_4)_3=2CuSO_4+10FeSO_4+4SO_3.$$

The liquors are then run through a series of settlers and then pass to the precipitating plants, where the copper is caught on scrap iron.[15]

Mr. Peters fears, from the description of the ore given by Mr. Muir, that, in the present instance, the percentage of sulphides might not be large enough to maintain the energetic and persistent chemical action necessary for the gradual decomposition of the chalcopyrite, and the formation of soluble salts of copper.

There is another very serious objection to the Rio Tinto method that does not always weigh sufficiently with the metallurgist, who confines his attention too closely to the perfection of his technical results, namely: The time and money required to demonstrate on a large and safe scale that any given ore will eventually yield up its copper to this slow and tedious process. There is also great difficulty in finding reliable deposits of sufficient size to yield the enormous quantities of ore of a nearly identical composition that are required for the profitable installment of this method, as well as in raising capital willing to wait so long for returns.

Recapitulation.—After enumerating the six methods of treatment that seem to Mr. Peters to be best suited to these ores, he has eliminated the first two, namely: (1) Direct smelting, and (2) mechanical concentration and lixiviation of the tailings. The slow Rio Tinto method of leaching, which he has called No. 6, demands most careful consideration in the few cases where the magnitude of the ore bodies and of the financial resources will permit of its application. This leaves only the three methods of direct and rapid lixiviation of the ore without any previous mechanical concentration. An intimate knowledge of local conditions and costs, wide technical experience with modern lixiviation methods, and long and careful experiments on an extensive scale, on the ore to be treated, can alone decide the method to be chosen. Mr. Peters is pretty well convinced, however, that if the choice should fall upon any one of these three methods, it will be found advantageous to crush the ore dry and to roast it, before lixiviation.

Proposed Process for the Extraction of Copper from Low-grade Ores.—G. D. Van Arsdale[16] proposes to extract copper from low-grade ores by means of a hot copper sulphate solution acidified with sulphuric acid. After the copper has been extracted from the ore, the solution is allowed to drain through a tower packed with coke or other materials, at the same time allowing sulphur dioxide gas to pass up from below, so that the gas is absorbed by the solution. The sulphur dioxide gas may be obtained either by using converter flue gases, or by roasting sulphide ores. The solution is drawn off from the bottom of the tower and run into a lead-lined, steel pressure tank and heated to 100°C., whereby a pressure of about 30 lb. per sq. in. is obtained. As a result of this treatment, 50% of the copper is precipitated, the reaction taking place in two stages as follows:

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[15] "Treatment of Cupreous Iron Pyrites as Carried on at the Portuguese Mines," by J. Henry Brown; *Journal of the Society of Chemical Industry*, Vol. XIII., pp. 472 and 473.

[16] United States Patent No. 723,949, March 3, 1903.

$3CuSO_4+3SO_2+4H_2O=Cu_2SO_3.CuSO_3+4H_2SO_4$; $Cu_2SO_3.CuSO_3+4H_2SO_4=Cu+2CuSO_4+2H_2SO_4+2SO_2+2H_2O$. By neutralizing the solution and reheating, 50% of the copper remaining in the solution may be precipitated. Instead of neutralizing, the solution may be used to leach fresh ore, and the process repeated. The precipitated copper may be directly melted and cast, or if impure, it may be added to the furnace charge. The solution used to leach the ore dissolves iron and other metals present, as well as copper; these impurities accumulate in it and must be removed from time to time, which can be done easily by neutralizing the solution, heating, and injecting air, whereupon the iron is precipitated, carrying down the other impurities. Before leaching the ore, any sulphur dioxide present in the solution must be removed, which is accomplished by heating.

Proposed Process of Extracting Copper from Its Ores.—Adolf von Gernet has patented[17] a process of extracting copper from its ores, which consists in slowly passing the ore in the form of pulp through a current of sulphurous acid passed in a direction opposite to that of the travel of the pulp.

Elimination of Impurities from Copper Matte.[17a]—(In connection with the following experiments on the relative rates and points of elimination of impurities during the Bessemerizing process, reference may be made to the article on "The Elimination of Impurities from Copper Mattes," which appeared in THE MINERAL INDUSTRY, Vol. IX.)—According to W. Randolph Van Liew, a converter was selected which was starting on its second charge. The first charge after lining had finished its copper "hot," and consequently no copper was adhering to the sides of the lining. All the copper and granulated slag from the previous charge were dumped, thus removing any possibility of "salting" the matte to be tested. The converter worked fast and well during the entire test. Periods of ten minutes were selected. The converter was brought from the stack to secure each sample of matte to be analyzed, and only that time counted during which air was being forced through the charge.

At the end of 40 minutes' actual blowing, the matte was up to white metal, the point at which the last skimming takes place; that is, matte of approximately 76·4% Cu. From this point, of course, average samples of the contents of a converter are impossible, since from this skimming point up to finished copper, the contents of a converter consist of constantly varying proportions of matte and copper, which, when a converter is brought from the stack and the blast-pressure turned off, settle according to their specific gravity. When the charge is completed, a granulated sample of finished copper is obtained and assayed. Accurate chemical analyses of these equal-period samples of matte and copper are given in the table on the following page.

The accompanying illustration (Fig. 9) shows graphically the course of the process of elimination. In this figure, the line of abscissa represents the 10-minute periods of blowing, and the ordinates represents percentages of copper, etc., from 0 to 100. The ordinates of the figures at the bottom are the same, but on a larger scale (from 0 to 1·2%), to show better the impurities in the matte

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[17] United States Patent No. 717,565, Jan. 6, 1903.

[17a] This article, which appeared in the *Engineering and Mining Journal*, June 27, 1903, is to be read before the autumn meeting of the American Institute of Mining Engineers.

carried to the extent of but a few tenths of 1%. The upper diagram shows that the silver almost parallels the enrichment of the matte in copper.

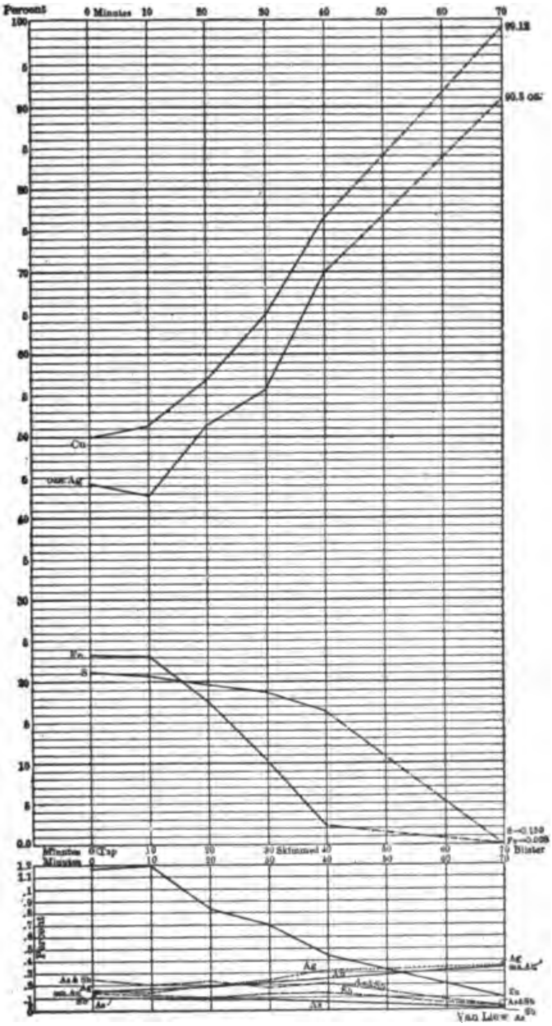

FIG. 9.—DIAGRAM SHOWING THE ELIMINATION OF IMPURITIES FROM COPPER MATTES.

Time.	Copper	Iron.	Sulphur.	Zinc.	Arsenic.	Anti-mony.	Silver.	Gold.
	%	%	%	%	%	%	Oz.	Oz.
Cupola tap	49·72	23·31	21·28	1·19	0·11	0·14	44·20	0·16
10 minutes	50·20	23·15	20·95	1·20	0·09	0·12	42·90	0·14
20 minutes	56·88	17·85	19·74	0·84	0·08	0·10	51·40	0·20
30 minutes	64·60	10·59	18·83	0·70	0·08	0·18	55·80	0·24
40 minutes (last skim)	76·37	2·40	16·30	0·45	0·08	0·13	70·00	0·32
70 minutes (blister copper)	99·12	0·038	0·159	0·09	0·0012	0·006	90·80	0·35

The lines showing the relative elimination of the iron and the sulphur are the most interesting. For the first 10 minutes of the blow, and while the matte is heating up, the iron and sulphur lines are parallel. From this point there is a marked change; the sulphur line is very gradual in its drop, showing that but little is being burned in comparison with what is taking place with the iron, whose line takes a sudden drop. The iron decreases during 30 minutes from 23·15% to 2·4% at the skimming point, while at this point there still remain 16·3% of sulphur in the matte. From this point, however, to blister copper, it is the sulphur that bears the brunt of elimination, the iron dropping only from 2·4% to 0·0038% at blister copper, while the sulphur decreases from 16·3% to 0·15%. This is of great interest, as it shows that up to the skimming point, it is the oxidation of the iron to ferrous oxide, and the union of the ferrous oxide with the silica of the lining, that affords the source of heat to carry on the operations within a converter; while from the skimming point (76·4% copper) to the finished blister copper it is chiefly the burning of the sulphur that gives the heat supply to finish the work started by the oxidation of the iron. The zinc is scarcely affected during the "heating-up" period; while after that its elimination is gradual. The arsenic and antimony curiously enough, are but slightly affected during the whole of the slag-forming period, or as long as enough iron remains to be slagged off. At the cupola-tap of matte into the converter, the arsenic amounted to 0·11%, and the antimony to 0·14%, while at the end of the slag-forming period the arsenic amounted to 0·08% and the antimony 0·13%. When the iron in the matte had been oxidized and slagged off the arsenic and antimony began to be oxidized and driven off, until, at the point of blister copper, but 0·0012% of arsenic and 0·006% of antimony remained.

Process for Treating Copper Matte.[18]—A patent has been issued to Messrs. Herman Thofern and B. D. St. Seine for a process of treating copper matte by blowing into the furnace a mixture of superheated steam, air and fine sand. This idea of simultaneously oxidizing and scorifying the metallic substances to be eliminated is not new, as it has been incorporated previously in patents issued in the United States and Great Britain. With matte containing 30% Cu, a rather large proportion of silica is used at first in the blast, and the oxidation and scorification proceeds very rapidly. The fusible slag collects on the surface of the bath outside of the blast zone, so as to protect the walls of the furnace. From a charge of 50 tons, most of the iron is slagged, and the sulphur driven off as dioxide in about six hours, the product being a matte of 80% Cu. At this stage in the operations, the proportion of sand in the blast is reduced, or the same proportion is used intermittently to slag the remainder of the iron and to burn off the last of the sulphur; while antimony, arsenic, phosphorus and similar impurities are converted by the hydrogen of the steam into volatile compounds and are thus eliminated. There is obtained finally a copper bath with about 99% Cu which can be cast into anodes, or further refined in the usual manner.

In this connection it is interesting to note the method patented[19] by George Mitchell of converting copper matte into metallic copper, which consists in feed-

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[18] United States Patent No. 723,500, March 24, 1903.

[19] United States Patent No. 719,438, Feb. 3, 1903.

ing pure or practically pure silica in a molten condition into the molten matte during the operation of blowing.

Copper Residues, Precipitates and Scrap.—(By H. A. Mather.)—Copper residues, precipitates and scrap are in some instances still reworked in graphite crucibles, but the wear and tear on them has been so excessive and costly, that they are being rapidly supplanted by the Schwartz melting furnace. The furnace is shaped similar to a copper converter, hung on trunnions and may be tilted to any angle. The air blast and oil for fuel are supplied under pressure through pipes universally jointed, which are attached at the top of the furnace. The oil and air blasts are directed downward on the molten metal at such an angle that a continuous agitation of the molten mass is maintained until the proper conditions of the charge are obtained, the furnace is then tilted forward and the charge blown out rather than calmly poured through the spout. The cover or lid is removed for charging and luted into place when the furnace is in operation. The linings used are highly siliceous material molded into shapes to conform to the shell. These furnaces are used for a variety of melting purposes other than that of copper wastes, especially by brass founders, and while somewhat expensive to install, they are reported to be extremely economical in time, labor and fuel consumption.

Brass turnings containing little or no aluminum are readily purchased for remelting. Turnings containing much heavy oil are washed with an alkaline solution and dried before being remelted into metal or directly alloyed in the kettle. Standard grades of brass scrap, such as old wire cloth from paper mills, skeleton brass sheets, etc., are melted directly for casting furniture trimmings and sundry articles of hardware. The addition of aluminum up to 1% appears to add to the soundness of brass or other alloys when cast in sand molds, but if cast in iron molds, the presence of 0·03% of aluminum will cause the casting to be dirty and full of dross.

Analysis of Copper Slags.—An action of interest to copper metallurgists, and in fact to all engaged in the smelting of base metals, has been instituted by Mr. Thorn Smith,[20] with the object of ultimately obtaining uniformity in the methods of analysis used by chemists for copper slags. Samples of a slag were sent to 40 chemists and a report of analysis were received from 23 of them. A collation of the figures showed differences so great that the necessity of having uniformity of method of analysis is strongly evident. The following differences were noted: SiO_2 3·88%, Fe 1·87%, Al_2O_3 3·92%, CaO 2·8%, MgO 2·01%, Zn 2·38%, Mn 1·42%, CuO 0·26% and S 0·53%. The article referred to concludes with a discussion of the methods used by the various chemists for the determination of the component parts of the slag. This subject has attracted so much attention that the New York section of the Society of Chemical Industry has decided to discuss the whole matter before a meeting of its members and to publish the results of their proceedings in the *Journal of the Society of Chemical Industry.*

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[20] *Engineering and Mining Journal*, Feb. 21, 1903.

PROGRESS IN THE ELECTROLYTIC REFINING OF COPPER IN 1902.*

BY TITUS ULKE.

Electrolytic Copper Refineries.—The world's average daily production of electrolytic copper at the close of 1902 was about 883 short tons, of which 764 tons, or 86·5%, were supplied by the United States. Of the balance amounting to 119 tons daily production, or approximately 13·5%, Great Britain furnished a little over 8·8%, Germany about 2·75%, and France a little over 1·6%. The United States now produces at the enormous rate of 278,860 tons of electrolytic copper per annum valued approximately at $72,503,600. The by-product recovered daily contains about 74,100 oz. silver and 948 oz. gold, which equals an annual output of over 27,000,000 oz. of silver, valued at nearly $13,000,000, and more than 346,020 oz. of gold, valued at $7,152,233. According to the United States Treasury Bureau of Statistics, the copper exports from this country consist chiefly of electrolytic copper, and for the year 1902, they represented a value of $45,485,598, as compared with $33,534,899 in 1901. The value of the exports of copper was exceeded only by the value of the exports of manufactured iron and steel and of mineral oils.

There are now in active operation, or ready to be placed in commission, 33 electrolytic copper refineries in the world, not including the plant of the Osaka Electrolytic Refining Co. now being constructed at Osaka, Japan.

During the past year there has been a notable increase in the quantity of concentrates from the Michigan copper mines cast into anodes and treated electrolytically, and for several years a large part of both the Tamarack and the Calumet & Hecla output has been refined electrolytically at Buffalo. The Quincy Mining Co. casts certain grades of argentiferous "mineral," and ships the metal East for electrolytic refining. The Isle Royale Copper Co. has found that it more than pays to save the silver, with the small difference between the price of Lake and electrolytic copper. It is reported that the copper from the Mass mine frequently carries $65 in silver per ton of ingots. As all Lake copper, judging from numerous analyses, carries noticeable quantities of silver, it is only a question of time, in my opinion, when all the fine copper produced in the United States will be made electrolytically, and only minor distinctions of brand will remain.

It is probable that an electrolytic refinery for treating the converter copper produced on the Pacific Coast will be built on Puget Sound; water power in large units is available here at a price per horse-power-year considerably lower than its equivalent, generated from coal, at the large refineries on the Atlantic seaboard, and lumber also is much cheaper. Even though the cost of labor and of most supplies is 60% greater in Seattle or Tacoma than in New York or Baltimore, there would still be a margin in favor of refining on Puget Sound. The refinery, if established, should be operated in conjunction with a plant for turning out the main part of the metal in the form of sheet copper and wire to supply the growing demand for these materials in the Orient, Australia and the west coast of South America, as well as that of the western part of the United States.

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* The growth and technique of the electrolytic copper industry has been fully discussed by Mr. Ulke in his work, *Modern Electrolytic Copper Refining*, New York, 1903. Much of the information contained in this book has appeared in previous volumes of THE MINERAL INDUSTRY.

It seems very strange that not a single electrolytic copper refinery in the East is located at the great water-power centers, such as Niagara Falls, Sault Ste. Marie, Massena, Lachine Rapids, Shawinigan Falls, etc., where large units of power—the chief item of expense in electrolytic refining—are obtainable at a much lower figure than at the places where the seven Eastern refineries are situated.

Output, Cost, etc., of Copper Refineries.—Carl Hering[1] states that, "A good process may readily be a commercial failure if it is not properly carried out from the industrial standpoint, while on the other hand, a poor process may sometimes, by good design of the installation and good management, be made a commercial success. In the first place, the cost of the power plant should approximately be proportional to the product of the annual output of refined copper and the current density, and in the second place, the approximate area of the refinery buildings for a given yearly output should be inversely proportional to the current density."

Starting with these fundamental propositions, Philip[2] finds that in England the cost of offices in pounds sterling may be stated by formula as *150×(0·1×No. of tons refined per year)*. Secondly, that the area of the refinery buildings for a given yearly output equals *30×(No. of tons refined per year÷current density in amperes per sq. ft.)*. The constant 30 is an average value; in six different plants it varied between 21·9 and 31·5. Thirdly, that the cost of the buildings in pounds sterling equals *7·5×(No. of tons refined per year÷current density in amperes per sq. ft.)*.

When the above special formulas are applied without modification to the electrolytic copper refineries in the United States, I find that they lead to erroneous results, and that the respective factors, *i.e.*, 150, 30 and 7·5, in formulating similar equations holding true in the United States, would have to be largely increased, and in most cases, made fully twice as large as those employed by Philip.

Current Densities in Refining.—The very high current densities employed by some American electrometallurgists must surprise European refiners, who seldom, if ever, use current densities exceeding 10 amperes per sq. ft. of cathode surface. The average density employed in the 23 European refineries is less than 6 amperes per sq. ft. At Great Falls, Mont., with anodes comparatively low in silver, arsenic and antimony, and with electricity cheaply generated by water power, current densities up to 45 amperes seem to yield good copper at a profit. Under otherwise favorable conditions, therefore, the profitable use of high-current densities, in order to enable the refiner to turn out copper at a very rapid rate, is seemingly limited solely by the excessive losses of current through heating, or boiling of the electrolyte, which occurs with currents above 45 or 50 amperes in density.

Use of Heavy Anodes.—Notwithstanding the fact that much more capital is tied up in employing heavy anodes than when light anodes are used, several custom refiners are now casting the anodes very thick and heavy, about 400 lb. in weight, as compared with 180 or 200 lb. in former years. This is partly due to

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[1] *Electrochemical Industry*, September, 1902.

[2] *Engineering*, London, August, 1902.

the fact that the percentage of scrap copper produced with the heavy anodes is only about one-half that made with light anodes, say, 7% as compared with about 15%, the weight of the scrap falling being approximately the same in both cases.

Regeneration of Foul Solutions.—The American Smelting & Refining Co. is introducing at its Perth Amboy plant the essential features of the Ottokar Hofmann method[3] for the purification of foul electrolytic solutions. This process requires the electrolytic to be first neutralized, which is done by adding to it cupric oxide (roasted copper matte), the bulk of solution obtained being increased. This increase may be worked off in two ways. (1) By treating the surplus solution in a separate system of tanks in which lead anodes and cathodes are used, copper being recovered, while sulphuric acid is set free and used to acidify that part of the electrolyte which is returned to the refinery. (2) By making blue

ELECTROLYTIC COPPER REFINERIES IN THE UNITED STATES OPERATED IN 1902.

Number.	Name of Company and Location of Works.	Kind of Material Chiefly Treated.	Approximate Daily Copper Output in Tons (2,000 lb.)	Number and Capacity of Generators. Kw. = Kilowatts.	No. of Tanks in Refinery.	Arrangement of Electrodes.	Approximate Daily Output of Gold and Silver from Slimes.
1	Raritan Copper Works (United Metals Selling Co.), Perth Amboy, N. J.	Converter Copper from Boston & Montana, Butte & Boston, Old Dominion, Arizona Copper Co., Copper King, Ltd., United Verde, Bingham, Greene Cons. and Highland Boy.	150 to 200 (Cap. 200)	Five @ 600 Kw.	1,600	Multiple.	8,000 to 10,000 oz. Ag. 175 to 200 oz. Au.
2	Guggenheim Refinery. Perth Amboy plant of Amer. S. & R. Co., Perth Amboy, N. J.	Anodes and pig copper from Mexico, Utah and Colorado.	100 (Cap. 150)	Three @ 520 Kw.	816	Multiple.	25,000 oz. Ag. 200 oz. Au.
3	Anaconda Mining Co., Anaconda, Mont.	Anaconda anodes.	84 (Cap. 150)	Three @ 240 Kw. Two @ 360 Kw. Four @ 220 Kw.	1,430	Multiple.	4,207 oz. Ag. 25 oz. Au.
4	Baltimore Smelting & Rolling Co. (Baltimore Copper Works), Baltimore, Md.	Converter copper from Anaconda, Mt., Lyell and part of the Germania Works output.	80 (Cap. 100)	Eleven @ 80 Kw.	540	L. p. series. S. p. multi.	6,400 oz. Ag. 28 oz. Au.
5	Boston & Montana Cons. Copper and Silver Mining Co., Great Falls, Mont.	Boston & Montana anodes.	75	Two @ 810 Kw.	324	Multiple.	5,000 oz. Ag. 70 oz. Au.
6	Nichols Chemical Co., Laurel Hill, N. Y.	Converter copper from the Mountain Copper, United Copper, Copper Queen and Granby Co. and metal from Canadian and Spanish pyrites cinders.	120	Six @ 75 Kw.	120	Series.	6,000 oz. Ag. 204 oz. Au.
7	Balbach Smelting & Refining Co., Newark, N. J.	Orford anodes and miscellaneous.	45 (Cap. 50)	One @ 300 Kw. Two @ 125 Kw.	430	Multiple.	8,000 oz. Ag. 15 oz. Au,
8	De Lamar Copper Refining Works, Carteret, N. J.	Blister copper from Bully Hill mines, Cal.	50	One @ 520 Kw.	408	Multiple.	10,000 oz. Ag. 200 oz. Au.
9	Buffalo Smelting Works, Black Rock, N. Y.	Lake Superior, argentiferous native copper "mineral."	30	One @ 510 Kw. Two @ 48 Kw.	270 490	Multiple.	600 oz. Ag. — oz. Au.
10	Chicago Copper Refining Co., Blue Island, Ill.	By-products and miscellaneous pig copper.	5	Two @ 64 Kw.	250	Multiple.	100 oz. Ag. 3 oz. Au.

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[3] THE MINERAL INDUSTRY, Vols. VIII. and X.

vitriol, in which case, of course, sulphuric acid must be bought for addition to the refined neutral electrolyte.

ELECTROLYTIC COPPER REFINERIES IN EUROPE.

Country.	Number.	Name of Company and Location of Works.	Kind of Material Chiefly Treated	Approximate Daily Copper Output in Tons (2,000 Lbs.).	Number and Capacity of Generators. Kw.=Kilowatts.	No. of Tanks in Refinery.	Arrangement of Electrodes.
Great Britain....	1	Bolton & Sons, Ltd., Froghall, England.	Gold and silver-bearing "bottoms."	18 to 20 (Cap. 24)	Eight @ 75 Kw.	550	Multiple.
	2	Pembrey Copper Works (Elliott's Metal Co.), Burry Port, South Wales.	Gold and silver-bearing "bottoms."	18 to 20	385 Kw.	1,065	Multiple.
	3	Bolton & Sons, Ltd., Widnes, England.	Gold and silver-bearing "bottoms."	10 to 12	Four @ 75 Kw.	240	Multiple.
	4	Leeds Copper Works, Hunslet, Leeds, Eng.	Chile bars (96% Cu.).	10 to 12 (Capacity)	Four @ 170 Kw.	216	Elmore.
	5	H. H. Vivian & Sons, Swansea, Wales.	Gold and silver-bearing "bottoms."	8 to 10	....	....	Multiple.
	6	McKechnie Bros., Widnes, England.	Miscellaneous crude copper.	9*	Three @ 75 Kw.*	234*	Multiple.
Germany........	1	Norddeutsche Affinerie, Hamburg, Germany.	Miscellaneous crude copper.	10	Ten @ 8 Kw.*	600	Multiple.
	2	Mansfeld Kupferschieferbauende Gewerkschaft, Eisleben.	Gold and silver-bearing "bottoms."	5	....	....	Multiple.
	3	Communion Huettenwerk, Oker.	....	5	Sixteen @ 4 Kw.*	600*	Multiple.
	4	Borchers Bros., Goslar	....	1	....	....	Multiple.
	5	Elmore Metall-Actiengesellschaft, Schladern an der Sieg.	Chile bars.	1*	....	....	Elmore.
	6	Stadtberger Huette, Niedermarsberg.	Argentiferous cement copper.	0·9 to 1	....	....	Multiple.
	7	Altenau Kupferhuette, Altenau, Harz.	....	0·8 to 1	One 21 Kw.	....	Multiple.
	8	C. Schreiber, Burbach, Siegen.	....	0·2*	One 11 Kw.	....	Multiple.
	9	Allg. Elektro-Metallurgische Gesellschaft, Papenburg a. d. Ems.	Ni+Cu matte.	0·2*	....	....	Hoepfner
Austria-Hungary	1	Bergbau u. Eisenhuetten-Gewerkschaft, Witkowitz.	Pyrites cinders from acid works.	0·25 to 0·3	Two @ 4 Kw.	72	Multiple.
	2	Berg u. Huettenverwaltung, Brixlegg, Tyrol.	Black copper (90% Cu.).	0·12 to 0·14	Two @ 5 Kw.	60	Multiple.
France..........	1	Société d'Electro-Metallurgie, Dives, France.	Chile bars.	10 to 12	Four @ 170 Kw.	216	Elmore.
	2	Société Anonyme des Fonderies et Laminoirs, Biache St. Vaast.	....	2*	Five @ 6 Kw.*	100*	Multiple.
	3	Grammont, Affinerie, Pont de Cheruy.	....	1·1*	....	....	Multiple.
	4	Hilarion, Roux et Çie, Marseilles.	....	0·23*	One @ 3 Kw.*	40	Multiple.
Russia..........	1	Kalakent Copper Works (Von Siemens & heirs), Kalakent, Caucasus.	Blister copper.	1·2 to 1·4	Two @ 24 Kw.	102	Multiple.
	2	Nikolajav Works, Nijni Novgorod.	....	0·75	....	70	Multiple.

* Doubtful.

Metallurgical Crane.—David W. Blair,[4] of Perth Amboy, N. J., has patented a metallurgical crane, comprising a member to be disposed over a metallurgical

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[4] United States Patent No. 697,782, April 15, 1902.

bath and adapted to be lifted, a plurality of longitudinal shafts connected with this member and free to shift endwise, hooks connected with the shafts and adapted to engage electrodes, the arrangement being such that the hooks are free to engage the electrodes when the shaft is shifted endwise.

Electrolytic Dissolution of Copper Anodes.—Woolsey McA. Johnson[6] assumes that ordinary copper anodes may be considered as being mixtures of pure copper and copper-silver alloys, cuprous oxide, antimony oxide and arsenic oxide, or solutions of these alloys and oxides in pure copper, and states that, in his opinion, because the electrical resistance of copper-silver alloys and of the oxides is higher than that of pure copper, the silver alloy and oxides would tend to "slime," under normal conditions, and thus tend to keep the solution in a pure condition. To explain these views, which have been more or less well recognized since 1885, when Dr. Kiliani's pioneer investigations were published, Johnson has recourse to the following known facts: (1) Every metal has a certain specific electrolytic tension or voltage depending upon its temperature, physical condition and the solution in which it dips. (2) Every metal has a specific electrical conductivity. (3) These two properties are profoundly modified by alloying with other metals.

On these properties of the resulting alloys segregated in the anode, depends the selective electrochemical dissolution. Metals unite with one another to form alloys, in most cases with the evolution of heat, and the atoms are then united with a firmer bond. In other words the free energy is diminished, and as the electrolytic solution tension is measured by the free energy of the metal, in normal solution of its ions, it also must decrease. The resultant product is harder and has less tendency to dissolve. That most alloys of any two metals show a poorer conductivity than the mean conductivity of the metals composing such alloy, and in many cases, than the conductivity of either metal alone, is well known.

These facts have an important bearing in electrolytic refining, in determining the behavior of alloys and oxides contained in ordinary copper anodes. For instance, if it is considered that a particle of silver-copper be surrounded by pure copper crystals, the effect of the great difference in electrical conductivity is certain to shunt the current around this silver-copper alloy and finally dissolve its copper backing. It then can be brushed off into the slime. This, of course, applies to all the alloys (and oxides) that have a lower conductivity. Arsenic and antimony, if present as metals, have a greater tendency to dissolve than copper, because of their high electrolytic solution tension. Fortunately for the electrolytic refiner, however, the larger portion of these elements are thoroughly oxidized, either in the converter or reverberatory furnace. The copper is then brought to "set" in the refining furnace, before casting, if it is not cast direct from the receiver, mixer or converter. The heats of oxidation of arsenic or antimony being many times larger than that of copper, the oxides of the former metals are not reduced to any extent in the "poling" operation, as long as any cuprous oxide is left. These oxides are thus present in the anodes as insulators and as such pass into the slimes directly from "oxidized" anodes.

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[6] **Paper read before the American Electrochemical Society, Sept. 16, 1902.**

COPPERAS.

BY JOSEPH STRUTHERS.

THE production of copperas in the United States during 1902 amounted to 19,784 short tons, valued at the works at \$118,474, as compared with 23,586 short tons, valued at \$112,366 in 1901. These figures do not include the quantity calcined for the manufacture of iron pigments, which is reported elsewhere in this volume under the caption "Ocher and Iron Oxide Pigments."

Ferrous sulphate ($FeSO_4,7H_2O$), or "copperas," as it is called in the trade, is produced chiefly as a by-product of the wire, tin plate and sheet steel industries of the country. Briefly, the usual method of manufacture (see THE MINERAL INDUSTRY, Vol. X., pp. 243 and 244) is to conduct the waste acid liquor from the "pickling" tanks in which the wire, rods or sheet steel have been cleansed, to a lead-lined vat where the proper strength and composition of the liquor is adjusted by the suitable addition of acid or iron. The liquor is then transferred to boiling tanks and the excess of water is expelled by evaporation for three or four days, until the solution becomes of proper strength, when it is removed to the crystallizing vats and cooled. The crystals of copperas form in from three to ten days and after drying are packed in barrels and shipped.

Copperas is used for a variety of purposes, principally in the manufacture of inks and blues, in dyeing cotton and woolen goods, in polishing plate glass (as it hardens the rouge paste which is used for this purpose) and in various branches of the chemical trade. To a minor extent it is used as a fertilizer, as a disinfectant, as a purifying agent in gas works, as a coagulent in water purification, and as a precipitant for sewage. Several towns have replaced the more costly coagulent alum by copperas for water purification. This latter demand has developed during the past year, due to experiments carried on at Quincy, Ill., which have resulted very successfully. In addition to this city, Rock Island, Ill.; Vicksburg, Miss.; Sandusky, O.; Little Falls, N. J., and several other communities are using, or arranging for the use of copperas in water purification, and the list will probably be largely increased during 1903. Copperas is also used in the treatment of sewage at Providence, R. I., and at several smaller places. The impure settlings at the bottom of the tank are sometimes utilized to manufacture Venetian reds, Indian reds and iron oxide pigments.

The largest producer of copperas is the American Steel & Wire Co., whose plants are operated in connection with the manufacture of wire at Worcester, Mass.; Cleveland, O.; Joliet, De Kalb and Waukegan, Ill. Among the other producers are the Pennsylvania Salt Mfg. Co., Natrona, Pa.; C. K. Williams & Co., Easton, Pa.: S. P. Wetherill & Co., Newcastle, Pa.; The Atlantic Dynamite Co., Dover, N. J.; The American Nickel Works, Camden, N. J.; Charles Lennig & Co., Philadelphia, Pa.; The American Tin Plate Co., Ellwood, Ind., and the Stauffer Chemical Co., of San Francisco, Cal. Shipments of natural copperas from Steubenville, O., where it is formed by atmospheric oxidation of pyrite, has been discontinued, as it was found to be unprofitable. The price of copperas at New York at the commencement of 1902 was about $8 per ton, against an average of $10 per ton for the previous year. The price early in 1903 was $9 per ton. These quotations are for carload lots, an additional $2 per ton being asked for lots of smaller size. There is no opportunity for export of copperas, for the reason that England, France and Germany also produce it as a by-product in larger quantities and at a lower cost than it can be manufactured in the United States.

PROGRESS IN ELECTROCHEMISTRY AND ELECTROMETALLURGY IN 1902.

By John B. C. Kershaw.

Introduction.—The year 1902 has not been marked by any striking advance in the electrochemical or electrometallurgical industries, and the chief features of the year have been the consolidation and improvement of existing industries rather than the development of new ones.

The alkali industry is now practically stationary in Europe, although still expanding in America. The fall in the selling value of bleaching powder is likely to be severely felt by some of the older works. The aluminum industry is likewise stationary in Europe, and further progress would seem to depend upon cheapened production of the metal. In America, however, this industry is in a more healthy condition. The incubus of unwise company promotion and overcapitalization still weighs upon the calcium carbide industry. The stocks of carbide accumulated in the years 1899-1901 are only being slowly disposed of and at greatly diminished prices. The industry is now established on a firmer financial basis and sales bureaus control the output and price in all the leading producing countries. The electrolytic chlorate industry is another stationary manufacture, and at the low prices which rule at present there is little inducement for manufacturers to extend their works or to build new ones.

Perhaps the most striking developments of 1902 have been the attempts to utilize electricity on a large scale for the production of glass and for the smelting of iron and steel. Details of these industrial trials will be found under the respective headings later in this section. In my opinion the prospects of permanent success are not hopeful. The regenerative gas furnace and the blast furnace are the most efficient heating appliances known, and so long as fuel remains plentiful and cheap, it will be practically impossible for the electric furnace to compete with them.

At Niagara Falls two new industries are now passing through their experimental stages, and barium hydrate and nitric acid and nitrates are being manufactured by aid of the electric current. The direct production of nitric acid by high tension discharge is a most interesting attempt to realize the dream of Prof. Crookes, as set forth in the presidential address delivered before the British Association at Bristol in 1898. If these trials to obtain nitric acid from the air should prove a success financially, one of the great problems of agriculture (the continued supply of nitrates to the soil) will have been solved, and Niagara Falls in years to come, may provide the world with one of the necessaries for the maintenance of its staple industries, the growth of corn and wheat.

Alkalies and Bleach.—In The Mineral Industry, Vol. X., the electrolytic alkali and bleach industry was described at considerable length and the two latest additions to the rank of industrial processes—the Acker fusion process and the "bell" gravity process—were illustrated and described. The most important event during the year 1902 was the failure of the negotiations for the renewal of the arrangement between the United Alkali Co., of Liverpool, and the Elektron Co., of Frankfort, regarding the output and price of bleaching powder in 1903. For the past three years these two firms, representing the chemical and electrolytic manufacturers, respectively, have maintained the price of bleaching powder in Europe at the comparatively high level of $28·80@$31·20 per ton. The failure to renew the agreement signifies that a period of open competition is now to be entered upon, and very large sales of bleaching powder for delivery over the entire year 1903 are reported to have been made at the low prices of $16·80@$18 per ton.

That some of the electrolytic alkali works will be heavily handicapped by the fall of nearly 50% in the selling value of the product upon which they have relied chiefly for profits is certain, and it is equally certain that some of the smaller and less well-equipped works will be compelled to suspend operations. In a recent series of articles[1] I have discussed at considerable length the present position of the electrolytic alkali industry, and have attempted to forecast its future in view of this fall in the price of bleaching powder. The following extracts summarize the position and prospects of the various processes and companies now in operation in Europe and America.

America.—The total power now available for the manufacture of caustic alkalies and bleaching powder by electrolytic methods is 11,500 H.P., and this will be increased at an early date to 14,000 H.P. On the assumption that the whole of the chlorine liberated by this process is absorbed in the manufacture of bleaching powder, we find that 40,000 tons and 49,000 tons are the present and prospective totals, respectively, manufactured by the American electrolytic alkali works. This is certainly a large proportion of the home consumption, and the striking growth of the new industry in America accounts for the considerable fall in the British exports of bleaching powder.

United Kingdom.—The total available power at Middlewich and Weston Point for the production of alkalies and chlorine products is now between 5,000 and 6,000 H.P. When the additions to the first-named works are completed over 7,000 H.P. will be devoted to the electrolytic decomposition of salt, which will equal an aggregate production of about 25,000 tons bleaching powder per annum.

Germany.—The maximum output of the group of works at Griesheim, Bitterfeld and Rheinfelden is stated to be 25,000 tons of caustic potash and 40,000 tons of bleaching powder per annum. The electrolytic works of the Solvay Co., at Osternienberg, add about 5,000 tons to the latter total. The home demand for bleaching powder is therefore more than met by the output of the electrolytic works.

France.—The position of the electrolytic industry in France is not encour-

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[1] *Electrician*, Nov. 14, 28, and Dec. 12, 1902.

aging. Of five works planned or actually erected, only one appears to be in regular operation for the production of caustic alkalies and bleaching powder, and the output of this works (Lamotte) is not large. The greater portion of the bleaching powder produced in France is still supplied by the old Leblanc works. The total supply largely exceeds the home consumption, and one-third of the aggregate output is exported.

Switzerland.—The position of the electrolytic alkali industry in Switzerland is no more satisfactory than in France, and, although only two works have been erected, neither is applying all the power available to the manufacture of caustic alkalies and bleaching powder.

Other Countries of Europe.—Russia, Austria, Italy and Spain are all provided with electrolytic alkali works, operating under more or less favorable conditions of local supply and demand. In these outlying countries of Europe some development of the industry may be expected, for hitherto they have drawn their supplies of caustic alkalies and bleaching powder, chiefly from France, Germany and the United Kingdom.

The three tabular statements of efficiency and costs which are given below are based upon the most reliable figures for the various processes, and are reprinted from my article in the *Electrician* of Dec. 12, 1902.

CURRENT AND ENERGY EFFICIENCIES OF THE VARIOUS ELECTROLYTIC ALKALI PROCESSES.

Process.	E.M.F. Required in Volts.	Actual Yield in Grams.				Efficiencies. Per Cent.	
		Per Amp. Hour.		Per Kw. Hour.			
		NaOH.	Cl.	NaOH.	Cl.	Current.	Energy.
Wet Processes.							
Castner-Kellner	4·0	1·365	1·136	340	284	91	52·3
Hargreaves-Bird	3·4	1·196	1·057	351	310	80	54
Rhodin	5·0	1·349	....	269	....	90·2	41·4
Aussig "Bell"	4·9	1·308	....	266	....	87·5	40·9
Theoretical figures	2·3	1·495	1·322	650	574	100	100
Fusion Processes.							
Acker	7·0	1·370	....	195	....	91·6	54·9
Theoretical figures	4·2	1·495	1·322	356	314	100	100

Using the above figures, we find that to obtain 1 metric ton of 72% caustic soda by the various processes, the following numbers of kilowatt hours are required, and that the relative costs of power for the processes are as stated in column 3 of the table.

KILOWATT HOURS REQUIRED TO OBTAIN 1 METRIC TON OF 72% CAUSTIC SODA BY VARIOUS ELECTROLYTIC ALKALI PROCESSES, WITH THE RELATIVE COSTS FOR POWER AT 0·25D. PER KILOWATT HOUR.

Process.	Kilowatt Hours.	Cost at 0.25d. per Kw. Hour.
Castner-Kellner	2,735	£2 17 0
Hargreaves-Bird	2,649	2 15 2
Rhodin	3,457	3 12 0
Aussig "Bell"	3.496	3 12 10
Acker (fusion process)	4,769	4 19 4

In comparing the above costs, it must be remembered that the processes yield the caustic soda solution in various degrees of concentration and purity. The Acker process, in fact, is stated to yield solid 77% caustic direct from the decomposing vessel attached to the cell, and thus, in the case of this process, no additional costs are entailed for evaporating the cell solutions.

ESTIMATE OF CHIEF ITEMS OF COST FOR PRODUCING 1 TON OF 72% CAUSTIC SODA AND 2·1 TONS 35% BLEACHING POWDER BY TYPICAL WET AND DRY PROCESSES.

	Castner-Kellner.	Acker.
Power	£2 17 0	£4 19 4
Raw materials (salt and lime)	1 7 0	1 7 0
Fuel (for evaporating)	1 8 0	....
Packages	1 10 0	1 10 0
Totals	£7 2 0	£7 16 4

The year 1902 in the electrolytic alkali industry has been marked by unwonted freedom from patent litigation. The patent case referred to in THE MINERAL INDUSTRY, Vol. X., as pending between the Commercial Development Corporation and the Castner-Kellner Alkali Co. did not come into the courts. The explanation of this may be found in the fact that the plaintiff company is in financial difficulties, and in November, 1902, the shareholders decided upon liquidation.

Aluminum.—See the special article elsewhere in this volume.

Antimony.—Izart has described[2] an electrolytic process for obtaining antimony from its ores, which is reported to be working at Nakety, in New Caledonia. A diaphragm type of cell is used, with the antimony in solution as polysulphide. With an E.M.F. of 1·6 volts and a current density of 0·80 ampere per sq. d.c.m. a current of 76% efficiency is said to be obtained. The Siemens & Halske process is reported to be at work at Banya, in Hungary, and at Vienna, while a new process, of which no details are published, is stated to be in use at Cassagna, in France.

Arsenic.—The Westman process[3] for extracting arsenic from arsenical ores was briefly referred to in THE MINERAL INDUSTRY, Vol. X. No further details relating to the operation of the process by the Arsenical Ore Reduction Co., of Newark, N. J., have been published. The process has been criticized unfavorably by the *Electrical Times* (London), which points out that it would yield the arsenic in the form of metal, not of oxide, and that this metal would be contaminated with zinc, sulphur and antimony, which are volatile at a red heat.

Barium Hydrate.—A wet method for producing barium hydrate from barium sulphide has been patented in Brussels and London, and an experimental plant has been erected in the former city. The process depends upon the use of a mixed solution of chlorides and sulphides as electrolyte in a diaphragm type of cell. Barium hydrate separates at the cathode, and sulphur at the anode, the former being separated from the electrolyte by a centrifugal machine. So far the attempts to introduce this process into England have not been successful. (For the Bradley & Jacob process, see under the section "Barytes," elsewhere in this volume.)

Bullion Refining.—The Deutsche Gold- und Silberscheide Anstalt, of Frankfort, one of the pioneer firms in electrolytic refining, has increased its capital by

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[2] *L'Electricien*, July 19, 1902.

[3] English Patent No. 17,027, 1902.

$360,000 during 1902, and has paid a dividend of 16%. This company is, however, interested in several subsidiary undertakings connected with the cyanide industry, and this profit has not been earned solely by bullion refining. According to Danneel[5] the Norddeutsche Affinerie at Hamburg, is producing 100,000 kg. silver, 3,000 kg. gold and 12 to 15 kg. platinum per annum by the Wohlwill processes. The Wohlwill gold refining process has recently been adopted by the Freiburger and Halsbergen Huettenwerken.

Calcium Carbide.—The calcium carbide industry during 1902 has continued to suffer from the effects of the overcapitalization and overproduction which marked the "boom" years of 1897-1900, and a large number of the works erected for the production of carbide in Europe are still closed, or are applying the power available, to the manufacture of other electrometallurgical products. The position as regards patents is gradually becoming simplified by the decisions of the courts in the various countries. In the United Kingdom during 1902 the holder of the Wilson patents:—the Acetylene Illuminating Co., has lost its appeal case against the United Alkali Co., and therefore the manufacture of calcium carbide is now an open industry, as in Germany. In France and the United States the manufacture is still controlled by the Bullier and Willson patents respectively; but it is possible that during 1903 an attempt will be made to upset the monopoly held by the Union Carbide Co. in America. The ground of the decision against the validity of the Willson patents in the United Kingdom, was the prior publication by Moissan in the *Comptes rendus,* of the method of calcium carbide production in the electric furnace.

Carborundum.—There is little that is new to report concerning the manufacture of carborundum. The outer micro-crystalline portion of each charge formerly wasted, is now utilized in the manufacture of a fire-proof stone. According to Hutton and Petavel, the present output of carborundum amounts to 2,690 tons per year, and over one-third of this total is used instead of ferrosilicon in the steel industry.[6]

Chlorates.—The electrolytic chlorate industry is reported to be slowly expanding in America; but in Europe it is in a stationary position, and prices of sodium and potassium chlorate have fallen to a level which leaves little margin of profit for the producer. During 1902, Messrs. Gall and Montlaur, the pioneers in this industry, have been awarded the Kastner-Bonnsalt premium by the French Academie des Sciences, for their work in developing this new manuafacturing process. In France, 6,000 tons of chlorate are reported to be now produced per annum by the electrolytic process, but this total evidently includes the output of the factory at Valorbes in Switzerland. The most important patent granted during 1902 is British Patent No. 14,387, in which protection is claimed for the continuous addition of dilute hydrochloric acid to the electrolyte. Foerster & Müller have published papers relating to several important investigations during 1902. Limits of space will not allow of an abstract of these valuable and important additions to the knowledge of the theory of the electrolytic process.[7]

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[5] *Zeitschrift fuer Elektrochemie*, March 6, 1902.

[6] *Electrical Review*, London, Dec. 12. 1902.

[7] *Zeitschrift fuer Elektrochemie*, Jan. 2, July 31, Aug. 28, and Sept. 4, 1902.

Copper.—The output and price of raw copper during 1902 have been dealt with at length in *The Engineering and Mining Journal,* 1903, and it is only necessary to point out here that the break in price which occurred 13 months ago, has caused serious financial loss to the electrolytic refineries, which had accumulated large stocks of ingot copper at the higher figure, or had delivery contracts running for ingot copper at the date of the collapse in value. The French and German Elmore companies appear to have been among the most unfortunate sufferers in this manner. Both companies have been obliged to report serious losses to their shareholders during 1902, whereas, if there had been no break in price, satisfactory dividends would have been paid. The continuance of the slump in price is also causing many of the new mining and smelting companies, floated during the boom, to cease operations, and my prophecy concerning these companies (see THE MINERAL INDUSTRY, Vol. X., p. 256) is rapidly being fulfilled. With regard to the work of the English Elmore Co., at Hunslet Leeds, the reorganized plant is now in operation, and according to the report presented to the shareholders in May, 1902, an output of 25 tons of tubes per week was being attained in the early part of the year. The maximum capacity of this plant is 60 tons per week. There is nothing new to report concerning the ordinary electrolytic refining process in Europe, and no figures of any value have been published during 1902 for the output of the electrolytic refineries in either France or the United Kingdom.

Danneel, in an article upon electrometallurgy in Germany,[8] gives the following figures for the production in that country: Norddeutsche (1900), 800 tons; Mansfelder Gewerkschaft (1900), 965 tons; Altenau, 220 tons; Niedermarsberg, 1,000 tons; Schladern, 1,200 tons. The total copper production of Germany is stated to have increased in the last ten years from 24,700 tons to 32,000 tons, but these figures evidently refer to crude copper and not to electrolytic copper. A new refinery is being erected by the Cape Copper Co., at Briton Ferry, Wales. The Dessolle method of depositing copper is in use at the small works of Levallois-Perret in France. This method depends upon the use of a jet for forcing the electrolyte against the surface of the cathode. The rapid circulation obtained in this manner enables a current density of 750 amperes (presumably per sq. d.c.m.) to be used, and a deposit 1 mm. in thickness can thus be obtained in 15 hours.[9] It is questionable whether this patent could be maintained either in the United Kingdom or in America, since in both countries, previous trials of this method have been made. With regard to the Hoepfner process for extracting copper from its ores, no new information is available for publication; presumably the Papenburg works are still operating this process. The Keith extraction process, which was worked for a time at the mines of the Arlington Copper Co., New Jersey, has been very fully described by the inventor in a paper read during 1902.[10] Financial difficulties are reported to have caused the temporary suspension of work at these mines. An illustrated description of the Raritan Copper Works at Perth Amboy, has been published in the paper named below.[11] This is practically a brief summary of the detailed description which was published in THE MINERAL

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[8] *Zeitschrift fuer Elektrochemie*, March 6, 1902.

[9] *L'Electrochemie*, November, 1902.

[10] *Electrical Review*, New York, March 22, 1902.

[11] *Scientific American*, March 15, 1902.

INDUSTRY, Vol. IX. The Raritan refinery possesses 1,600 depositing vats, and its monthly output averages 11,000,000 lb. of copper.

Ferrochromium and Similar Alloys.—At Holcombe Rock, Virginia, the Willson Aluminum Co. is reported to be producing 150 tons of ferrochromium per month, in a modified form of the Willson electric furnace. The Carnegie and Bethlehem steel companies are believed to be using practically the whole of the American output of this alloy for the manufacture of the hardened chrome-steel for armor-plates. According to Krull, the crystalline product is preferred by the steel makers, possibly because it is purer than the other variety.[12] The erection of a works is planned at Orlu in the French Pyrenees, for the production of ferromanganese by the Simon process. In principle this process resembles the Heroult process for aluminum reduction. Manganese dioxide containing iron as an impurity is dissolved in a bath of molten calcium fluoride, and the mixture is electrolyzed at a temperature of 1,300°C. The reduction which occurs is partly chemical and partly electrolytic. The cost of the product, which contains 84% Mn, 8% Fe, and about 7% C, is reported to be $38·40 per ton.[13] The alloys or compounds of iron and silicon have been examined by Touve and by Lebeau. The product obtained by heating iron with excess of silicon in the electric furnace, is reported by the latter[14] to have the formula $FeSi_2$.

Ferrotitanium and similar alloys are being produced at Niagara Falls, N. Y., by A. J. Rossi, in a furnace absorbing 200 H.P. If a market can be created for such products in America it is probable that this industry will grow rapidly in magnitude and importance. At present the work carried out by Rossi would appear to be largely experimental in character. Full details of these experiments will be found in the paper read by Rossi before the Franklin Institute.[15]

Glass.—A brief reference was made by me in THE MINERAL INDUSTRY, Vol. X., to the proposed use of the electric furnace for glass manufacture. In spite of the unfavorable economic conditions which appear to render such use of the electric furnace doomed to failure, the two engineers, Becker and Völcker of Cologne, who have devoted time and attention to this subject, have been able to raise the capital required for trial of their electric-glass furnaces upon an industrial scale. At Matrei, in the Tyrol, the power originally developed for carbide manufacture, is to be applied to this new use, and furnaces to use 3,000 H.P. are now being erected. A similar works at Plettenburg in Germany, is reported to be already in operation. At this works 2,000 H.P. is available. The Aktien Gesellschaft fuer Elektrokeramic is the name of the company which has been floated to develop industrially the Becker and Völcker patents relating to glass manufacture. I am doubtful concerning the financial success of these attempts to compete with the regenerative gas furnace, and I shall be much surprised if the electric glass manufacture becomes an established industry, until the coal fields of Europe are more nearly exhausted than is the case at the present time.

Graphite.—(See page 343 of this volume.)

Hypochlorites.—Little information has been published during 1902, relating

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[12] *Elektrochemische Zeitschrift*, February, 1902.

[13] *Zeitschrift fuer Elektrochemie*, May 15, 1902.

[14] *Comptes rendus*, Vol 132, p. 681.

[15] *Journal of the Franklin Institute*, 1902.

to the progress of the electrolytic bleaching industry. The fall of 50% in the price of bleaching powder in Europe, will for the time stop expansion in the use of electrolytic bleach solutions, and possibly some of the plants already installed may be compelled to cease operations. Foerster & Müller have published details of laboratory investigations relating to the behavior of hypochlorite solutions on electrolysis.[16] A new form of electrolytic cell for producing hypochlorites, has been patented, and is described in the paper named below.[17] With this cell, a current of 50 amperes and 100 volts, is reported to produce 1 kg. active Cl per hour. This cell is manufactured by the Fabrik Elektrischer Bleichapparate at Pfronten in Bavaria. Ahlin has patented an improved process for bleaching wood-pulp, in which the exhausted hypochlorite liquors are emulsified with air, and are again used for bleaching the pulp. Remarkable effects, as regards the color of the bleached pulp,[18] are obtained, supposed to be due to mechanically held oxygen.

Iron and Steel.—The direct production of iron and steel in the electric furnace by heating the ores with the theoretically necessary weight of coke, has continued to receive much attention throughout 1902, and a very large number of patents are being taken out in connection with this use of the electric current. The unsatisfactory position of the calcium carbide market, and the closing down of a large number of the carbide works in Europe, has rendered it comparatively easy for the inventors to obtain trial of their processes on an industrial scale; and in every country of Europe where such works are in existence, experimental trials of the electrometallurgical processes for iron and steel production are now taking place. So far as the limits of space allow, the various patented processes are dealt with below:—

The Conley Furnace.—In this furnace the reduction is effected by contact of the ore and coke with transverse plates, placed in the throat of a conically-shaped furnace. A current is passed through these plates sufficient to keep them at a red heat, and the hearth of the furnace is further heated by an electrically heated belt. It is estimated that for a Conley furnace of 100 tons per day capacity, 5,000 E.H.P. would be required, and that steel could be produced at a cost of $11·85 per ton. The patents for this process are owned by the Electric Furnace Co. of New York, and it is stated that the company is now engaged in erecting an 8,000-H.P. plant at Elizabethtown, N. Y. The Massena Electric Steel Co. with a capital of $500,000, has also been formed to erect and work a similar plant at Massena.[19]

The Harmet Furnace.—The Harmet furnace consists of a smelting-furnace, a reduction furnace and a refining furnace, using both resistance and arc-heating. The waste-gases from the reduction and refining divisions of the furnace are utilized for heating the raw materials with which the furnace is fed. According to the inventor, 3,600 E.H.P. hours are required to produce 1 ton of steel at an estimated cost of $5·61.[20] The furnace is reported to be operating successfully at St. Etienne in France.

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[16] *Zeitschrift fuer Elektrochemie*, Aug. 28 and Sept. 4, 1902.

[17] *Elektrochemische Zeitschrift*, October, 1902.

[18] *Papier Zeitung*, Vol. 26, 1901.

[19] *Electrochemist and Metallurgist*, March, 1902.

[20] *L'Electrochemie*, July, 1902.

The Heroult Furnace.—This furnace is still undergoing industrial trial at Le Praz in Savoy. According to report, representatives of Schneider et Cie., of Creusot, have seen the Heroult process and furnace at work, but did not enter into negotiations for the purchase of the patents.

The Keller Furnace.—This furnace is based on the blast-furnace principle of construction, and both resistance and arc-heating are used. The furnace has been very fully described by Bertolus at the September (1902) Congress on "White Coal" in France. An experimental plant has been erected at Kerrousse, Morhiban, where 550 H.P. are available. According to the inventor, one metric ton of steel can be obtained in his furnace, with an expenditure of 2,800 K.W. hours of electric power; and the cost per ton is stated to be from $17·28 to $19·20.[21] The furnace at present in use at Kerrousse absorbs 375 H.P. A larger furnace for production of from 15 to 20 tons steel at one charge is to be erected. The developments at this place are controlled by the Compagnie Electrothermique Keller Leleux & Co., which is exploiting the Keller patents. New Zealand iron-sand from Taranaki is reported to be used as raw material at Kerrousse.

The Kjellin Furnace.—The operation of this furnace at Güssingen in Sweden, was referred to in THE MINERAL INDUSTRY, Vol. X. Little new information concerning this experimental plant has been published during 1902. According to a United States consular report, a larger furnace was to be erected and an output of 1,800 tons steel per annum with a 300-H.P. plant was contemplated.[22] This is equivalent to 1,162 kw. hours per ton of steel.

The Stassano Furnace.—Practically nothing has been published during 1902 relating to the progress made with the Stassano furnace trials in Italy, and it is impossible to say whether the plant erected at Darfo has realized expectations. It is, however, ominous that the Societa Elettro-sidercorgica Camuna, the company which was exploiting the process, has come to the end of its resources, and is now in liquidation.[23]

With regard to the prospects of these processes generally, I see as yet no occasion to revise the forecast given in an article written and published two and a half years ago. After an examination of the figures published for the operation of the experimental Stassano furnace in Rome (2,700 E.H.P. hours per 1 ton of steel), I stated my belief that the electric furnace methods of iron and steel production, could only hope to succeed in countries where fuel was expensive, water power abundant, and where heavy protective tariffs on iron and steel shut out products of the ordinary blast-furnace and Bessemer processes.[24] Given such conditions, in conjunction with a brisk home demand for the products, these electrical processes may pay. But this combination of favoring conditions is somewhat unusual, and the general adoption of electric furnace methods in iron and steel manufacture is improbable. Many of the present attempts in my opinion are doomed to failure.

Lead.—The process operated by the Electrical Lead Reduction Co., at Niagara Falls, N. Y., has been fully described during 1902, in a paper read by the inventor Mr. Pedro G. Salom before the newly formed American Electrochemical

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[21] *L'Eclairage Electrique*, Vol. 33, p. 45, 1902.

[22] *Electricity*, New York, July 30, 1902.

[23] *Zeitschrift fuer Elektrochemie*, Jan. 23. 1902

[24] *Electrical Review*, London, June 15, 1900.

Society.[25] Lead sulphide is used as cathode in an acid solution, and the reduction occurs as the result of the action of nascent hydrogen upon the sulphide, with the formation of spongy lead and hydrogen sulphide gas. The chief difficulties met with in operating the process are due to incomplete reduction of the sulphide, and to the escapes of H_2S gas. Two pounds of lead are stated to be obtained per E.H.P. hour. In August, 1902, a report was current in New York that the company was in financial trouble; and possibly the difficulties referred to above have proved insurmountable. A new electrolytic process for treatment of lead bullion is reported by Titus Ulke to be in use at Trail, B. C.[26] The process which has been patented by Anson G. Betts, is based on the solubility of lead in an acid solution of lead fluosilicate. The E.M.F. required to deposit the lead from this solution is only 0·2 volt; the slimes are worked up for gold and silver. The works using this process are designed for the treatment of 10 tons lead bullion per day, averaging 8,000 oz. gold and silver per ton.

Magnesium.—There is nothing new to report concerning the electrolytic method of producing magnesium from fused carnallite.

Molybdenum and Other Rare Metals.—In the United Kingdom a company entitled the Tungsten & Rare Metals Co. has recently been floated with a capital of $96,000 to purchase and work patents granted to Steinhart & Vogel for the production of rare metals. The methods by which these are to be obtained from their ores, are presumably electrometallurgical in character; $22,560 has been paid for the patents and the supervision by the inventors for five years.

Nickel.—The chief event of 1902 with regard to the nickel mining and refining industry has been the formation of the International Nickel Co., with a capital of $24,000,000. This company has absorbed the Nickel Corporation of London, and several other large companies interested in the metal, and with the Rothschilds of Paris, this company now practically controls the world's output of nickel. The following figures have been published during 1902 for the world production: 1899, 6,460 tons; 1900, 7,892 tons; 1901, 10,401 tons.

As regards the progress of the Hoepfner process at Papenburg in Germany, little fresh information has been published during 1902. Replying to statements that the process was a failure, Dr. L. Hoepfner has published official figures showing that in 1901, 150 tons nickel were produced at Papenburg, and that in April, 1902, the output of the metal at this works amounted to 800 kg. per day.[27]

The Frasch extraction process at Hamilton, Ontario, is reported to have failed, and the same result is believed to have attended the trial of the Hoepfner process at this place.

The development of nickel mining properties in the Sudbury district of Canada is proceeding rapidly, but the latest reports do not indicate that either electrometallurgical or electrolytic methods of treatment are yet being used tor the ores obtained. The pure nickel ore from this district is to be smelted with iron ore in ordinary blast furnaces at Saulte Sainte Marie. These furnaces are now being erected. The mixed ores of iron and copper are being smelted

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[25] *Electrical Times*, June 26, 1902.

[26] *Engineering and Mining Journal*, Oct. 11, 1902.

[27] *Zeitschrift fuer Elektrochemie*, April 24, 1902.

at the mines, and the matte thus obtained containing 16% Ni and 8% Cu, is to be purified by treatment in a Bessemer plant. An electrolytic refinery is projected for separating the nickel and copper in the refined matte, at Saulte Sainte Marie, but no details have been published concerning the process which is to be used. According to Ulke, the Browne process, the details of which have been worked out at the experimental works of the Canadian Copper Co., at Cleveland, Ohio, is the only electrolytic process for separating nickel and copper in actual use in America at present.[28] The process is based upon the use of the copper-nickel matte as anode material in an electrolyte composed of nickel and copper chlorides. The copper is deposited first from this electrolyte, and the last traces of copper and impurities are removed by a chemical treatment, before the nickel is deposited.

The development of the Mond process at Clydach, in South Wales, has been hindered during 1902 by strikes and by a mysterious illness among the workpeople. One of the men taken ill died in December, and medical experts are now engaged in trying to ascertain the cause of the trouble.

As regards the use of nickel and nickel-steel, there is little new to report. Capt. Longridge, in his paper upon "Motor-Car Construction," read before the Institution of Mechanical Engineers, in London, recommended the use of an alloy containing 5% Ni and 0·35% C for rivets, pins, springs, etc.[29]

Nitric Acid and Nitrates.—Darling has worked out the details of a process by which metallic sodium and nitric acid can be obtained by electrolysis of fused sodium nitrate, and the John Scott premium and medal have been awarded to the inventor by the Franklin Institute of Philadelphia, Pa. The chief feature of the invention is the use of the diaphragm walls as secondary anodes, in order to protect them from the action of the fused salts.[30] This process has not hitherto been applied upon an industrial scale, but it is possible that more will be heard of it. At Niagara Falls, N. Y., the production of nitric acid or nitrates by high tension spark discharges through the air, has been the subject of experiments for many months, and according to the latest report this method of producing combination of the oxygen and nitrogen of the air, promises to develop into a commercially successful process. The Atmospheric Products Co., with a capital of $1,000,000, has been formed to exploit the Bradley & Lovejoy patents relating to this process. The experimental plant absorbs 45 K.W., electrical energy, and a direct current of from 8,000 to 15,000 volts is used. Mechanical devices have been planned for breaking the 138 arcs 3,000 times per minute. The air after passing through the apparatus contains 2·5% nitrogen oxides. A 2,000-H.P. plant is to be erected shortly.[31] The fundamental idea of this process is old, but Bradley & Lovejoy are the first engineers who have obtained anything approaching commercial success with their experimental plant, and the dream of Sir William Crookes, of Niagara Falls supplying the world with sodium nitrate, is thus one step nearer realization.

Organic Products.—There have been a large number of laboratory researches relating to the electrolytic production of organic compounds, published during

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[28] *Electrochemische Zeitschrift*, December, 1902.

[29] *Engineering*, Nov. 7, 1902.

[30] *Journal of the Franklin Institute*. January, 1902.

[31] *Electrochemical Industry*, No. 1, September, 1902.

1902. As regards the industrial application of these methods, there is nothing to add to the paragraph devoted to this subject in THE MINERAL INDUSTRY, Vol. X.

Oxygen and Hydrogen.—There is nothing new to report relating to the commercial production of these gases by the electrolysis of water, beyond the publication of a hand-book devoted solely to this branch of the electrochemical industry. The author is Dr. Victor Engelhardt, of Vienna, and his work forms the first of a projected series entitled, *Monographien ueber angewandte Elektrochemie*, by authors who may be regarded as experts in the various subjects dealt with.

Ozone.—The year 1902 has been marked by a distinct revival of interest in the applications of ozonized air for water purification and sterilization. At Lea Bridge, London, the East London Water Co. has been carrying out experiments with this method of water sterilization. No official results of these trials have yet been published. In Holland the noted chemist, Prof. Van't Hoff, has been devoting some attention to the subject, and has read a paper describing trials with the Vosmaer-Lebret ozonizer and process at Schiedam. These trials were satisfactory, and it is possible that the process may be tried on a larger scale at Rotterdam.[32] In Germany, Siemens & Halske has devoted much attention to the problem, and has erected small plants which are operating on a commercial basis at Schierstein and at Paderborn, two small towns in western Germany. Satisfactory results are stated to have been obtained. Illustrated descriptions of these two installations may be found in the paper named below.[33]

As regards the Marmier & Abraham ozonizer and process, full details of which have appeared in earlier volumes of THE MINERAL INDUSTRY, a small plant has been erected in the brewery of M. Velten, at Marseilles, using a voltage of 30,000; a concentration of 12 g. ozone per cubic meter of air, is obtained with a discharge equivalent to 5 K.W. per sq. m. of electrode surface.[34]

Sodium, Sodium Peroxide and Sodium Cyanide.—There is little to add to the information given in THE MINERAL INDUSTRY, Vol. X., relating to the electrolytic production of metallic sodium, or of its derivatives, sodium peroxide and sodium cyanide. The English, German and French firms engaged in this industry convert most of their sodium into the peroxide or the cyanide. At Niagara Falls, N. Y., according to Prof. Richards, the Niagara Electro-Chemical Co. is employing 1,000 H.P. in the manufacture, and is producing daily 6,250 lb. of metallic sodium.[35]

Swinburne, in the presidential address delivered early in December in London before the members of the Institution of Electrical Engineers, referred to the attempts that have been made to electrolyze fused sodium chloride, and to separate metallic sodium and chlorine from this salt. Though these experiments failed he is still hopeful concerning this process, and predicts that in a few years metallic sodium will be sold for a few dollars per ton. In this connection, Darling's process for electrolyzing fused sodium nitrate (see nitric acid), and the laboratory research carried out by Le Blanc & Brode on the chemistry of the Castner process,[36] are of interest.

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[32] *Zeitschrift fuer Elektrochemie*, July 24, 1902.

[33] *Ibid.*, Nov. 27, 1902

[34] *Revue de Chimie Industrielle*, August, 1902.

[35] *Electrochemical Industry*, September, 1902.

[36] *Zeitschrift fuer Elektrochemie*, Sept. 11 and 18, 1902.

Tanning.—There is nothing to add to the information contained in THE MINERAL INDUSTRY, Vol. X., relating to the use of the electric current for tanning purposes.

Tin.—The electrolytic method of stripping tin from tin scrap and waste appears to be extending, and in a recently published memoir upon the subject[37] Mennicke gave a list of eight factories in Germany and Austria, where the electrolytic method is employed.

The consumption of tin scrap in Germany alone is said to reach 30,000 tons per annum, and as this is greater than the total production of the country, scrap is being imported from Switzerland and other countries. Mennicke recommends sodium hydrate as electrolyte, and it is believed that this is the process generally used. At Manchester, England, trial has been made with the Gelstharpe process, which is based upon the use of an electrolyte containing 1·25% hydrochloric acid free from arsenic, and a small percentage of sulphuric acid. Sixty tons of waste cuttings are said to have been treated by this plant.[38] Neuhardt has described the use of an electrolyte containing ammonium sulphate, and 10% sulphuric acid, but this process does not appear to have been worked on an industrial scale.[39]

As regards the electrolytic extraction of tin from ores or slags, Bergsoe has patented a process based on the use of a stannic chloride solution for leaching the ore. It is doubtful if this will be successful, since the difficulties that have checked the development of the Hoepfner process for extracting copper, will be met with in this procedure. The Robertson & Bense process for the treatment of slags at Tostedt, in Germany, has been referred to in previous reports, and the only new fact concerning this process is that the plant at Tostedt is to be enlarged.

Zinc.—The electrolytic zinc industry has not made much progress during 1902. At the Winnington works of Brunner, Mond & Co., England, where the Hoepfner process is employed, 1,663 tons of zinc are said to have been obtained up to April 30, 1901, together with 5,000 tons of bleaching powder as a by-product. The present output is reported to be 3 tons zinc, and 9 tons bleach per day.[40] The bulk of this company's output of zinc is reported to be used, after alloying with copper, for the manufacturing of cartridge cases.

As regards the Swinburne & Ashcroft fusion process (see THE MINERAL INDUSTRY, Vol. X.), the erection of the plant at Weston Point, Lancashire, has been completed during 1902, but the patentees in answer to direct inquiry state that at present, they prefer to say nothing concerning the progress made with the development of the process. (See also under the caption "Zinc," elsewhere in this volume.)

The Casaretti & Bertani process for the treatment of zinc ores in the electric furnace and volatilization of the zinc by heat, which was referred to in THE MINERAL INDUSTRY, Vol. X., does not appear to have yet been tried upon an in-

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[37] *Zeitschrift fuer Elektrochemie*, May 22, June 5 and 12, 1902.

[38] *Electrochemist and Metallurgist*, December, 1901.

[39] *Chemiker Zeitung*, Jan. 15, 1902, and German Patent No. 118,358, 1902.

[40] *Zeitschrift fuer Elektrochemie*, April 24, 1902.

dustrial scale. An illustrated description of the furnace and details of its working will, however, be found in the journal named below.[41]

The Strozda process (see THE MINERAL INDUSTRY, Vol. X.) is reported to be in operation at two works in Germany. According to Danneel its success is doubtful. The electrolytic process introduced at Friedrichshütte for parting silver and zinc, has proved unsuccessful, and according to the same authority its use is to be dropped.

Borchers in a paper read before the general meeting of the "Verein" of German chemists in May, 1902, gave details of several electrolytic processes for extracting zinc from mixed ores and other materials now wasted. Blende carrying lead sulphide is charged into a revolving drum containing a dilute solution of sodium chloride, and chlorine gas is passed into the mixture. The sulphur separates in solid form, and the metals are converted into chlorides and pass into solution. The solution is freed from the insoluble gangue by filtrations and from impurities by chemical treatment; after concentration and fusion the mixed chlorides are electrolyzed. Zinc ores containing heavy spar as an impurity, can also be worked by this method. For zinc ores containing silicates Borchers recommends Dorsenmagen's procedure, which is based on reduction in an electric furnace with distillation of the zinc and formation of silicon carbide. This same procedure can also be applied to mixtures of iron and zinc sulphides, sufficient quartz being added to convert all the iron into ferrosilicon.

As regards electro-galvanizing, there is little that is new to report. Each country now possesses one or more of these works, but the electrolytic method does not extend rapidly, and its competition with the older dipping method is hardly felt. Paweck has patented the use of boric acid and borates in the galvanizing baths.[42] I am unable to say whether this addition is being employed in any of the electro-galvanizing works situated in France or other European countries.

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[41] *Elektrochemische Zeitschrift*, December, 1902.

[42] French Patent No. 318,168, 1902.

FELDSPAR.

THE statistics of the production of feldspar in 1902 are not yet available, but the output in 1901 amounted to 31,019 long tons, valued at $220,422, as compared with 29,447 long tons, valued at $136,773 in 1900, and 26,968 tons ($137,886) in 1899. During 1902, veins of feldspar were worked in Connecticut, Maryland, Maine, New York and Pennsylvania.

For a detailed account of the occurrence, mining and uses of feldspar, reference may be made to the article by T. C. Hopkins in THE MINERAL INDUSTRY, Vol. VII.

PRODUCTION OF FELDSPAR (CRUDE AND GROUND) IN THE UNITED STATES IN 1901.

State.	Crude.		Ground.	
	Quantity.	Value.	Quantity.	Value.
	Short Tons.		Short Tons.	
Connecticut	3,514	$4,902	7,275	$49,956
Maine	896	2,400	(a)	(a)
New York	1,060	1,000	3,344	20,600
Pennsylvania and Maryland	4,490	13,367	14,162	128,197
Totals	9,960	$21,669	24,781	$198,753
Totals in long tons	8,893	21,669	22,126	198,753

(a) Included with New York.

PRODUCTION OF FELDSPAR IN THE UNITED STATES IN 1898, 1899 AND 1900.

State.	1898.		1899.		1900.	
	Long Tons	Value.	Long Tons.	Value.	Long Tons.	Value.
Connecticut	6,696	$37,944	11,104	$61,311	13,166	$63,872
Maine and Pennsylvania	12,954	58,953	14,644	71,755	14,481	65,901
Massachusetts	150	525	160	560	800	2,800
New York	1,550	9,725	1,060	4,240	1,000	4,200
Totals	21,350	$107,147	26,968	$137,866	29,447	$136,773

The price of feldspar did not vary throughout the year 1902, the ground product bringing $8@$9 per short ton, as compared with $7 per short in 1901. In 1901, unground feldspar was sold in bulk at the mine from $3@$6 per short ton.

FLUORSPAR.

By Henry Fisher.

The production of fluorspar in the United States continues to be derived chiefly from the mines in Crittenden, Caldwell and Livingston counties, Ky., and Hardin and Pope counties, Ill., and in 1902 the quantity produced was 27,127 short tons, valued at $143,520, as compared with 19,586 short tons, valued at $113,803, in 1901. The producers of fluorite were the Kentucky Fluor Spar Co., the Fluorspar Co., Western Kentucky Mining Co., and Lucile Mining Co., all of Marion, Ky.; the Eagle Fluorspar Co., at Salem, Ky., the Rosiclaire Lead & Fluorspar Mines at Rosiclaire, Ill., and the Tennessee Fluor Spar Co., at Nashville, Tenn. Early in 1902, the Kentucky Fluor Spar Co., which has been the chief producer of fluorspar in recent years, absorbed The Fluorspar Co., and is now by far the largest producer in Kentucky. This company and the Rosiclaire Lead & Fluorspar Mines produced nearly 80% of the total output during 1902.

PRODUCTION OF FLUORSPAR IN THE UNITED STATES. (IN SHORT TONS.)

Year.	Tons.	Value.	Per Ton	Year.	Tons.	Value.	Per Ton	Year.	Tons.	Value.	Per Ton
1891....	6,320	$38,000	$6·00	1895.....	4,000	$24,000	$6·00	1899.....	24,030	$152,655	$6·35
1892....	9,000	54,000	6·00	1896.....	6,000	48,000	8·00	1900.....	21,656	113,430	5·24
1893....	9,700	63,050	6·50	1897.....	4,879	36,264	7·65	1901.....	19,586	113,803	5·81
1894....	6,400	38,400	6·00	1898	12,145	86,985	7·16	1902.....	27,127	143,520	5·29

For the American market fluorspar is divided into six grades, namely, American lump No. 1, American lump No. 2, gravel, crushed, ground fine, and ground extra fine. The foreign product appears in two grades only—lump and fine.

The prices for fluorspar per short ton during 1902 did not change throughout the year, and were as follows: American lump, first grade, $14·40; second grade, $13·90; gravel and crushed, first grade, $13·40; second grade, $12·40; ground, first grade, $17·90; second grade, $16·50. The prices of the foreign fluorspar were: lump, $8@$12; ground, $11·50@$14. The average value of fluorspar per short ton, f. o. b. at mines, was: lump, $5; gravel, $4.

Arizona.—The fluorspar mined at Castle Dome, Yuma County, is being shipped to California, where it is used in the manufacture of Portland cement.

Illinois.—Golconda, on the Ohio River, is the shipping point of the southern Illinois fluorspar fields. The Illinois Central Railroad now extends from Golconda to Reevesville, and will help the development of the mineral resources of both Pope and Hardin counties. The Rosiclaire mine, at Rosiclaire, operated by the Rosiclaire Lead & Fluorspar Mines has attained a depth of 300 ft. in the main shaft, and has four levels, the first at a depth of 100 ft. and the other three 50 ft. apart. The levels have been driven 700 ft. on each side of the shaft. At the 300-ft. level the vein of spar is 20 ft. wide. The company's mill has two large boilers and hoisting engines, an engine for operating the washing plant, crusher, bucket elevator, five sets of jigs and a Griffin mill for crushing. The large lumps of spar are separated by hand, the rest being crushed, screened to four sizes and jigged. The capacity of the mine is 100 tons of spar per day. The Fair View mine near the Rosiclaire mine has been recently sold to a new company after having been idle for 15 or 20 years. The old mill is being dismantled, a new building erected, and improved machinery added. The Lead Hill mine owned by the Hardin County Mineral & Mining Co., four miles north of Cave-in-Rock, began operations in 1902. The Empire Mining Co. of Cleveland, O., is mining fluorspar, lead, and zinc at the Empire mine, 15 miles from Golconda. The Grand Pierre Lead & Zinc Mining Co. is also developing its fluorspar property in Pope County. There are other fluorspar mines in this county, not as yet developed, owing to lack of transportation facilities.

Kentucky.—The Western Kentucky Mining Co. sold its property to a new corporation, the Columbia Mining Co., which is now erecting a plant. The Columbia mine, where lead was mined 25 years ago, and which was abandoned when lead was discovered in Colorado, is being re-opened and will be worked for lead and fluorspar. The Kentucky Fluor Spar Co. owns and operates the Memphis, Yandell and Hodge mines. At the Yandell mine, the workings extend over an era of 1,000 ft. and three shafts each 100 ft. deep have been sunk. At the Hodge mine, at a depth of 100 ft. a 20-ft. vein is being developed. This company not only mines the mineral, but buys the production of nearly all the small operators. The National Lead, Zinc & Fluor Spar Co., of Cleveland, O., has erected a 100-ton concentrating plant at the Marble mine near Crider, Caldwell County. Two 100-ft. shafts have been sunk. The Bonanza mine, near Salem, is being operated by the American Lead, Zinc & Fluor Spar Co., of Cleveland, O. At the Cullen mine, owned by the Eagle Fluorspar Co. experiments are being made to separate the fluorspar and the zinc blende contained in the ore.

Tennessee.—Flourspar is being mined near Rome, Smith County, by the Tennessee Fluor Spar Co. and shipped to Nashville. The fluorspar occurs in crystalline masses in a vein, reported to be 100 ft. wide in some places, and assays from 92 to 98% CaF_2, no zinc or lead being present. The material is easily mined and the cost is said to be only 75c. per ton.

PRODUCTION OF FLUORSPAR IN THE PRINCIPAL COUNTRIES OF THE WORLD. (*a*)
(IN METRIC TONS.)

Year.	France.	Germany.					Spain.	United Kingdom	United States.	Total.
		Anhalt.	Bavaria.	Prussia.	Saxony.	Schwarzburg.				
1897	2,722	7,000	4,904	10,095	592	641	2	803	4,299	34,678
1898	3,077	6,415	4 440	11.863	775	294	5	507	11.018	38.394
1899	5.140	5.815	3 631	12.932	1.355	573	310	796	21.800	52.352
1900	3,430	3.028	7.456	13.820	(*b*) 2.019	987	4	1.472	19.646	54.862
1901	3.970	5.707	5,220	14,973	(*b*) 1,825	1,016	*Nil.*	4,232	17.768	54.711

(*a*) From the official reports of the respective countries except the United States, for which the totals are based on direct returns of the producers, and for Anhalt, Saxe-Weimar and Schwarzburg-Sonderhausen, which are due to the courtesy of Herr von Scheel, director des Kaiserlichen Statistischen Amts. (*b*) Includes 557 metric tons from Saxe-Weimar in 1900, and 210 metric tons in 1901.

THE USE OF SODIUM FLUORIDE FOR THE PURIFICATION OF WATER.

BY CHARLES A. DOREMUS.

MECHANICAL filtration of water was first applied on a large scale during the summer of 1888. Later in that year attempts were made near New York to use caustic alkali to soften water, but with very unsatisfactory results; and numerous tests were made with various chemicals to precipitate the lime and magnesia contained in the waters in common use, sodium fluoride being finally selected. This salt, however, could not be purchased, so that when in May, 1889, a patent for its use as a precipitant for lime and magnesia in water was granted in the United States and in Europe, the question of getting a supply of the salt became a serious one. It was thought that a cheap and abundant supply could be easily obtained from cryolite, a compound consisting of 51% NaF, the sale of which in the United States was in the hands of the Pennsylvania Salt Manufacturing Co. This company manufactured, at its works at Natrona, Pa., the first large quantity used in this country, but the price was excessive and the sodium fluoride had to be obtained elsewhere, chiefly from fluorspar and soda ash.

Repeated attempts have been made to find a simple method to cheapen the manufacture of this article. In 1900 I patented a method which consists in treating the cryolite with superheated steam. The fluorine of the cryolite is liberated as hydrofluoric acid, while the residue consists of sodium aluminate, a commercial product. Thus the cryolite in its entirety is rendered useful. The small quantity of impurities—iron, lead, etc.—is left as a residue on leaching out the sodium aluminate. The small proportion of silica is evolved as hydrofluosilicic acid, or it can be removed by one of the several methods in common use. Experiments with this process on a large scale have not been a commercial success.

The chief use of sodium fluoride is to prevent incrustations in steam boilers. The precipitated calcium and magnesium fluorides form a non-adherent sludge which is easily blown out, and as the calcium or magnesium salts present react to form fluorides, the grains per gallon of calcium and of magnesium need only be known in order to calculate the weight of sodium fluoride necessary to precipitate them. If water is to be softened, the chemically equivalent proportion of sodium fluoride must be added, but in practice one-quarter of the theoretical quantity will prevent incrustation, the physical properties of the sludge preventing the precipitated calcium and magnesium salts from adhering to the sides of the boiler.

FULLERS EARTH.

BY HENRY FISHER.

THE production of fullers earth in the United States during 1902 was 14,100 short tons, valued at $109,980, as compared with 14,112 short tons, valued at $96,835 in 1901. The greater part of the product continues to be supplied from the mines at Quincy, Fla., the balance being obtained from the mines in Arkansas, California, Colorado, Georgia, and New York.

Imports.—The imports of fullers earth in 1902 were 13,513 long tons, valued at $102,580, as compared with 10,769 long tons, valued at $80,697 in 1901.

New York Market.—The consumption of English fullers earth during 1902 was greater than it has been for a number of years; the demand for the earth was steady and active throughout the year. It has been used in preference to the domestic product for refining vegetable and animal oils. Owing to the fact that the bulk of the domestic production is generally contracted for in advance, quotations remain practically unchanged throughout the year. Prices for ordinary lump during 1902 were 75c. per 100 lb., and for powdered, 85c. per 100 lb. during the first half of the year, and 80c. per 100 lb. during the second half.

Arkansas.—The Arkansas Fullers Earth Co. did no mining in 1902, but sank more prospect shafts and developed the ore bodies on its property.

Florida.—According to T. W. Vaughan[1] fullers earth occurs near River Junction, Mosquito Creek and Quincy in Gadsden County; near Tallahassee, Leon County, and near Alachua, Alachua County. The deposits vary in thickness up to 10 ft. The fullers earth varies in its bleaching properties, but it is not equal to the English product. Analysis shows: SiO_2, 36·73 to 70·78%; Fe_2O_3 and Al_2O_3, 11·38 to 30·99%; CaO, 0·81 to 6%; MgO, 0·64 to 3·15%; H_2O, 7·72 to 10·3%, and moisture, 6·41 to 7·45%. The Chesebrough Manufacturing Co. in February, 1902, discontinued the mining of fullers earth and the product from Florida is now limited to the Owl Commercial Co. at Quincy and the Standard Oil interests at Manatee. The latter company does not mine the product, but purchases it direct from small producers.

Georgia.—Fullers earth occurs near Attapulgus, Decatur County, Ga. Ten pits have been sunk in the deposit of earth which varies in width from 2·5 to 9 ft.

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[1] *Contributions to Economic Geology*, United States Geological Survey, 1902, p. 392.

Two samples analyzed showed SiO_2, 55·90% (57·26%); Al_2O_3, 12·40% (18·33%); Fe_2O_3, 2·40% (1·87%); CaO, 1% (2·58%); MgO, 8·12% (1·06%); H_2O, 10·50% (9·40%); and moisture, 9·40% (9%). Deposits of fullers earth occur also in this county near Sears, Wolffs and Withlacooche creeks.

France.—In 1901, France produced 3,400 metric tons of fullers earth, valued at $3,400, as compared with 3,700 metric tons, valued at $3,580 in 1900. The output in 1901 was obtained near Louviers in the Department of Eure.

Turkey.—Fullers earth is quarried on a large scale in Turkey, the deposits extending over 60 miles in length. The mines are located mainly in the caza of Eskichehir in the Kutahia district, between the Poursaktchai and the Sakaria Rivers. In the caza of Killis there is a mine which has been in operation many years, the product being exported to all parts of Syria and Anatolia.

TECHNOLOGY.

In his paper[2] entitled Experiments on the Diffusion of Crude Petroleum through Fullers Earth, Dr. D. T. Day reviews a series of experiments, which he has carried on during the past five years, on the changes which take place when crude oils are diffused through various substances. Quartz sand, amorphous silica and powdered limestone exhibit practically no selective action. Different clays show greatly differing capacities for separating the oils; the greatest effectiveness being secured as the clay approaches fullers earth in composition and texture. When crude petroleum was allowed to pass through finely powdered fullers earth, it became separated into a series of oils differing in color and specific gravity from the original product. The fractions varied in color from dark brown to clear white, and the specific gravity from 0·70 to 0·85. The differences in the resulting products are entirely physical, no chemical changes whatever taking place during the process of diffusion.

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[2] Read at the meeting of the Geological Society of Washington, April 22, 1903; abstract in *Science*, June 26, 1903, p. 1007.

GARNET.

The production of garnet for abrasive purposes in the United States during 1902 amounted to 3,722 short tons, valued at $88,270, as compared with 4,444 short tons, valued at $158,100 in 1901. The output was derived mainly from the mines in the vicinity of Ticonderoga, N. Y. The prices for garnet remained unchanged throughout the year, being $25@$35 per short ton, according to quality. In New York there were no new developments during 1902, the output of garnet for abrasive purposes in the North Creek section being but slightly greater than that of 1901. H. H. Barton & Sons, of Philadelphia, Pa., continues to mine its supply of garnet for its sandpaper factory in Philadelphia from its mine located on Gore Mountain. The North River Garnet Co. mines and concentrates during the summer months enough garnet to supply the demands for the Adirondack mineral of the other large sandpaper manufacturers. A new mine has been opened in St. Lawrence County by the Gouverneur Lead & Garnet Co. The ore is composed mainly of quartz containing very small pink garnets, unlike the standard Adirondack mineral. This company has erected a concentrating plant, and is trying to establish a market for its product. The concentrates carry a considerable percentage of quartz.

The geology and mineralogical character of the Adirondack deposits and the preparation and uses of the mineral product are given in THE MINERAL INDUSTRY, Vol. VI., pp. 20-22.

GEMS AND PRECIOUS STONES.

BY JOSEPH STRUTHERS AND HENRY FISHER.

THE value of the precious stones produced in the United States in 1902 was $318,300, as compared with $289,050 in 1901. Of the total, the value of the sapphires and turquoises produced aggregated $245,000. In 1902, the imports were as follows: uncut diamonds, $8,230,735; cut diamonds, $13,852,949; other uncut precious stones, $52,025, and other cut precious stones, including natural pearls, $4,641,339; a total of $26,777,048.

The following table gives the value of the production of precious stones in the United States, according to Mr. George F. Kunz:—

Variety.	1901.	1902.	Variety.	1901.	1902.
Agate	$1,000	$1,000	Peridot	$500	$500
Agate (moss)	500	500	Pyrite	3,000	3,000
Amazon stone	200	500	Quartz, crystal	10,000	12,000
Amethyst	500	2,000	Quartz, gold	2,000	3,000
Anthracite ornaments	2,000	2,000	Quartz, rose	150	200
Arrow points	500	....	Quartz, rutilated	50	100
Beryl (aquamarine, etc.)	5,000	4,000	Quartz, smoky	1,000	2,000
Catlinite (pipestone)	2,000	2,000	Quartz, tourmalinated	1,000	....
Chlorastrolite	3,000	4,000	Rhodolite	21,000	1,500
Chrysoprase	1,500	10,000	Ruby	500	....
Diamond	100	....	Sapphire	90,000	115,000
Emerald	1,000	1,000	Silicified wood	7,000	7,000
Fossil coral	100	....	Tourmaline	15,000	15,000
Garnet (almandite)	100	....	Turquoise	118,000	130,000
Garnet (pyrope)	1,000	1,000	Utahlite (variscite)	250	....
Malachite	100	....			
Mesolite (thomsonite)	1,000	1,000	Total	$289,050	$318,300

DIAMONDS.—*United States.*[1]—There were no diamonds found during 1902, as compared with an output valued at $100 in 1901. There was, however, a diamond discovered in a meteorite from Cañon Diablo, at the foot of Crater Mountain, Ariz. The stone is of irregular shape and so hard that when attempts were made to cleave and to polish it, two chisels were broken and an emery wheel ruined.

South Africa.—The report of the De Beers Consolidated Mines, Ltd., for the fiscal year ending June 30, 1902, shows that the value of the diamonds sold amounted to £4,687,194. After deducting expenditures of £2,524,485, the profit balance for the year was £2,162,709. The balance brought forward from the previous year amounted to £1,277,342, which, added to the profit balance, together with interest and revenue from various sources, increased the balance to

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[1] The diamond deposits in the United States were fully described by William H. Hobbs in THE MINERAL INDUSTRY, Vol. IX., pp. 301–304.

£3,560,280. From this amount dividends and bonuses amounting to £2,445,000, and life governors' remuneration of £316,594 were paid, leaving a balance of £798,696 to be carried forward. The output of blue ground was 4,347,641 loads, equal to 3,478,113 short tons; 3,734,241 loads were washed, yielding 2,025,224 carats of diamonds. There were also 1,151,816 loads of tailings treated, yielding 202,830 carats of diamonds, and 18,728 carats of diamonds were recovered from old concentrates. The average yield per load of blue ground and lumps from the De Beers and Kimberley mines for the fiscal year was 0·76 carat, at an average value of 46s. 5·7d. per carat. The average yield per load for the Premier mine at Wesselton was 0·3 carat valued at 33s. 5·9d. per carat. The average yield from the Bultfontein mine was 0·21 carat, valued at 30s. 4·7d. per carat. At the Dutoitspan mine 4,916 loads of débris were washed producing 218 carats of diamonds. A diamond weighing 67·5 carats was found in the Premier mine, but on account of its irregular shape will be cut down to about 30 carats. Its value is estimated to be $15,000. The stock of blue ground and lumps on the floors of the De Beers and Kimberley mines at the end of the fiscal year was 2,630,040 loads; at the Premier mine, 1,573,914 loads, and at Bultfontein mine, 480,934 loads. Operations at the mines were hindered by the war and the resultant difficulty of getting labor, coal and supplies. The report of the Kamfersdam Mines, Ltd., for the year ending June 30, 1902, states that 517,899 loads of blue and yellow ground were hauled and washed, yielding 51,857 carats of diamonds. The diamonds sold realized £40,513, and the stock on hand was valued at £23,745. The total income was £64,741, and expenditures £58,365, leaving a balance of £6,376, which, with the balance brought forward from the previous fiscal year, makes the present balance on hand £17,448. The Orange Free State & Transvaal Diamond Mines, Ltd., report for the four years ending Dec. 31, 1902, an expenditure of £17,699, and an income of £1,151. At the end of 1902 there was on hand cash amounting to £11,320 and diamonds valued at £45,165, also a large quantity of blue ground ready for washing. The Lace Diamond Mining Co., Ltd., reports that between May 12 and Dec. 31, 1902, 142,060 loads of material were washed, and 16,562 carats of diamonds, valued at £21,412 obtained. The cost of recovering the diamonds was £19,913, leaving a profit of £1,499. The profit and loss account at the end of the year showed a balance of £13,661. The output of diamonds for the second half of 1902 from Christiana, as reported by the Transvaal Mines Department, was 759·25 carats, valued at £1,983. A new plant for the treatment of diamondiferous earth is being erected in the Pretoria district. It is estimated that it will treat 200 loads per day. The diamonds sell for 30s. per carat. Cape Colony in 1901 produced 2,747·2 carats diamonds, valued at £5,259, as compared with 1,803 carats, valued at £3,212 in 1900. The exports in 1902 were valued at £5,427,360, as compared with £4,930,104 in 1901. Diamonds have been found on a farm 24 miles from Griquatown. A reef of blue whitestone rock has been discovered, and two shafts have been sunk. By washing one lot of 20 loads, 40 diamonds have been obtained, and 120 diamonds were obtained from another lot of 50 loads. It is also reported that diamonds have been found at Sydney on the Vaal River.

The phenomena of the diamondiferous deposits have been discussed by

E. F. Heneage in a paper read before the Institution of Mining and Metallurgy, Nov. 20, 1902.

An article on diamond mining at Kimberley appeared in *The Engineer*, Jan. 16, 1903, p. 59, and Jan. 30, 1903, p. 115.

These deposits are also described by G. F. Williams in his valuable book on *The Diamond Mines of South Africa*, The Macmillan Co., 1902.

Australasia.—The output of diamonds in New South Wales in 1902 is estimated at 11,995 carats, valued at £11,326, as compared with 9,322 carats, valued at £9,756 in 1901. The diamonds were chiefly obtained from the Boggy Camp in the Copeton district, the mines in operation being the Star of the South, Malacca, and Elliott's mine. Diamonds were also found by prospectors while searching for stream tin. In October, 1902, the Monte Cristo mine, in the Bingara division, resumed operations after a long period of idleness. The Inverell Diamond Field Co., Ltd., operating on an alluvial deposit which yields per load 1·25 carats of diamonds, valued at 28s., and tin worth 8 to 9s., is in financial trouble, and the future policy of the company is still unsettled. The Soldier's Hill Diamond & Tin Mining Co., having exhausted its mine, has removed the plant to a prospecting area at Staggy Creek. During 1901, a few diamonds were found in an alluvial deposit near the Abercrombie River in the Cowra district, of which some were reported to be of a high value. The Australia Diamond Mining Proprietary Co. was engaged in removing its plant, and did no mining during 1901.

Brazil.—The Brazilian Diamond & Exploration Co., Ltd., capitalized at £225,000, obtained in September, 1902, the privilege of operating for a period of 90 years in the Republic of Brazil. Two-thirds of its capital must be raised within two years from the date of the privilege.

According to H. W. Furniss, the State divides the diamond region into 14 districts: Lençoes, Andarahy, Chique Chique, Santa Isabel, Cravada, Lavrinha, Campestre, Morro do Chapero, Bom Jesus, S. Ignacio, Chapada Velha, Paraguaçu, Sincorá and Cannavieiras, each region taking the name of the town near its center. Geologically there are but two sections, one in the central portion of the State along the Paraguaçu River, and the other in the southern part along the Pardo River. The Paraguaçu region is about 172 miles long and from 3 to 16 miles wide, the most productive area being in the foothills to the southeast of Serra das Lavras Diamantinas. The original rock is granite, frequently broken by gullies and crevasses. Sandstone and a conglomerate composed of round water-washed pebbles and a very hard matrix occur with the granite, and in these diamonds are found. The diamond-bearing material is called "cascalho." One method of mining is by removing the surface disintegration, or mining by tunnels between the boulders into the pockets in the deposit and taking out the cascalho. The cascalho is collected for a week, when it is washed, either by pouring it into ditches of running water and agitating it with a hoe, or by washing small quantities in large wooden basins. In the former case, arrangements are made to catch the heavy mass containing the diamonds, which is then washed in large wooden basins, the rock being hand picked. Another method of mining, carried on mostly on the Paraguaçu River, consists in diving to the bottom of the river and removing the silt till the underlying layer of clay or stone is reached. This latter method of obtaining the stones is centered near the village of Tamandoá, where six diving machines are located. Two men are employed to a machine, diving alternately. Each man remains below the water three hours and loads the cascalho into sacks. Diving without the use of the machine is also done.

The State owns all the diamond-bearing fields, and leases them from one to ten years to the highest bidder. A claim consists of not less than 29,040 sq. m., nor more than 484,000 sq. m. All diamonds exported are subjected to a tax of 13%. The output averages about 2,500 carats of diamonds a month. Stones of more than 0·75 carat are bought at $24 per carat, between 0·5 and 0·75 carat at $7·20 per carat, and less than 0·5 carat at about $2·75 per carat. In 1901, a stone weighing 577 carats was found and was sold by the miner for $17,380. The stones are classified as: *bons, fazenda fina, mellé, vitriar,* and *fundos. Bons* comprise stones of good color and form; *fazenda fina,* small stones of good quality and various colors; *mellé,* off-colored and imperfect stones; *vitriar,* small stones of good shape and luster, but of various colors, and *fundos,* small, imperfect, and badly colored or broken stones. The diamonds found in the Cannavieiras district are clearer and more perfect than those in the Paraguaçu district. In this district, State concessions of about 9 sq. miles have been granted, three to native Brazilians and one to a French company. There are several cutting factories in the diamond regions and one in the City of Bahia. The diamonds are exported to London and Paris.

British Guiana.—The output of diamonds in 1902 was 173,744 stones weighing 11,518·5 carats. The output in 1901 was valued at $56,050. In 1902 there were exported 12,565 carats, valued at $124,464, as compared with 4,406 carats, valued at $56,057 in 1901. The output is from three districts: in the north on the Barima River, between Jumbo and Five Star creeks and 60 miles southeast at Jauna on the Barima River; in the valley of the Mazaruni and Putareng rivers, and south of Georgetown in the Omai district on the Potaro, a tributary of the Essequibo River. The diamonds are found in a siliceous clay formation. No deep mines have been found, and as yet prospectors have confined their operations to the surface. New discoveries have been made on the Essequibo River, on the Konawaruk Creek, a tributary of the Essequibo, and on the Cuyuni River, but the Massaruni and Potaro are the only fields regularly worked. The question of transportation is still a difficult one, and it was suggested that a tramway be built to extend the Bartica-Caburi road to the diamond fields. The Massaruni Diamond Mines, Ltd., has been capitalized in London at £10,000, in £1 shares, to acquire 45 claims owned by the Lucky Jim Syndicate in the Massaruni district. The Massaruni Co., Ltd., is operating new machinery. The Massaruni British Guiana Diamond Syndicate in the early part of 1903 produced 60 carats of diamonds per week. Other companies operating in the Massaruni district are the Demarara Diamond Co., the Maharba Syndicate, and the Hatton Garden Syndicate. Work, however, has been retarded by litigation in connection with the location of some of the claims.

Dutch East Indies.—The estimated output of diamonds from Western Borneo was 1,972 carats in 1899, and 1,950 carats in 1898.

India.—Very little is being done in the diamond industry in India. Workings are still carried on by the Madras Diamond Co. at Vajrakarur, but this company made no output during 1902, nor did the Bundelkhand alluvial mines of Central India produce any diamonds.

Dr. Albert Ludwig[2] showed that diamonds could be obtained by subjecting carbon to strong gaseous pressure (pressures to 3,100 atmospheres being used) at a low temperature in the presence of iron, or at the melting point of carbon without using such a contact agent. For the purpose, he imbedded an iron spiral in powdered retort carbon and raised it to a red heat in an atmosphere of hydrogen by means of the electric current.

M. Chaumet[3] has discovered that a close relationship exists between the fluorescent property and the brilliancy of diamonds under artificial light, especially candle light, which brings out the quality of the stone. Diamonds which are non-fluorescent when exposed to violet light, become violet themselves, the brilliant stones showing a fluorescence of a very luminous and clear blue.

Technology.—A patent has been granted to F. E. Hilliard[4] for a machine for grinding and polishing gems, which consists of a standard, adjustable both vertically and horizontally, which carries a screwed shaft-support capable of being revolved about the standard and fixed in any position and at any desired angle. Adjustment pins on the side regulate a pointer on a scale or small dial at the top of the machine, showing the exact inclination at which the stone is held by the shaft. It is claimed that it is possible so to adjust the position of a stone that a series of facets, four, eight or more, may be cut on a piece of gem material at any given angle, and each angle and facet be mathematically symmetrical.

EMERALDS.—There was no change in the value of emeralds produced in the United States during 1902, the outputs in 1901 and 1902 being valued at $1,000 each. The Colombian Government during 1901 offered for sale or lease the emerald mines of Muzo and Coscuez. These mines have been worked continuously for more than three centuries. The annual output is not reported by the companies working the mines. The Somondoco Emerald, Ltd., owning mines in Columbia, in its report for the year ending June 30, 1902, states that its operations were hindered by the revolution. Its expenditures during the year amounted to £2,436, and the emeralds on hand were valued at £500. Emeralds are also mined near Minne, Norway, although no statistics of production are obtainable.

OPALS.—The production of opals in New South Wales in 1902 was valued at £140,000, as compared with £120,000 in 1901. About 1,100 miners were employed during 1902. Operations were carried on with extreme difficulty on account of the severe drought, which lasted until the month of November. Several fine specimens were found at White Cliff during 1902; one specimen weighed 17 oz., and another weighing 13 lb. was a solid mass of gems. One part of this specimen, estimated to weigh 22 oz. is brilliant, and after being polished, will be the finest opal extant. There was only a slight decrease in the value of the opals produced in Queensland in 1902, although the conditions

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[2] *Chemical News*, LXXXVII., Jan. 1, 1903.

[3] *Comptes rendus*, 134, (20), pp. 1139-1140.

[4] United States Patent No. 701,879, June 10, 1902.

under which mining was carried on were unfavorable. The output of opals in 1902 was valued at £7,000 as compared with £7,400 in 1901. Owing to the lack of rain, 200 men were employed in 1902, as compared with 293 in 1901, and no attempts were made to prospect new country. The output was obtained from the districts of Yowah, Eromanga, Jundah, Opalton, Duck and Horse Creeks. Two new discoveries were reported in the Eromanga district; one called Brown's Last Chance is located about 7 miles south of the Mascotte mine, and the other, the Federal mine, 4 miles northwest of the Exhibition mine. The first parcel of opals from the Federal mine realized £150. Transactions between producers and buyers are now almost entirely carried on by mail, as the expense and loss of time experienced by the buyers were too great. This, however, also has its disadvantages, as the New South Wales opal, as mined, is 90% matrix, which greatly adds to the expense of postage. Although milky white, resinous, bluish and brown jasperoid varieties of the common opal are found at Bothwell, on the Clyde River, Tasmania, no specimens of precious opal have as yet been found. The common opal occurs also in the Gelantipy district, Victoria. An opal mine at Niagara, Western Australia, was sold to an English company for £3,500. A parcel of 119 tons was treated and yielded 83 oz. 12 dwt. of gems. As there has been a large output of Australian opals in 1902, and as the cutting and polishing costs but 12s. per gross in Germany, the price of the crude stone has fallen considerably.

RUBY.—In 1901, the production of rubies in India was 210,784 carats, valued at $384,417, as compared with 214,856 carats (value not stated) in 1900. Rubies are produced only in Upper Burma, the mines being at Mogok, where in 1901 the Burma Ruby Mining Co., Ltd., employed 1,237 persons and produced 210,784 carats of rubies ($384,417), 9,786 carats of sapphires, and 10,241 carats of spinel. The dirt is raised to the surface by endless rope from open quarries excavated to a depth of 50 ft. It is crushed in rotary pans and separated by pulsators and hand picking. The power is supplied either directly from Pelton wheels or by electricity generated at a distance of two miles from the mines. A number of workings are operated by natives who pay royalty to the Burma company, the royalty in 1901 amounting to $81,500.

M. Chaumet[5] states that Siamese rubies under the action of violet light scarcely fluoresce, while all Burmese rubies fluoresce intensely and exhibit a clear, vivid red light; by this means stones from the two districts can be distinguished.

SAPPHIRES.—In 1902, the output of the New Sapphire Mines Syndicate, operating the Yogo mines in Fergus County, Mont., was about 200,000 carats of sapphires. The sapphires occur in a dike of trap-rock in white and grey limestone. The dike extends over a distance of five miles. Occasionally stones as large as 5 carats have been found. The stones are obtained by means of sluice boxes fitted with Hungarian riffles, the boxes being given a slight pitch in order to prevent the stones from being carried over the riffles. During the winter of 1902, 15 men were employed at the New Syndicate mines, and extensive development work was done on the property, including the opening up of the

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[5] *Comptes rendus*, 134, (20). pp. 1139-1140.

lead and the erection of a new hoist. The largest stone found by this company weighed 9 carats. The stones are sent to New York and London to be cut. The American Gem Mining Co. produced about 50,000 carats of sapphires in 1902, which were cut by lapidaries in Helena, Mont. The Northwest Sapphire Co., of Butte, Mont., is mining sapphires on the Dry Cottonwood placers in Deer Lodge County, Mont., by means of a hydraulic. Stones of various colors are found in the gravel. It is reported that sapphires have been found near Culling's Well, Ariz.

In 1901, the Burma Ruby Mining Co., Ltd., India, produced 9,786 carats of sapphires ($3,768), as compared with 7,239 carats in 1900.

The production of sapphires in Queensland in 1902 was valued at £5,000, as compared with £6,000 in 1901. During 1902, the drought in the Anakie fields retarded the industry, which was further hindered by the low prices obtained for the sapphires. The surface workings are being exhausted, and the deeper deposits will soon have to be worked.

According to B. Dunstan the sapphires from Anakie, Queensland, have certain peculiarities in color, being either parti-colored or of a very deep and non-uniform blue, which by artificial light appears almost black, a characteristic which distinguishes them from sapphires found in other parts of the world. The bright green and yellow shades which are also found in this field have no optical peculiarities. The sapphire fields comprise Retreat, Sheep Station, Policeman, Tomahawk and Central Creeks. In some cases the wash is clayey and requires puddling before the sapphires can be extracted, in other cases it is loose and friable and free from clay, and the sapphires can be obtained by "dry sieving." In these deposits other precious stones are found also, notably ruby, topaz, peridot, chrysoberyl, amethyst, moonstone, cat's eye, cairngorm, diamond and tourmaline.

TURQUOISE.—Turquoises are obtained from more than ten localities in Alabama, California, Colorado, Nevada, New Mexico and Arizona. The most extensive deposits exist in New Mexico; valuable mines occurring in the Burro Mountains near Silver City, and about the Hachitas and Jarillas Mountains as far south as Lascruces. There are six companies operating the mines: The American Turquoise Co., the Azure Mining Co., the American Turquoise & Copper Co., the Toltec Mining Co., the Himalaya Mining Co., and the Silver City Turquoise Co. The formation in which the turquoise is found varies greatly. Near Santa Fé, the matrix is usually a white trachyte stone filled with crystals of pyrite, the matrix in some cases being red sandstone. In the Burro Mountains, the formation is red quartz, slender needles of which penetrate the turquoise deposit. In the Hatchitas Mountains, the matrix is a red granite. The turquoise is mined by sinking a shaft, blasting the rock, breaking it into shape by means of sledge hammers, putting the pieces into buckets, hoisting them to the surface by windlass, sorting the pieces, packing them into boxes and shipping to the cutters. Most of the material is shipped to New York.

In Western Australia, turquoise has been found by a copper company while developing its property in the Murchison district. The stone occurs in pockets in a highly ferruginous sandstone near copper and gold veins, and some blocks have been found weighing 100 lb.

In Egypt, a turquoise deposit is being worked by the Egyptian Development Syndicate in the Sinai Peninsula. The stone usually occurs as a lining to cavities and fissures in sandstone, and it varies both in color and hardness. Small specimens have also been found near Eridia. Turquoise veins are found 40 miles from Nishapur in Khorassan, Persia. The annual rental charged by the Government for the lease of the mines amounts to £4,800, and the value of the gems produced considerably exceeds this sum.

OTHER GEMS.—During the 15 years ending December, 1902, California produced tourmaline valued at $20,500. The San Diego Tourmaline Mining Co., capitalized at $500,000, bought the Gail Lewis tourmaline mines at Mesa Grande, San Diego County, Cal. The company is also establishing a cutting and polishing plant at San Diego. The deposit of chrysoprase in Tulare County, Cal., is being developed, and a new deposit of this stone has been discovered near Sugar Loaf, Cal., and another deposit has been located at Buncombe County, N. C. An amethyst mine has been opened in South Carolina, and two new deposits have been found in Virginia.

GOLD AND SILVER.

BY JOSEPH STRUTHERS, D. H. NEWLAND AND HENRY FISHER.

THE production of gold in the world during 1902 was 14,414,186 fine oz., valued at $297,960,910, as compared with 12,606,183 fine oz., valued at $260,877,429 in 1901. This increase was due chiefly to the United States, Mexico, Rhodesia, Australasia, and the Transvaal.

During the year 1902 the United States was passed by Australasia, which now occupies the foremost position as a gold-producing country, followed by the United States, Transvaal and Russia, in the order named. These four countries produced in the aggregate about 75% of the total world's production of gold in 1902. The largest individual increase in gold output was in the Transvaal, amounting to 1,465,419 oz., valued at $30,310,211, due to the declaration of peace and the resumption of work in the mines. Should the production of gold in the Transvaal continue to increase at this rate, it will require but a year or two for it to attain the record output of the year 1898.

PRODUCTION OF GOLD IN THE UNITED STATES.

State or Territory.	1899.		1900.		1901.		1902.	
	Fine Ounces.	Value. (a)	Fine Ounces.	Value. (a)	Fine Ounces.	Value. (a)	Fine Ounces. (c)	Value. (a)
Alaska	247,944	$5,125,000	364,385	$7,531,835	333,096	$6,885,700	403,730	$8,345,099
Arizona	124,577	2,575,000	131,834	2,725,000	197,515	4,083,000	198,933	4,111,945
California	730,527	15,100,000	757,136	15,650,000	817,121	16,891,400	812,319	16,790,634
Colorado	1,282,471	26,508,675	1,391,486	28,762,036	1,339,678	27,693,500	1,377,175	28,466,207
Idaho	84,664	1,750,000	100,000	2,067,000	90,427	1,869,300	71,352	1,474,846
Montana	233,147	4,819,157	249,153	5,150,000	229,495	4,744,100	211,571	4,373,173
Nevada	107,644	2,225,000	97,910	2,023,803	143,374	2,963,800	140,059	2,895,020
New Mexico	24,190	500,000	36,284	750,000	33,302	688,400	25,693	531,074
Oregon	62,893	1,300,000	79,342	1,640,000	87,950	1,818,100	87,881	1,816,500
South Dakota	282,944	5,848,464	320,513	6,625,000	313,446	6,479,500	336,952	6,964,798
Southern States (b)	8,466	175,000	11,127	230,000	11,402	235,700	15,404	318,400
Utah	166,909	3,450,000	200,296	4,140,000	178,513	3,690,200	173,886	3,594,224
Washington	32,656	675,000	38,703	800,000	28,082	580,500	13,166	272,141
Other States	2,164	44,725	3,145	65,000	2,104	43,500	1,879	38,839
Total domestic	3,391,196	$70,096,021	3,781,310	$78,159,674	3,805,500	$78,666,700	3,870,000	$79,992,800
Foreign	1,423,449	29,422,691	1,948,519	40,275,888	1,730,856	35,776,794	1,689,991	34,932,211
Grand total	4,814,645	99,518,712	5,729,829	118,435,562	5,536,356	114,443,494	5,559,991	114,925,011
Total domestic—kg	105,471	....	117,611	....	118,363	....	120,369	....
Total foreign—kg	44,274	....	60,605	....	53,835	....	52,564	....
Grand total—kg	149,745	....	178,216	....	172,198	....	172,933	....

(a) 1 oz. gold = $20·67; 1 kg. = $664·60. (b) Virginia, South Carolina, North Carolina, Georgia, Alabama and Texas. (c) Estimate furnished by Mr. G. E. Roberts, Director of the United States Mint.

GOLD PRODUCTION OF THE WORLD.

Countries.	1900.			1901.			1902.		
	Fine Ounces.	Kilograms.	Value.	Fine Ounces.	Kilograms.	Value.	Fine Ounces.	Kilograms.	Value.
AMERICA, NORTH:									
United States	3,781,310	117,604·6	$78,159,674	*h*3,805,500	118,363·3	$78,666,700	*h*3,870,000	120,369·5	$79,992,800
Canada	1,350,176	41,992·4	27,908,153	1,183,465	36,807·4	24,462,222	1,003,447	31,210·4	20,741,245
Newfoundland	2,400	74·6	49,608	2,110	65·6	43,613	4,000	124·4	82,680
Mexico (*a*)	455,204	14,158·3	9,409,063	499,725	15,554·2	10,329,816	546,373	16,994·0	11,293,524
Central America	38,703	1,203·7	800,000	42,332	1,316·7	*e* 875,000	45,960	1,429·8	*e* 950,000
AMERICA, SOUTH:									
Argentina	2,112	65·7	43,655	2,112	65·7	43,655	2,900	90·2	*e* 60,000
Bolivia	7,257	225·7	*e* 150,000	7,257	225·7	*e* 150,000	7,257	225·7	*e* 150,000
Brazil	127,820	3,975·4	2,642,060	133,636	4,156·5	2,762,248	146,898	4,569·0	3,036,381
Chile	43,541	1,354·2	*e* 900,000	21,771	677·1	*e* 450,000	24,189	752·4	*e* 500,000
Colombia	111,272	3,460·7	*e* 2,300,000	100,145	3,114·7	*e* 2,070,000	101,597	3,159·8	*e* 2,100,000
Ecuador	9,676	300·9	200,000	12,700	394·9	*e* 262,500	13,304	413·8	*e* 275,000
Guiana (British)	110,640	3,441·0	2,286,918	92,032	2,862·3	1,902,301	88,492	2,752·6	1,829,137
Guiana (Dutch)	27,082	842·3	559,793	24,203	752·8	500,276	18,892	587·6	390,498
Guiana (French)	68,353	2,126·0	1,412,857	101,340	*b* 3,152·0	*b* 2,094,698	115,744	*e*3,600·0	2,392,428
Peru	52,480	1,632·3	1,084,750	80,369	2,499·6	1,661,234	82,245	2,558·0	*e* 1,700,000
Uruguay	2,283	71·0	47,187	1,587	49·3	32,799	1,608	*e* 50·0	33,237
Venezuela	49,194	1,530·0	1,016,838	38,704	1,203·8	*e* 800,000	38,704	1,203·8	*e* 800,000
EUROPE:									
Austria	2,279	70·9	47,120	1,498	46·6	30,970	1,498	*e* 46·6	30,970
Hungary	105,143	3,270·1	2,173,308	105,931	3,294·8	2,189,724	105,931	*e*3,294·8	2,189,724
France	6,527	203·0	134,914	*Nil.*	....	....	*e Nil.*	....	....
Germany (*c*)	3,601	112·0	74,435	2,894	90·0	59,814	2,894	*e* 90·0	59,814
Italy	1,849	57·5	38,215	132	4·1	2,725	132	*e* 4·1	2,725
Norway	87	2·7	1,794	129	4·0	2,658	129	*e* 4·0	2,658
Portugal	84	2·6	1,728	64	2·0	1,323	64	*e* 2·0	1,323
Russia	1,072,434	33,354·2	22,167,201	1,253,592	38,988·5	25,911,744	1,183,379	36,803·8	24,460,044
Spain	377	11·7	7,800	515	*b* 16·0	10,645	515	*e* 16·0	10,645
Sweden	3,414	106·2	70,580	2,016	62·7	41,671	2,016	*e* 62·7	41,671
Turkey	375	11·6	7,751	1,479	*b* 46·0	30,571	1,479	*e* 46·0	30,571
United Kingdom	12,760	396·8	263,749	5,189	161·2	107,267	5,189	*e* 161·2	107,267
AFRICA:									
Transvaal	348,760	10,846·9	7,208,869	238,991	7,432·9	4,939,944	1,704,410	53,012·7	35,250,155
Abyssinia	33,865	1,053·3	700,000	33,865	1,053·3	*e* 700,000	33,865	1,053·3	*e* 700,000
Rhodesia	79,354	2,468·0	1,640,251	148,753	4,626·4	3,074,730	172,899	5,377·7	3,573,822
Soudan	2,701	84·0	55,826	2,701	*e* 84·0	55,826	2,701	84·0	55,826
West Coast	36,284	1,128·5	*e* 750,000	30,000	933·0	620,100	19,352	601·9	*e* 400,000
Madagascar	33,471	1,041·0	691,849	26,332	*b* 819·0	544,282	26,332	*e* 819·0	544,282
Mozambique	8,475	263·6	*e* 175,176	12,377	384·9	255,840	7,257	263·3	*e* 150,000
ASIA:									
Borneo (British)	19,873	616·9	410,098	12,095	376·2	*e* 250,000	12,095	376·2	*e* 250,000
China	208,031	6,470·1	4,300,000	145,138	4,514·0	3,000,000	193,517	6,019·0	*e* 4,000,000
East Indies (Dutch)	26,609	827·5	550,000	27,425	853·0	566,875	31,800	958·0	657,306
India (British)	512,710	15,946·0	10,597,712	455,870	14,178·2	9,422,855	468,495	14,571·7	9,683,798
Japan	68,485	2,130·0	1,415,508	79,729	2,479·9	1,647,998	*e* 79,729	2,479·9	1,647,998
Korea	87,882	2,733·3	1,816,525	111,272	3,460·9	*e* 2,300,000	217,706	6,771·4	*e* 4,500,000
Malay Peninsula	17,048	530·2	352,382	18,338	570·4	379,037	*e* 18,338	570·4	379,037
AUSTRALASIA (*d*)	3,568,279	110,978·5	73,756,325	3,719,103	115,676·1	77,174,268	3,989,083	124,073·4	82,454,344
Unspecified (*f*)	21,771	677·1	450,000	21,771	677·1	450,000	21,771	677·1	450,000
Totals	12,522,031	389,453·0	258,829,702	12,606,183	392,096·8	260,877,429	14,414,186	448,331·2	$297,960,910

(*a*) Figures based on exports and coinage. (*b*) As reported by the *Statistique de l'Industrie Minerale*. (*c*) Includes output from domestic ores only. (*d*) Six States and New Zealand. (*e*) Estimated. (*f*) Includes Servia, Persia, West Indies, Formosa, British New Guinea and Philippine Islands. (*h*) Statistics reported by Mr. George E. Roberts, Director of the United States Mint.

NOTE.—The value of gold is $20·67 per Troy ounce, which is equivalent to $664·60 per kilogram.

The production of silver in the world during 1902 amounted to 163,936,704 Troy oz., valued at $85,479,547, as compared with 174,851,391 Troy oz., valued at $102,769,792 in 1901, a decrease in production of 10,914,687 oz. The United States no longer occupies the first position, being passed by Mexico, which during the year 1902 showed an increase in the output of silver of 2,829,995 oz. The United States and Mexico produced collectively nearly 70% of the total output of the world during 1902.

PRODUCTION OF SILVER IN THE UNITED STATES.

State or Territory.	1899.		1900.		1901.		1902.	
	Troy Ounces.	Commercial Value (*a*)	Troy Ounces.	Commercial Value. (*a*)	Troy Ounces. (*b*)	Commercial Value. (*a*)	Troy Ounces. (*b*)	Commercial Value. (*a*)
Alaska.......	150,000	$89,370	200,000	$122,660	47,900	$28,237	92,000	$47,987
Arizona......	2,000,000	1,191,600	1,750,000	1,073,275	2,812,400	1,657,910	3,043,100	1,587,281
California....	600,000	357,480	1,170,902	718,114	925,600	545,641	900,800	469,857
Colorado.....	23,114,688	13,771,731	20,336,712	12,472,500	18,437,800	10,869,083	15,676,000	8,176,602
Idaho........	4,800,000	2,859,840	6,100,000	3,741,130	5,542,900	3,267,540	5,854,800	3,053,864
Michigan	....	....	....	....	81,000	47,750	110,800	57,793
Montana	16,850,735	10,039,680	17,300,000	10,610,090	13,131,700	7,741,137	13,243,800	6,907,966
Nevada......	575,000	342,585	1,300,000	797,290	1,812,500	1,068,469	3,746,200	1,954,018
New Mexico.	550,000	327,690	550,000	337,315	563,400	332,124	457,200	238,476
Oregon......	140,000	83,412	150,000	91,995	160,100	94,379	93,300	48,665
South Dakota	350,000	208,530	210,000	128,793	78,000	45,981	340,000	177,344
Texas........	450,000	268,110	525,000	321,983	472,400	278,580	446,200	232,738
Utah.........	7,183,107	4,279,695	9,569,183	5,868,780	10,760,800	6,343,492	10,831,700	5,649,815
Washington..	300,000	178,740	300,000	183,990	344,400	203,023	619,000	322,870
Others.......	63,284	37,705	100,000	61,330	43,100	25,408	45,100	23,523
Totals ...	57,126,834	$34,036,168	59,561,797	$36,529,250	55,214,000	$32,458,653	55,500,000	$28,948,800

(*a*) The average value in 1899, 59·58c.; in 1900, 61·33c.; in 1901, 58·95c., and in 1902, 52·16c. (*b*) Figures furnished by Mr. George E. Roberts, Director of the United States Mint.

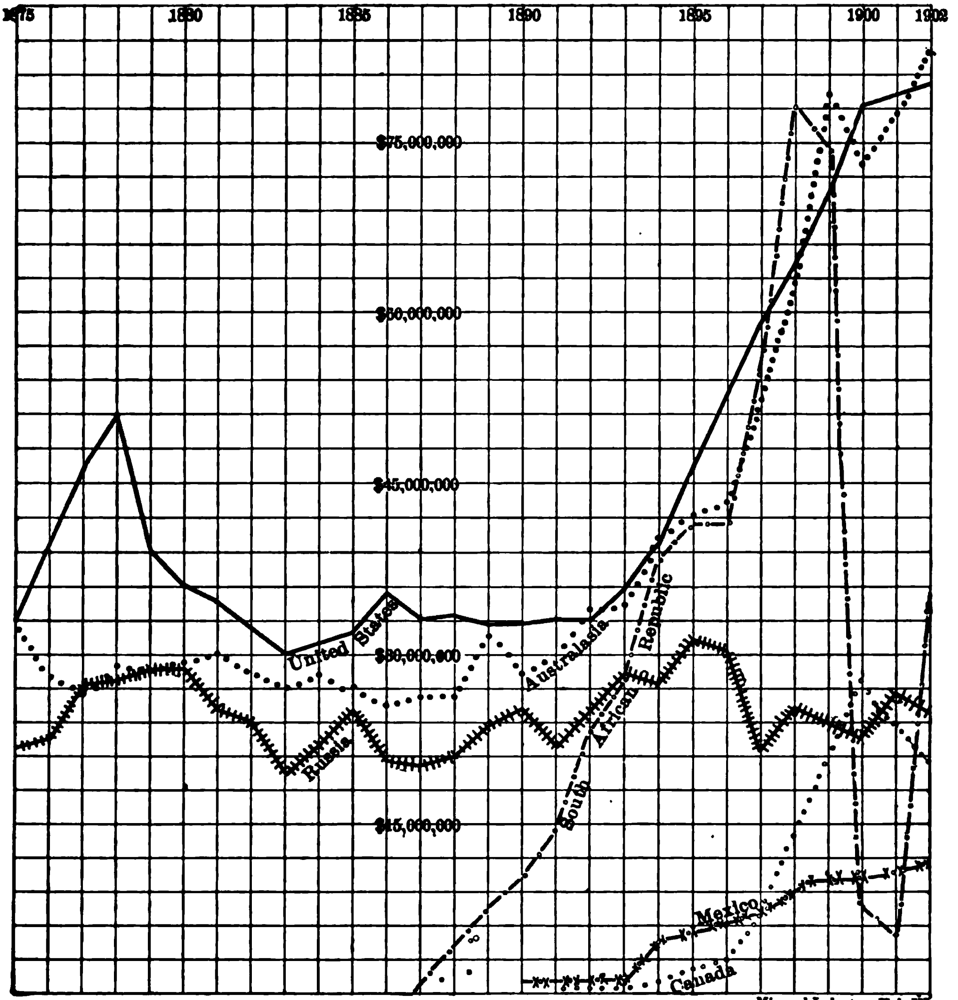
SILVER PRODUCTION OF THE WORLD.

Countries.	1901.			1902.		
	Troy Ounces.	Kilograms.	Commercial Value.	Troy Ounces.	Kilograms.	Commercial Value.
AMERICA, NORTH:						
United States.....................	55,214,000	1,717,333·8	$32,458,653	*f* 55,500,000	1,726,229·4	$28,948,800
Canada	5,539,199	172,287·0	3,265,356	4,372,986	136,014·0	2,280,955
Mexico (*a*)........................	55,152,840	1,715,416·0	32,512,304	57,962,335	1,803,438·0	30,243,655
Central America..................	1,072,095	33,345·6	632,000	*e* 1,200,000	37,323·9	625,920
AMERICA, SOUTH:						
Argentina.........................	*e* 150,000	4,665·4	88,425	*e* 150,000	4,665·4	78,240
Bolivia...........................	9,439,294	293,592·4	5,564,464	*b* 7,500,000	233,274·2	3,912,000
Chile.............................	2,199,003	68,365·0	1,296,312	*b* 1,650,000	51,320·3	860,640
Colombia.........................	2,520,000	78,380·1	1,485,540	*e* 2,520,000	78,380·1	1,314,432
Ecuador..........................	84,818	2,638·1	50,000	*e* 50,000	1,555·2	26,080
Peru (*a*)...........................	4,276,083	133,000·0	2,520,749	4,276,083	*e* 133,000·0	2,230,410
EUROPE:						
Austria...........................	1,351,950	40,205·0	762,005	1,351,950	*e* 40,205·0	674,288
Hungary..........................	727,770	22,636·0	429,020	727,770	*e* 22,636·0	379,606
France...........................	384,076	*g* 11,946·0	226,413	384,076	*e* 11,946·0	200,334
Germany (*c*)......................	5,522,802	171,777·0	3,255,689	5,522,802	*e* 171,777·0	2,880,700
Greece...........................	1,100,754	34,237·0	648,894	1,100,754	*e* 34,237·0	574,154
Italy.............................	1,043,750	32,464·0	615,290	1,043,750	*e* 32,464·0	544,422
Norway..........................	147,895	*e* 4,600·0	87,184	147,895	*e* 4,600·0	77,142
Russia...........................	157,058	4,885·0	92,585	146,898	4,569·0	76,622
Spain............................	5,947,935	185,000·0	3,506,305	5,947,935	*e* 185,000·0	3,102,450
Sweden..........................	50,059	1,557·0	29,510	50,059	*e* 1,557·0	26,111
Turkey...........................	480,400	*g* 14,942·0	283,196	480,400	*e* 14,942·0	250,577
United Kingdom..................	175,287	5,452·0	103,332	175,287	*e* 5,452·0	91,430
ASIA:						
Dutch East Indies.................	85,000	2,643·8	50,107	119,825	3,726·9	62,501
Japan............................	1,763,135	54,839·2	1,039,367	1,763,135	*e* 54,839·2	919,658
Australasia.......................	10,848,420	337,420·9	6,395,144	9,724,538	302,464·6	5,072,330
Other countries (*d*)................	48,226	*e* 1,500·0	28,429	48,226	*e* 1,500·0	25,155
Totals...........................	174,851,391	5,438,443·2	$103,769,792	163,986,704	5,097,116·2	$85,479,547

(*a*) Statistics compiled from exports and coinage. (*b*) Statistics furnished by H. R. Wagner. (*c*) Silver produced from domestic ores only. (*d*) The output is mostly from China and Persia. (*e*) Estimated. (*f*) Estimate furnished by Mr. George A. Roberts, Director of the United States Mint. (*g*) From the *Statistique de l'Industrie Minerale.*

NOTE.—Unless specified to the contrary, the statistics have been taken from official sources or have been collected directly from the producers by THE MINERAL INDUSTRY. The average commercial value of silver for 1901 was 58·95c. per ounce, equivalent to $18·958 per kilogram. The value for 1902 was 52·16c. per ounce, equivalent to $16·77 per kilogram.

During the period from 1875 to 1899 the production of gold in the world increased from $115,576,598 (173,904 kg.) to $311,505,947 (468,695 kg.), a gain of more than 170%. In the fifteen years following 1875 there was little change in the annual output, the totals ranging between the high mark of $123,513,916 (185,847 kg.) for 1878, and the low mark of $95,185,564 (144,727 kg.) for 1883. From 1890, when the production was $119,600,000 (181,256 kg.), the growth has been very rapid, owing to a variety of causes, chief among which are the application of the cyanide and chlorination processes in treating refractory ores, the development of the South African fields and the discovery of the gold placers of Alaska. A marked decline in the output occurred in 1900, when operations in the Transvaal mines were suspended by the war, and some time must elapse before the production in this country again reaches normal proportions.

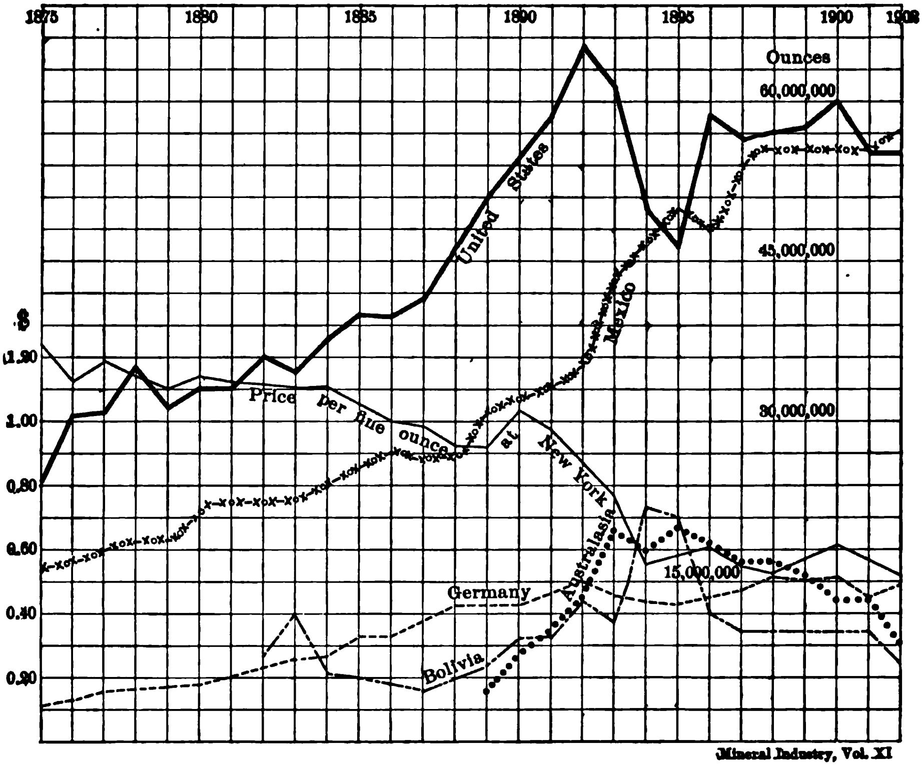


Mineral Industry, Vol. XI

THE PRODUCTION OF GOLD IN THE PRINCIPAL COUNTRIES OF THE WORLD.

PRICES OF SILVER.

The average prices of silver in New York and London, as computed by the *Engineering and Mining Journal,* are shown in the subjoined table. The lower average in 1902 was due to the smaller demand for silver for coinage purposes in the Far East.



THE PRODUCTION OF SILVER IN THE PRINCIPAL COUNTRIES OF THE WORLD.

Month.	1900.		1901.		1902.		Month.	1900.		1901.		1902.	
	London. Pence.	New York. Cents.	London. Pence.	New York. Cents.	London. Pence.	New York. Cents.		London. Pence.	New York. Cents.	London. Pence.	New York. Cents.	London. Pence.	New York. Cents.
January	27·30	59·30	28·97	62·82	25·62	55·56	August	28·13	61·14	26·94	58·37	24·23	52·52
February	27·49	59·76	28·13	61·06	25·41	55·09	September	28·85	62·63	26·95	58·26	23·88	51·52
March	27·59	59·81	27·04	60·63	25·00	54·23	October	29·58	63·83	26·62	57·59	23·40	50·57
April	27·41	59·59	27·30	59·29	24·34	52·72	November	27·66	64·04	26·12	56 64	22·70	49·07
May	27·56	59·96	27·43	59·64	23·71	51·31	December	29·68	64·14	25·46	55·10	22·21	48·03
June	27·81	60·42	29·42	59·57	24·17	52·36							
July	28·23	61·25	26·96	58·46	24·38	52·88	Year	28·17	61·33	27·11	58·95	24·09	52·16

NOTE.—The New York prices are per fine ounce; the London quotations are per standard ounce, which is 0·925 fine.

COINAGE OF THE MINTS OF THE UNITED STATES.

Year.	Gold.	Silver.	Minor.	Total.
1898	$77,985,757	$23,034,033	$1,124,835	$102,144,626
1899	111,344,220	26,061,520	1,837,452	139,243,192
1900	99,272,943	36,345,321	2,031,137	137,649,401
1901	101,735,188	30,838,461	2,120,122	134,693,770
1902	47,109,853	30,028,167	2,447,796	79,585,816

UNITED STATES: IMPORTS AND EXPORTS OF GOLD AND SILVER.

	1901.			1902.		
	Exports.	Imports.	Difference.	Exports.	Imports.	Difference.
Gold:						
Coin and bullion	$56,771,350	$33,237,629	Exp. $23,533,721	$35,722,835	$22,710,957	Exp. $13,011,878
In ores	1,012,589	21,524,251	Imp. 20,511,662	307,756	21,482,360	Imp. 21,174,604
Totals	$57,783,939	$54,761,880	Exp. $3,022,059	$36,030,591	$44,193,317	Imp. $8,162,726
Silver:						
Coin and bullion	$55,526,975	$12,957,987	Exp. $42,568,988	$49,228,303	$8,502,614	Exp. $40,725,689
In ores	111,383	18,188,795	Imp. 18,077,412	44,651	17,900,321	Imp. 17,855,670
Totals	$55,638,358	$31,146,782	Exp. $24,491,576	$49,272,954	$26,402,935	Exp. $22,870,019

AUSTRIA-HUNGARY: IMPORTS AND EXPORTS OF COIN AND BULLION.

Year.	Gold.			Silver.		
	Imports.	Exports.	Difference.	Imports.	Exports.	Difference.
	Crowns.	Crowns.	Crowns.	Crowns.	Crowns.	Crowns.
1898	44,966,000	117,216,000	72,250,000	1,868,000	2,264,000	396,000
1899	39,876,000	62,711,000	22,835,000	3,189,000	5,353,000	2,164,000
1900	41,094,000	57,686,000	16,592,000	3,734,000	6,165,000	2,431,000
1901	168,657,000	34,114,000	134,543,000	4,716,000	4,897,000	181,000
1902	150,459,000	66,548,000	83,911,000	15,416,000	12,833,000	2,583,000

FRANCE: IMPORTS AND EXPORTS OF COIN AND BULLION.

Year.	Gold.			Silver.		
	Imports.	Exports.	Difference.	Imports.	Exports.	Difference.
	Francs.	Francs.	Francs.	Francs.	Francs.	Francs.
1898	198,715,221	312,858,950	114,143,729	195,418,221	189,935,299	5,482,922
1900	459,111,000	125,568,000	333,543,000	145,840,000	206,786,000	60,946,000
1901	428,425,000	154,443,000	273,982,000	97,788,000	140,515,000	42,727,000
1902	440,457,000	127,041,000	313,416,000	96,717,000	119,614,000	22,897,000

GERMANY: IMPORTS AND EXPORTS OF COIN AND BULLION.

Year.	Gold.			Silver.		
	Imports.	Exports.	Difference.	Imports.	Exports.	Difference.
	Marks.	Marks.	Marks.	Marks.	Marks.	Marks.
1898	326,208,000	221,769,000	104,439,000	8,303,000	27,811,000	19,508,000
1899	271,275,000	135,745,000	135,530,000	7,284,000	23,964,000	16,680,000
1900	241,243,000	113,860,000	127,383,000	13,955,000	23,885,000	9,930,000
1901	256,833,000	51,591,000	205,242,000	15,878,000	26,544,000	10,666,000
1902	138,983,000	106,022,000	32,961,000	20,091,000	26,645,000	6,554,000

UNITED KINGDOM: IMPORTS AND EXPORTS OF COIN AND BULLION.

Year.	Gold.			Silver.		
	Imports.	Exports.	Difference.	Imports.	Exports.	Difference.
1898	£43,722,960	£36,590,050	£7,132,910	£14,677,799	£15,623,651	£945,852
1899	32,533,497	21,536,052	10,997,445	12,727,989	13,955,132	1,227,143
1900	26,190,873	18,397,459	7,793,414	13,822,300	13,574,580	252,280
1901	20,715,628	13,965,265	6,750,363	11,501,678	12,049,837	548,159
1902	21,629,049	15,409,088	6,219,961	9,764,296	10,716,118	951,822

GOLD AND SILVER MINING IN THE UNITED STATES DURING 1902.

Alaska.—The gradual exhaustion of the rich placers in the Klondike and Cape Nome fields has been followed by increased activity in prospecting for new territory, and by the development of low-grade deposits which under former conditions could not be worked at a profit. Many new discoveries have been made in the interior of Alaska, particularly in the region lying between the Yukon and Tanana rivers. Glenn Creek, a tributary of Baker Creek, which joins the Tanana about 80 miles from the Yukon, and Chena River, some 200 miles further up the Tanana, are the sites of the most recent discoveries. Operations are still conducted on Fortymile River, and the Copper River district is being actively developed.

Nome District.—The Nome district, according to reliable estimates, produced gold to the value of $5,050,000 in 1902, an increase over the preceding year. Work during 1902 was retarded owing to the small supply of water, it having been the dryest season for several years. A pumping plant was completed in the middle of the year by the Wild Goose Mining, Transportation & Trading Co., and water was pumped from Snake River, near the town of Nome, over Anvil Mountain to Nikola Gulch, 45 miles distant, where it was used on several claims. The daily delivery was 4,500,000 gal. The expense of operating the pumping station was large, coal costing $15 per short ton. This company, working 120 days, produced $1,076,000 gold from its claims in the Nome district and on Ophir Creek in the Council City district. The Ophir Creek claims produced $1,250,000 during 1902. The Miocene Ditch Co. has constructed two ditches to carry water from the Snake River to Dexter Creek, and is also building a ditch to supply Anvil Creek with water from Snow Gulch. The company was operating an hydraulic lift at Snow Gulch, and will erect four more in 1903. Its plant has already cost about $300,000. Several other companies are being supplied with water by the Miocene Ditch Co. The cost of mining with the sluice-box has been from $1 to $2 per cu. yd. The Hot Air Mining Co. has been one of the largest producers, extracting gold to the value of $250,000 during six weeks of operation. Of the other regions during 1902, that around Boulder Creek, in the Kugruk district, produced approximately $7,000 and Candle Creek in the Fair Haven district, produced about $150,000. The Iron Creek district produced $100,000, and the Solomon River district about $200,000.

Juneau and Other Districts.—The Alaska Treadwell Gold Mining Co. reports for the year ending May 15, 1902, that it mined and treated 682,893 tons of ore yielding $665,591 in free gold and $639,129 in sulphurets, a total of $1,304,720 or $1·9106 per ton as compared with $1,153,368 or $2·07 per ton in the preceding year. The profits on merchandise, etc., were $34,799, which made a total earning of $1,339,519 ($1·9615 per ton). There were 12,408 tons of sulphurets saved from the mill tailings by concentration, of which 368 tons remained on hand at the close of the year. The working expenses were $823,087 ($1·2053 per ton), and the construction expenses $52,942 (7·75c. per ton), making a total expenditure of $876,029, which left a net profit of $463,490 (67·87c. per ton) as compared with $352,559 (77·01c. per ton) in 1901. Dividends of

$300,000 or 6% on the capital stock were paid, leaving a balance of $163,490. Adding to this the sum of $650,458 carried forward from the previous year the total surplus for 1902 was $813,898. Three mines in the Arbacoochee district were under development in 1892; the Woodward, the Pinetucky, and a third near Goldburg. No mills or smelters have been erected.

Arizona.—The output of gold and silver in 1902 was about the same as in 1901. The Socorro Gold Mining Co. is building a 20-stamp mill at the Socorro mine to which is to be added a cyanide plant. The ore assays about $20 gold per ton. The Congress mine has been sold to the Development Co. of America, which also owns the Poland mine in the Big Bay mining district. The mine is now being actively developed; a 20-stamp mill and eight concentrating tables have been installed, and a tunnel 8,000 ft. long is being driven, which will tap the veins at from 600 to 800 ft. below the outcrop.

California.—The output of gold was greater in 1902 than in 1901. This was due to the increase of milling facilities at established mines and to a larger use of the cyanide process, many old beds of tailings being treated. The utilization of electric and water power and oil for fuel has materially cheapened the cost of mining, and ores are now worked which were formerly too low grade for profitable treatment. Several new mills of from 10 to 20 stamps are either being erected or have been placed in operation. In Butte County in 1902, nine dredging companies operated 22 dredges, and six new dredges are being built. The Feather River Exploration Co. and the Boston & Oroville Co. each operate three dredges. The dredges have a capacity of 2,000 tons of gravel daily, the gravel carrying from 30 to 40c. in gold per cu. yd., and costs 4c. to work. The California Débris Commission in its annual report for June 30, 1902, states that 836,500 cu. yd. of gravel were hydraulicked in the San Joaquin and Sacramento River districts. Its engineers are to be employed in the construction of dams across the Yuba River to hold back the mining débris, the dams to be built jointly by the Federal and State Governments. In addition, each individual mine will have to construct and maintain its own dam. Hydraulic mining in California has received a setback due to a decision of the court that the Caminetti law, under which the California Débris Commission acted, is not absolute, and that the permits granted by this commission are no bar to injunction suits, when the débris from the hydraulic mines is injuring the rivers and valley lands, even though the miners have constructed impounding dams in accordance with the commission's plans. According to W. E. Thorne, the working cost of moving material hydraulically at Georgetown by the Gold Bay Mining Co., was 18·3c. per cu. yd. A controlling interest in the North Bloomfield hydraulic mine, the largest of its kind in the world, has been sold to the W. B. Bourn Co. There are 11,000 ft. of tunnels and 45 miles of ditches, the entire cost being over $1,500,000. The blue gravel is about 135 ft. deep. At the Fremont mine a 60-stamp mill is being erected. The California Gold King Mines Co., operating the Picacho mines, is treating 300 tons of ore per day and intends to double its milling capacity early in 1903. The cost of mining is 10c. per ton and the ore is mined, crushed, and leached for less than $1 per ton. Two new veins are being developed, the ore in one averaging $5 per ton and the other, which is 20 ft. wide averaging $6 per ton. The Eagle-Shawmut mine added 60 stamps to its 40-stamp mill and began operations with the enlarged plant in August, 1902. It is treating 500 tons of ore daily. The North Står Mines Co., during the first eight months of 1902, treated 3,678 tons of ore yielding about $146,000 at a cost of $40,000. The North Star Mines Co., Grass Valley, Nevada County, reports that it mined 17,399 tons of ore, realizing $411,148. Total receipts for the year were $431,149. The operating costs were $154,228, and total expenses were $340,630, leaving a balance of $90,519. The balance on hand at the close of the year was $99,001 in cash and $14,711 in supplies at the mine, making a total of $113,712. The Bay Counties Power Co. transmits power from the Yuba River, a distance of 30 miles, and the Butte Creek Power Co. transmits power from Butte Creek, a distance of 20 miles, with which to operate the dredges. The Valley Power Co. is building on French Creek, and at Nimshew, Butte County, another supply is being developed. Power is sold at approximately $5 per H.P. per month.

Colorado.—Mining progress was hampered by the decline in the price of silver and the exhaustion of several of the large gold mines without a commensurate development of new districts. The Cripple Creek mines gave a largely increased tonnage, but the total yield of gold was only slightly in excess of that for 1901, which shows that a much lower grade of ore was handled than in the previous year. This was made possible by a reduction in treatment charges; a number of companies contracted at the rate of $5·75 per ton, including freight charges, for ore up to 0·5 oz. With the depletion of the rich ore bodies the future of the district depends upon the possibility of new discoveries, and the lowering of the working costs. From the numerous developments that have been made in the outlying territory, it would appear that no extension of the ore-bearing district beyond the present limits can be expected. There remains, however, a large field for exploration within the district proper, and some of this ground is known to contain good ore. Rich discoveries were reported during the year in the lower workings of the Last Dollar and Blue Bird mines, which are now below the 1,200-ft. level. Plans have been formulated for a drainage adit to be driven in a northeasterly direction from the junction of Arequa Gulch and Cripple Creek for a total distance of about 6,000 ft. It will be 235 ft. below the present water level, and will drain an area extending from Gold King on the north to El Paso and Elkton on the south. Heavy shipments of ore were made from Stratton's Independence mine, particularly from the low-grade ore reserves in the upper levels. The Portland Gold Mining Co., reported a production during 1902 of $2,334,024 from 89,664 tons of ore, out of which the net earnings amounted to $471,920. A reduction of about $1·20 per ton was made on the ore treated by the company's new mill at Colorado City. The most important development in the Leadville district was the discovery of an extension of the old bonanza ore-shoots in Fryer Hill. The sinking of the El Paso shaft has made possible the unwatering of a large area on this hill and opened much valuable ground for exploitation. At the present time the bulk of the ore tonnage of Leadville is in the form of fluxing iron ores, so that the output is largely dependent upon the rates allowed by the smelters. The Tomboy Gold Mines, Ltd., during the fiscal year ending June 30, 1902, mined 85,726 tons of ore for a yield of $856,065; the net profits were $354,317. In the San Juan district, the Camp Bird gold mines, which were purchased by English capitalists for $3,500,000, have given most satisfactory returns. The ore reserves have been largely increased under the new management, and it is planned to sink a new shaft which will be equipped for reaching a depth of 1,500 ft. Owing to the decline in ore shipments from the Colorado and Utah mines, the Philadelphia smelter at Pueblo was closed down.

Georgia.—According to W. H. Fluker, the vein of the Parks mine varies in thickness from 2 to 11 ft., and assays from $10 to $200 per ton, the average free-gold value of the ore being $32·60 per ton. The National Mining Co., of Chicago, has a 20-stamp mill at its mine. The shaft has been sunk 150 ft., at which depth the vein is 4 ft. thick and assays $21·40 per ton. The Landers mine, newly discovered, has two veins varying from 5 to 18 in. and assaying from $20 to $30 per ton. The Columbia mine operated by the Columbia Mining Co. is still the largest producer in the State, the ore from the vein at the 140-ft. level assaying about $34 per ton. The geology of the Dahlonega Gold district is described by E. C. Eckel in the *Engineering and Mining Journal,* Vol. LXXV., 1903, p. 219.

Idaho.—According to the report of State Mine Inspector, three counties produced over $300,000 in gold; Owyhee County, $753,277; Boise County, $396,864; and Lemhi County, $320,385. The Thunder Mountain district where gold was discovered in 1901, did not produce as much gold as was expected, Idaho County, in which it is located, producing in all but $264,452. The Dewey mine owned by the Thunder Mountain Gold & Silver Mining & Milling Co., has a 10-stamp mill and is erecting another of 100 stamps. The gold mines near Wardner are being developed by a New Jersey company, which will use water power to operate 40 stamps. The De Lamar Co., Ltd., reports that during the year ending March 31, 1902, it milled 35,469 tons of ore, shipped 23 tons of ore, and cyanided 937 tons of coarse tailings and 22,985 tons of old tailings. Its income was $519,879 and expenditures $307,793. The output amounted to 23,846 oz. gold and 39,867 oz. silver. The average recovery was 84·2% in the mill and 69·7% in the tailings plant.

Montana.—(By W. H. Weed.)—There has been increased activity in the development of the gold deposits, due chiefly to the successful investments in the Judith district of Fergus County. The operation of the silver mines, however, has been retarded on account of the low price of silver during the year, although the demand for silver-lead ores by the smelters has kept many producing properties in operation. The development of electric power for mining purposes has continued and Butte is now supplied from dams on the Missouri 72 miles away, on the Madison, and the Big Hole rivers. The first named also supplies power to the East Helena smelter, and to various mining and industrial plants. In Fergus County several large cyanide mills are in operation or in course of construction, notably the Kendall property in the North Moccasin Mountains, which was treating 350 tons of ore daily at the end of 1902, and the adjacent Barnes-King mill, which has been enlarged to a daily capacity of 240 tons. There are also several minor cyanide plants operating in the State. In October, 1902, the Winscott mine near Helena under control of the Big Indian Gold Mining

Co., started with 60 stamps driven by electric power from the Canyon Ferry on the Missouri River. The mill and cyanide plant of the Columbia Gold Mining Co. at York was destroyed by fire during the summer. In the Marysville district the Bald Butte mine yielded a steady output of high-grade gold ore during the year. The Drumlummon mine is practically worked out, and on the exhaustion of the old stope-fillings now treated will probably be permanently abandoned. A 500-ton cyanide mill was operated at Empire on old tailings from the Empire mine. In the Phillipsburg district, the Sunrise Gold property is again operating mine and mill; and the Granite Bi-Metallic Co. has decided to double the capacity of the new 600-ton concentrator which was completed late in 1901. A new 50-drill Rix compressor has been installed, and electric haulage introduced in the mine, the power for this purpose and for the mill being furnished by the newly completed electric power plant at Flint Creek Falls. The Bear Gulch mines, near the Yellowstone Park boundary, were tied up by litigation, which is said to be now settled, with a prospect of a re-opening and working of the property on a largely increased scale. The Mayflower mine is to be abandoned. In the Rochester district the Watseca mine is opened up to the 500-ft. level, and a 125-ton concentrator will be added. The Cable mine, near Anaconda, is being re-opened by a Butte syndicate. The Jeannette Mining Co. stopped working on the 100-stamp mill last spring at the Boss Tweed-Clipper group of mines, near Pony, and is awaiting the results of development work. Six dredges have operated during the season, three at Bannock, two near Virginia City and one on French Gulch, near Anaconda. Two of the Bannock dredges will be removed, having entirely exhausted the pay ground. The French Bar dredge has handled gravel profitably at a cost less than 5c. per cu. yd., inclusive of interest on investment, and all fixed charges. The two Bannock dredges were the pioneers in this work in the country, and have extracted over $600,000 from an abandoned placer field. Near Virginia City the boats operating on the old Alder Gulch placers have cost nearly $500,000, but have operated so successfully that other boats, it is reported, will be built. The Montana Mining Co., Ltd., for the half year ending June 30, 1902, reported a net profit of £1,780. This company owns the Drumlummon mine at Marysville, which during the half year treated 13,200 tons of ore for a yield of $61,631. The tailings plant between April 12 and June 30, 1902, treated 31,649 tons of tailings from which $66,310 were realized. The total income was $127,941, and expenses $115,501, leaving a profit of $12,440. The ore and tailings contained 5,622 oz. gold and 31,462 oz. silver.

Nevada.—Development work has been done in the Tonopah district, and new companies have been formed. The Dexter Tuscarora Gold Mining Co. for the 11 months ending Nov. 15, 1902, reports that it treated 30,093 tons of ore at a cost of less than 72c. per ton and extracted $2·88 gold per ton. From 22,930 tons of tailings treated by cyaniding at a cost of $1·10 per ton, it obtained $1·89 gold per ton. Its total receipts were $130,713, and expenses $125,021, of which sum $18,000 were expended in new development work. The Bamberger De Lamar Gold Mines Co., capitalized at $5,000,000, has bought the De Lamar's Nevada Gold Mining Co., Magnolia Gold Mining & Milling Co., Boston De Lamar Gold Mining & Milling Co., Mono Gold Mining & Milling Co., April Fool Gold Mining

& Milling Co. and the Rose and Pleides group of gold claims. The De Lamar's Nevada Gold Milling Co., which has produced over $13,000,000 in seven years, has an estimated ore reserve of 314,000 tons. The April Fool mill is being improved, and the De Lamar mill is being increased from 200 tons to 500 tons daily capacity. The Nevada Keystone Mining Co., with two Huntington mills and a 30-ton cyanide plant is reported to be producing $40,000 a month. The Lucky Girl group of mines at Edgemont, owned by the Montana Mining Co., Ltd., during the half year ending June 30, 1902, treated 8,165 tons of ore in its 20-stamp mill obtaining bullion valued at $30,438. The tailings will be treated in a cyanide plant which is being erected.

New Mexico.—Mining properties were under development in 1902 in the districts about the Sierra de Mogollon, the Black Range and the Sierra Blanca. Large bodies of medium grade ore are said to exist, which can be treated by the cyanide process. Apart from several mills now being erected to treat those ores four mills are in operation near the Mogollon Range. The Mogollon Gold & Copper Co. has a 35-ton mill, and ships the concentrates to the El Paso smelter. At the Hopeful mine in the White Oaks district a 1,000-ton pneumatic cyanide plant is in operation, and the Alamo Reduction Co. will erect a 500-ton concentrating plant in the Bland district. Placer mining has been carried on in the Nogal and Elizabethtown districts. The Lake Valley and Polomos Chief silver mines, after lying idle for several years, have again been worked. At Chloride, two mills are treating ore containing 12 oz. of silver per ton. The Kodoc Mining Co. has seven Hooper pneumatic dry concentrators of 10 tons capacity operating on ore assaying 20% Pb, and from 3 to 10 oz. silver per ton. The American Gold Mining Co. and the Eagle Co. are developing claims at Nogal and Parsons, and at the Old Abe and Somestake mines. The Helen Rae and American mines are being connected by a tunnel and a 50-stamp mill and cyanide plant are being erected.

North Carolina.—According to Mr. J. H. Pratt, gold occurs in an area of from 8,000 to 10,000 sq. m. in the middle and western part of the State, either in quartz fissure veins, carrying free gold or gold-bearing sulphurets; impregnations of free gold and finely-divided sulphurets in schists and slates; or in placer deposits. The mines in operation are situated in six counties. Several of them were sold during 1902, and are being developed. The Iola Gold mine with a 10-stamp mill, between June and October, produced $15,000 in gold. The Russell, Fentress and McMackin mines, the latter operated by the Whitney Reduction Co., each had a 10-stamp mill in operation.

Oregon.—In the Sumpter district, which is the richest in Oregon, the greatest amount of development work was done. The Maxwell mine and 10-stamp mill were sold for $140,000; the mill is being repaired and is expected to become operative early in 1903. The Pole Consolidated Mining Co., capitalized at $5,000,000, has acquired the Oregon Clipper, Deer Lodge, Hansen and half of the Yankee Jim mines. Four tunnels have already been started, and a compressor plant will be installed. The North Pole mine with 10 stamps will increase its mill by adding 20 stamps. In all there are 758 stamps in eastern Oregon. The placer deposits of Josephine County were actively exploited. The placer ground gives returns of from 10 to 12c. per cu. yd., the cost of working being about 1·5 per cu. yd., the water being supplied by the Rouge River. The Golden Drift Mining Co. is building a power dam across the river, and will install ten 600-H.P. turbines, and operate three or four giants. The Galice mines operated by the Old Channel Mining Co. has three 6-in. giants, which obtain their supply of water by means of 18 miles of ditches and flumes. The Eureka mine in the Soldier Creek district owned by the Oregon & California Gold Fields Co. is developing a vein from 8 to 10 ft. wide, which assays from $20 to $35 gold per ton. The Greenback mine on Grave Creek has 35 stamps, and a 60-ton cyanide plant in operation.

South Dakota.—The satisfactory condition of the gold mining industry in the Black Hills during 1902 is evidenced by the increase in output, which was brought about by the enlarged operations of old producers, and by the contributions from mines recently developed. The steady advance recorded in the last few years may be attributed to the introduction of the cyanide process, for with its aid enormous bodies of mineralized material formerly regarded as too low grade for profitable working have been made available for treatment. Full details of the progress in the cyanide process in this State will be found on page 310 of this volume. The Homestake Mining Co. during the year ending June 1, 1902, treated 1,218,089 tons of ore, which yielded bullion valued at $4,314,059. Deducting mint charges the net bullion return was $4,303,977, while the income from miscellaneous sources amounted to $72,453, making the total working receipts, $4,376,427 or $3·60 per ton. The working expenses were $4,017,131, so that the net profits of operation were $359,296, or $0·29 per ton of ore milled. A dividend of $1,260,000 was paid. During the year the stamp mill was increased by 100 stamps, making a total capacity of 900 stamps, and a 900-ton cyanide plant was erected, which increased the cyaniding facilities to 1,900 tons. The Horseshoe Mining Co. was reorganized during the year. The company purchased the 300-ton smelter of the National Smelting Co., at Rapid City, and began construction on a new 1,000-ton cyanide plant. When the improvements and additions are completed the plant will be able to treat 1,600 tons of ore per day. The smelter of the Golden Reward Consolidated Mining & Milling Co., at Deadwood, was in continuous operation, treating ore principally from the company's mines.

Texas.—Although this State produces very little gold, its output of silver is quite large, almost the entire quantity coming from the mine of the Presidio Mining Co., at Shafter in Presidio County. The ore is silver chloride carrying traces of gold, with isolated pockets of lead ore. Three or four carloads of this high-grade lead ore are shipped yearly to the El Paso smelter. The gold ore is treated at the 15-stamp mill of the Cibolo Creek Mining & Milling Co., one mile from the mine. The pulp is ground for three hours with salt, mercury, and copper sulphate in amalgamation pans, of which there are twelve. The amalgam is collected in six settlers, and retorted. The tailings are again milled. The process requires six hours for completion, the mill treating 62 tons of ore per diem, and the average extraction being 85%.

Utah.—There was no material change in the mining situation during 1902.

The large copper and lead mines shipped bullion containing gold and silver throughout the year. The American Smelting & Refining Co. had in operation at its two plants four and six furnaces respectively, and treated 1,400 tons of ore daily. The United States Mining Co. with four furnaces treated 1,000 tons of ore a day. A 300-ton mill for the cyanide treatment of the slimes of talcose ores by a method patented by G. Moore[1] has been erected at Sunshine. The extraction varies from 77% to 95·6%. The South Swansea mine during the year treated 15,715 tons of ore, realizing $363,331, out of which $39,000 in dividends were paid. The Horn Silver Mining Co. during 1902 mined 12,159 tons of ore, of which 4,549 tons were shipped and 7,610 tons milled. The cost of mining was $7·45 per ton, and of milling $1·47 per ton. There was realized from the sales of ore $109,707, and from other sources $7,001, a total of $116,708, while the disbursements amounted to $137,406. The balance carried forward from 1901 was $87,448, leaving a surplus of $66,750 at the close of 1902. The ore shipped contained 203 oz. gold, 112,813 oz. silver, 1,829 tons lead and 717,353 lb. copper. The Park City district, in which are located the Daly-West, Ontario, Daly, and Silver King mines, maintained its output of smelting ores, and some encouraging developments were reported. The Daly-West Mining Co. during the year shipped 3,575,796 oz. silver, 1,202 tons copper, 14,953 tons lead, and 9,738 tons zinc, for which it received the sum of $1,827,586. Receipts from other sources were $4,052, making the net revenue $1,831,638, while the total mining expenses amounted to $625,654. Out of the surplus of $1,477,127, which included $271,143 brought forward from the previous year, the sum of $1,049,000 was distributed in dividends, and $255,516 carried forward to the next year's account. The company purchased the property of the Quincy Co. paying therefor 30,000 shares of its stock, which were provided by increasing its capital to 180,000 shares. The contract with the American Smelting & Refining Co. fixing the price of $3·50 per 100 lb. for the lead content of the company's ores was renewed to run until March 1, 1904. The Anchor and Judge properties in this district have been combined to form the Daly-Judge company. The Daly-Judge mine up to Dec. 31, 1902, produced 94,639 tons of concentrates valued at $25·54 per ton. The crude mill ore assayed Pb 10·29%, Zn 16%, and silver 9·85 oz. per ton. The new mill has a capacity of from 300 to 400 tons per day. In the early part of 1903, 100 tons of ore per day were being milled, making 25 to 30 tons of silver-lead concentrates, and about 25 or 30 tons of iron-zinc middlings, which were sent to the zinc plant of the Park City Metals Co. In the southern end of the district, in Thaynes Cañon, the California Co. has enlarged its mill, and the Comstock is now building a large mill. A new mill is also being started in Park City to handle the zinc middlings by the combined roasting and magnetic separation process, which will ship high-grade blende to the Eastern refineries. The Tintic district consists of the Eureka, Mammoth, Robinson and Silver City. The principal mines of the Eureka district are the Bullion Beck, Eureka Hill, Gemini and Centennial Eureka. The first two have been closed down during the year. The Gemini has been shipping steadily during 1902. The Centennial Eureka has completed its contract with the American Smelting

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[1] *Engineering and Mining Journal*, July 12, 1902, p. 42.

& Refining Co., and has shut down its plant pending the completion of the smelter of the United States Mining Co., which now owns this mine. The Mammoth mine is engaged in litigation with the Grand Central mine, and until a settlement has been made the work on both will be retarded. The ores of the Tintic district are subject to high smelting charges, and ores up to $15 value do not pay to treat. The largest mines in the Mercur district are operated by the Consolidated Mercur Gold Mines Co., which during the year ending June 30, 1902, produced gold to the value of $1,457,064. The company's working expenses were $1,116,692, and the net profits $342,085. Six dividends amounting in all to $235,000 were distributed during the year.

Washington.—It is estimated that the total production of the Republic district in Ferry County up to Jan. 1, 1902, is about $1,400,000 in gold and silver, the silver being only a small percentage of the whole. The ore averages from $12 to $16 per ton, and the present cost of mining and smelting is $10 per ton. The Republic mill treats 200 tons of ore per day, but like most mines in this State, the smelting ore is shipped to the Granby smelter, at Grand Forks, or to the Northport smelter, near the Canadian boundary. The California mine in Ferry County from July 15 to Dec. 30, 1902, produced 3,411 oz. gold and 4,346 oz. silver. The Hollyhock group, also in this county, mined ore which assayed on the average 0·3 oz. gold, 5·3 oz. silver, 10% Cu, and 9% Pb per ton. The San Poil mine, Ferry County, shipped ore to the Granby smelter, and showed a net profit of $8·80 per ton on ore, which assayed $17·80 per ton. The reserve ore of this mine on Oct. 4, 1902, was estimated at 22,000 tons. The Park City claim of the Cliff group, is developing a vein of galena 700 ft. long and 22 in. wide, which assays 69% Pb, 33 oz. silver, and 0·2 oz. gold. In the Pride and Mystery mines in the Monte Cristo district, the ore varies from 0·6 to 0·95 oz. gold and from 7 to 12 oz. silver. In the Independent mine, at Silverton, Snohomish County, the low grade ore assays $7 per ton, while the high-grade ore varies from $40 to $50 per ton. The ore consists of pyrite and löllengite with a little galena and zinc blende. A mill of from 100 to 200 tons capacity is to be erected.

Wyoming.—(By Wilbur C. Knight.)—There was no marked advancement made in gold and silver mining during 1902. As usual, the Sweetwater district furnished nearly all of the gold and silver ore produced during the year. At South Pass, Atlantic, and Lewiston, considerable property changed hands in the fall and a number of new companies entered these fields. The indications are that these camps will be very active during 1903. In November the Home Placer mine on Douglas Creek near Laramie passed into the control of a company which expects to install a dredge to work the property. In the Wood River district, near Kirwin, Big Horn County, several companies have done sufficient work to patent many claims. The ores of this camp are lead and silver chiefly, and assays showing upward of 100 oz. silver per ton are not uncommon. At present this camp is too far from transportation to handle the ores successfully. In Crook County there has been much activity in the vicinity of Welcome, and not far from the Interocean mine. Several companies have bonded property, and expect to inaugurate extensive plans for work in 1903.

GOLD AND SILVER MINING IN FOREIGN COUNTRIES DURING 1902.

NORTH AMERICA.—*Canada.—British Columbia.*—(By Samuel S. Fowler.)—According to returns made to the Provincial Mineralogist, Mr. William Fleet Robertson, the combined output of alluvial and lode gold for 1902 was 290,148 oz., equivalent to $5,961,409, being an increase in value of $642,706 above the output of 1901. Alluvial gold is derived chiefly from the central and northwestern districts of Cariboo and Cassiar (Atlin), these districts alone furnishing 90% of the production in 1901. The output for the year amounted to $1,073,140, an increase of about $100,000 over 1901, which was less than was expected owing to the shortage of water. Considerable expenditure was made on ditches and flumes, and it is anticipated that 1903 will show a material gain. The output of lode gold was 236,491 oz., valued at $4,888,269. This was derived, geographically, as follows: West Kootenay, 79%, Yale, 18%, other districts, 3%. As to classes of ores, 79% was from copper ores, 13% from free-milling ore and 2% from lead and dry smelting ore. The output of silver in the Province was 3,917,917 oz., valued at $1,941,328, a decrease of about 24% in quantity, and nearly 33% in value as compared with 1901. This loss was perfectly natural, in view of the low range of prices for silver, as well as for lead, with which so great a part of the silver is associated. Most of the large silver-lead mines were closed during a large part of the year, although many of the smaller and richer ones remained in operation. West Kootenay provided 87·6% of the silver, Yale 5·6%, elsewhere 6·8%. Lead ores contained 57% of the silver, gold-copper ores 18%, and milling and dry ores 25%.

Southern British Columbia presents an enormous development of igneous rocks, and it is from these that the bulk of the lode gold is derived. The vicinity of Rossland is the center of greatest gold production, its few large mines having contributed over 68% to the total for 1902. The Rossland ores are essentially iron and copper sulphides, and their chief value is in gold, the silver and copper being of minor import. The output of this district in 1902 was nearly 330,000 tons, an increase of about 45,000 tons over 1901. The ore was smelted either at Northport, Wash., or Trail, B. C., at both of which points are large, modern, well-equipped plants. For various reasons the matte is shipped elsewhere for conversion. The increased tonnage from the mines was due chiefly to reduced smelting charges, and it would have been much larger except for the fact that the smelters were compelled to curtail operations because of the shortage in coke supplies, due to strikes and accidents at the mines of the Crow's Nest Pass Coal Co. As in former years, the larger producers were Le Roi, Le Roi No. 2, Center-Star and War Eagle; these mines exploit a low-grade ore, on some of which apparently successful experiments in the direction of preliminary concentration have been made. The ultimate commercial success of these experiments means much to the district. The "Boundary" portion of the Yale district lies about 40 miles west of Rossland. This is the second chief mining center of gold-copper ores, but the gold value is generally much inferior to that of copper. The deposits are of enormous size, of very low average grade in gold and silver, and of self-fluxing composition. The chief producers are the

Knob Hill, Old Ironsides, and Snowshoe, near Phœnix, and the Mother-Lode and Sunset, about three miles west of Greenwood. These mines in 1902 shipped to three smelters in the vicinity over 500,000 tons, an increase of 125,000 tons over 1901, due to increased smelting facilities. At the three plants are seven furnaces having a daily aggregate capacity of about 2,500 tons. Three other furnaces are in course of construction. Free-milling gold ores are found at only a few widely separated points. The Ymir mine, 20 miles south of Nelson, is the largest mine of the class, and last year produced over $300,000 in gold, together with silver and lead valued at about $45,000. The Cariboo-McKinney mine at Camp McKinney in the south-central portion of Yale district, is the next largest free gold producer, and has been a steady profit payer since 1894. The Granite-Poorman and Athabasca-Venus, near Nelson, run regularly, and the Stemwinder, near Fairview in the western part of the Yale district, is about to be added to the list of producers. The gold derived from this class of ores amounted in 1902 to approximately $650,000. Some of the lead ores of Slocan and Lardeau carry appreciable values in gold, and there are also dry smelting gold ores at various localities in southern British Columbia. The latter class of ores has not as yet been largely produced.

OUTPUT OF TRAIL CREEK MINES FROM 1898 TO 1902.

Year.	Tons of Ore.	Gold. Oz.	Value.	Silver. Oz.	Value.	Copper. Lb.	Value.	Total Value.
1898..........	111,282	87,343	$1,746,861	170,804	$94,539	5,232,011	$639,411	$2,470,811
1899..........	172.665	102,976	2,127.482	185,818	105,173	5,693,889	996,431	3,229,086
1900..........	257,686	111,625	2,306,172	167,878	97,648	2,071,865	335,435	2,739,300
1901..........	283,360	132,333	2,735.323	970,460	543,458	8,333,446	1,342,518	4,621,299
1902..........	329,534	162,146	3,351,558	373,101	184,871	11,667,807	1,356,966	4,893,395

Silver-lead mining under former conditions has been a profitable industry owing to the high ratio of silver to lead in the ores which last year was slightly over two ounces to each unit of lead. The low prices that prevailed during 1902, together with the fact that the shortage of lead has lessened the demand for dry ores, and also that many former clean ore mines have had to resort to concentration, have tended, however, to extinguish profits except in a few instances. Silver mining at present is in an unsatisfactory condition. The gold-copper ores of Rossland and Boundary carry respectively, about 1 oz. and 0·5 oz. silver per ton; and although this is a small average the aggregate output from these districts was nearly 593,000 oz. The gold-milling ores also carry small amounts of silver, *e. g.*, the Ymir mine bullion contains about 40%, and the concentrates about 12 oz. silver per ton. Under improved conditions East Kootenay is capable of producing much silver, but because of the low ratio of silver to lead in the ores low prices have affected that district possibly more seriously than they have West Kootenay. The Slocan portion of West Kootenay continued to furnish the greater part (nearly 65%) of the total output of silver.

Dawson.—According to official authorities, the production of gold in the Yukon district during 1902 amounted to about $18,000,000, a decrease of $4,000,000 from the output of the previous year. In arriving at these statistics there are two uncertain factors, one the quantity of gold which is carried out of the country by individuals, thus escaping record, and the other the quantity retained in the country as circulating medium. The Yukon district has now entered the transition period common to all new placer mining countries. The decreased production has resulted chiefly from the dearth of new discoveries of placer deposits, augmented by the scarcity of water. At All Gold Creek, 50 miles from Dawson, which was abandoned in 1899 because of the uncertain character of the gold-bearing ground, a pay streak was found during the summer reported to be from 120 to 200 ft. wide and 2 ft. in thickness. The shipments from Dawson for the year is recorded as $11,655,000, a decrease which is partly due to the change from a direct royalty of 5% on the gross output of gold to a tax of 2·5% on the exports. A feature of the usual development of a gold-bearing district is shown in the number of quartz claims that have been recorded. The properties are adjacent to Bonanza, Eldorado, Gold Run and Hunker creeks in the Indian River slope, and on the hills near Dawson. The Munger Mill Co. has installed a stamp mill on Gold Run Creek. A dredge 25×80 ft. has been built at White Horse to operate on the Stewart River; its daily capacity is rated at 1,000 cu. yd. Piping has been laid on Excelsior Creek above Dawson for a hydraulic plant. The Yukon Goldfields, Ltd., for 15 months ending Dec. 31, 1902, reports sales of gold amounting to £12,003, and an income from other sources of £937, a total of £12,940, against a total expenditure of £26,239, a loss for the year of £13,299. The company intends to increase its property by the addition of 5 sq. miles of territory situated on Russel Creek, 450 miles from Dawson City.

Newfoundland.—According to James P. Howley, the production of gold in Newfoundland in 1902 is estimated at 4,000 oz., valued at $82,680. Almost the entire output was contained in copper ores treated by the Nichols Chemical Co. in the United States and the Cape Copper Co. in England. During the year some promising gold finds have been made, and two mines are now in active operation, one at Rose Blanche on the south coast, and the other at Sop's Arm in White Bay on the northeast coast. At the latter, machinery for stamp mills is now on the ground, and a cyanide plant is under construction which will begin operations in March, 1903. The ore at Rose Blanche assays from $4 to $5 per ton, while that at Sop's Arm assays as high as $15 per ton.

Nova Scotia.—The production of gold during the fiscal year ending Sept. 30, 1902, was 28,279 oz. as compared with 30,537 oz. for the previous fiscal year. The quantity of gold reported to the Mines Office during the calendar year 1902 amounted to 31,141 oz.; of which the Brookfield Mining Co. contributed 4,692 oz.; the Boston-Richardson Gold Mining Co., 3,408 oz.; the Waverly Gold Mining Co., 2,836 oz.; the Royal Oak Gold Mining Co., 2,394 oz.; and the Bluenose Gold Mining Co., 2,391 oz. The Brookfield Mining Co., at North Brookfield, stamped 6,475 tons of ore; the mining operations were confined to ground below the sixth level. At the Waverly mine development work was carried on actively, and an average of 20 stamps were in operation in the latter part of the year. The Boston-Richardson Gold Mining Co. at Country Harbor stamped 30,405 tons of ore, yielding about $3 per ton by amalgamation. The Wilfley tables have been abandoned, as better results are claimed by treating the tailings at the cyanide plant and the concentrates by the bromo-cyanide process. The Royal

Oak Mining Co., at Goldenville, operated mainly at the western end of its property. The Baltimore and Nova Scotia Mining Co. was very active. The main shaft of the mine is now 700 ft. deep, intersecting at the 500-ft. level the lenticular fissue vein in the form of a chimney. The 40-stamp mill is well arranged. Although inoperative at present the St. Anthony mine is being kept unwatered.

Ontario.—In Eastern Ontario the principal properties are the Belmont mine operated by the Cordova Exploration Co. and the Deloro mines of the Canadian Goldfields, Ltd. The Belmont veins consist of free milling quartz which is treated in the 30-stamp mill and amalgamation plant, the pulp being subsequently cyanided. At Deloro, the ore is mixed quartz and mispickel, from which the gold is extracted by leaching with bromo-cyanide solutions, and the arsenic by a process of sublimation (see "Arsenic" elsewhere in this volume). In the Lake of the Woods district the Black Eagle mine, formerly known as the Regina mine, has been actively operated during the past two years, and the mill thoroughly overhauled. The present equipment includes a 30-stamp mill. A 250-ton cyanide plant is being constructed for which about 1,500 tons of concentrates, valued at from $35 to $50 per ton, have been accumulated. The Sultana mine, operated by the Sultana Mine of Canada, Ltd., has not proved very successful. During the fiscal year ending Sept. 30, 1901, 7,000 tons of ore were milled, which yielded an average of only $5·15 per ton. Although the mining costs of the Mikado Gold Mining Co. averaged but $3·50 per ton of ore during 1901, a debit balance of £5,052 is given in the report of the company. Operations at the Sakoose mine, owned by the Ontario Gold Mining & Milling Co., were suspended in March, 1902, owing to the exhaustion of the ore in the levels under development. In all 7,735 tons of ore have been removed from the stopes. Prospecting was actively carried on in the Sturgeon Lake region, and several companies have developed mines or erected mills, notably, the United States Gold Mining Co., the Sturgeon Lake Mining Co., the Jack Lake Gold Mining Co., Ltd., and the Anglo-Canadian Gold Estates, Ltd. A deposit of gold-bearing gravel similar to that of the Vermilion River was discovered at Savant Lake, 150 miles north of Ignace, and an examination over an area six miles long by one mile wide, showed an average value of from 8 to 10c. per cu. yd. The gold is in small rounded particles. Robert H. Ahn, of Toronto, reports satisfactory experimental treatment of Vermilion River gravels by a combined amalgamation and cyanide process.

Mexico.—(By James W. Malcolmson.)—(The output of gold and silver is derived largely by smelting gold and silver ores with those of copper and lead, and it is practically impossible to classify the subject under the heads of the respective metals without causing duplication. Therefore reference should also be made to the "Progress of Mining in Foreign Countries," under the sections devoted to "Copper" and "Lead," elsewhere in this volume.)

Owing chiefly to the cheap mining and the absence of labor troubles, there has been a large influx of foreign capital seeking investment in silver, gold, copper and lead mines. From a wage standpoint, a ton of ore can be mined in Mexico for 40% of the cost of mining similar ore in the United States, assuming that the miner in the latter country does twice as much manual labor as the one in Mexico. Development has progressed mainly along the railroad lines, and is due to the growth of the smelting industry. In the smelters of Mexico, copper seems to be displacing lead as a vehicle for the concentration of silver and gold values, and it is probable that recent improvements in the metallurgy of copper together with the large deposits of copper ore being exploited will increase considerably the quantity of gold and silver so treated.

Aguascalientes.—The copper mines of Tepezala, operated by M. Guggenheim's Sons, have maintained a steady production of siliceous silver-copper pyrites. The Aguascalientes Metal Co., at Asientos, has maintained a steady output, and in the same camp the American Smelting & Refining Co. purchased the Santa Francisca mine in March, after uncovering a very large body of siliceous silver-lead-zinc sulphides.

Chiapas.—The copper-gold mines of Santa Fé have been worked steadily, and an excellent record has been made by the management.

Chihuahua.—The extension of the Mexican Central Railway into Parral and Santa Barbara has resulted in lasting benefit to the mining camps, which now supply all the smelters in northern Mexico with siliceous ores. The Hidalgo Mining Co., of Pittsburg, reopened the old San Juanico mine, and discovered a siliceous vein in shale containing high gold and silver values. The Pedro Alvarado in the porphyry overlying the shale produced regularly throughout the year. The Veta Grande and Verde mines in the Veta Colorado ledge were acquired by the Guggenheim Exploration Co., and a rich ore body was cut in the Morena mine in the same ledge by the Hidalgo Mining Co. Near Chihuahua City, the Kraft mine yielding fluxes containing gold, silver, manganese and lime was closed down during the first of the year on account of the fire at the El Paso smelting works, but later it was reopened, and ore was produced from the open cuts at a rate of 3,000 tons per month. In the Sierra Madre Mountains the gold-silver quartz ores are receiving considerable attention. In the Jesus Maria district the ore is treated by pan amalgamation solely, with a probable loss of from 25 to 30% of the silver and gold contents. This camp is 60 miles from a railroad, and the cost of mule freighting is $60 per ton. The ore is high grade, and the value of the monthly production is $100,000, the bullion averaging above $1 per ounce. The Concheno Mining Co. is successfully treating the ore by crushing it and passing it over Wilfley tables, which effects a 2,000 to 1 concentration, cyaniding the sands in the usual way, and the excessively fine slimes by agitation and filtration. During the year the Dolores mine shipped several hundred tons of ore, which assayed over 500 oz. silver and 6 oz. gold per ton. The problem of the local treatment of ores in this district is receiving merited attention, as the best work so far shows an extraction in cyaniding of but 80% of the gold and 55% of the silver. The camps at Barranca de Cobre, Batopilas, Urique, Guazapares and Palmarejo received much attention from investors, and a valuable silver bonanza was uncovered at the Batopilas mine. The Ardagas mines near Jimenez producing gold, silver and lead ore, reduced its shipments during the second half of the year. The value of the ore produced annually in Chihuahua is greater than that of any other State in Mexico.

Coahuila.—The blowing in of the Torreon smelter stimulated mining considerably in the southern part of the State, and a number of good lead-silver prospects are being developed. At Viesca a smelter has been erected to treat the low-grade siliceous copper carbonates, which carry some silver. The output of the Sierra Mojada was greatly reduced owing to the burning of the El Paso smelting works. The Fortuna mine has been actively worked, due to the discovery of a rich deposit of silver-lead carbonates. The fire in the San Salvador mine continued throughout the year—the mine contains 30,000,000 ft. of lumber and immense quantities of native sulphur. In the Fronteriza mine, a valuable extension of the main ore zone has been discovered, but operations here and in the adjoining Encantada mine of M. Guggenheim Sons were hindered by the fire in the San Salvador mine. The Norias de Banjan, Cerralvo and Cuatro Cienegas silver-lead camps were operated in a small way throughout the year.

Durango.—The silver-lead-copper mines and smelter of the Velardena Mining & Smelting Co., of Omaha, were sold in November to the American Smelting & Refining Co., an action which will have a radical effect on the smelter situation. The Compañia Minera de Peñoles, at Mapimi, mined 171,000 metric tons of ore in 1902, and produced 92,000 kg. silver and 24,000 metric tons lead. The ore occurs in a series of irregular pipes which have been explored by diamond drills to a depth of 2,300 ft. Thirty electric hoists from 1 to 50 H.P. are used successfully in opening up the ore reserves. A complete reverberatory roasting plant has been installed. Due to the extension of the International Railroad to Chinacates, the Promotono silver-gold siliceous mine has installed a concentrator and a 100-ton smelter. The Lustre Mining Co., of Pittsburg, operating the Magistral mine near Inde, is experimenting with the treatment of the ore which assays 0·5% copper and 0·5 oz. gold per ton. Guanacevi, which is probably the most important siliceous district in the country, continues to be handicapped with high freight rates and heavy milling losses—the work on the extension of the International and Central railroads having been suspended. Development work at the Avino Mines of Mexico, Ltd., has shown the presence of copper oxide with native copper in the lower leads. The concentration works has been superseded by a thiosulphate leaching plant which extracts 85% of the silver and 30% of the gold. The Vacas mines shipped high grade silver-lead concentrates low in silica. The ancient Rosario mine is being reopened, and the old workings contain large quantities of silver-gold ore amenable to profitable treatment by leaching processes. The San Andres de la Sierra silver-lead mine ships $100,000 of base bullion monthly. The Bacis Gold and Silver Mines, Ltd., operates 40 stamps, and concentrates and amalgamates its ore. The Cushing & Walkup Co., at Trinidad smelts siliceous gold-silver-copper ore, and ships to the Aguascalientes smelter, which yields copper matte assaying 20% copper, 350 oz. silver and 8 oz. gold per ton. The Candelaria Consolidated Mining Co., at San Dimas, increased its yearly output, which is obtained by stamps and pan amalgamation. At La Puerta a large body of gold-silver ore has been uncovered and a mill is under construction. The value of the ore produced annually in the State of Durango is second only to that of Chihuahua.

Guanajuato.—The ancient siliceous silver-gold mining district of Guanajuato has been actively operated. These mines are believed to have produced one-sixth of the silver of the world; one of them, the Valenciana, having an established record of production of over 300,000,000 oz. silver. The gold in these ores varies from 15 to 50% of the total values, and in the patio process 75% of this gold is lost. At the Sirena mine during October, the Guanajuato Consolidated Co. with 40 stamps, milled and treated by pan amalgamation, 100 tons of ore daily. The extraction was 85% of the gold and silver values at a cost of mining and milling of $10·11, Mexican, per ton. Enormous bodies of ore in sight carry values of over $20, Mexican, per ton. The Aparecida, La Luz, Cubo, Refugio, Carmen and Bolanitos mines have been taken up by Boston, Chicago and New York interests, with the object of introducing American methods of mining and milling, and a partnership mill capable of handling 1,000 tons of ore daily is under consideration. The native owners of Esperanzas, Cedro, and other famous properties are alive also to the need of reorganization, and there is no doubt that this camp will resume the premier position it has held for 200 years in the silver mining industry. No matter to what price silver may fall, the gold content of the ores will continue to sustain profitable operations for many years. Exploration work has demonstrated that the deeper mines were abandoned on account of the cost of unwatering, and very valuable ore deposits have been revealed in the bottom of the old workings. Power in Guanajuato under the most economical conditions cost during 1902, $350, Mexican, per H.P. per year. The Guanajuato Power & Electric Co. has completed arrangements to transmit 6,000 H.P. from the Duero River, near Zamora, in the State of Michoacan, a distance of 100 miles, which will reduce the cost per horse-power per year at the mines to less than $200, Mexican currency. At Pozos, operations have been very active and considerable interest is again being taken in mining operations.

Guerrero.—The ancient camp of Taxco is again receiving some attention. The ore bodies are large in extent, but usually do not exceed 15 to 20 oz. silver per ton. The ores contain silver, lead, zinc, and iron sulphides in such proportions that it is difficult to find a process to treat them profitably. A large body of pyrrhotite is being developed in the Campo Morado. The ore lies on a contact between black shale and igneous rock, and assays 2% copper, 40% iron, 5% silica, 45% sulphur and 0·2 oz. gold and 6 oz. silver per ton.

Hidalgo.—The Pachuca mines treat more than 7,000,000 oz. silver annually. The Santa Gertrudis Mining Co. and the Guadalupe mill have been amalgamated. The electric power plant operating from a distance of 21 miles has been of great advantage to the camp, and fair profits have been obtained. The patio process has perhaps reached its highest efficiency in this camp, 90% of the silver and 20% of the gold being extracted from ores assaying 25 oz. silver and 0·08 oz. gold per ton, although the rise in the cost of treatment points to its early abandonment. In Zimapan considerable work has been done in the silver-lead carbonate and copper properties, the English company having been bought out by Colorado capitalists.

Jalisco.—Work has been started on the extension of the Guadalajara branch of the Central Railway to the Pacific. This railway, from Sayula to Colima, passes through an almost virgin copper-gold country. Labor is cheap, and on account of the proximity to the Aguascalientes smelter, ore can be readily marketed. On the Santiago River the Castellanos gold-silver mine has been purchased by the Mexican Gold & Silver Recovery Co.

Mexico.—The El Oro gold mines have been operated successfully, but the scarcity of fuel is becoming a serious feature. The owners of the Dos Estrellas mine have cut a rich and productive ore body. El Oro Mining and Railway Co. has acquired a large number of claims adjoining its properties. This camp is the richest gold mining district in the Republic. The ore occurring as gold quartz in shale is crushed, carried over plates, and the residues cyanided yielding 80% of the total values. The adjoining camp of Tlalpujahua is a silver camp, and the change to gold mining in this district resembles the similar change in Colorado after 1893.

Michoacan.—The operations of the Inguaran Copper Co. have not increased during the year. The French owners have not yet decided to build the contemplated electric power transmission plant. In Angangueo 2,000 tons of silver-bearing iron pyrites have been mined monthly. The ore carried over 20 oz. silver per ton, 8% zinc blende, with some galena and 30% sulphur. This ore was formerly roasted in open heaps and shipped as an iron flux to Aguascalientes, but the crude ore is now shipped to the same point, and used in the copper plant.

Oaxaca.—The Oaxaca and Ejutla Railway has been extended into the district of Taviche, and the operations in the Ocotlan mining camp have been very active. The principal mine in the district, the Escuadra, containing siliceous silver-gold ore, has been purchased by Omaha capitalists. About 1,500 tons of ore, assaying 90 oz. silver, and from 0·2 to 0·5 oz. gold per ton is being shipped monthly, and a local treatment plant is under construction by the Taviche Milling Co. The gold-silver ore bodies of Ixtlan are being worked very actively, and large profits are being made by the owners of the Natividad mine.

Puebla.—The pyritic deposit of basic, silver-gold, zinky copper ore at Tezuitlan has been actively worked throughout the year. The ore is now being smelted at the rate of 5,000 tons per month, and the copper matte converted into blister copper. Power is obtained from a 1,000-ft. water fall and transmitted five miles to the mines and smelter.

San Luis Potosi.—A new bonanza has been found in the sulphide zone of the La Paz silver mine in Matchuala, which assures the future of the mine for a long time. The monthly production is 4,000 tons of ore assaying from 45 to 50 oz. per ton. The Guggenheim Exploration Co. has secured in Matahuala, the Trinidad mine and the stock of the Azul mine, both adjoining the Dolores property, which is a producer of copper ore carrying silver and gold. In Charcas the Tiro General silver-zinc mine is being developed, and a considerable tonnage of ore was shipped.

Sonora.—The Yaqui Indian uprising has disturbed conditions in the southern portion of the State, and freighting has almost ceased in the central portion from the lack of pasture. The Picacho mine north of Arispe, belonging to Phelps, Dodge & Co., made regular shipments of high-grade siliceous gold ores, and the Chispa mine, south of Arispe, again commenced to ship high grade gold-silver ore. The development of mining in the Sonora, Oposura and Yaqui valleys is greatly retarded by the excessive cost of transportation to the Sonora Railroad.

In the northern portion, the extension of the El Paso & Southwestern Railroad to Douglas, Texas, and the extension of the Mexican Central Railroad to Nacosari has considerably stimulated mining which has been further aided by the entrance of Phelps, Dodge & Co. into custom smelting on a large scale. The Pilar de Teras, a siliceous camp, is producing high-grade ore. On account of their location the Lampazos silver mines and the lead properties in Sahuaripa have received but limited attention. Shipments of lead-copper-silver concentrates have continued from the Dura and the Bufa mines. Progress in the Minas Prietas gold district, south of the Batuc district, has been interrupted; the Grand Central mine is reported to have been closed down permanently, and the cyanide mill has treated all of the tailings available. The Creston Colorado mines seem to be the only properties in successful operation around Alamos, the Predras Verdes and Quinteras copper-silver mines continue to produce the bulk of the values and ship matte assaying 40% copper, 20% lead and 200 oz. silver per ton. The Colorado de Ures property of the Mexican Gold & Silver Recovery Co. has been closed down. The Dos Cabezas mine has opened up a very large siliceous silver-gold deposit, and the problem of local treatment is receiving the attention of the leading mill-men of the United States. So far, the best work shows an extraction of 80% of the gold and 55% of the silver content by a combined cyanide process.

Zacatecas.—The San Rafael group of mines in Zacatecas City has been acquired by English capitalists. The Boti mine continues to produce gold-silver ore, and operations at the Veta Grande silver mines have been very successful. Attention has been paid to the Zacatecas gold belt, and the introduction of the cyanide process will materially aid the work during 1903. Development on a large scale at the Mala Noche mine has demonstrated the value of the ore deposit in depth. At Concepcion de Oro and Mazapil the building of a smelter and a railroad into this gold-copper camp by the Mazapil Copper Co., has been the cause of increased activity. The production of copper and lead ores from this district is approximately 7,000 tons monthly. The Minillas camp produces lead sulphides with high silver content. The San Carlos and Santa Maria de Guadalupe properties have paid very large dividends during the past two years. At the Sombrerete mines the lixiviation plant has been running steadily, and the shipments of high-grade ore were maintained throughout the year.

Territory of Baja California.—Renewed activity is taking place in the gold mines of this Territory, and large profits have been made in the Ensenada country. The scarcity of fuel and water is a great drawback.

Territory of Tepic.—At La Yesca the siliceous lime-manganese ores carrying 40 oz. silver and 0·3 oz. gold per ton have been treated successfully by roasting with salt and cyaniding. The erection of a large plant is now under consideration.

Central America.—*Costa Rica.*—The Bella Vista and Thayer mines equipped with 20-stamp mills, were worked during 1902. The present capacity of the Thayer mine is 100 tons per day, which yields from $8,000 to $10,000 per month. The ore is low grade, but is easily mined. The Abengarez goldfields include the Tres Amigos, Tres Hermanos, and Boston mines. The

Abengarez Co. is substituting water power (300 H.P.) with electric transmission, for steam power, enlarging its mill and cyanide plant, and putting in air compressors for drilling. The ore averages 15 dwt. gold per ton. The average value of the ore of the El Porvenir mine, now owned by the Rio Grande Gold Mining Co., is from $40 to $60 per ton. A new 1,000-ft. main tunnel was to be built and power drills were to be installed in May, 1902.

Honduras.—The production of precious metals during 1902 was 23,234 oz. gold and 1,010,204 oz. silver. The report of the New York & Honduras Rosario Mining Co., for the fiscal year ending Nov. 30, 1902, states that dividends amounting to $105,000 (7% on the capital stock of the company) have been paid during the year, making the total dividends to date $1,800,000. The expenditures for the year including dividends amounted to $631,245, while the income from interest and sale of bullion amounted to $490,274. The surplus at the end of the fiscal year was $842,294. The ore in sight is estimated to be about 30,000 tons. The company is now shipping the concentrates to the United States. A Herreshoff roaster and a reverberatory furnace are being erected in order to reduce the quantity of concentrates to be shipped. The Aramecina mines continued in operation. The Ulna Co. is surveying a road in order to develop the Olancho gold mining district. It is believed that the line can be built in two years.

Nicaragua.—In Nueva Segovia and Prinzapulca, placer mining on a small scale is being done. In the vicinity of Rama there are rich mines. The El Mico mine employs a 20-stamp mill, the ore vein being 22 ft. thick.

Salvador.—The Loma Larga mine has a 3-ft. vein, which averages $20 in gold and silver. The main shaft is 394 ft. deep, and the main level is 1,640 ft. long. About 30,000 tons of ore have been taken from this vein, but water now prevents further working. The San Francisco vein is 6·5 ft. wide and assays $10 per ton of ore in gold and silver, the gold being free. The main shaft is 230 ft. deep with 1,640 ft. of drifts. The Mantos del Socorro and De la Senora mines yielding ores which assay $12 gold per ton, are operative, 600 tons of ore were treated by the cyanide process. The capacity of the plant is 40 tons per day, and 150 men, all natives, are employed. The exports of gold in 1901 were $192,735, a large increase over the exports for the previous years.

SOUTH AMERICA.—*Argentina.*—The Famatima Development Corporation, Ltd., capitalized at £400,000, has been formed to take over the Famatima Copper and Gold Syndicate, Ltd. The mines are in the Mexicana spur of the Famatima Range. There are 14 lodes of ore averaging 4 ft. in width and two miles long. An aërial tramway is being built to the town of Chilecito, a distance of 25 miles, which will reduce the cost of carrying ore to the smelter from 35s. to 2s. per ton. Water is abundant, and the cost of labor 2s. 2d. per day. The ore, which contains gold, silver, and copper, on smelting 30-ton sample lots, gave results varying from £7 15s. per ton to £22 10s. per ton. The Rosario Co. is operating a 36-in. water-jacket blast furnace for copper in the Calamuchita district, 60 miles southwest of Cordoba City. The ore smelted consists of chalcopyrite and pyrite in quartz, yielding from 5 to 6% Cu. The 65% matte product containing 30 oz., silver per ton is exported. In the Rioja province, an Otto overhead wire rope tramway 22 miles long is being installed to transport the rich ores of the Mexicana district to the four copper smelters near Chilecito. This will also revive work in the silver mines of the range which have been inoperative since 1893. The Upolongos mine in the Mexicana district, which has been in continuous operation for many years yields ore assaying 15·3% copper, 65·5 oz. silver and 1·2 oz. gold per ton. The 65% matte produced by smelting contains 271·4 oz. silver and 4·9 oz. gold per ton. The Andueza mine in this district produces ore containing from 5 to 7% copper, 2 oz. gold and 30 oz. silver per ton, while the San Pedro shipping ore assays up to 30% copper, 15 oz. silver and 0·5 oz. gold per ton. The gold and silver ores are smelted with copper ores in the four furnaces in that district, and the matte containing from 60 to 65% copper, together with the precious metals, is crushed and shipped to Europe. The Carranza-Lafone Copper Smelting Corporation of London, capitalized at $3,000,000, has acquired the mines and smelters in the Capillitas and Atajo districts, and a thoroughly modern plant is proposed which is to utilize power from an electric plant at Huason, 10 miles distant. In the Santa Catalina district the new railroad from Jujuy City to Bolivia will aid the development of gold mining. There are several quartz veins containing 2 oz. gold per ton, which, owing to the elevation of 12,000 ft. and lack of fuel cannot now be profitably worked.

Bolivia.—The California, Sallfria and Socorropata mines are situated in Yani County, State of La Paz, about 100 miles from the coast, and at an altitude of 12,690 ft. The lode consists of quartz between walls of slate, varying in width from 35 to 400 cm. and carry from 25·5 to 54·5 oz. gold per cajon (two tons). Lumber and water power are abundant, and the native Indian receive 25c. per day wages. At the Huanchaca mine an electric plant of 2,000 H.P. run by water power has been installed, the current being transmitted a distance of 80 km., and many improvements in the reduction works are under way.

Brazil.—According to Antonio Olyntho, the output of gold in Minas Geraes for 1902 was 4,469 kg., valued at $2,722,780, of which 4,063 kg. were from mines operated by foreign companies. For the half year ending Aug. 31, 1902, the Morro Velho Co. reports an output of 41,044 oz. gold bullion which sold in London for £137,953. The quantity of ore raised amounted to 79,141 tons, of which 72,700 tons were crushed. The total expenses amounted to £88,872. The Ouro Preto Gold Mines of Brazil, report an output during the fiscal year ending June 30, 1902, of 21,258 oz. fine gold, valued at £89,664, which with the receipts from rents and from the sale of arsenic increased the total income to £90,169. The total expenses amounted to £83,642, leaving a balance of £6,527. The amount of ore milled was 67,792 tons as compared with 64,082 tons for the previous 12 months. The new cyanide plant was completed in January, 1902, and the company no longer uses the chlorination method, but treats all its concentrates by the cyanide process. An extraction of 89·1% was obtained as compared with 83·5% for the previous year. Development has now reached a depth of 2,210 ft. The vein which is 13 ft. wide at this level consists of good milling ore. No work has been done upon the Santa Anna property owned by the same company.

The gold fields of the State of Minas Geraes have been well described by

H. Kilburn Scott in a paper read before the American Institute of Mining Engineers, May, 1902. Veins of gold in quartz, assaying 470 g. per ton (equivalent to $235 in value) are reported to have been found in Tassaras, 2 km. distant from the Ouro Preto mines. Dr. Timothes Da Costa reports the results of 10,500 pan washings of gravels from the Carno River to average 3·13 g. gold per ton.

Chile.—The South Chilean Syndicate, capitalized at £32,000, operated placers near San José, but the Valdivia Co., with a capital of £15,000, which started operations at Panquinlahue, suspended work. A gold mine is being operated at Quinco. During 1902 a company operating the cyanide process on old mill tailings, extracted and shipped gold precipitate to the value of $80,000, and the Anglo-Chilean Exploration Co. at Huasco produced from 10 to 11 kg. gold per month from its stamp mill. The principal silver mines which produce about 7,000 oz. per month, are located in the district of Caracoles, 150 miles inland from Antofagasta. Operations are carried on by the leasing system, the lessees paying the owner of the property a royalty of from 15 to 30% upon the net value after deducting mining expenses. The silver-lead smelting works are at Antofagasta, one being in the suburb Bella Vista, owned by the Antofagasta Smelting Co., and the other at Playa Blanca, owned by the Compañia de Minas de Huanchaca. American and French capitalists are interested in the Huanchaca company. Up to March 1, 1903, the Chilean Government melted and sold in the London market 3,300,000 silver soles, replacing the coinage by imports of gold —a step necessary in order to maintain the gold standard.

Colombia.—The continuation of the civil war has hindered the active development of mining, although in the interior of the country operations have been conducted successfully. The Province of Antioquia produces 90% of the total output of gold, which during the past few years has exceeded annually $2,000,000 in value. Silver ore is exported chiefly to Germany and England, in value amounting annually to about $1,500,000. The Zaucudo mines operated entirely by native management employed nearly 2,000 people in 1902, and produced about $20,000 in bullion per month. The Frontino and Bolivia Gold Mining Co., Ltd., which owns the Salada and Silencio mines, operates three California and several native wooden mills. The Leristales and San Nicolas mines, with a 35-stamp California mill, are in operation again after having been closed during the revolution. The Colombian Mines Co. has a native 24-stamp mill at its Venecia mine, and will erect a California mill. The Bramadora mine is being developed, and a Californian 80-stamp mill will be erected. At the San Andres mine, there are over 26,000 tons of ore reported in sight, valued at $42·63 per ton, and 5,000 tons of tailings, valued at $28 per ton. The ore is iron pyrites carrying a little galena and zinc blende, and the vein averages about 5 ft. wide.

Ecuador.—The South American Exploration Co., of New York, continues to operate successfully the mines in the Zaruma district, Province of El Oro. The principal veins vary from 15 to 16 m. in width. The work is through tunnels, the lowest and principal tunnel being 2,300 ft. in length, reaching a depth of 650 ft. The ore is chiefly blue and white quartz, containing about 10% of iron, copper, zinc and lead sulphides, with occasional free gold. The ore is extracted chiefly by stoping large chambers and filling with surface rock, although small chambers are sometimes stoped, and left open until convenient filling is obtainable. Timber is excessively costly, and the common timber of the vicinity becomes decayed in a few years. The mill is equipped with 40 stamps, each of 850 lb. weight. The pulp passes over three 5-ft. copper plates for amalgamation, and thence to steel cyanide vats. Amalgamation yields 30% of the product, and subsequent cyanide treatment of the mill pulp, to which discarded slimes are added, yields 70%. The slimes are impounded in large reservoirs adjacent to the vats. The strength of the cyanide solution is 0·075%. Freight from the coast by mule back costs from $1 to $2 per 100 lb., according to the class of material and the time of the year, travel being very difficult from January to April. Native labor costs $0·50 gold per diem and native contract miners from $0·50 to $2 per diem.

Guiana.—The quantity of gold entered at the Department of Lands and Mines, British Guiana, during 1902 amounted to 103,050 crude oz. (about 900 fine) as compared with 105,945 crude oz. in 1901, while the exports for 1902 were 108,522 crude oz., valued at $1,898,672, as compared with 101,014 crude oz., valued at $1,771,620 in 1901. A large hydraulic plant has been installed at the Omari mine, which promised very satisfactory returns. The cessation of dredging by the British Guiana Co., on the Barima River, is reported to have been due to the unwarranted large scale of operations. A foreign syndicate has been formed to operate a dredging concession in the Peruni district. The British Guiana Consolidated Gold Mines, Ltd., organized Nov. 29, 1902, has acquired the Barima mine and works four miles southwest of Arakaka, in territory recently awarded to Great Britain. The property aggregates 322 acres, and the mill is equipped with a 20-stamp battery and accessories, 75-H.P. vertical boiler, 60-H.P. engine, etc. The ore is free milling quartz assaying about 1 oz. gold per ton. A grant of 500 acres of Crown land and freedom of royalty for 10 years is offered by the Government to any one who discovers platinum, silver, copper, coal or petroleum in the colony before January, 1907.

In French Guiana the higher tax rate on gold (8%), as compared with 5% in Dutch Guiana, is accountable for the difficulty in obtaining exact statistics of production. The reports of organized companies which cannot evade the tax give an aggregate output of from 90 to 100 kg. gold per month, while the actual monthly exports amount to from 250 to 280 kg. This shows that the greater part of the output is derived from the operations of the small workers or "marauders," who are not particular as to the ownership of the territory from which the stock of the precious metal is obtained. According to David Levat in his excellent work *La Guyane Française en 1902*, the tax is evaded by the presentation of a sworn statement that the gold was derived for the most part from beyond the frontier, paying perhaps the 8% tax on a small portion only. This is especially true of the workers in the Inini placers. Furthermore, the statistics of exports of gold from Dutch Guiana during 1901, which amounted to 23,270 oz., valued at £82,630, include 13,139 oz. of gold obtained from French Guiana, the difference in the tax rate of the respective governments causing shipments through Dutch Guiana.

The production of gold in Dutch Guiana during 1902 is officially reported to have been 587·6 kg. as compared with 752·8 kg. in 1901. The statistics of export include a portion of the production of French Guiana, which passes through Dutch Guiana on account of the lower Government tax rate in the latter country. The development of the gold mining industry is seriously hampered by the difficulties of transport, an obstacle which will be removed by the construction of the proposed railroad from Paramaribo to the Lawa district.

Peru.—The production of gold during 1900 was 52,480 oz., valued at $1,084,750. The Nimrod Syndicate has acquired the Chuquitambo gold mines near Cerro de Pasco, formerly worked by the Spaniards. A large quantity of ore is available which though not rich is of sufficiently high grade to be treated with profit. A New York syndicate has purchased practically all of the productive properties in the Cerro de Pasco district at a price of $2,650,000, thereby controlling at least 80% of the mines. A railroad from this district to Oroya is under construction, and will probably be completed before the end of the year, which will lower the freight rates to 24 soles ($11·66) per ton from the present rate of from 70 to 80 soles ($34 to $39) now paid for transportation on the backs of llamas. The Caylloma Silver Mining Co., Ltd., operating the San Pedro, Santa Isabel tunnel, Bateas and Eureka mines report for the fiscal year ending June 30, 1902, gross receipts from ore and bullion amounting to £47,541; deducting £2,000 for depreciation the net loss was £3,421. The year's work showed 730 tons of ore shipped, of an average assay of 416 oz. 6 dwt. silver and 1 oz. 1 dwt. gold per ton, the total value being £29,837. Bar silver sold during the year contained 166,051 standard oz. silver and 154 oz. gold of an aggregate value of £17,703. Owing to the decline in the price of silver, it is reported that the company is seriously contemplating a shut-down of the works. The Inca Mining Co., owning mines in the interior of the country, has recently purchased from an American company a $40,000-milling plant, consisting of a 30-stamp mill, 8 Wilfley concentrators, engines, boilers, etc. The machinery was packed in 300-lb. lots as the only means of transportation is on the backs of llamas. During 1902 Barkis & Johnson Co. shipped to London 3,000 tons of copper matte containing from 40 to 50% copper and from 225 to 235 oz. silver per ton. The company is developing rapidly and expects to produce more than double its present output during 1903. The Alpa Mina in the Yauli district, produced 250 tons of ore assaying 40% lead and from 30 to 100 oz. silver per ton.

Uruguay.—The quartz mines of Cunapiru, San Gregorio and Santa Ernestina in the Rivera department, have been operated by a French company, which during 1901 treated 6,183 tons of ore, yielding 72 kg. gold, valued at $47,815, as compared with 7,345 tons, yielding 71 kg. gold, valued at $47,342, in 1900. The cyanide process recently adopted has given better results. The mines are small—mostly surface work—and assays from 12 workings range from 6·75 to 30·79 g. ($4·50 to $20·50) per ton. During 1901, 25 new applications for mining privileges were filed in the departments of Cerro Largo, Minas, Maldonado, Canelones and Florida. A serious obstacle to the development of the mines is the lack of water. A percentage of the total output of gold is paid to the Government.

EUROPE.—*Russia.*—Reports of operations at the so-called "Finnish Klondyke" on the banks of the Iraljoki and Tolosjoki in Lapland, state that several hundred men are engaged in working the deposits. The severe climate is a serious obstacle to development. The gold mining region of Primorski, Siberia, is divided into two parts—the northern, on the Amur River and the Okhotsk Sea, and the southern, on several small rivers along the South Ussuri district and the island of Askold. Mining has increased in the former since the construction of the Ussuri and Transbaikal Railroad. Trial excavations are made at a distance of 1 verst (0·653 mile) apart. The ground is stripped by hand digging, the turf being removed by horse cars; but recently ground sluicing has been introduced for this purpose. A workman is paid from 61·2 to 92·7c. a day. The richest gold placers in the South Ussuri region have been worked by ancient Chinese processes, which limit the quantity to be washed in 24 hours to 375 cu. m.; for this reason no deposit is worked which yields less than 1·65 mg. gold per cu. m. For washing 900,000 cu. m. sand per year, 2,000 men and 500 horses are required. The Russian Ministry of Finance is projecting a railroad 600 miles in length from the upper reaches of the Angara River to the River Vitim across the richest gold-bearing district of Siberia, lying to the northeast of Lake Baikal. It has also decided to establish four new gold refineries in Eastern Siberia; two to be installed by the Ministry of Finance at Blagovestchensk and Krasnoïarsk, one at Nicolaïevsk, and one at Badaïbo.

Servia.—The Rusman gold mine at Glogowitza on the Timok River is still in its preliminary stage. A mill consisting of 10 stamps weighing 550 kg. each, together with an amalgamation and concentrating plant, was set in operation toward the end of 1900. The ore consists of pyrite averaging 30 to 40 g. gold per ton. Two Servian companies prospected for gold in the valley of the Pek River, near Kutchevo, where alluvial deposits containing fine and coarse grains of gold have been found. A large number of quartz veins were found showing free gold, galena, chalcopyrite and pyrite.

Spain.—English capital has become interested in alluvial mining in the provinces of Lugo, Orense and Leon on the rivers Sil and Miño and tributaries; in all 33 properties of an aggregate area of 4,179 acres have been acquired. The nature, value and depth of the alluvial is common to all, and covers almost the entire area of each concession, its depth varies from 10 to 25 ft. of a minimum value of 5 dwt. gold per cu. yd. The cost of working the deposit by small machines of a daily capacity of 25 cu. yd. is stated to be 2·5d. per cu. yd.

AFRICA.—*Egypt.*—During 1902 the Egyptian Mines Exploration Co., Ltd., the Egyptian Development Syndicate, and the Egypt & Soudan Mining Syndicate have explored the property granted to them by the Egyptian Government. The first of these companies has been working on its mines at Um Rus, the main shaft now being 250 ft. in depth. The vein varies in width from 4 to 40 in., and assays from 1 dwt. to 5 oz. gold. Native labor is in abundance at wages from 1s. 6d. to 1s. 8d. per day, while the cost of fuel is 35s. per ton. At the Fatira mine the vein varies in width from 8 to 40 in., and samples assay from 1 dwt. to 3 oz. 15 dwt. gold. Both mines had been worked in ancient times. The Central Egypt Exploration Co., Ltd., which is a subsidiary company of the Egyptian Exploration Co., has been capitalized at £150,000. The district owned by the company occupies 1,200 sq. miles. Two ancient gold mines have been rediscovered—the Fowkir and the Um Esh. The quartz vein in the latter is half a mile long and from a few inches to a foot thick. A part of the ore assayed 11 dwt. 12 gr. gold per ton. In the Fowkir mine samples assay from 1·5 to 5 dwt. gold per ton. Labor is abundant and cheap, but fuel and timber will have to be imported; the mines, however, are easily accessible from the coast. The Nile Valley Co. in its report of March 5, 1903, states that it has received a concession of 6,000 sq. miles from the Egyptian Government. At the Um Garaiart mine, owned by this company, there is a complete hoisting and pumping plant and a small battery is being erected. Three shafts have been sunk, the reef varying from 18 in. to 9 ft. in thickness, and the ore assaying from 20 to 250 oz. gold. Ore valued at £11,000 has been taken out of the mine. The Egypt & Soudan Mining Syndicate, Ltd., for the year ending September 30, 1902, reports that its concessions in Egypt comprise an area of 2,000 sq. miles, and in Soudan about 20,000 sq. miles. On its Egyptian property at Hamesh three shafts have been sunk, the ore assaying from 12 gr. to 1 oz. 4 dwt. per ton, and at Samut three other shafts show the vein to vary from 0·5 to 1·5 ft. in width and to assay from 2 dwt. to 2 oz. 18 dwt. per ton. On its Soudan property investigation and development work have been carried on at Om Nabardi and Nabi, and it has been found that the ore assays from 5 dwt. to 1 oz. 16 dwt. gold per ton.

Gold Coast.—According to the Controller of Customs at Accra, the exports from the Gold Coast Colony during 1901 amounted to 6,163 oz. bullion, equivalent to 5,224 oz. fine gold, valued at £22,187, as compared with 10,557 oz. bullion, valued at £38,007, in 1900. The Asiakwa Hydraulicking & Mining Corporation, Ltd., owns 20 sq. miles of territory; a test on 338 cu. yd. of gravel gave by hydraulic mining 20 oz. 1 dwt. gold assaying 930 fine. A plant is to be built to produce 40 oz. gold per day. The New Gold Coast Agency, Ltd., has acquired the Gold Coast Agency, Ltd., and obtained large concessions in the Tarkwa district belonging to the Nassau Gold Coast Mining Co., Ltd., and the Gold Coast Pioneer Syndicate, Ltd. The new company has formed two subsidiary companies—the Adjak Bippo Deep, Ltd., and the Cinnamon Bippo Co., Ltd.—both capitalized at £100,000. Both of these latter companies are developing their properties. The reef of the first varies in thickness from 10 to 44 in. and assays from 2 to 23 dwt. gold per ton, while the reef of the second varies from 2·5 to 18 in. and assays from 3 to 24 dwt. gold per ton.

Ivory Coast.—The Consolidated Goldfields of the Ivory Coast, Ltd., increased its capital to £1,000,000 after taking over the property of the New Austral Co., Ltd. The concession owned by the company covers 2,000,000 acres. The New Austral properties are situated in the districts of the Baoulé, Sanwi, Indénié, Attie and Biano rivers. The sample of the ore taken from the Amangara reef assayed from 1 to 18 oz. gold, and from 0·5 to 2 oz. silver. Engineers have been sent out to investigate the property. On the bank of the Menzan River quartz has been found which assays from 2 to 30 dwt. gold per ton. At Assikasso, where the work has reached a depth of 60 ft., assays show gold throughout the deposit.

Madagascar.—The exports for 1901 were gold dust, 2,374 lb., valued at $590,765, and gold in bars, 245 lb., valued at $46,073, as compared with gold dust, $641,355, and gold in bars, $51,114 in 1900. The property of the Suberbieville Co. is to be developed by the South African Gold Dredging Co., the former company to receive 2 fr. for every hectare exploited, and a royalty of 20% of the value of the gold recovered from the placers and 25% of that from crushing. Three years ago the Suberbieville Co. erected a dredging plant at Majunga, but it was not placed in operation. It is reported that placer gold has been found near the port of Manangary. According to the mining regulation, which went into effect February, 1902, a 5% tax of the value of all mineral extracted is levied, being calculated on the quarterly production. In no case can the quarterly tax be less than $50.

Portuguese East Africa.—The exports of gold in bars and gold dust, domestic or foreign, in 1901, amounted to 1,136 lb., valued at £52,577. New regulations were made for the mining fields by which the reef claims have been doubled in size, runing 100 m. along the reef and 200 m. across. Companies floated on properties must pay to the Mozambique Co., either 10% (a reduction from the former 50%) of their nominal capital, or 20% of the vender's shares fully paid up. Claim holders may pay four times the tax above specified and dispose of their claims without any revision of share to the Mozambique Co. Concessions have also been granted on the rivers of the Mozambique Co.'s territories and dredges have been installed. Some work has also been done on the Richmond, Braganza, Revue and Guy Fawkes mines. Boys for working the mines are provided by the company at £1 per head per month. More than 2,000 boys are at work in the mines. Rich discoveries have been made in Mozambique. The Macequeci promises good results, and a valuable discovery has been made in the Uanetz district. The formation is the true conglomerate. as in the Witwatersrand. The reef extends for a long distance, 7 miles having been prospected. The district is north of Incomati, near the Transvaal. It is healthy, and there is an abundant supply of water and timber. A syndicate recently formed is prospecting the field.

Rhodesia.—The ore crushed in 1902 was 142,037 tons, yielding 194,268 crude oz., as compared with 172,150 crude oz. in 1901. The number of stamps in operation during the year was 370, of which 60 represent prospecting batteries. There are in course of erection 68 additional stamps, and 240 additional stamps have been ordered. The Selukwe mine, which during 1902 paid a 20% dividend, produced from 2,566 to 3,685 oz. of gold per month in its mill, while its cyanide plant produced 1,200 to 1,812 oz. per month. About 1,000 natives are employed. The working of all the mines in Rhodesia has been hindered owing to the difficulty of obtaining native labor. Then again the laborers, from no apparent reason, take a strong dislike to certain mines, which in consequence find the greatest difficulty in obtaining labor. For this reason the mines are now employing Shangaans from Portuguese territory, who are more disposed to settle down and work for a longer period. In the Geelong and Geelong Valley mines it is estimated that there are 53,000 tons of ore in sight averaging 15 dwt. gold per ton. In the West Nicholson mine the ore in sight is estimated at 70,000 tons, assaying from 8 to 12 dwt. per ton, in addition to large tonnage of low grade ore. The 10-stamp mill is to be increased by the addition of 50 new stamps. The Red and White Rose mine has erected a 20-stamp mill and cyanide plant. Its ore assays 12 dwt. gold per ton. The Rhodesia Exploration & Development Co., Ltd., during the fiscal year ending June 30, 1902, was engaged in devoloping its six mines, excavating 12,635 yd. material at an average cost of £2 18s. 2·6d. per running foot. The Ayrshire Gold Mine & Lomagunda Railway Co., Ltd., for the year ending June 30, 1902, reports that the railroad from Salisbury to the mine has been completed. Its mine is being developed, 62,100 tons of ore averaging 10 dwt. having been blocked out. Its 5-stamp mill, which crushed 7,033 tons of ore yielding 3,895 oz. of bullion between April, 1900 and August 31, 1901, will be increased, and a cyanide plant added. The V. V. (Gwanda) Syndicate, Ltd., is also developing its ten properties and a 10-stamp mill is to be erected. It has sold three of its properties to the Imani Gold Mining Co., Ltd. The Selukwe Gold Mining Co., Ltd., for the year ending March 31, 1902, reported that it crushed 62,301 tons of rock yielding 38,049 oz. bullion, and treated in its cyanide mill, which was completed in October, 1901, 28,160 tons, yielding 6,472 oz. bullion. It realized from the sale of gold £159,862, and its total income was £160,101. The net profit for the year was £43,898, which with £52,275, the balance brought forward from the previous fiscal year, made a total balance of £96,171. A dividend of 10% was paid in August, 1902.

Transvaal.—(We are indebted to W. Fischer Wilkinson[1] for valuable information contained in this review.)—The opening of the year 1902 found the war still in progress, although the British troops were able to maintain tranquil conditions throughout most of the colony. By December, 1901, only 11 companies had taken advantage of the order issued in May granting permission to resume operations on a small scale, and the number of stamps dropping was only 653 out of the 5,970 at work before the war. As the difficulties incident to repairing damages, procuring supplies and getting a sufficient quota of native laborers were overcome, the list of operative mines was gradually increased. In January, 1902, 21 companies with 1,075 stamps were working; in April, 33 companies, 1,760 stamps; in June, 37 companies, 2,130 stamps; in August, 39 companies, 2,395 stamps; in October, 41 companies, 2,570 stamps, and in December, 45 companies, with 2,845 stamps. Hostilities ceased on May 31, 1902, when the peace negotiations were signed by the two parties. The losses sustained by the mining companies on account of the war were heavy, although little wilful damage was committed by the Boers. The largest item—the costs of care-taking, unwatering, repairs, salaries and wages—amounted to £3,400,000; while the gold appropriated by the Boer Government from the mines was £2,475,178. Exclusive of interest on capital the total loss may be placed at about £6,000,000. In some respects the changed conditions under the new rule have been for the benefit of the mining companies. The latter have profited

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[1] *Engineering and Mining Journal*, Jan. 3, 1903, p. 16.

by a material reduction in the price of explosives and coal, and also by the removal of certain import duties. The high railway rates, however, have not been altered. As an offset to the concessions granted, account must be taken of the increase in the profit tax to 10%, which will directly affect the dividend distribution upon mining shares. The greatest difficulty in the way of rapid progress at the present time is the scarcity of native labor. Of the 100,000 natives employed before the war less than half that number returned to the mines in 1902, despite the best efforts of recruiting agents in all the native districts. The experiment of replacing their labor by unskilled whites has been unsuccessful, and there are serious objections to the importation of Asiatics. The scarcity of natives has been due to several causes—the employment of large numbers in the army, the abundance of harvests and the reduction in the wages paid at the mines. Under the present stringent administration of the liquor law, it is stated that the natives give much more efficient service than formerly. The output of gold for the year ending June 30, 1902, according to the report of the Commissioner of Mines, was 891,999 fine oz., valued at £3,788,968. Of this amount, the mines on the Witwatersrand contributed 851,799 fine oz., valued at £3,618,206, while the output of the reduction works amounted to 40,200 fine oz., valued at £170,762. Of the tailings treated during the year 1,092,369 tons of sand and 220,997 tons of slimes were treated by the zinc process, and 71,302 tons of sands and 41,675 tons of slimes were treated by the Siemens-Halske process. The percentage of waste rock sorted on the surface before milling averaged 19·012%, and for each ounce of fine gold produced, 2·457 tons of ore were raised. The total output of gold for the Witwatersrand in 1902 was 1,690,101 fine oz., valued at £7,179,074, as compared with 238,995 fine oz., valued at £1,014,687 in 1901, an increase of 1,451,106 fine oz., valued at £6,164,387. The increase was divided as follows: Mill yields, 897,231 oz.; concentrates and by-products, 48,836 oz.; tailings, 458,243 oz.; slimes, 46,283 oz., and other sources, 512 oz. The gold exported during 1902 amounted to £7,239,888. The mining companies of the Transvaal, excluding investment and land corporations, represent an investment of 200 millions sterling, or about a billion dollars. This is approximately equal to the cost of the Boer war. The number, nominal capital and market valuation of the companies are as follows:—

Description.	Number.	Nominal Capital.	Market Valuation.
Mining	301	$460,440,000	$979,090,000
Investment	36	124,000,000	495,000,000
Land	13	38,550,000	90,000,000
Totals	350	$622,990,000	$1,564,090,000

Messrs. Leggett and Hatch estimate the ore lying within the depth of 6,000 ft. and length of 46·9 miles at £1,233,560,709. The output should average £30,000,000 per year, and at this rate it would take 42·5 years to exhaust the fields. During 1902 the mining companies paid dividends amounting to £1,442,375. The Consolidated Goldfields of South Africa, Ltd., for the year ending June 30, 1902, reports a profit of £893,385, out of which £124,629 for dividend and tax were paid, leaving £663,722; this, with amount brought forward from the previous year, £1,512,206, makes £2,175,928, out of which a dividend of £500,000 is to be paid, leaving £1,675,928 to be carried forward. The Robinson Deep Gold Mining Co., owned by this company, re-started in March, 1901, with 50 stamps, and between March 1 and August 30, 1901, the company milled 48,615 tons of ore, yielding 23,934 fine oz. gold, valued at £99,452. The working expenses amounted to £81,355, leaving a profit of £18,097. The Glen Deep, Ltd., for the year ending July 31, 1902, states that operations were resumed in March, 1902, and between March and July 31, 1902, it crushed 27,328 tons of ore with 35 stamps, yielding 9,380 fine oz. gold, valued at £39,336; the expenditures during the same period amounted to £32,682, leaving a profit of £6,653, from which must be subtracted interest charges of £2,481, making the net profit £4,173. The ore reserves were estimated at 383,694 tons. The Simmer and Jack Proprietary Mines, Ltd., for the year ending June 30, 1902, reports a resumption of operations April 23, 1902, with 50 stamps, which were increased to 100 in June. The total tonnage crushed was 28,404, yielding 8,225 fine oz. gold, valued at £34,642, and the working expenses were £35,608. The 40 additional stamps started before the war were completed, increasing the capacity of the plant to 320 stamps, and a drying and a reverberatory furnace were built for drying and smelting the gold slimes. The Jumpers Deep, Ltd., for the year ending September 30, 1902, reports that it resumed operation in February, 1902, and in eight months treated 74,146 tons of ore, yielding 26,115 fine oz. gold valued at £109,152, and expended £95,090, leaving a net profit, after paying interest charges of £966, of £13,096. The ore reserves on September 30, 1902, were estimated at 619,137 tons. The Langlaagte Deep, Ltd., for the year ending July 31, 1902, reports that during seven months it milled 66,531 tons, yielding 25,433 fine oz. gold, valued at £106,448, and expended £81,284 for operating its property, and £25,161 for interest. The ore reserves on July 31, 1902, were estimated at 762,317 tons. The Nourse Deep, Ltd., for the year ending July 31, 1902, reports that during five months it milled 36,008 tons of ore, yielding 10,484 fine oz. gold, valued at £43,637, and expended £40,905 for operating its property, and £316 for interest, leaving a net profit of £2,416. The ore reserves on July 31, 1902, were estimated at 495,126 tons.

West Africa.—In January, 1903, the Prah Gold Mines, Ltd., the Clinton's Gold Concessions, Ltd., the United Gold Mines of West Africa, Ltd., the Atomé Mines, Ltd., and the Bakrobo Mines, Ltd., were consolidated. The consolidated company owns 1,000 sq. miles in West Africa. The nominal capital at the time of consolidation was £900,000, of which £694,000 had been paid in. The name of the present company is the United Gold Mines of West Africa, with a nominal capital of £500,000, of which £464,000 were issued at once, leaving £36,000 to be issued as required.

ASIA.—*China.*—The Syndicat du Yunnan, Ltd., has obtained a concession from the Chinese Government for a period of 60 years to exploit the mines and mineral deposits in 35 districts of the Province of Yunnan. These districts cover 40,000 sq. miles and contain 59 mines:—25 copper, 27 silver, 6 gold and one tin mine. Of the net profits of the company, 10% is to be paid to the Provincial

Government of Yunnan, 25% to the Imperial Chinese Government, and 65% to the Syndicate of Yunnan. The annual output of silver in Mongolia averages from 80,000 to 100,000 oz., and is obtained by the natives in a very primitive manner. Modern methods of treatment recently introduced were unsuccessful owing to the high cost of coke and machinery unsuited for concentrating the galena, which is very finely disseminated throughout the ore. The principal silver mines are 45 miles northeast of Jehol, the capital of Mongolia, first worked by the natives 50 years ago. There are two mines, the Ku Shan Tze and Yen Tung Shan, about five miles apart. The vein in the upper levels is composed of galena in iron ore from 2 to 4 ft. thick, while in the lower the silver-lead ore occurs between quartz porphyry walls. The deepest workings are 400 ft. below the surface. The ore is hand concentrated and roasted for a week in a primitive furnace 6 ft. in diameter and 5 ft. high, constructed of blue bricks. The roasted ore is then continuously smelted with fluxes in a brick furnace 1 ft. in diameter and 3 ft. high, until 100 lb. of lead has accumulated when the metal is quenched with water and cupelled in a furnace having a muffle 18×12×8 in. in size with a hearth of wood ashes. Ten hours are required to cupel 100 lb. of charge. When the product is 995 fine the silver is cooled in water, removed from the furnace and cut into pieces varying in weight from 5 to 50 oz.

Dutch East Indies.—(For a general description of the gold resources of the Dutch East Indies consult THE MINERAL INDUSTRY, Vol. X., p. 319.)—The development of the mining industry in Borneo, Sumatra and Celebes, where active exploration work has been carried on for several years, has not been attended thus far with financial returns. In the period 1893-1901 inclusive, 53 mining companies were organized with an aggregate capitalization of about $12,500,000, and more than $2,500,000 were expended in exploring various properties; of these ventures three have reached the producing stage, but as yet have not earned sufficient profits to warrant the payment of dividends. The Redjang Lebong mine in Sumatra has a 40-stamp mill and exploits a reef carrying about 2 oz. gold, and from 7 to 10 oz. silver per ton. During the year 1902 the mill treated 16,435 metric tons of ore for a yield of 21,982 oz. gold and 118,225 oz. silver, while 6,021 tons of ore were reserved for further treatment. Some difficulties were experienced in operating the slimes plant, and the production was greatly reduced by lack of water which necessitated an almost complete suspension of operations during September and October. At the Lebong Soelit mine, now owned by the Mynbouw Maatschappij Katahoen, a 20-stamp mill has been placed in operation. In northern Celebes, the Palehleh mine, which is located on an irregular vein averaging about 6 ft. in width, during the first nine months of 1902, produced 118 kg. gold and 43 kg. silver from 17,655 metric tons of ore. The production for the year 1901 was 143·5 kg. gold from 15,618 tons of ore. This property is operated by the Nederlandschindische Gold Mining Co. The Soemalata Co., whose mine is located 40 miles west of Palehleh, reported for 11 months of 1902 an output of 5,430 oz. gold; in 1901 its output was 8,460 oz. The most promising developments in Borneo have been made in the southern part near the Kahajang River, but as yet no mines have reached the producing stage.

India.—The quantity of gold produced from the Kolar field during 1902 was 513,220 oz. crude gold, valued at £1,959,268, as compared with 504,732 oz., valued at £1,921,000 in 1901. During the year the Government works for supplying electrical power to the mines was completed, and the full 8,000 H.P. will soon be available. Of the 15 operative companies in the Mysore district, five paid dividends amounting to £874,158, five produced gold but paid no dividends, while five were non-producers. The Coromandel, Nine Reefs, and West Balaghat mines are no longer producers; the first of these, however, will probably resume crushing in 1903. The production of gold decreased considerably during April, May and June, 1902, due to the scarcity of water. At the Hutti (Nizam's) Gold Mines, Ltd., at Hyderabad, a 10-stamp mill has been erected. The report of the Champion Reef Gold Mining Co., Ltd., for the fiscal year ending September 30, 1902, shows an income from the sale of gold of £571,705, and a total income of £543,326 after deducting the royalty paid to the Government, as compared with £576,329 in 1901. The expenditures amounted to £259,489, leaving a net balance of £288,293, out of which £130,075 in dividends were paid, or at the rate of 110%. The quantity of ore crushed amounted to 134,088 tons yielding 138,872 oz. bar gold, an average yield of 1 oz. 17 gr. per ton, while the tailings and slimes amounting to 115,411 tons treated by the cyanide process, yielded 11,873 oz. bar gold, an average of 2 dwt. 1 gr. per ton. The total production of bar gold was 150,745 oz. A new 120-stamp mill was placed in operation. The scarcity of water during the dry season (April to July) caused a large decrease in the output. A new cyanide plant with a capacity of 8,000 tons of tailings per month was started in August, which increases the total capacity of the plant to 20,000 tons of sand per month. The Mysore Gold Mining Co., Ltd., during 1902 milled 140,306 tons of ore yielding by amalgamation 154,905 oz. bar gold, an average of 1 oz. 2 dwt. 2 gr. per ton. The cyanide works treated 114,549 tons of tailings, from which 12,927 oz. gold were obtained, an average of 2 dwt. 6 gr. per ton. The plates yielded 672 oz., making a total output of 168,504 oz., as compared with 164,581 oz. in 1901. The gold realized £657,918, upon which £32,610 in royalties were paid. Receipts from various sources amounted to £3,131. Expenditures amounted to £253,704, and £344,500 were paid in dividends, a rate of 130% for the year. The balance on hand at the end of the fiscal year was £376,145. Since January, 1898, the company has paid £3,175,152 in dividends on a capital of £265,000. In November, 1902, the capital was raised to £290,000 by the issue of 50,000 shares of 10s. each, 15,000 of these shares and £20,000 being paid to the Gold Fields of Mysore & General Exploration Co., Ltd., for their 342-acre block. The capacity of the cyanide plant is 15,000 tons of tailings per month. The new 60-stamp mill was started in October, which increases the total number of stamps to 210; of these, 150 are operated by electric power. The ore reserve is estimated to be over 340,000 tons. The Ooregum Gold Mining Co., Ltd., milled 106,930 tons of ore during 1902, yielding 88,069 oz. gold valued at £327,846. The ordinary expenditure amounted to £164,675, and the profit to £148,937. The mills contributed 68,942 oz., the cyanide works 16,239 oz., and 2,888 oz. were obtained from skimmings, dismantling old mills, etc. The new 120-stamp mill has been in operation for the greater part of the year. The Nundydroog Co., Ltd., during 1902 produced 58,034 oz. gold, valued at £218,171. The mills treated 55,940 tons of quartz, yielding 52,677 oz. gold, and 60,409 tons of tailings were cyanided for a recovery of 5,357 oz. gold. The Balaghat Gold Mining Co., Ltd., during 1902 produced 23,762 oz. gold from 25,635 tons of quartz crushed, and 2,635 oz. gold from 24,030 tons of tailing cyanided, a total of 26,397 oz., valued at £102,021. The expenditure amounted to £65,988. A dividend of £8,945 was paid, leaving a balance of £14,211 to be carried forward.

Japan.—The placer fields of Hokkaido, which cover some 20 sq. miles, made an output estimated at 10,000 oz. in 1901. Many of the individual operators have combined into small companies for the purpose of adopting American methods and working the sections more thoroughly. The development of the district is hampered by governmental restrictions, owing to which the actual working period in the year does not exceed three months.

Korea.—The development of gold mining in Korea has been hindered by the Government restriction, whereby but one concession is granted to each prominent power; so far, subjects of the United States, United Kingdom, Germany and Japan have located workings, and of these the American concession only has arrived at a producing stage. This property of from 400 to 500 acres in extent, is located in the northwestern section near the border of Manchuria. The principal mines with stamp mill equipment in operation are in three groups—Chittabalbie (20 stamps) and Maihong, 40; Kuk San Dong, 20; Tabowie, 40, and Taracol, 80. The groups are 22 miles apart, and each one is under a superintendent. In addition, prospecting and development are being carried on, and several mines are let to native tributors. The ore is quartz in granite, and the mills are equipped with vanners, but have no cyanide plant for the tailings. Very rich concentrates are shipped to the United States. With regard to the local conditions, water is plentiful except during a short period in winter; lumber is cheap, though not plentiful, and labor is cheap. Japanese are largely employed as carpenters, blacksmiths and engineers at about 3s. per day; Chinese mainly as surface coolies at the mills, although some are employed underground at 10·5d. per day; Koreans as miners or carpenters at 1s. 3d.; coolies at 7·5d. per day. Satisfactory results are obtained by having the natives work under direct supervision of a white man without an intermediate native foreman. The ground is not hard, but requires dynamite and timbering, square sets being used in large stopes, which vary from 4 to 15 ft., averaging 8 ft. The somewhat complicated occurrence of ore shoots is not conducive to cheap systematic mining. S. J. Speak estimates mining costs at from 4s. to 5s. per ton, with a width of stope not less than 4 ft. and moderate dead-work. Recent milling and concentrating costs at the Tabowie mill of 40 stamps with vanners and canvas plant, run by steam power using wood fuel were as follows: May, 1902, treating 4,008 tons, 1s. 8·8d. per ton; June, treating 4,130 tons, 1s. 7·5d., and July, treating 4,589 tons, 1s. 7·1d. The average working cost of a 40-stamp mill in this district varies from 1s. 9d. to 2s. per ton. The satisfactory work accomplished in Korea by Chinese labor under the supervison of white men is an indication of what may be hoped for in mining in the temperate zones of the Far East.

Malay Peninsula.—The output of gold in Pahang in 1901 amounted to 23,948 oz., valued at £77,831, as compared with 17,048 oz. (£65,229) in 1900. The Kedana Co., which owns a mine near Mt. Ophir, Malacca, has erected a mill and has crushed ore for six months of 1902. The mill at Ketchau was not in operation during the greater part of the year, as it had no ore to crush. The Punjum Gold Mining Co. and the Tin Concession & Batu Bersawah Mining Co. are still prospecting. The Raub Australian Gold Mining Co. increased its output from 12,477 oz. in 1900, to 18,901 oz. in 1901. Four companies began exporting gold in 1901—the Malaysian Mining Co., 1,315 oz.; Queensland Raub Syndicate, 75 oz.; Malaysian Mining Co., 1,164 oz., and Bentong, 114 oz. In the Bentong mine a shaft was sunk 105 ft., but no defined lode was discovered; at the Raub mine samples assayed 11·5 dwt. gold. No deep shafts have been sunk; it is not known, therefore, if any of the mines continue in depth. The country is covered with heavy jungle, transportation facilities are inadequate, and means of communication are lacking, and although alluvial deposits are known to exist from Budu to Sepan, from Benta to Lipis, and along the Semantan and Krau rivers, and the tributaries of the Jelai River, the deposits have not been worked.

AUSTRALASIA.—(Through the courtesy of F. Danvers Power, special notes on the mining industries of the States have been incorporated in the following review.)—The year 1902 was one of depression throughout Australasia, principally on account of the low price of metals and the prevailing drought. The latter has acted directly by forcing certain mining operations to cease temporarily for want of water, and indirectly by its effect on the general prosperity of these States, inasmuch as the wool clip was a failure and the output of wheat did not suffice for domestic consumption, so that export was out of the question. Mining legislation did not encourage the investment of foreign capital. Despite the baneful effects of the drought development work has been carried on actively in some cases. That the present depression is not due to anything radically wrong with the mines themselves is indicated by the increased yield of gold in the principal States over that of last year, and the fact that other mines are ready to recommence work as soon as the prices of copper, lead and silver rise, or a sufficient supply of water is obtained. The combination of adverse conditions has caused a few mines to try to meet them by increasing their output with the same management, while being satisfied with smaller profits. By this means,

PRODUCTION OF GOLD IN AUSTRALASIA.

States.	1900.		1901.		1902.	
	Fine Oz.	Value.	Fine Oz.	Value.	Fine Oz.	Value.
New South Wales	281,616	$5,821,008	216,888	$4,483,075	254,435	$5,259,171
New Zealand	339,395	7,015,293	412,875	8,534,126	458,933	9,486,145
Queensland	677,024	13,994.086	598,382	12,368,556	640,463	13,238,370
South Australia (a)	19,376	400,502	21,946	453,624	24,082	497,775
Tasmania	74,552	1,540,990	69,491	1.436,789	70,996	1,467.487
Victoria	752.284	15,549,710	730,449	15,098,380	720.866	14,900,300
Western Australia	1,354.343	27,994,270	1,669,072	34,799,718	1,819,308	37,605,096
Totals	3,498.590	$72,315,854	3,719,108	$77,174,268	3,989,088	$82,454,844

(a) Includes Northern Territory.

as also by effecting other economies, the Broken Hill Proprietary Co. has been able to pay a half-yearly dividend. A proposal was made to amalgamate the principal Broken Hill mines in order to save expenses in administration, but it did not meet with a favorable reception.

New South Wales.—The increase in the output of gold is considered to be due to the gold extracted by smelters from ores received from other States and included in the returns as the actual produce of the colony. The industry has been severely affected by the drought, and many of the mines have been shut down from six to nine months. The Cobar district still continues to be the chief producer, the output for 1902 being 26,956 oz.; Wyalong contributed 20,718 oz.; Adelong, 14,414 oz., and Araluen, 13,909 oz. Seven suction and 22 bucket dredges were in operation in 1902, the Araluen Valley, Araluen Central, Tulloch's, Perry's, Jembaicumbene and Kiandra being the most successful. These dredges during 1902 produced 25,473 oz. gold, valued at £97,891, against 23,585 oz. gold, valued at £89,628 in 1901. The Araluen district contributed 52% of this total. At Nerrigundah, the Red Creek Gold mine has two veins, one 2·5 ft. wide and developed to a depth of 120 ft., the ore averaging 2 to 3 oz. gold per ton, and the other 6 in. wide, and averaging 10 oz. gold per ton. The Cobar Gold Mines, Ltd., reports for the year ending September 30, 1902, that it treated 30,730 tons of ore, 18,291 tons of tailings, and 9,965 tons of slimes, yielding 11,216 oz. gold, valued at £32,641. The total expenditures for the year amounted to £31,930, and the income amounted to £32,648. Besides adding to the plant and machinery, some development work was done. The company could only operate during five months of the year on account of the drought. The King Conrad Silver & Lead mine, situated at Inverell has gone into liquidation, while the Prince of Wales mine, at Gundagai, and the Post Office mine, at Stuart Town, the latter belonging to the Emma Co., have closed down. The Lachlan Gold Fields, Ltd., crushed and concentrated 7,192 tons of ore, and obtained from the sale of gold bullion, slag, and concentrates a net return of £17,906. The total output of silver, concentrates, ores, etc., in 1902, was valued at £1,440,179. The low price of silver caused the temporary closing of all the Broken Hill mines with the exception of the Proprietary, Central, Block 10 and South mines. The Federal tariff is felt more in New South Wales than in any other State, as in the past most goods were entered free. Its effect upon the mining industry is illustrated by the Broken Hill mines, where Oregon timber is used for the square sets. A duty is now levied of 6d. per 100 ft. on large timber, and 18d. per 100 ft. on smaller sizes.

New Zealand.—The exports of gold during 1902 were 508,043 oz., valued at £1,951,430, an increase of 52,482 oz., of the value of £197,647 over the preceding year. The quantity of silver exported during 1902 amounted to 673,986 oz., valued at £72,001, as compared with 571,134 oz., valued at £65,258 in 1901. The greater portion of the silver has been obtained from the mines in the Hauraki district. The gold produced by the Otago dredges during 1901 amounted to 65,227 oz. from an average number of 46 working dredges, while 63 dredges in 1902 produced 105,786 oz. According to C. E. Turner, the cost of operating a dredge designed to lift 2,000 cu. yd. per day of 24 hours is

£53 10s. per week. The total dividends paid by New Zealand mines, but not including the West Coast, during 1902, amounted to £145,967. On the West Coast 44 dredges produced 30,000 oz. gold, valued approximately at £120,000. Hydraulic sluicing is receiving increased attention, both in the Otago and West Coast districts. The Waitekauri Gold Mining Co., for the year ending May 31, 1902, produced 55,413 oz. bullion, valued at £46,728. The New Zealand Crown Mines Co., Ltd., during the year ending August 31, 1902, treated 32,561 tons of ore, obtaining 16,994 oz. gold and 13,266 oz. silver, valued at £74,238. The expenditures amounted to £53,521, leaving a profit of £20,717, which, with £5,236 brought forward from previous account, gave a surplus of £25,953, out of which a dividend of £15,000 was declared. The balance carried forward was £10,203. The 60-stamp mill now in operation is to be enlarged for 20 additional stamps. The Waihi Gold Mining Co., Ltd., during 1902 treated 179,487 tons of ore, yielding gold bullion valued at £520,138, and a dividend of £250,000 was paid. The company acquired the mines and 40-stamp mill owned by the Union-Waihi Co., so that it now operates 330 stamps. It is converting its dry crushing into a wet crushing plant. On the average 17,000 tons per month are crushed, and when all the stamps are converted the capacity will probably be raised to 20,000 tons per month. The Progress mine treated 55,976 tons of ore, yielding £106,996, the expense being £44,670, leaving a profit of £62,526. An important discovery of gold is reported from Kawhia, where the Government has withdrawn the land from sale on the ground that it contains minerals. All kinds of mining machinery in this colony are driven by electric power generated by the water supplied by rapid streams and rivers, the current in many cases being carried a considerable distance. The cyanide process has now been introduced in the Hauraki gold fields with an 85 to 90% extraction, where formerly an extraction of only 65% was obtained by amalgamation. The New Zealand Government, having bought the patent rights to the cyanide process from the Cassel Gold Extraction Co., received £4,577 as royalties for the fiscal year ending March 31, 1902.. As soon as the Government is paid a sum equal to its outlay for the patent rights, all royalties will cease.

Queensland.—The dividends paid by the Queensland mines in 1902 amounted to £987,541. The report of the Mount Morgan Gold Mining Co., Ltd., for the year ending May 31, 1902, shows an output of 213,907 tons of ore, 120,641 tons of which were oxidized ore and 93,266 tons were sulphide ore. The plant treated 232,953 tons, 19,046 being tailings, and obtained 147,628 oz. gold valued at £570,337. The total income was £574,573, and expenditures £313,690, leaving a profit of £260,883. To this is to be added £22,279 brought forward from the previous year, making a total of £283,162. Dividends of £204,167 were paid, leaving a balance to be brought forward of £78,995. The cost of treating the oxidized ore was $2·68 per ton, and the sulphide ore $4·07 per ton. The Charters Towers mines for the year 1902 produced 378,194 oz. gold, against 336,431 oz. in 1901. The dividends paid by the various companies amounted to £415,564 in 1902, against £319,944 in 1901. The New Queen Gold Mining Co., Ltd., for the year ending August 31, 1902, treated 2,889 tons of ore, obtaining by crushing 3,367 oz. gold, valued at £11,359, and by cyaniding 1,044 oz., valued at

£3,474. Its total expenditures amounted to £31,882 and income £25,830, a loss of £6,052. The Queen Cross Reef treated 16,578 tons of ore for 42,136 oz. gold, and paid dividends of £116,667; the Brilliant Central obtained 31,020 oz. gold from 30,889 tons of ore, and paid dividends of £68,750; the Brilliant and St. George United obtained 18,225 oz. gold from 26,232 tons of ore and paid dividends of £52,200, and the Day Dawn Block and Wyndham obtained 26,510 oz. gold from 40,730 tons of ore and paid dividends of £49,840. The Croyden field in 1902 produced 44,200 oz. gold from 27,600 tons of quartz crushed, against 49,468 oz. gold from 26,277 tons in 1901. There was a great decrease in the yield from cyaniding due to the scarcity of water, no rain having fallen for eight months. The Brilliant Gold Mining Co., Ltd., during the year ending October 9, 1902, crushed 11,540 tons of ore, yielding 13,497 oz. gold, valued at £46,046. For the half year ending October 9, 1902, this company treated 5,010 tons yielding 5,615 oz. gold, valued at £19,059, an average of 1 oz. 2 dwt. 10 gr. gold per ton. From the tailings gold to the value of £1,020 was obtained, a total of £20,080.

South Australia.—During 1902 the Government expended £32,017 on five plants at a loss of £26,370, each plant showing a deficit for the year. Gold has been discovered in Arltunga, a northern district of this colony 1,000 miles from Adelaide. In the White Range gold mines, Northern Territory, no defined lodes have been found but the gold occurs in cellular quartz which crops out in irregular shaped masses and blocks. This quartz occurs also in irregular crevices and fissures, whose course changes in being followed downward, so that the workings assume a very irregular shape. The lowest depth reached is from 50 to 60 ft. and the width from 2 to 15 ft. Samples taken from the different parts of the field assay from 2 dwt. to 8 oz. 16 dwt. gold per ton. The Government has erected a stamp mill, which in the latter half of 1902 treated 424 tons of ore and obtained 741 oz. gold. The Northern Territories Mining & Smelting Co., Ltd., capitalized at £175,000, owns properties at Iron Blow, Mount Ellison, Mount Bonny, and on Howley, Yarn and Brocks Creeks. At the Iron Blow mine the lode has been developed 100 ft. deep. It is 20 ft. wide, and the oxidized ore averages £4 1s. 8d. per ton, and the sulphide ore averages £7 2s. 10d. per ton in copper, gold and silver. At Mount Ellison the ore varies from 10 to 20% Cu. At the Howley mine there is a 40-stamp mill, the ore varying from 3 to 5 dwt. gold per ton. At Yarn Creek there is a 20-stamp mill, and at Mount Bonny the ore body, which is 28 ft. wide, assays from a trace of gold and 19 dwt. silver to 1 oz. gold and 4 oz. silver per ton. A 60-ton water-jacket furnace and two reverberatory furnaces are to be erected, and are expected to be in operation before the end of 1903.

Tasmania.—Gold and tin in combination have been found at the Royal Tasman mine, near Gladstone. The Tasmania Gold Mining & Quartz Crushing Co., at Beaconsfield, one of the principal gold mines of this colony, has been offered to an English company. There are silver-lead mines working on a fairly large scale. The Mount Lyell Mining & Railway Co., for the half year ending September 30, 1902, mined 159,634 dry tons of ore, of which 154,152 tons were from open-cut, and 5,482 tons from underground workings. The smelter treated 240,999 tons of ore. There were 8,858 tons of matte treated in the converter, yielding 11,681 oz. gold and 341,346 oz. silver. The total cost of treating the ore was $4·73 per ton, as compared with $5·10 in the preceding half year. The metal obtained was valued at £268,569; the total receipts were £284,325, and expenditures £207,211, leaving a net balance for the half year of £77,114. The company has absorbed the Mt. Lyell Reserve copper and gold mines, the Glen Lyell copper mine, South Tharsis flux mine, Royal Tharsis and the King Lyell mines.

Victoria.—The gold in this colony was obtained both from alluvial workings and from lode mining. Of the seven districts, Ballarat and Bendigo still continue to be the largest producers of gold, their output amounting to about two-thirds of the total yield. The output of gold in Ballarat in 1902 was 62,712 oz. gold. The Long Tunnel Extended, Walhalla, is the most productive mine. On January 1, 1902, there were 27,777 men engaged in gold mining, 12,886 of them working on the alluvial deposits, and 14,891 working in the quartz mines. The receipts of the Melbourne branch of the Royal Mint during 1902 amounted to 1,016,682 oz. gold. By an act of the Government all gold buyers are obliged to take out a license.

Western Australia.—There was a large increase in the production of gold in this colony in 1902, the mines treating 1,888,950 tons of ore for a yield of 2,117,241 oz. gold, as compared with 1,572,951 tons of ore yielding 1,841,498 oz. gold in 1901. The gold entered for export or sent to the Perth Mint in 1902 was 2,177,442 crude oz., or 1,871,037 fine oz., valued at £7,947,662, as compared with 1,703,417 fine oz., valued at £7,235,653 in 1901. The greater portion of this output was obtained from the Kalgoorlie district, but there were substantial increases in the output of the Murchison, East Murchison, Mount Margaret and North and East Coolgardie; many of the other gold fields showed a decreased output, especially the gold fields from Peak Hill northward. In the Ashburton, Gasgoyne and Kimberley fields the alluvial deposits are being worked out, and at Pilbarra and West Pilbarra the workings have reached water level and the mine owners, having no capital to provide for machinery for sinking deeper, have had to abandon their properties. The Phillips River gold field, which was declared in 1901, has developed slowly, owing to the absence of crushing facilities, but several batteries are now being erected. The cost of mining in the Kalgoorlie district has been steadily reduced, and will be further reduced as the Coolgardie water works are now completed. These works bring water to a district 1,300 ft. above and 350 miles from the source of supply by means of 8 pumping stations, and supply daily over 6,000,000 gal. of water. The Government operates several batteries and cyanide works to enable miners to treat their ores independently of the large mines. According to Mr. Alfred James the roasting (called the Marriner process in Western Australia) and Diehl processes have been successfully employed on the telluride ores at Kalgoorlie. On low-grade ores, roasting is not required, but with rich ores, the ore must first be roasted and then bromo-cyanided. At the Great Boulder Main Reef mine an extraction of 90% has been obtained with this process, at a minimum cost of $5·25, and an average of $6·25 per ton for the year. On the richer ores of the Hannan's Brownhill and Lake View mines the cost was $8·19 per ton.

The companies operating in the Kalgoorlie gold fields during 1902 paid £1,086,250 in dividends, and 13 of them together produced 1,057,132 oz. gold from 787,188 tons treated, an average of 1 oz. 9 dwt. 9·5 gr. gold per ton of ore. Of these 13 companies, four produced over 100,000 oz. each—the Golden Horseshoe, 190,119 oz. gold from 116,276 tons of ore; the Great Boulder 166,510 oz. gold from 104,231 tons of ore; the Ivanhoe, 142,291 oz. gold from 131,810 tons of ore; and the output of the Great Boulder Perseverance. The Great Boulder Perseverance Gold Mining Co., Ltd., during 1902 treated 140,642 tons of ore and 41,392 tons of oxidized tailings and slimes, yielding 193,383 oz. bullion, valued at £693,215, as compared with £487,733 for the previous year. The gross profits for the year, after deducting administration charges amounted to £412,683. The balance to the credit of profit and loss was £357,115, out of which four dividends amounting to £350,000 were paid, leaving £7,115 to be carried forward. The cost of mining and treating the ore was less in 1902 than in 1901. There were 383,600 tons of ore in sight at the end of the year. Two new furnaces began operations at the beginning of the year, and the plant has been greatly improved. It has been proposed to form a new company with a capital of £1,500,000 to take over the present company. The Kalgurlie Gold Mines, Ltd., for the year ending July 31, 1902, reports that it treated 22,060 tons of ore, obtaining 24,842 oz. gold, valued at £95,648. Its total income was £95,822, and expenditures £81,454, leaving a balance of £14,367, which, with balance of £23,253 brought forward from the previous year, after paying a dividend of £15,000, leaves £22,620 to be brought forward. The cyanide works of the Cumberland Niagara Gold Mines, Ltd., were completed and operations commenced in February, and from that date to June 30, 11,408 tons of tailings were treated, yielding 1,549 oz. of bullion. The Bayley's Gold Mines, Ltd., for the year ending June 30, 1902, reports a gold production during 18 months from all sources of 5,923 oz. gold. Its reduction works, cyanide and slimes plant were shut down during the greater part of the year. Alluvial deposits have been discovered near the Lady Mary mine, Norseman.

New Guinea.—In 1901 New Guinea produced 7,685 oz. fine gold, valued at £32,646. No new discoveries have been made in the Yodda gold fields. The ground now being worked is quite poor and requires an abundance of water. The drought during the year dried up many of the smaller streams from which the water supply for the mines was obtained. Many of the dry beds have been worked, and a few have yielded fair quantities of gold. The dry weather also affected mining at Woodlark Island. The Woodlark Island Proprietary Co., Ltd., reported for the fiscal year an income from the sale of gold of £10,073, and an expenditure of £8,623. The debit balance is £6,036, as against £6,504, brought forward from the previous half year, showing an increase of £468.

PROGRESS IN GOLD MILLING DURING 1902.

BY R. H. RICHARDS.

GOLD MILLING.

Stamp Mill Construction.[1]—J. J. Deming discussed this subject in an interesting manner, the following being a few of the observations made: The *back knee frame,* while it has some faults, is considered best for a battery frame. The *iron battery frame* has gradually come into general use in Australia, experience having shown the fallacy of the idea that the iron work became crystallized by repeated shock. No serious effects have resulted in mills using iron frames for years. The *mortar* should be designed to suit the ore, *i.e.,* along the lines of inside amalgamation, or speed of crushing, or both. It is better to put more metal in the *stem* and less in the *boss-head;* with a steel *tappet* there is less vibration in the stem and consequently longer life; with a steel tappet, and the end of the cam chilled, there will be less friction and little wearing of cams. *Shoes* and *dies* should not be of the same hardness; the best results being obtained with steel shoes and chilled cast iron dies. *Stamps* vary in weight up to 1,250 lb. according to the work to be done. It has been demonstrated at the Alaska-Treadwell mill that a stamp heavier than 1,000 lb. is a good pulverizer, but not a good amalgamator. For rapid crushing, the order 1, 5, 2, 4, 3 will work well, while for the long, slow drop, the order, 1, 5, 3, 2, 4 will give an even distribution of the ore in the battery. The order 1, 4, 2, 5, 3 for heavy stamps and inside amalgamation will give good results. The order, 5, 1, 3, 4, 2, commonly used in Australia, is a very good system. The order of the drop, however, is more or less a fancy of the mill man; rarely do two use the same order. *The Muntz metal plate,* 60% copper and 40% zinc, used in Australia is in some instances superior to the silver-plated copper plate, being more easily cleaned as verdigris is absent, but its absorbent power for mercury is limited. In general, the silver-plated copper plate is considered to be superior to all others.

Mortar Foundations in Oregon.[2]—According to W. H. Washburn, it became necessary to place at a mill in Oregon a set of mortar blocks on what is known as webfoot, *i.e.,* a sort of indurated clay. The pits for each 10 stamps were 3 ft. 2 in. wide × 13 ft. 2 in. long × 20 ft. deep. Beginning 3 ft. from the bottom, each pit was undercut at an angle of 45° to a point level with the bottom and undercut 1 ft. at the ends. A layer of sand was spread over the bottom, and a row of timbers 10×12 in.×7·5 ft. was laid crosswise, being well pounded down and leveled. On these were laid lengthwise three timbers, each 10×12 in.×14 ft. long and a series of 2-in. planks was spiked lengthwise along the top row to prevent the presence of sand between the timbers, and also to serve as an additional binder. The upper surface of the timber was made level and the mortar blocks put in place. The blocks were built of 2·5-in. plank, 24 ft. long, one layer being of three planks, each 10 in. wide and the next of two planks, each 15 in. wide, in alternate layers. These foundations have proven satisfactory, and no settling was noticed after a three weeks' run. (See Fig. 1, on next page.)

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[1] *Mining and Scientific Press,* Vol. LXXXV., (1902), p. 188.

[2] *Ibid.,* Vol. LXXXIV., (1902), p. 246.

Mortar Foundations in California.[3]—Two years ago at the North Star Mill, Grass Valley, the old wood foundation blocks were replaced by a concrete base with granite foundations. As a result the stems do not break as often as formerly, the mill crushes more ore and the mortars are absolutely solid. When the mortars were first erected, sheet lead 0·0312 in. ($\frac{1}{32}$) thick was placed between the mortar and the granite in order to fill the interstitial space, but it worked out and left the mortars loose. Furthermore, the mortars had become somewhat dished as a result of the pounding on a soft foundation, to counteract which the granite surface was made slightly concave.

The Individual Mortar Stamp Mill.[4]—This arrangement consists of three parallel mortars, designed for the independent action of each stamp in its separate mortar, as well as to secure the largest area of screen discharge.

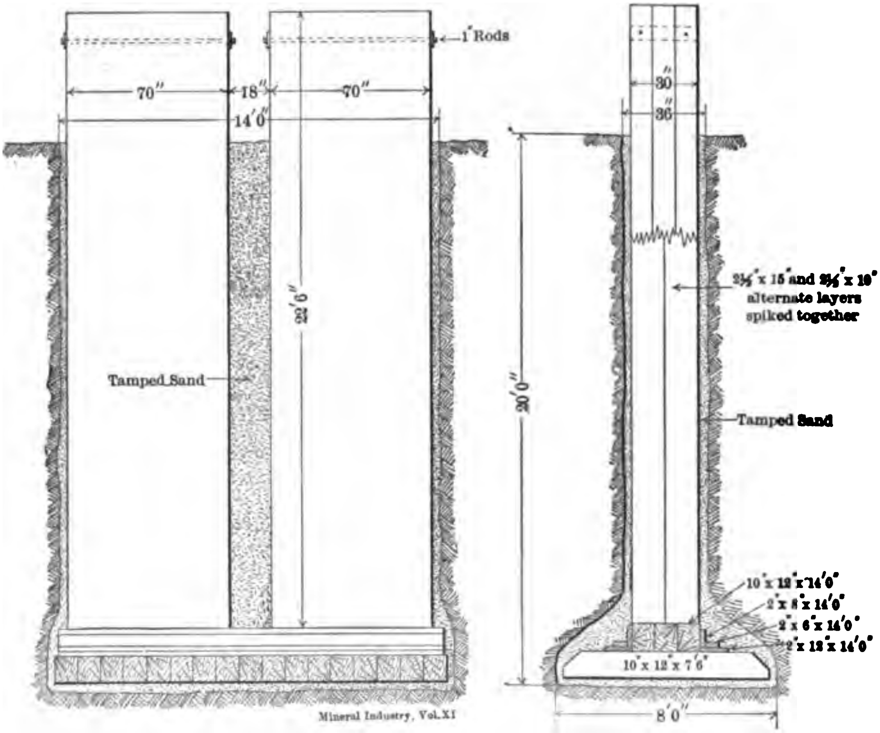

FIG. 1.—MORTAR FOUNDATION, SPECIAL CONSTRUCTION.

Sluice Plates.[5]—According to W. J. Adams, sluice plates should not be as wide as the apron plates, a width of 20 in. being preferable. They should have a less grade (about 1·25 in. in 1 ft.) owing to the greater clearance of the sulphurets, and the concentration of the pulp; and as no free gold should be found at this distance from mortar, it is not necessary to turn the pulp over in waves.

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[3] *Mining and Scientific Press*, Vol. LXXXIV., (1902), p. 157.
[4] *Ibid.*, Vol. LXXXV., (1902), p. 247.
[5] *Ibid.*, Vol. LXXXV., (1902), p. 268.

Morison's Open-Front Mortar Box.[6]—The front of the mortar in the Morison box is entirely open from the discharge lip upward; that portion of the box above the screen opening being closed by means of a removable pressed steel door, which is dished and flanged for strength and rigidity; when closed the end flanges seat themselves upon suitable ledges on the main casting and are secured thereto by studs fitted with wing nuts.

Theory of the Patio Process of Amalgamation.[7]—Miguel Bustamente, Jr., calls attention to the difficulties experienced in extracting the gold from Mexican ores composed principally of decomposed iron pyrites in quartz with native gold in irregular grains; the metallic value in some portions, however, being in calcite and siderite. At first the extraction of gold by amalgamation from 1-oz. ore was about 10%, and was attended with an excessive loss of mercury. Direct amalgamation combined with cyaniding of the concentrates gave an extraction of 32%. Occasionally during amalgamation, the odor of hydrogen sulphide gas was noticed, which accounted for the great loss of mercury. A preliminary roasting and washing of the ore raised the extraction to 63%, with a mercury loss of 11%. Upon investigation, the gold which had escaped amalgamation was found in a spongy state, similar to "platinum sponge," and in contact with the mercury it caused an energetic electrochemical action, which decomposed a relatively large quantity of water; the oxygen set free being absorbed by the sponge while the hydrogen combined with the sulphur of the pyrite, and produced hydrogen sulphide of which a part escaped and a part attacked the mercury causing the heavy loss of the metal. The actual chemical reactions are quite complicated, but the formation of mercury sulphide was proved by an analysis. The loss of gold is explained thus: Whenever the sponge or black gold is present under such conditions that it will act as the electro-positive element, it will receive, condense, and hold oxygen which will be returned when the gold is made the electro-negative element of the couple. Mr. Bustamente perfected a method by which the loss of mercury was reduced to 0·03%, and the extraction of gold raised to 95% of the assay value, at the low cost of $0·42 per ton for crushing, and $0·19 for amalgamation, including the electric current. At first the ore was roasted in a reverberatory furnace and washed abundantly with water; it was then passed through the mortars where it was pulverized and the amalgamation begun. The mortars were fitted with inside plates, connected with the poles of a dynamo that produced a current of 150 amperes and 14 volts. The two stamp batteries discharge into a common channel, in which, side by side, were placed the large amalgamating plates, one connected with the positive pole, and the other with the negative; an arrangement which gave encouraging results; but, in view of the energetic decomposition of water, the electro-motive power was lessened by subdividing the amalgamating plates and uniting them in parallel, thereby diminishing the liberation of gases and reducing the loss of mercury to an insignificant quantity. Similar arrangements were made for the pans and the washers. An average of 9 tons of ore was treated in 24 hours with an

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[6] *Engineering*, Vol. LXXIV., (1902), p. 145.

[7] *Transactions of the American Institute of Mining Engineers*, November, 1901.

extraction of 94% of the gold. The preliminary roasting was abandoned later, and a maximum gold extraction of 95% was obtained.

Mill Practice in Arizona.[8]—At the Commonwealth mill at Pearce, the ore consisting of hard, decomposed quartz and talc carrying silver chloride and free gold, is coarsely crushed by a Blake breaker and roughing rolls, thence it is passed to 80 stamps each of 950 lb. weight which drop 102 times per minute, and crush 210 tons of ore per day through a 35-mesh screen. There is no battery or plate amalgamation, the pulp passing direct to settling tanks and thence to the amalgamating pans. The tailings are impounded for future treatment. Crude oil is used for power purposes.

Mill Practice in Colorado.[9]—At the Portland mine, Cripple Creek, the fine portion of the ore is separated by a screen; the coarse portion, which constitutes the bulk of the ore, being hand sorted. Formerly the fine material with a value in gold of about $4 per ton was rejected, but at present a saving of 50% of the contained value is effected by a simple washing process. The washer consists of an inclined iron plate perforated with holes 0·625 in. (⅝) in diameter, on the upper surface of which numerous jets of water impinge in various directions. The waste is passed over a screen which removes the dry fines; the coarser portion, which forms the bulk of the waste, is then passed over the perforated plate, the adhering fines being washed off by the jets of water, and collected and dried on a sheet iron box, heated by exhaust steam. The small quantity of water used is circulated through a boiler-feed pump operated by exhaust steam. In this way the final waste is reduced in value to an average of about $2 per ton.

Mill Practice in South Dakota.[10]—The Wasp No. 2 Mill, at Kirk, has been in operation since September, 1900. The gold in the ore, which varies in value from $4 to $20 per ton, is on the cleavage planes of quartzite; very little pyrite is present, with an occasional trace of stibnite. Crushing and screening is done as follows: (1) Ore; to (2). (2) Ore bin; to (3). (3) Grizzly; 4×8 ft., with 1·5 in. spaces; oversize to (4); undersize to (5). (4) No. 3 Gates breaker, set to 1·25 in. ring, to (5). (5) Storage bin, to (6). (6) Coarse rolls, 14×24 in., to (7). (7) Stationary inclined screen, 7 ft. long, 1 ft. wide, 2 mesh, oversize to (8); undersize to (9). (8) Finishing rolls, 40×24 in., to (9). (9) Bucket elevator, to (10). (10) Shaking finishing screen, 2·5 mesh; oversize to (8); undersize to (11). (11) Finished product bin. The ore is cyanided.

Mill Practice in California.[11]—At Hedges the crushed ore is conveyed to the mill bins by a hoisting tram line, and is fed automatically to the batteries of the 100-stamp mill which is in two sections, 50 stamps on a side, the ore bins being above and between them. Each stamp weighs 1,000 lb. and drops 96 times per minute, crushing 4·5 tons of ore per 24 hours. The screens are No. 10 diagonal slot-punched, equivalent to 40-mesh. Below each battery is a copper amalgam plate, 28 ft. long, with a fall of 1·5 in. to the foot; 70% of the total saving is reported as made on the plates.

Mill Practice in Bendigo.[12]—H. C. Boydell states that the ore treated is

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[8] *Mining and Scientific Press*, Vol. LXXXIV., (1902), p. 103.

[9] *Mining Reporter*, March 6. (1902), p. 252.

[10] *Mining and Scientific Press*, Vol. LXXXIV., (1902), p. 232.

[11] *Ibid.*, Vol. LXXXIV., (1902), p. 50.

[12] *Australasian Institute of Mining Engineers*. Vol. VIII., Part II., p. 236.

essentially free milling, and carries 1% of sulphides in a quartz gangue, the gold being coarse. Hand breaking is the common practice except in three mills, where Gates breakers are in use. The lack of uniformity resulting from hand breaking is given as the cause of the low efficiency per stamp. Hand feeding is used except in four mills equipped with mechanical feeders. The cost of a local mechanical feeder is $121·75, while the cost per day of feeding 10 stamps by hand is from $1·22 to $1·46. The mortar boxes weigh from 2 to 3·25 tons, the bottoms being 5·5 in. thick. No liners are used, because the ores being mainly custom, their removal at the frequent clean-ups would entail too much labor; therefore, the box is of greater thickness than usual. Inside copper plates are not used. The discharge is vertical, and with new dies is less than 3 in. in depth, sometimes being but 1·5 in. Chock blocks are not used, and the height of discharge increases with the wear of the dies. Punched screens with from 12 to 16 holes per linear inch are generally used. The stamps weigh from 600 to 1,000 lb. The average height of drop is from 6 to 8 in. with from 75 to 80 drops per minute. In each head of five stamps, the middle stamp drops first, and both end ones next. The stems are of best hammered iron generally 12 ft. long and from 2·75 to 3·125 in. in diameter. With one exception screw tappets are in use. The weight in the stamp is distributed approximately as follows: stem, 43%; head, 23%; shoe, 25%; and tappet, 9%. In all cases the cam shaft is driven by gearing. The "horse" battery frame is most common although in a few of the smaller batteries the "A" frame is used. The frame is generally constructed of wood although sometimes of cast iron. The reason for the use of the horse frame is that the cam shaft being driven by gearing necessitates the counter shafts on the same level. The output per stamp per 24 hours averages but 2 tons, the low efficiency results from the absence of breakers and automatic feeders; however, the mining conditions in Bendigo do not require a maximum output. The main ore supply is not sufficient to keep the mills in continuous operation, and it is supplemented by custom ore. While increased capacity per stamp would reduce labor charges per ton, it would involve increased first cost which is not warranted by existing financial conditions. Clean-ups are made weekly, the retorted gold being sold without refining. The copper plates of an average length of 10 ft. are inclined 1 in. per foot, and have several steps with a riffle between each set. In a few cases the last plate is not amalgamated. Mercury is fed into the mortar at regular intervals from which a large portion of the total amalgam is obtained. The loss of mercury per 100 tons of ore averages one pound. The plates are usually scaled every six months by being heated to redness; this oxidizes the copper and causes spots to form, which tarnish readily, and require constant attention. To within 18 months ago, concentration by blanket strakes and Halley tables was common. Recently, however, Wilfley tables have been introduced. Apparently but little attention is paid to the production of clean concentrates as they contain 50% silica. The concentrates are roasted and amalgamated in crude pans. At one plant the cyanide process is used.

Mill Practice at the Kalgurli Gold Mines, Limited.[13]—The percentages of gold

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[13] *Australasian Institute of Mining Engineers*, Vol. VIII., p. 51.

contained in sands and slimes by dry separation and by hydraulic separators are as follows: *Dry Separators with* 110-*mesh sieve.*—The sand contained 27·27% and the slimes 72·73% of the total gold content. *Hydraulic Separators*—(average for three months).—The sands, including free gold and concentrates, contained 56·67% and the slimes 43·33% of the total gold content of original ore.

HYDRAULICKING AND PLACER WORKING.

Hydraulic Mining.[14]—Wm. H. Radford gives the cost of hydraulicking low-grade gravel in northern California. The grade of the sluices was 7 in. in 12 ft., the boxes being paved with 12-in. block riffles. Long bedrock cuts extended from the heads of the sluices to within a few feet of the banks, and were kept to grade as the work advanced. During 9 months, 1,251,399 cu. yd. of material were washed, averaging 1·91 cu. yd. per miner's inch of water with a yield in value of 2·52c. per cu. yd. of gravel. The average height of bank washed was 63 ft. The itemized cost is given as follows:—

	Cost.	Cost per Cubic Yd.
Care of ditch, reservoir, and siphon: labor and supplies	$2,786·54	$·00223
Washing (piping)	2,401·05	·00192
Drilling in bedrock cuts	1,320·53	·00105
Timbering bedrock cuts	157·39	·00012
Electric lighting	598·62	·00047
Sluice building and repairing: labor and supplies	1,081·20	·00086
Blacksmithing	644·02	·00051
Cleaning up	968·79	·00077
Moving pipes and "giants"	898·85	·00071
Breaking rocks and clays	6,124·91	·00490
Clearing ground for piping (cutting brush)	158·37	·00012
General expenses, watching sluices, and odd jobs	3.068·69	·00250
Supplies used in mine	3,015·37	·00241
Taxes, office expenses, legal expenses, surveying and salaries	4,267·31	·00341
Totals	$27,511·64	$0·02198

The Gold Bug Mining Co., Georgetown, Eldorado County, Cal.[15]—W. E. Thorne states that this company worked the ground through bedrock sluices, 8 ft. wide on the bottom, and laid in a cut having a maximum depth of 25 ft. at the lower end and a minimum depth of 4·5 ft. at the upper end. At the lower end each 12-ft, box has a fall of 4 in., while at the upper end the fall is but 1 in. The sluices are paved with 6-in. blocks set on end. The working costs per cubic yard of material hydraulically moved were:—

Water	$0·030	Blacksmithing	$0·003
Labor	0·015	Lumber	0·030
Débris dams (*a*)	0·030	Labor on sluices	0·040
Moving of pipe, etc	0·005	Powder, fuse, etc	0·017
"Crevicing" and cleaning bed-rock	0·006		
Taxes, salaries, etc. (*b*)	0·007	Total	$0·183

(*a*) Represents the total cost of the work divided by the total capacity in tons of the reservoirs thus created.
(*b*) This item is exceptionally large owing to the short season of operation—15 days.

The results were not financially satisfactory. Two undercurrents were tried, but were unsuccessful, and a hydraulic elevator is now being installed.

Distribution of Gold in Sluice Boxes.[16]—At a low-grade gravel property in

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[14] *American Institute of Mining Engineers*, Vol. XXXI., p. 617.

[15] *Ibid.*, (1902).

[16] *Mining and Scientific Press*, Vol. LXXXV. (1902), p. 324.

California, the distribution of the gold as caught in the sluice boxes, 6 ft. wide × 4·5 ft. deep × 12 ft. long was:—

	Boxes.	Per Cent.
First section....................	15	73·6
Second section....................	30	18·4
Third and fourth sections.......	71	1·6
Undercurrent..............	....	11·5

Under the conditions that prevailed a long sluice was unnecessary, the coarse gold being caught in the first boxes, and the fine in the undercurrent. The gravel averages from 4 to 6c. per cu. yd., and from 2·5 to 3 cu. yd. of material were moved per miner's inch of water at a total cost of $0·08219 per inch.

A "Crown Gold" Dry Concentrating Plant.[17]—The capacity of the 80-ton concentrating plant of this type which has been erected at Tintic, Utah, is claimed to be fully up to the requirements.

Dry Blowers in Australian Gold Placers.[18]-[19]—According to B. Dunstan, the types of dry blowers in use at the Clermont gold field are constructed on three principles: (1) the separation of the larger pebbles from the finer portion by a coarse punched plate; (2) the delivery of the material which passes through the coarse screen to a fine punched plate; and (3) the forcing through the screen of a blast of air sufficiently strong to remove the earthy particles, but not the gold. The machines are not suited to clayey earth, although this difficulty can sometimes be overcome by heating the earth and then powdering it on a flat sheet. The losses of gold are generally due to the presence of clay. Fans are not suited for producing the blast as it must be pulsating. The cost of a machine varies from $32·50 to $50, and the daily capacity under normal conditions is from four to five loads. Dry jigs also are used successfully on gravels carrying coarse gold.

The Placers of La Cienega, Sonora, Mex.[20]—R. T. Hill calls attention to the importance of underground water in arid districts.

Hydraulic Practice in Oregon.[21]—In Josephine County, along the Illinois River, ground sluicing is being replaced by hydraulic operations on a large scale. The gold is coarse, and is generally saved by the ordinary pole or block riffles in the sluices.

GOLD DREDGING.

Recovery of Fine Gold from Snake River Sands.[22]—Robert Bell states that the fine gold in the Snake River placer beds is recovered on a commercial scale up to 95% of the gross content of the gravel. The fine material after separation from the coarser gravel by passage through a screen-floored sluice box, is concentrated by gravity on burlap tables, the gold in the small quantity of concentrates being collected by mercury in a clean-up barrel. This method is simple, efficient and adapted for operation on a large scale.

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[17] *Mining and Scientific Press*, Vol. LXXXIV., (1902), p. 22.

[18]-[19] *Engineering and Mining Journal*, Vol. LXXIV., (1902), p. 482.

[20] *Ibid.*, Vol. LXXIII., (1902), p. 182.

[21] *Ibid.*, Vol. LXXIV., (1902), p. 582.

[22] *Ibid.*, Vol. LXXIII., (1902), p. 241.

A Snake River Suction Dredge.[23]—According to Robert Bell, a dredge with a 10-in. nozzle has a daily capacity of 2,500 cu. yd. at a cost of 4·5c. per yd., the motive power is supplied by a 125-H.P. vertical, compound-condensing marine engine. Under less favorable conditions a chain elevator bucket dredge showed a capacity of 2,000 cu. yd. per day, at a cost of 5·5c. per cu. yd.

Advance Stripping in New Zealand.[24]—According to F. W. Payne, the saving of gold in Otago has occasionally been rendered difficult by the presence of a large quantity of clay, which, in rolling inside the screen and over the tables, collected the gold on its surface and carried it overboard. This difficulty has been overcome to a great extent by what is known as "advance stripping," the clay being removed first and the auriferous gravel left for the next cut. The clay containing no gold is not treated on the tables, but is delivered direct to the tailings elevator. A centrifugal tailings elevator wheel has been used in this district with reported satisfactory results.

Dredging in New Zealand.[25]—The latest New Zealand dredge is of the bucket elevator type. The bulkheads of the bucket ladder are set diagonally, the device being designed for paddock dredging, where grass, tussock, flax and small scrub have to be removed. It is claimed that the absence of cross-stays and bracings avoids the accumulations of débris. In the Southland dredging field several machines are fitted with tines to loosen the ground in advance of the buckets.

Dredging in British Columbia.[26]—The development of gold dredging on the Saskatchewan River is progressing favorably. Of the several dredges that have been used, the bucket elevator type gives the best results.

Dredging Practice in General.[27]—David K. Blair describes the construction and manipulation of gold dredges, including accidents to various parts of the machinery—their cause, effect and remedy.

Dredging in California.[28]—At Oroville, a conveyor 75 ft. long, with a 28-in. belt inclined 18° traveling at the rate of 250 ft. per minute can handle 75 cu. yd. per hour.

Dredging in Nevada.[29]—A current motor dredge is being operated in the Colorado River, near El Dorado canyon. One man operates the dredge, which is claimed to have a capacity of 10 cu. yd. per hour in loose, river-bar gravel. The dredge consists of two flat bottom scows connected side by side by a hinged platform, having the current wheel in the intervening space between them. The wheel is connected to the dredging machinery which is set on a second pair of scows having the bucket ladder between them; the two pairs of boats are connected by a hinged frame, forming a catamaran structure.

Dredging in West Siberia.[30]—According to C. W. Purington and J. B. Landfield, Jr., dredging during the past three years has received attention, and the dredge in operation during 1900 is reported to have been a complete success.

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[23] *Engineering and Mining Journal*, Vol. LXXIII., (1902), p. 241.

[24] *Institution of Mining Engineers*, Vol. XXIII., p. 582.

[25] *Engineering and Mining Journal*, Vol. LXXIV., (1902), p. 680.

[26] *Canadian Mining Review*, Vol. XXI., (1902), p. 59.

[27] *Ibid.*, Vol. XXI., (1902). p. 274.

[28] *Engineering and Mining Journal*. Vol. LXXIII., (1902). p. 184.

[29] *Mining and Scientific Press*, Vol. LXXXIV., (1902), p. 48.

[30] *Engineering Magazine*, Vol. XXII., p. 893.

PLATINUM WASHING IN THE URALS.[31]

According to L. St. Rainer, it is necessary to use a large volume of water in washing the clayey gravels, and mechanical agitation is also required in order to disintegrate the material. In one intsance a trommel 3 m. long, 1 m. diameter at the feed end, and 1·6 m. diameter at the outlet is used. It is made of strong iron plate perforated with 15-mm. holes. A strong stream of water is played into the trommel which revolves slowly, the fines passing through to the washing apparatus below. It is necessary to treat tough gravels in a "boronka" in order to free the rich sands. A boronka consists of a third of a conical trommel made of cast iron plates, having suspended stirrers which are given a slow backward and forward motion, thereby causing the gravel to be gradually passed along to the discharge end. The stirring combined with the strong streams of water thoroughly disintegrates and washes the gravel so that the discharged material is practically free from rich sands. In the Plast district, however, the gravel requires even a more thorough stirring, and for this purpose a "tschascha" is used, which consists of a cast-iron cylindrical tank 2·1 to 3·5 mm. diameter, containing a six-armed stirrer revolved by a central vertical shaft. Attached to the arms are vertical iron bars which disintegrate the clayey pulp. The bottom is made of three cast-iron sectors with conical holes 15 mm. diameter at the top. One of the sectors is fitted with a gate or trap so that from time to time the tailings can be discharged. A machine of this type 4·16 m. in diameter, the arms making 25 revolutions per minute, requires 13 H.P. to operate, and has a capacity of 40 tons of clayey gravel per hour; from five to ten volumes of water per volume of sand is required for successful work. The washed material passes direct to the riffle tables from 8 to 13 m. long having 44-mm. riffles, 265 mm. apart; the grade is from 13 to 16%. The upper portion of the table is covered with linen or felt protected by a wooden grate. When necessary the tailings are elevated by a machine of the Archimedian screw type. Washing is carried on continuously for 11 hours when the feed is stopped, the riffles removed, and the concentrates carefully washed on the table until reduced to one-third the original bulk. The concentrates are then shoveled into buckets and rewashed on a smaller table until there remains only a fine gray slime, which subsequently is worked on a plane surface with a brush, the gold being extracted with mercury. The tailings are washed in sluices, and the resulting concentrates treated as described above. In working a gravel carrying 2·6 g. metal per ton, the loss by washing was 0·27 g. per ton, while that by theft amounted to 0·43 g. per ton, making a total of 27% of the metal content. It would seem that improved methods especially of classification would give more satisfactory results.

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[31] *Berg- und Huettenmaennisches Jahrbuch*, Vol. L., p. 265.

A REVIEW OF THE CYANIDE PROCESS DURING THE YEAR 1902.

BY CHARLES H. FULTON.

THE progress in cyaniding during 1902 has consisted mainly in the perfection of detail and a more extended application of the process, especially in South Dakota, where a number of new and important mills have been erected. The wet crushing of ore by stamps in cyanide solution and the treatment of the slimes by decantation have been much improved, and are supplanting fine dry-crushing by rolls in South Dakota. An innovation in American progress has been the adoption of the filter press method for the treatment of slimes at the Sunshine mine, Utah.

Arizona.—In Arizona several new cyanide plants have been erected. The Cyclopic Co. at Gold Roads in Mohave County has added to its plant. The cyanide plant of the Congress Gold mine in Yavapai and the tailings plant of the Mammoth Cyanide Co. in Pinal County have been in operation. The G. & C. Consolidated Mining Co. is erecting a cyanide plant 12 miles southwest of Prescott.

California.—A number of new mills have been erected, all of small capacity, principally in Southern California, where the ores are more amenable to treatment, than are those of Northern California. Practically all of the cyaniding is carried on in San Bernardino, San Diego, Inyo, El Dorado, Placer, Shasta, Kern and Mono counties. According to the report of the State Mineralogist, Mr. Lewis E. Aubury, the following plants are in existence, most of them being in operation:—

	Capacity in Tons per Day.		Capacity in Tons per day.
San Diego County—American Girl	100	*San Bernardino County*—Bagdad Mill	25
Blossom M. & M. Co	18	Black Hawk Mill	20
California Kings G. M. Co	750	Fearnot M. Co	20
Free Gold Mining Co	426	T. K. Mill	16
Western Extraction Co	50	Rose Min. Co	70
El Dorado County—Vandalia Mill	200	Yoder Mill	18
Shasta County—Midas Mill	48		

A number of small cyanide plants are in operation, and some are being erected in Inyo County. The Standard Consolidated is operating in Mono County, and a few scattered ones in other counties.

The tailings plant of the Free Gold Mining Co., formerly the Golden Cross Mining Co., at Hedges, San Diego County, has been operative during the year treating about 420 tons of tailings per day. The process there is described by H. A. Barker in a private communication. There are 5 steel leaching vats 45 ft. in diameter and 7 ft. deep, which are charged from a bridge work constructed over them, by means of 2·5-ton side discharge cars. The mill tailings, which are treated, are in beds from 15 to 30 ft. in depth, the tailings being shoveled into the cars, 6 cars being loaded at a time and run down an incline about 400 yd. long. From the foot of the incline the cars are hoisted to the bridge work over the vats. The actual treatment extends over a period of four days. The strong solution is 0·12% cyanide, and the weak solutions 0·08 and 0·04% cyanide. All solutions whether strong or weak pass through the same zinc box. The precipitation is very good notwithstanding the presence of considerable copper in the tailings. The strongest solution, which runs lowest in gold, assays 10c. per ton after precipitation. The total quantity of zinc available for precipitation is from 100 to 120 cu. ft. The precipitates obtained vary in value and quantity, the bulk of the values coming generally from the short coppery shavings removed each month. These shavings are treated with sulphuric acid, and the sludge washed, dried and roasted with gentle rabbling. It is then returned to the acid tank and again treated with dilute acid, and in this way the great bulk of the copper removed. The coppery washings after thorough settling are run to waste over scrap iron. The precipitates after this treatment are then clean enough to be cast into a brick of base bullion.

The entire water supply is drawn from the Colorado River, 12 miles distant, at a cost of approximately 2c. per ton of ore treated. The leaching vats are sluiced out, by pressure furnished by a steam pump, in from 3 to 4 hours, through four 16-in. square gates. The average value of the tailings treated approximates $1·40 per ton, the residues assaying 40c. to the ton, making an extraction of 71·4%. Material of $1 per ton in value has been treated with a small profit at the plant.

Successful experiments are being made at some of the Mother Lode mines in the treatment of raw concentrates by the cyanide process. The concentrates are ground to 100-mesh size or finer, and then agitated.

The largest plant in the State is that of the California King Gold Mining Co., at Picacho, in San Diego County, near the Arizona line. It has a capacity of over 750 tons per day, and although constructed in 1901, it has not yet become operative.

Colorado.—A few new mills have been constructed, mainly of small capacity, the principal one being that of the Tobasco Mining Co., near Lake City, Hinsdale County. Some plants have been projected to treat Cripple Creek dumps, and one or two small ones have been built which are said to operate successfully on $4 to $5 material when it is suitable. One of these plants is treating the dump of the Pharmacist mine, and another is soon to be erected in the district by Temple & Crumb, of Colorado Springs, which is to crush coarse, and have a capacity of 50 tons per day. The cyanide plants of the Liberty Bell and Smuggler-Union mines near Telluride, have been in operation during the year, as well as the Gold Run cyanide plant, which treated old accumulated tailings from the Tomboy and Smuggler-Union mines. The cyanide tailings plant of the Camp Bird mine, near Ouray, has also been in operation.

The cyaniding of the Cripple Creek milling ores has received a serious check on account of the preference for chlorination, the Dorcas mill at Florence being the only cyanide mill in continuous operation. This mill has installed the Begeer pneumatic cyanide process, which consists essentially in passing the cyanide solution from the extractor boxes (after standardizing) repeatedly through a centrifugal pump, provided with suitable pipes and cocks to allow the absorption and mixing of air with the solution to the fullest extent, thereby causing the solutions to absorb a maximum quantity of oxygen.

At Colorado Springs the Telluride Reduction Co. has erected a bromination plant, in which it is intended to treat the dust by the Riecken process.

A small plant using the pneumatic process has been erected at the Gold Standard mine at Idaho Springs.

The process at the Smuggler-Union mine is described by Mr. William H. Davis[1] as follows: "The plant was designed and built by F. L. Bosqui in 1901, and began operations early in 1902. There are 16 leaching tanks arranged in 2 rows of 4 double tanks, one above the other for double treatment. The upper tanks are 40×8 ft., and the lower, 40×9 ft. made of California redwood and holding 475 tons of tailings, the daily capacity. Each tank gets a 16-day treatment. The tailings come to the plant by launders, and the tailings are charged into the tanks by Butters & Mein distributors. Overflow gates carry off the slimes. The fineness of the ore is regulated by the height of the column of water over the ore, manipulated by the overflow gates. It has been found, that when from 30 to 35% of the deposited tailings pass a 120-mesh screen, about the limit is reached at which the tailings will leach satisfactorily. However, as much of the slimes as possible, without impairing the leaching, must be settled. The filling is completed in 24 hours, the tank is then allowed to drain as dry as possible, and the material is leveled, lime added, and a waste solution applied. The waste solution having a high protective alkalinity distributes the lime and displaces the water, and is applied for 18 hours, after which it is displaced by weak solution, which is allowed to stand on the ore for 24 hours, and it is then leached with weak solution until the tailings are dried for shoveling into the lower vats. The drying is accomplished by vacuum until 15% moisture remains. In the upper tanks the weak solution coming off after the 24-hour contact is the first to carry values in either cyanide or gold. (The weaker solutions do not attack silver.) Usually the solutions must carry 0·5 lb. cyanide before they have value in them. The solutions from the upper vat treatment are run through the waste solution zinc box, and are re-used as waste solution, which includes also all solutions in the plant containing less than 2 lb. KCN per ton.

The dried ore in the upper vats is shoveled into a 6-lb. solution in the lower vats, and allowed to stand for 36 hours, which equalizes the density in the vat, gives a more uniform leaching, and also equalizes the values in the solution, which carries the highest values and passes to the weak zinc boxes. The strong solution is succeeded by weak solution, then by waste solution, and finally by water. The waste solution is used here in order that the solutions may not be diluted more than is necessary.

Zinc shavings are used to precipitate the values, with good results. The Smuggler-Union ore is a difficult one to treat, the rock being very close-grained and hard. The values are about equally distributed between gold and silver, the latter being present as a double sulphide with arsenic and sometimes with antimony, which is difficult to decompose. The tailings are very low grade, but the plant has been a success, although owing to the recent troubles at Telluride the Smuggler-Union mines have suspended operations.

Gravity filtration was formerly used to settle out solids and precipitates which formed in the weak solution before it entered the extractor boxes, but it was lately displaced by a filter press.

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[1] Private communication.

A canvas plant has been installed, in which the overflow slimes from the mill amounting to about 30% of the ore crushed, are handled by contract.

According to Mr. Charles A. Chase,[2] of the Liberty Bell cyanide plant, the cost of cyaniding at that plant on a 4,700-ton per month basis, is as follows:—

Labor.	Cents Per Ton.	Supplies.	Cents Per Ton.
Foreman	1·5	Cyanide	17·2
Solution men	6·7	Zinc	3·0
Laborers	6·8	Lime	5·2
Assays	2·5	Miscellaneous	0·5
Repairs	0·4	Sulphuric acid	0·3
Labor	17·9	Supplies	26·2
		Total labor and supplies	44·1

The Tobasco Mining Co. erected a mill at Lake City, which is described by Smith McKay,[3] of Denver. The rough crushing is done by a 10×15-in. Dodge crusher, the product from which passes to 36×16-in. rolls for the coarse crushing. The ore is fine crushed by two 30×6-in. high-speed rolls. The screening is done by flat impact screens, the final screens having 8-mesh wire cloth. The product from the screens passes to three Bartlett concentrating tables, which separate out concentrates consisting mainly of iron sulphides amounting to from 1 to 2%. The tailings from the tables pass to a tank, and from this to a revolving distributor over the leaching vats. The slimes overflow from the vats and are discarded. There are six 18×5-ft. leaching vats, three 10×12-ft. solution tanks, two 8×10-ft. gold storage solution tanks, all of steel. Precipitation is done in zinc extractor boxes by zinc shavings. Electric power is used at the mill, being transmitted over a distance of 8 miles. A 75-H.P. motor runs the crusher, elevator, screens and rolls, and a 5-H.P. motor the three Bartlett tables. A 20- and a 5-H.P. motor operate three triplex pumps for solutions and water supply.

Idaho.—No new cyanide plants of any size have been erected, although several have been projected, namely, in Shoshone and Lemhi counties. The plant of the De Lamar Co. in Owyhee County, has treated 35,400 tons of ore, valued at $12·24 per ton. The costs amounted to $2·70 per ton, with an extraction of 84·2%. The cost of treating 22,900 tons of old tailings in cents per ton, was labor, 62·42c.; chemicals, 88·53c.; fuel, 15·46c.; supplies, 12·70c.; assaying and express, 5·10c.; total, $1·8421. The average value of the tailings was $3·97 per ton, and the extraction 69·7%.

Montana.—A number of mills have been in steady operation, some new mills have been built and old ones have increased their capacity. The greatest activity is in Fergus County, where, according to Alex. N. Winchell,[4] the following companies are active:—

The Abbey Cyanide Gold Mining & Milling Co., Barnes & King, Kendall Gold Mining Co., McCormack Brothers, Central Montana Mines Co., Great Northern Mining & Development Co., New Year Gold Mining Co.

The Barnes-King and Kendall properties, near Lewiston, are operating on a large scale, the first having a capacity of 240 tons and the latter 350 tons per

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[2] Private communication.
[3] Private communication.
[4] Private communication.

day. The Central Montana Mines Co., near Lewiston, has a dry crushing plant of 250 tons capacity, but is treating at present only 100 tons per day.

The large properties above mentioned treat the ore by direct cyaniding. The ore is quarried and crushed dry to about 0·25-in. size. As a rule, the values are readily extracted, but clayey material is occasionally met with, which is unfavorable to leaching. I am indebted to Mr. W. J. Sharwood, of Marysville, Mont., for much of the information concerning Montana and Nevada.

In Lewis and Clarke County, the plant of the Montana Mining Co., Ltd., at Marysville, has been modified during the year. Six of the seven leaching vats have been fitted with agitators for the treatment of slimes by decantation. Extensions of sheet iron have also been added to the vats, so that these are 38-ft. diameter and 13 ft. deep. Charges of 135 tons of slimes were run through in 48 hours, and while the original plant has treated over 500,000 tons of tailings, it was shut down for the winter.

At the Empire mine, near Marysville, a 500-ton tailings plant has been installed to treat the stored tailings, which are conveyed to and distributed in the 500-ton leaching vats by a system of Robins belt-conveyors. The solutions are precipitated by an electrolytic process on sheet iron plates 3×5 ft. placed 1 in. apart. These plates divide the tank into nearly tight compartments, and the current passes from plate to plate, the side which acts as the anode being protected by a carbonaceous coating, while the other acts as the cathode, and receives the gold, silver and copper as a coherent film which is later removed by stripping.

Nevada.—No new plants of any size have been built in this State, although several have been steadily in operation on the Comstock Lode, treating old tailings from the silver amalgamation mills of early days.

At Tuscarora, in Elko County, the Dexter Gold Mining Co.'s plant treated 22,930 tons of ore in 11 months, at a cost of $1·10 per ton, and an extraction of $1·89 per ton. Near Tuscarora the Montana Mining Co. erected a cyanide plant to treat the tailings from the 20-stamp mill on the Lucky Girl group of mines. The sands are treated by percolation, and the slimes by decantation. The Dexter Gold Mining Co. experimented with the Godbe agitation process on slimes, but with indifferent success. Attempts are now being made with other methods of treatment.

On the Comstock Lode at Virginia City, Charles Butters is treating silver-bearing tailings by the cyanide process, using an electrolytic system of precipitation with aluminum cathodes, from which the deposit of precious metals is said to be readily removed by stripping.

At the new wet-crushing plant of the Chainman Mining & Electric Co. a small tonnage was treated by dry-crushing and direct leaching. The plant has now suspended operations. The Ely Mining & Milling Co.'s plant also has suspended operations. The De La Mar Mining Co.'s plant in this State is expected to resume operations shortly.

The practice in use at the mill of the Horseshoe Gold Mining Co. at Fay, Lincoln County, is described by Ernest Gayford as follows: The ore passes over a grizzly, with 0·5-in. spaces, to a No. 3 Gates breaker crushing to a 2·5-in.

ring. This product passes to another grizzly, again with 0·5-in. spaces, whose oversize passes to a style H Gates crusher, all the ore below 0·5-in. size going to 300-ton bins, which feed into a Gates revolving dryer, whose product is taken by an elevator to a 4×8-ft. revolving 6-mesh screen. The oversize from this goes to a set of 36×16-in. Gates rolls, the product of which is returned to the screen. The undersize from this screen goes by elevator to two 4×8-ft. 12-mesh revolving screens, whose oversize goes to two 26×15-in. rolls. The product from these rolls is returned to the 12-mesh screens whose undersize goes by elevator to three 4×8-ft. 24-mesh revolving screens. The undersize from these screens is finished product, and goes to a 150-ton bin, while the oversize goes to an extra 26×15-in. Gates rolls, whose product is returned to the 24-mesh screens. The cyaniding is done in nine 24×5-ft. steel leaching vats, each holding 90 tons of dry ore. These vats are charged by cars running on suspended tracks above the vats. The leaching tanks are discharged by shoveling into cars beneath the vats through four 16-in. discharge gates. There are also three 15×9-ft. stock solution tanks, which act also as sump tanks, and three 15×9-ft. gold solution storage tanks. The ore is leached with a 0·3% solution, which is first aërated by compressed air in the sump tanks. The solution is put on from the bottom, to the extent of 25 tons, and allowed to have 12 hours' contact, when it is drained off and is followed by 30 tons of weak solution 0·16% KCN, which is drained continuously. This is followed by 8 tons of wash water, and the sands drained by vacuum until they contain 15% moisture. The total time for one tank from filling to filling is 9 days. Four pounds of quicklime per ton of ore are added at the first crusher. Precipitation is carried on in extractor boxes, 7 compartments, each compartment is 15×9·5 in. in cross section and 16 in. deep. The consumption of cyanide is 0·4 lb. per ton of ore, and the consumption of zinc from 0·25 to 0·30 lb. per ton. The precipitates are shipped to smelters for treatment. The cost of cyaniding is $1·35 per ton.

New Mexico.—Cyaniding has not been very active. The new plant, that of the Last Chance Mining Co., at Mogollon, treat 1,200 tons monthly. It is said on good authority that a 3,000-ton per day plant is projected at Nogal. near the Old Abe mine.

Oregon.—The North Pole and Cougar cyanide mills, at Sumpter, have not been in steady operation. About 18 miles west of Sumpter, the Red Boy mine has a cyanide annex for the treatment of raw concentrates from vanners.

South Dakota.—Great activity has been displayed in building new mills, and four large plants have been erected. The 700-ton Gayville plant of the Homestake Co., or "cyanide No. 2," has been in commission for a few months. The recently completed wet-crushing mill of the Penobscot Mining Co. at Garden City, is in operation with a capacity of 125 to 150 tons per day. The Hidden Fortune Co. is erecting a mill below Deadwood with a capacity of 200 to 250 tons per day, with a probability that another section will be added. The Horseshoe Mining Co. is building a large plant at Terry, wet-crushing to be employed. This mill is to be erected in two sections of 250 stamps each, the second section to be commenced immediately after the first begins operations. The capacity of the plant when finished will be in the neighborhood of 1,000 tons per day. Aside from these three plants, there is under construction, a cyanide annex to the stamp mill of the Jupiter Mining Co. in Blacktail Gulch, with a capacity of 50 or 60 tons per day, and a small 5-stamp 20-ton wet-crushing cyanide mill, at Two Bit, for the Golden Crest Mining Co. The Pluma Mining Co. is adding a cyanide annex to the old Hawkeye mill at Pluma, and Hall & McConnell have built a 60-ton per day tailings plant at Pluma to treat the very low-grade tailings which accumulated before the main cyanide plant of the Homestake Co. began operations. The old Kildonia chlorination mill of the Horseshoe Co. at Pluma has been converted into a dry-crushing cyanide mill, and has been in steady operation during the latter half of the year, with a capacity of about 200 tons per day. These additions to the mills already in operation will give the district the following plants in operation in the near future with a chance for an increase during 1903:—

Name of Mill.	Location.	Ore Treated Per Day.	Name of Mill.	Location.	Ore Treated Per Day.
		Tons.			Tons.
Homestake, tailings plant	Lead	1,800	Wasp No. 2 Mining Co	Flatiron	100
Homestake, tailings plant	Gayville	700	Dakota Mining & Milling Co	Deadwood	100
Imperial Mining Co	Deadwood	125	Deadwood Standard M. Co	Cyanide	125
Golden Reward Co	Deadwood	125	Portland Mill, Columbus M. Co.	Gayville	60
Horseshoe Co. Pluma Plant	Pluma	200	Rossiter or Golden Gate Mill	Deadwood	60
Horseshoe Co. Terry Plant	Terry	500	Alder Creek Mining Co	Flatiron	60
Spearfish M. & M. Co	Cyanide	250	Jupiter Mining Co	Blacktail	50
Hidden Fortune Min. Co	Deadwood	225	Golden Crest M. Co	Two Bit	20
Penobscot Mining Co	Garden City	125	Highland Chief Plant	Spruce Gulch	50

The total tonnage treated, or to be treated shortly, is 125,250 tons per month. The capacity of some of the plants is in excess of their present working.

The most noticeable feature of the mill construction in the Black Hills during 1902 is that all the new mills are wet-crushing mills. The method is to crush the ore with stamps in cyanide solution, the resultant pulp being separated into sands and slimes by hydraulic classifiers and distributors, the sands are leached and the slimes treated by agitation with pumps, and decantation. When this method was first introduced by John Henton in 1899 for those Black Hills siliceous ores which had to be crushed fine, its practical applicability was doubted by many, but the method has certainly demonstrated its usefulness during the last three years, and has practically displaced fine dry-crushing. All new mills are wet-crushing mills. The dry-crushing mills in the district are the Spearfish, the Deadwood Standard, the Wasp No. 2 and the Alder Creek plants, which crush coarse, and the Imperial, the Rossiter, the Golden Reward and the Pluma plant of the Horseshoe Co., which crush fine, the last using dry-crushing mainly for the reason that the plant is the old Kildonia chlorination mill, converted for cyaniding, the rolls and other machinery already being in place. Where coarse dry-crushing is sufficient to liberate the values and make them soluble, that method is preferable to wet-crushing in solution with stamps, because in plants of similar capacities the cost of treatment will be less, but where fine crushing is needed it is the general opinion that wet-crushing in solution is better. The dry-crushing mill, no matter how complete its exhaust facilities to remove dust from its crushing and screening machinery, is always troubled with dust, especially in the tank rooms of the newer mills where belt-conveyors are used in charging the vats. This last trouble has been overcome in an ingenious manner by J. V. N. Dorr at the Rossiter plant. Here the ore is removed at the finished-product bin into a trough about 6 ft. long, in which is a screw-conveyor. Just above the trough is a perforated pipe, through which a 0·25% cyanide solution is sprinkled into the finely crushed ore (20-mesh size), to the extent of from 5 to 10%. The screw-conveyor serves to mix the ore and solution thoroughly, and to carry it to a 12-in. belt-conveyor, which, with a short auxiliary conveyor serves to charge the leaching tanks.

The advantages of this device are: 1. That the charging operation is practically dustless. 2. The ore is placed in the tank in such a condition that percolation is easier and much more uniform, channeling is avoided, and more dust can be charged with the ore and still have a leachable product. Another feature of fine dry-crushing which must be taken into consideration with many ores of the district, is the quantity of dust produced in the comminution and collected by the exhaust apparatus. This, in many cases, is too large to permit mixing with the ore without seriously affecting the efficiency of the percolation, reducing the extraction by uneven leaching, and thus necessitating its separate treatment by agitation and decantation. This introduces into the dry-crushing mills that adjunct of the wet-crushing plant, the treatment of slimes, to which the advocates of dry-crushing object, as expensive and cumbersome. Generally the dust is of higher value than the crude ore.

In the case of the Golden Reward plant, the dust amounts to about 4% of the ore crushed, and at the Rossiter plant to about 6 or 7%. In both plants it is treated separately by decantation, while at the Imperial plant, it is charged with the sands into the leaching vats, being mixed with the sands automatically by a conveyor. While, however, the fine dry-crushing system is open to objections, it cannot be said that no unsolved problems confront the metallurgist in the wet-crushing with cyanide solution method. The first of these is the larger quantity of dilute solution to be handled in the mill. The ratio of solution to ore crushed varies between 3 and 4 to 1. The quantity of solution to be handled in a wet-crushing mill is about 1·5 to 2 times that in a dry-crushing mill.

The second is the problem of washing the values from the slimes. This would be simple if enough wash water could be applied, but the quantity necessary is prohibitive, since it would enormously increase the mill solution. One wash water, and in most cases two are not sufficient. In dry crushing it is the general practice to use one final wash water amounting to from 10 to 25% of the ore tonnage, and of this from 6 to 15%, and even more, is discharged as moisture in the tailings, depending on the coarseness of the ore and the use of a vacuum. This practice keeps the quantity of mill solution about constant. In washing slimes, the percentage of water must be increased, and in order to remove dissolved values more than one wash should be employed. This, however, would so increase the bulk of solution that at frequent intervals some of the weaker solutions would have to be run to waste. When the precipitation of the values is good, and it may not be very good with a weak solution, the quantity of precious metals thrown away may be insignificant, but combined with the loss of cyanide this factor will in time become a serious item.

The extraction from slimes is rarely less than 88%, and in some cases more, but in one mill even with two wash waters only from 80 to 82% is recoverable, the balance passing out in the retained moisture with the slimes which are, when discharged, about 50% liquids and 50% solids. Hence, while with fine crushing and the production of slimes, a higher extraction is possible, from the nature of the case, the mills are not able to take advantage of it to the full extent and recover it. In order to keep the bulk of solution within limits, the wash water in most cases is cut down, on the sands as well as on the slimes, from what it should be to wash out most of the values, and the total extraction in a wet mill is but little above that in a dry-crushing mill, working on the same ore. Naturally the final test is the question of the relative cost of treatment by the two methods. In one of the older wet-crushing 60-ton plants the cost amounted to $1·45 per ton of ore treated, exclusive of taxes and insurance. This figure has recently been reduced to about $1·25 per ton, and it is of interest that the estimated cost of treatment by wet-crushing for a 120-stamp unit of the 1,000-ton Horseshoe plant at Terry is 70c. per ton. The cost of fine dry-crushing is not available, but in most instances it is higher than the figures given above. It has been estimated that a new plant treating 4,500 tons per month can do so for $1 to $1·10 per ton. In one of the old small mills the cost has been as high as $3·50 to $4 per ton. The coarse dry-crushing mills, which reduce to from 4- to 10-mesh size, cyanide the ore for from 75 to 95c. per ton, based on capacity of comparatively small plants. According to C. W. Merrill, the cost of cyaniding Homestake tailings is now about 35c. per ton, the mill labor included in this amounting to but 6c. per ton.

The wet-crushing method has the advantage that weaker solution can be used, the usual battery solution being made up with 2 to 2·5 lb. of cyanide per ton, the sands being leached with a somewhat stronger solution, 3 to 3·5 lb. per ton. The usual strong solution for a dry-crushing plant is 5 to 6 lb. per ton. The quantity of lime is greater for wet- than for dry-crushing, for while less is used at the battery, a large quantity is used with the slimes to aid settling.

It has been a problem to find an efficient method of separating the sands from the slimes, for the sands, in order to get a uniform leaching, should be as free as possible from slimes. In the newer mills, the crude and rectangular two-compartment separator box has been discarded, and in general a similar method to that used by C. W. Merrill in the Homestake tailings plants is employed. At the Penobscot mill at Garden City, two cone-shaped hydraulic classifiers in series are employed, in which, if necessary, a rising current of cyanide solution can be used; the overflow from the last classifier passes to the slime vats, and the bottom discharge of the two, passes by launders to a Butters & Mein distributor over the leaching vats. The peripheral overflow from the sand vats again passes to the slime vats. At the new mill of the Horseshoe Co. at Terry, Klein classifiers are to be installed, using an air current introduced at the bottom to aid in the separation. The overflow containing the slimes will pass to the slime vats while the sands pass directly into the leaching vats. At the new Hidden Fortune mill below Deadwood, the crushed pulp will pass directly to Butters & Mein distributors placed above the leaching vats, this separation being deemed sufficient to eliminate the slimes, as the crushing will be coarse.

At the cyanide plants of the Homestake Co. the separation is made by a triple set of cones placed in series, the first set at the stamp mills and the other two at the cyanide mills. The first two sets are large flat cones, with no current except that induced by charging at the center and the overflow. The last sets are smaller and deeper, and have a rising current introduced at the bottom, as in the case of the regular hydraulic classifier. Aside from these, the leaching vats are charged by Butters distributors, the overflow at the periphery of the vats passes to waste, the Homestake plants treating sands only.

The pneumatic cyanide process has been introduced at the Pluma plant of the Horseshoe Co., where three 35-ft. tanks are fitted with the pneumatic process, as an experiment. An air pressure of 4 or 5 lb. is put on after the vats are charged, and air forced through the ore for 4 hours. Then leaching is commenced, the time on the pneumatic tanks is 72 hours, while on the other tanks the time is 120 hours. It is, however, questionable whether any benefit is derived from the pneumatic process for the Black Hills siliceous ores, for while the time is shortened, the extraction is not much increased, and difficulty is encountered in discharging the tanks, owing to the network of pipes. The Hidden Fortune and the Hall-McConnell tailings plant also will use the pneumatic process. During the year, some of the plants experimented with the Schilz barium dioxide process, but it was found to possess no advantage for their ores. With the exception of the Homestake mills, which use zinc dust, all mills use zinc shavings. The method of precipitating in barrels or precipitation vats, instead of the compartment zinc box, is finding much favor.

The new wet-crushing plant of the Horseshoe Co., in course of erection at Terry, will have its rough crushing department separate from the mill, and above the stamps. The crushed product from four No. 5 Gates crushers will be conveyed to the main storage bins above the stamps by a belt-conveyor 610 ft. long. which extends the length of the bins, and is provided with a movable automatic discharge tripper to distribute the ore uniformly in the bins. The main bins have a capacity of 7,000 tons, while the ore bin ahead of the crusher has a capacity of 1,000 tons. The mill is being built in two sections of 120 stamps (500 tons) each. One section is to be completed before the other will be started. The stamps are of 1,000 lb. weight, with a 6- to 7-in. drop. Double discharge mortars are to be used with a depth of issue of about 1 in., crushing in cyanide solution through a 20-mesh woven wire screen. The pulp from the stamps is raised by two spiral sand pumps, with two extra ones to act as relays to 4 Klein classifiers, the height of lift being 20 ft. For each 500-ton section there will be 8 sand leaching vats 40 ft. diameter and 5 ft. deep; 16 slime vats, 20×10 ft., 8 gold solution storage tanks, 15×10 ft.; 8 sump tanks, 24×10 ft.; and 4 solution storage tanks, 30×16 ft. There will also be two water tanks 35×16 ft. All tanks are of steel. It is the intention to complete the slimes treatment in one vat, sluicing the exhausted material from it after treatment. The slimes will be agitated with air at 30 lb. pressure by a special arrangement of pipes.

The sands, after leaching, will be discharged through four 18-inch bottom discharge gates on to belt-conveyors. The scarcity of water does not permit of sluicing. It is estimated that the total water consumption of the plant will be one ton of water per ton of ore treated. Precipitation will be effected in zinc compartment boxes.

The new Penobscot mill at Garden City, erected during 1902, is well designed, and an improvement on the older wet-crushing mills of the district. The mill is situated a few hundred feet from the mine, with which it is connected by a covered way. A 13×24-in. Blake breaker, on a rock foundation, does the rough crushing. A Jeffrey elevator, capacity 40 tons per hour, takes the crushed product to the stamp supply bins. At the discharge from the elevator an automatic conveyor cuts out 1-60 for the sampling room. The stamp supply bins, of a capacity of 250 tons each, are flat bottomed, the ore sliding on its own cone to the gates. Eight Challenge feeders charge the ore to forty 950-lb. stamps, making a hundred 7-in. drops per minute. The shoes, dies, tappets and cams are of chrome steel. Single discharge mortar-boxes are used, with a low depth of issue. The ore is crushed with cyanide solution. The pulp from the stamps is raised by two Frenier 10×54-in. sand pumps to four cone classifiers, two in a series. The height of lift is 16 ft. The sands pass to Butters & Mein ball-bearing distributors, having twelve 1·5-in. pipe arms. The distributor is on a trolley above the vats and can be shifted to each one in turn. The solution and slimes overflow at the periphery of the vat over a 0·5-in. tongue of wood inserted into the staves. This device was first used by C. W. Merrill at the Homestake plants to secure a uniform overflow. This tongue or feather can be readily planed and the overflow kept perfectly level, which is necessary to prevent an uneven settling of the sands with slimes. The overflow from the sand vats is collected in an annular launder around the tank and can be conveyed to any slime vat in the mill by a 3-in. pipe discharge. There are six sand tanks, 30×6 ft. outside measurements; eight slime vats, 24×12 ft.; two gold solution storage tanks, 20×10 ft.; two sump tanks of the same size, and three stock solution tanks, 16×16 ft. All tanks are of Oregon fir. The siphoned solution from the slime vats is filtered in sand filters, 15 ft. diameter and 2·5 ft. deep, placed above the gold solution storage tanks. The sand leaching vats are discharged by sluicing through three 12-in. bottom discharge gates, by water furnished from a 50,000-gal. tank, with a pressure of 15 lb. per square inch. The slimes are pumped and agitated by two centrifugal pumps, lined with manganese steel. The precipitation is carried on in four 8-compartment steel boxes, 20 ft. long, each compartment being 2×2·5 ft. in cross section and 18 in. deep to the filter. Before entering the compartment boxes the solutions will pass through 25 precipitating barrels. In all 400 cu. ft. of zinc are available for precipitation.

The sand leaching vats are connected beneath the filters with a Rand vacuum pump, and a 3×10 ft. vacuum tank. The precipitates are refined by sulphuric acid in a steel acid tank, 6×3 ft., which discharges in a vacuum steel filter tank, 3 ft. diameter, placed over a wooden waste tank, 10×8 ft. The pumping of solutions and water in the mill is done by three Dean pumps, two of which are 4·75×5·25×5 in., and the other 7·5×6×6 in.

The new cyanide mill of the Hidden Fortune Co. is in course of erection a few miles below Deadwood on Whitewood Creek. As in the Horseshoe mill at Terry, the crushing department is separate from the mill. The crushing will be done by a 15×30-in. Blake, and the crushed product conveyed to the stamp-bins by a 24-in. belt-conveyor discharging by an automatic tripper into 500-ton bins. The railroad bins above the mill have a capacity of 800 tons. Challenge feeders supply the 60 stamps, which are each of 1,000 lb. weight, making 7-in. drops, 90 per minute. The capacity of the mill will be about 250 tons per day. The mortars will be double discharge, with 1-in. depth of issue. Crushing will be done in a cyanide solution. The pulp from the batteries will go to Butters & Mein distributors, placed over the sand leaching vats, in which overflow gates will carry off the slimes, to the slime vats. The pulp is raised to the distributor by three Frenier-spiral sand pumps. The leaching vats will be discharged by sluicing through six 15-in. bottom discharge gates. The five leaching vats are 40×6 ft. There are 4 sump tanks, 3 gold solution storage tanks, 2 stock solution tanks, 7 slime vats—21 tanks in all.

The new Gayville mill of the Homestake Co. is similar to the Lead mill.[5]

Utah.—During the year the Golden Gate and Manning mills have been in operation at Mercur, the latter mill treating old Mercur tailings at a cost of 59·4c. per ton. The Annie Laurie mill in Piute County, built in 1901, has been steadily at work and the new mill of the Ophir Mining Co. in Iron County, situated near the Nevada State line, not far from the Horseshoe mill above described, has also been in operation. At the Sunshine mine at Sunshine, the old mill has been remodeled, and a slimes treatment plant installed. The mill has been in operation treating from 100 to 125 tons per day, although it has a nominal capacity of 300 tons per day. Recently the mill was closed for further changes. The process at this mill, which is rather an innovation in slimes treatment in this country, has been described by Mr. M. D. Stackpole.[6] The ore is crushed to 4-mesh size, and the slimes, which are considerable, on account of the talcose and clayey nature of the ore, are separated in a special conically shaped separator, the patent of George Moore. The slimes are agitated in vats by a centrifugal pump, and are separated from the solution by means of four 30-frame filter presses. This is the only plant in this country, as far as I know, that uses the filter press method of treating slimes.

The Midas Mining Co. in the Mercur district, Tooele County, has a cyanide plant in operation treating tailings from amalgamation.

Washington.—Cyaniding has not been active in Washington during the year; the Republic and Mountain Lion mills at Republic have not been in operation.

CYANIDE PRACTICE IN FOREIGN COUNTRIES DURING 1902.

Western Australia and New Zealand.—According to Alfred James[7] the Great Boulder Main Reef, the Great Boulder Proprietary, the Hannan's Star, the Brownhill and the Perseverance and others, in the Kalgoorli district in Western

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[5] *Engineering and Mining Journal*, Jan. 4, 1902.
[6] *Ibid.*, July 12, 1902.
[7] *Ibid*, Jan. 3, 1903.

Australia have successfully operated the cyanide process on sulpho-telluride ores during 1902. Of all the modified cyanide processes advocated and tried only the Diehl bromo-cyanogen and the roasting process are still in use. The Diehl process has been successful on the low-grade ores (0·4 oz. gold) of the Hannan's Star mine, but it is the opinion that on the higher grade ores, roasting must be employed, at least for some part of the ore, in order to get sufficient extraction.

The mills using the Diehl process are experimenting with concentration, combined with the use of bromo-cyanogen, *i.e.,* concentrating out the refractory material, which amounts to from 15 to 20% of the ore, roasting and cyaniding these concentrates and treating the tailings by bromo-cyanide. The process to be employed in the future will depend on the result of experiments in concentration now being carried on.

If these are successful, the scheme of treatment will consist of wet crushing by stamps (wet crushing on account of concentration), amalgamation on plates, concentration, roasting the concentrates, regrinding them in tube mills, cyaniding, with filter press treatment of the slimes. The tailings from the concentrators will have similar treatment except that they will not be roasted. The Diehl process as such and with it the use of bromo-cyanide, would then disappear, in favor of the above-described process.

Wilfley tables are used in the district, but suffer a considerable loss in fine sulphides, which are carried away with the coarser tailings. At the Perseverance mill, the canvas strakes which follow the Wilfley tables, yield a concentrate of higher value than that made by the tables.

It is found that to treat the ore raw, without bromo-cyanogen, the sulphides must not exceed 0·5%, so that the concentration must be carried to that extent.

Ball and tube mills have proved themselves efficient crushing machines in the district. The tube mills are very efficient for sliming the sands, one standard mill crushing 70 tons per day from a 12-mesh size feed, through a 60-mesh screen, consuming 27 H.P. The agitator used in the cyanide vats is one with radial arms on a vertical spindle, suspended over the vat, there is no step, but the spindle is guided in a guide of cement or iron. An arrangement for raising the agitator is rarely employed, South African tailings wheels are used to elevate the slimes, which are thickened in multi-bottomed spitzkasten. Dehne filter presses are used, operated by compressed air, but plunger pumps are preferable on account of economy.

The Riecken electrical precipitation process has been tried at the South Kalgurli mine, and at the Great Boulder No. 1, but has been discontinued owing to the defective electrical precipitation, which is the essence of the process.

Mr. S. J. Truscott[8] gives the cost of amalgamation, milling and cyaniding for the year ending December, 1901, as follows:—

Ivanhoe Gold Corporation.—88,084 tons milled (0·58 oz. per ton) (amalgamation) cost $1·66 per ton; 46,459 tons of sands (0·043 oz.), cyanided, cost $1·27 per ton; 60,624 tons of slimes (0·41 oz.), cyanided, cost $1·61 per ton.

Golden Horseshoe.—77,801 tons (0·75 oz.) (milled, including pan amalgama-

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[8] *Journal of the Chemical and Metallurgical Society of South Africa*, III., iv., 43, August, 1902.

tion) cost \$2·34 per ton; 40,108 tons sands (0·84 oz.), cyanided, cost \$1·50 per ton; 51,588 tons slimes (0·44 oz.), cyanided, cost \$2·46 per ton.

Lake View Consols.—76,571 tons milled (1·58 oz. amalgamated) cost \$1·66 per ton; sands cyanided, cost \$1·44 per ton; slimes cyanided, cost \$1·70 per ton.

Mr. Alfred James, in the article already mentioned, gives the cost at the Hannan's Star mill, which uses the Diehl process, at \$5·33 per ton, on 0·4-oz. ore. The same process on the considerably higher grade ores of the Hannan's Brownhill and Lake View Consuls, cost \$8·19 per ton, which includes \$2 alone for bromocyanogen. The cost at the Great Boulder Main Reef, which uses the roasting process, is \$6·25 per ton with an extraction of 90%. Costs in Kalgoorlie are necessarily high, for power costs about \$19 per H.P. per month, and water from 80c. to \$1·50 per 1,000 gal.

During 1902 in New Zealand 25 of the 26 cyanide plants were in operation.[9]

Wet Crushing and Direct Cyaniding.—Hamilton Wingate[10] describes the direct cyaniding of wet crushed ores at the Waitekauri Extended mine, Maratoto, N. Z., as follows: Formerly the ore was dry crushed and cyanided, but this method was found to be unsuited to the lower level ores and was high in cost. The choice of a satisfactory process depended on a successful method of slime treatment. In this respect the liberal use of lime was found satisfactory. The ore is a hard, flinty quartz carrying finely divided pyrite. The gold content is uniformly distributed in a fine state of division, while the silver is present as a sulphide. The base sulphides comprise 5% of the ore, and the average value of the ore is from 0·3 to 0·4 oz. gold and 1·75 oz. silver. The mortar boxes, which were double discharge for the old dry crushing method, had one discharge closed for the wet crushing, but were still unsuitable, as a large quantity of slime was produced owing to improper dimensions. A higher extraction by cyanide, however, was obtained on slimes than on sands. The ore was crushed through a 40-mesh screen, the classification of 656 tons of ore giving 54·11% sands, and 45·89% slimes; 70% of the total pulp passed an 80-mesh screen, which was the fineness necessary for a good extraction.

The crushed pulp passed to a 5-ft. square pyramid shaped spitzkasten, 5 ft. deep. At the apex was a 2·5-in. cock to regulate the discharge of the sands. A perforated pipe or rose at the overflow end was necessary to prevent the settling of the slimes with the sands. It was essential to make a clean separation of the sands from the slimes, since those slimes that pass with the sands are lost in the overflow from the sand vats, while any sands in the slimes cause a portion of the slimes pulp to set hard at the bottom of the vat, in a mass too tough to be affected by the agitator.

The discharged sands from the spitzkasten passed to a vat into which they were charged by a Butter's distributor, and the overflow of the spitzkasten containing the slimes passed to an agitator vat. The 30-ton sand vats were 20 ft. in diameter and 4 ft. deep. The sands were treated first with a preliminary alkaline wash, then with a weak sump solution, followed by a 0·5% cyanide solution, and finally by the usual washes of strong and weak sump and wash water. The sands in general presented no difficulty of treatment.

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[9] *New Zealand Mines Record*, May, 1902.

[10] A paper read before the American Institute of Mining Engineers, New Haven meeting, 1902.

The slime vats were 22 ft. in diameter and 7 ft. deep, holding on the average 25 tons of slimes. The overflow from the spitzkasten is run in at one end, and the clear liquor allowed to flow off at the other. After charging the vat, the slimes are allowed to settle, and the water is drained off by an inside siphon pipe, leaving a pulp which contained from 42 to 58% of dry slimes. The agitator is then started, being at the same time gradually lowered. The charge was accurately sampled by dip samples. On the average 14 lb. of lime were added, and the charge agitated for an hour to neutralize the acid in the ore. In order to economize cyanide and prevent the quantity of solution from becoming unmanageable, the weight of cyanide required for the slimes was dissolved in 5 tons of strong sump solution, and added to the slimes, the resultant solution containing 0·16% cyanide. The slimes pulp was then agitated for 3 hours at the rate of 40 r. p. m. Then strong sump solution was run on, during agitation until the depth of slimes pulp in the vat was 6·5 ft. The agitator was then raised, and the slimes allowed to settle after which decantation was begun. The decanting pipe consisted of a 2-in. wired, rubber hose fixed inside the vat, and connected at the bottom and side of the vat with the solution pipe to the extractor boxes. The end of the hose is held in an iron collar to which is attached an arm made of 0·5 in. square iron. This arm passes through a guide which can be moved freely along an iron bar 3 ft. long, which is bolted to the inside edge of the top of the vat. A thumb screw through the guide holds the arm in position, and as the hose is lowered the guide can be moved along the fixed iron bar and the arm securely clamped. After the first solution had been drawn off, agitation with sump solution, followed by decantation was continued. From four to eight washes were required, the total weight of which was three or four times that of the dry slimes present in the charge. Each wash was passed through the extractor boxes before being returned to the slimes charge. The rate of flow through the extractors was 2 tons of solution per hour per cubic foot of zinc shavings. The extraction from a test lot of 1,440 tons was 81·4% of the gold and 45% of the silver. Consumption of cyanide was 2·7 lb. per ton, consumption of zinc 0·75 lb. per ton, lime 7 lb. per ton caustic soda 0·75 lb. per ton. The total cost was $2·07 per ton, including all charges. The necessity of strong solutions owing to the nature of the ore and the need of obtaining an adequate extraction of the silver makes the cyanide consumption much higher than the average. Mr. Wingate states that wet crushing has practically superseded dry crushing in New Zealand for the reasons given above.

Several mills in New Zealand crush in the battery with a 0·1% cyanide solution, the process being practically the same as that which is used in some of the South Dakota mills. This method, however, would not be applicable to acid ores owing to the heavy cyanide consumption involved.

The Treatment of Slimes.—A patent has been issued to E. Godbe for a process of treating slimy ores by cyaniding, which consists of stirring the pulp with cyanide solution containing lime, in a circular vat of no greater diameter than depth, and while stirring introducing a stream of cyanide solution from below a false filter bottom. This solution rises up through the agitated and suspended ore, and overflows at the top clear and free from slime. To do this the stirrer is placed close to the bottom and does not revolve fast enough to throw the slime to the surface, but just sufficient to keep the entire mass in suspension and flowing around the tank, leaving a few inches of perfectly clear solution at the top. Compressed air can be blown into the vat to aid in the solution of the gold. The overflowing solution is ready for precipitation. Weak solution and washes are introduced in a similar manner to the strong cyanide solutions.

J. Yates[11] states that in South Africa the cost of a plant for treating slimes by the decantation method is from $750 to $1,000 per head of stamps. An average of 60% extraction by the decantation method on slimes is the best obtainable in South Africa. Led by these facts John R. Williams is to make a test on a working scale, side by side, of the decantation and filter press methods of slime treatment, which will be of very great interest.

The Bromo-Cyanogen Process.—The Diehl process as practiced at some of the Kalgoorlie mines, Western Australia, and already mentioned, is described by H. Knutzen[12] as follows: The process is used at three mines, the Hannan's Star, the Hannan's Brownhill and the Lake View Consols, at the last named mine both the Diehl process and the roasting process were operated. A number of analyses were made on Kalgoorlie ores, from the different mines, with the following results:—

Insoluble matter (insoluble in dilute hydrochloric acid), 40 to 78%; iron carbonate (spar), 10 to 30%; calcium carbonate, 9 to 38%; gold, 0·8 to 5·5 oz. per ton.

It is thought that this composition accounts for the trouble met with in the roasting process, as the finely ground ore after roasting has cement-like properties, forming an iron cement, which sets in the vats. The Diehl process comprises the following essential stages:—

1. Crushing and sliming the ore.
2. Treating the slimes in agitators with a solution of potassium cyanide in combination with cyanogen bromide.
3. Filter pressing the sludge and precipitating the gold from the solution by means of zinc shavings.

According to the nature of the ore, amalgamation and concentration may be added as part of the process.

It was found that in order to get a good extraction on Kalgoorlie ore it must be slimed. Only part of the gold is present in the metallic state, the greater part being present as a telluride and in sulphides. The slimes from the ore are richer than the sands owing to the brittleness of the telluride minerals. Ore was crushed in a battery through a 40-mesh wire screen with this result:—

On 3·25-oz. ore the sands contained 20·27% of the gold value; the concentrates, 38·49%; the slimes, 29·62%; and amalgamable gold, 11·62%.

On 0·85-oz. ore the sands contained 26·24% of the gold value; the concentrates, 37·51%; the slimes, 35·37%; and amalgamable gold, 0·88%.

The best extraction on sands with a 7-day leaching did not exceed 50% of the gold. The best machine to slime the ore was found to be a Krupp tube mill,

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[11] *Journal of the Chemical and Metallurgical Society of South Africa*, III., iv., 41, August, 1902.

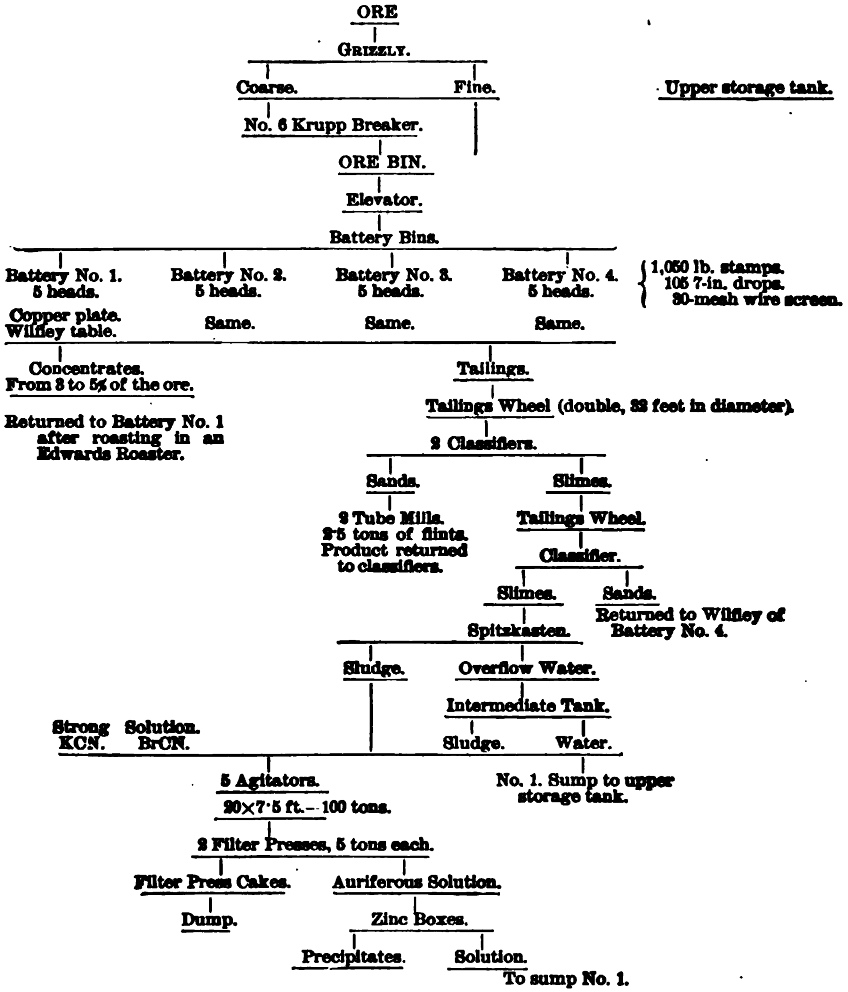
[12] A paper read before the Institution of Mining and Metallurgy, June 19, 1902.

using flint balls. The mill is 18 ft. long, 4 ft. in diameter and charged with 4 tons of flints. The sands are fed by a nozzle at one end, and the slimes discharge at the other. All of the product passes a 200-mesh screen, and less than 3% remains on a 220-mesh screen. One of the advantages of this mill is the small quantity of metallic iron that contaminates the slimes. From the tube mill, the slimes containing from 3 to 5% of solids pass to a system of classifiers to separate out any remaining sands which are sent back for recrushing. The slimes flowing from the classifiers pass to a system of spitzkasten, where they are concentrated to a pulp containing from 40 to 50% dry material. This goes to agitators, which are covered tanks from 20 to 25 ft. in diameter, and 7·5 to 8 ft. deep, provided with stirrers. The capacity of an agitator is from 120 to 125 tons of pulp. When the agitator is filled, a strong solution of potassium cyanide is added (4·4 lb. of cyanide per ton of dry material) and agitated for 1·5 hours, when a solution of bromo-cyanogen is allowed to flow in (1·1 lb. per ton of dry material). Then the pulp is agitated until the total time of agitation is 24 hours. The quantities of chemical vary according to the richness of the ore, the above quantities being for 2 to 3-oz. slimes. Two hours before the agitator is ready to discharge to the filter presses, from 1 to 4 lb. of lime per ton of dry slimes is added, which has the effect of giving a clean precipitate in the zinc boxes. Experiments were made to test the extraction with and without bromo-cyanogen. With plain cyanide solutions ranging in strength from 0·1 to 0·3% an extraction of from 41 to 62% was obtained. With the same cyanide solutions plus bromo-cyanogen added from 0·025 to 0·075% strength the extraction was increased from 77 to 97% on ore carrying approximately 2 oz. gold. Chloro-cyanogen was found to be non-effective in increasing the extraction, rather the contrary.

The filter press is indispensable to the Diehl process owing to the high value of the slimes. The filter presses used have a capacity of from 4·5 to 5 tons. They consist of 50 frames, the cakes from which measure 39·5 in. square and from 2·5 to 3 in. thick. A dry cake weighs from 1·75 to 2 cwt. Each filter press has its own system of receivers, one for slimes, one for weak solution and one for wash water. The presses are operated by compressed air. The cakes are washed once with weak solution and once with wash water. For a charge of 5 tons from 350 to 500 gal. each of weak solution and wash water are used. The cakes are then dry blown 10 or 15 minutes with 80 lb. of air, and then the cakes are discharged into cars below. The time occupied from one charge to the next is 2 hours. The solution goes to the zinc boxes, first, however, being passed through a special filter or another small filter press for clarifying. The plant at the Hannan's Brownhill mine is a new one, built specially for the Diehl process, having a capacity of 75 tons per day. The scheme of working is given on the following page.

At this mill, 2,210 tons of ore were treated during July, 1901, at a cost of $5·84 per ton, which was rather high, the average cost being $5·34.

The Lake View Consols mine had in operation alongside of the Diehl plant a plant using the roasting process, in which the ore was dry crushed by Krupp ball mills. The ore treated by one plant was precisely the same as that treated by the other, hence a comparison of costs is interesting. In August, 1901, the roasting process treated 3,411 tons of ore producing 5,287 oz. of bullion at a cost of $9·08 per ton. The Diehl process treated 5,888 tons producing 9,020·48 oz. of bullion at a cost of $8·36 per ton. With the same kind of ore going to the plants, the extraction by the Diehl process was $28·16 per ton, as against $27·27 by the roasting process, the difference between these costs should be added to the cost of the roasting process.



At the Hannan's Star mill the ore is crushed dry in 2 No. 5 Krupp ball mills, through a 30-mesh screen, from which it goes to a mixing machine, where it is mixed with water. From here the pulp follows the same course as at the Hannan's Brownhill.

Refining of Precipitates.—Hamilton Wingate[13] describes the method used at the Waitekauri Extended mine, Maratoto, N. Z. Roasting the vacuum-dried

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[13] A paper read before the American Institute of Mining Engineers, New Haven meeting, 1902.

precipitates was adopted in place of treating with sulphuric acid, the facilities for the latter method not being available. It is also a question whether the acid treatment presents any advantages in the treatment of bulky precipitates such as are obtained from ores containing considerable silver. All the precipitate is first washed through a 40-mesh screen. After drying on a filter by the aid of a vacuum pump, the precipitate was weighed and transferred to the oxidizing furnace, consisting of a square cast iron tray 6 in. deep, built over a brick furnace using wood fuel. The tray has a sheet iron hood over it, to collect the fumes, which are conducted through a flue to the dust chamber. The oxidation of the precipitate was conducted at a low heat, which was gradually raised to a dull red, the precipitate being kept broken up by a rake, care being taken to avoid dusting. The oxidized precipitate was fluxed as follows: 50 parts anhydrous borax, 15 parts of anhydrous sodium carbonate, 100 parts of precipitate. This was charged into a No. 50 graphite crucible and melted at a moderate heat, the pot being carefully covered during the fusion and recharged in each case before fusion was quite complete. When the crucible was three-quarters full, the temperature was raised and the slag, now thoroughly liquid, was ladled into molds and the crucible recharged as before until two-thirds full of molten bullion. The bullion was poured into molds, each bar being again melted in a crucible of smaller size and skimmed if necessary before pouring. The bullion averaged 941 fine. This fineness was mainly due to the passage of the precipitate through a 40-mesh screen, which eliminates the coarse zinc. It is impossible to oxidize zinc scattered through a bulky precipitate, and as its presence causes mechanical and volatilization losses, it must be eliminated if subsequent losses in melting are to be avoided. The slags were crushed at the mill and yielded in shot 1·5% of the total value of the bullion. The crushed slag after panning had a value of $121·50 per ton. The sweepings from the dust chamber and flue yielded only $43 after the roasting of about $30,000 worth of precipitates.

P. S. Tavener[14] describes a new method of treating zinc-gold slimes, which consists of smelting them with litharge in a reverberatory furnace, and cupelling the auriferous lead. The process was first introduced at the cyanide plant of the Bonanza Co. at Johannesburg in 1899, and since the resumption of milling 14 months ago, has been in continuous and satisfactory operation. The clean-up of the slimes is conducted in the ordinary way, except that the whole precipitate is pumped at once from the clean-up tub into the filter press, the fine zinc which remains at the bottom of the tub being heaped to one side and allowed to drain before it is transferred to the smelting room. The cakes from the filter press are dried in an oven, 15 minutes per tray being sufficient. The fine zinc is kept separate from the filter press slimes. The dried slimes are passed through a 4-mesh sieve and roughly weighed, for the addition of the mixed fluxes. The charge is made up approximately as follows: Slimes, 100 parts by weight; assay slag, 10 to 15 parts; foul slag, 10 to 15 parts; silica, 5 to 10 parts; litharge, 60 parts; fine zinc, 100 parts; slag, 20 parts; litharge, 150 parts.

The charge is shoveled directly into the furnace, the fine zinc part being

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[14] A paper read before the Chemical and Metallurgical Society of South Africa, III., iv., 70-78, October, 1902.

placed on top of the slime charge to prevent loss by dusting and also to have an excess of litharge at the top of the charge. No absolute rule for fluxing can be formulated as that depends upon the nature of the precipitates smelted. In practice it is found that considerably less slag (30% less) is required than

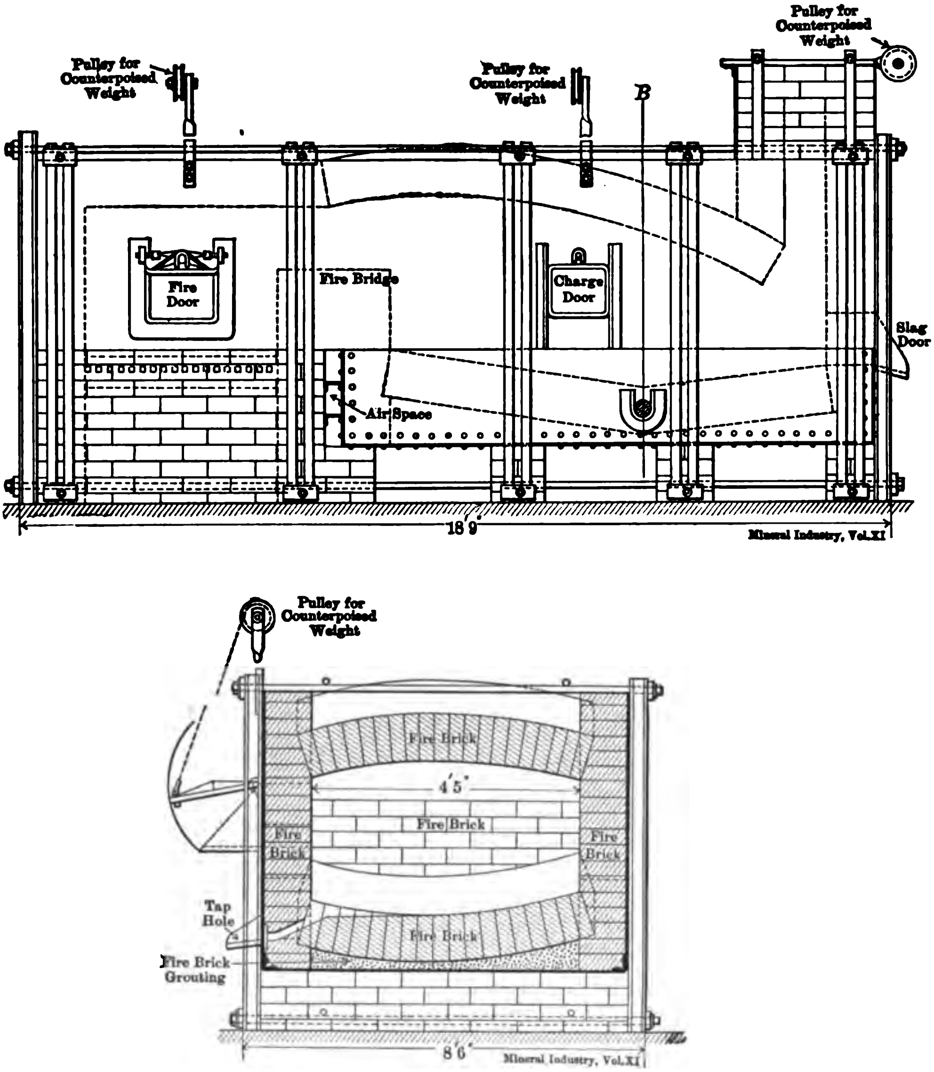
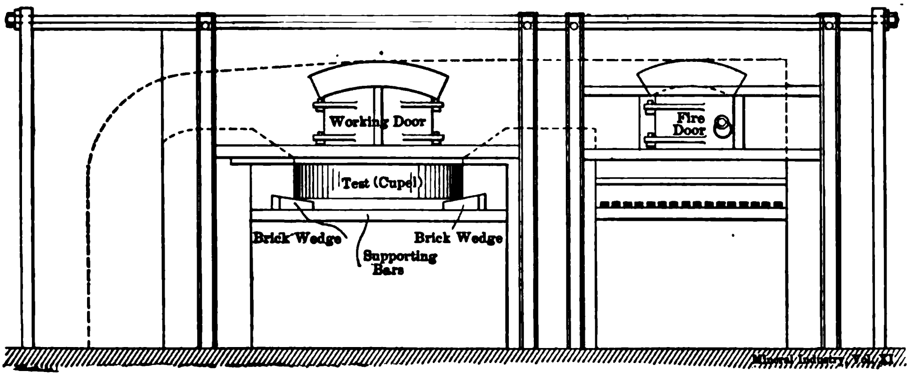


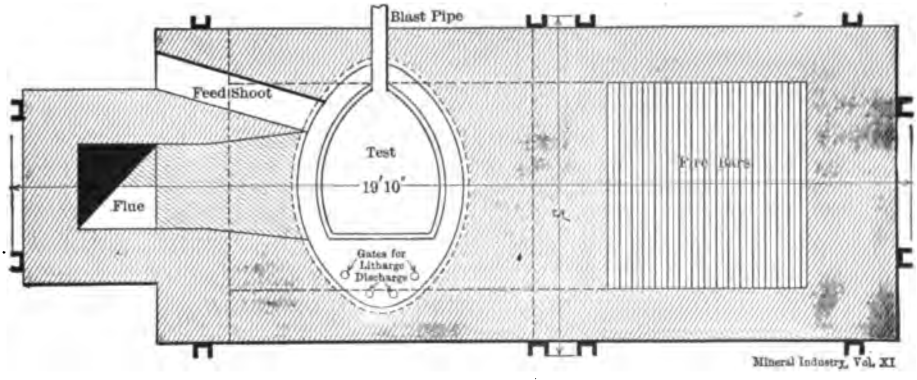
FIG. 1.—TAVENER'S FURNACE FOR SMELTING ZINC-GOLD SLIMES.

in smelting small quantities of precipitates in crucibles. The lead bullion produced should contain not more than 8% of gold—10% being the limit. As a reducing agent sawdust was employed to the amount of from 1 to 2% of the weight of the litharge present. No sawdust is added with the fine zinc charge, the zinc in the latter acting as the reducing agent. The reverberatory furnace is shown in Fig. 1, except that the roof should be that of a true reverberatory. The pan should be filled, and the sides lined for 12 in. above the hearth with the best quality of fire brick. The bottom is laid with close joints on a grouting of crushed fire brick mixed with sufficient fire clay to make a binding material, which is tamped into the pan to the required level and faced with cement.

The charge is placed in the furnace, covered first with a thin layer of litharge, followed by a thin layer of easily fusible slag. The furnace is charged on the day previous to the smelting. At 3 A.M. a slow fire is started to dry the charge, at 5 A.M. the fire is urged, the furnace being raised to a smelting heat in 30 minutes. By 9 or 10 A.M. the charge is reduced, and any sweeping or foul slag on hand is added. The charge is then well rabbled and sawdust thrown on, repeated to reduced the excess of litharge until the slag shows clean on the rabble. The slag is then drained off into pots. The slag door is 4 in. above the center of the lead charge, when about 12,000 oz. of lead bullion are in the furnace. Before charging the furnace the slag door is built up 12 in. by means of cast iron plates laid in fire clay. In order to draw off the slag these plates are removed one by one. The filled slag pots are allowed to stand a few minutes, and then are tapped 2 in. from the bottom (to recover any lead), the shells and



Side Elevation.



Horizontal Section.

FIG. 2.—TAVENER'S FURNACE FOR CUPELLING ZINC-GOLD SLIMES.

bottoms being reserved for resmelting. The last of the slag is waved off by rabbling. The last skim of slag on the bath is thickened by cooling and throwing a shovelful of lime over the charge, when it is easily detached, and reserved for the next melt. A clean surface of lead is then exposed, and any zinc present quickly burns off. The lead recovered is clean and soft. The bullion is sampled accurately after stirring by taking a ladleful, and is then poured into bars.

The cupelling test is an oval, cast iron frame filled with bone ash ground to pass a 20-mesh sieve, and moistened with a potash solution of 1 lb. of potash for every 33 lb. of bone ash. The bone ash must be moistened just sufficiently so that if squeezed into a ball in the hand it will break clean. The test requires 500 lb. of bone ash to fill it, 300 lb. remaining after the necessary cutting out. (See Fig. 2.)

The test has a basin cut into it, from 2·5 to 3 in. deep, and is put away to dry at least two weeks before using. A cupel of this size is sufficient for four charges each of 1·5 tons of lead. The last one used at the Bonanza lasted 4 months, and cupelled 7·5 tons of lead bullion, producing 14,978 oz. of bullion.

When the new cupel is placed in the furnace a slow fire is kept burning for 3 or 4 hours before starting to refine. The blast is introduced into the test by a 3-in. pipe flattened at the end, and turned down so that the blast may strike the lead. The temperature is now raised to melt lead, and six bars are put into the furnace by the working door. When these are melted, the temperature is increased, and the remainder of the lead is introduced through the feed chute, the ends of the bars being allowed to melt off gradually. Lead is thus fed in until the bath almost reaches the level of the litharge channel, which has been cut in the meanwhile. The temperature is then increased to the melting point of litharge, and as soon as the bath is covered with litharge the blast is turned on, the litharge formed running into a pot similar to a slag pot, but only 12 in. in diameter and 8 in. deep. The flow of litharge is controlled by the quantity of lead melted from the bars introduced through the feed chute. When the feeding is completed, and there remains only the bath of concentrated bullion, the temperature is raised, and the litharge channel deepened. Nearly all the copper in the bullion enters the litharge just before the completion of the operation, which makes the litharge thick and heavy and requires a high temperature. Just before the cupellation is finished there is danger that the bath will freeze under the cold blast; if that occurs the blast is shut off and the temperature raised until the bath is molten again, after which the blast is turned on and the last impurity driven off. From 6 to 8 lb. of assay slag are then added and melted, and allowed to run off, and by this means the gold is given a clean, bright surface. The fire door is now opened and the gold allowed to cool to a point where it will not crumble when a bar is inserted under the cake. This is lifted, broken in halves, and pulled out into a slag pot. The gold is remelted in crucibles and cast into bars. The advantages of the process can be stated as follows: 1. Saving in cost of treatment. 2. Absence of by-products. 3. Reduced loss in handling. 4. Increased recovery of gold. 5. Facility for treating foul slag.

The results of four months' smelting at the Bonanza are as follows: Weight of moist filter press slimes, 9,058 lb.; of fine zinc, 7,662 lb.; lead bullion cupelled, 15,269 lb.; gold recovered, 12,810 fine oz.; materials used, coal, $396·74; coke, $45·24; fire clay, $14·40; fire brick and slabs, $83·32; paper bags, $9; lead foil, $14·56; bar iron, $0·76; crucibles and liners, $8·40; caustic potash, $2·88; bone ash, $48; sundries, $6·04; total, $631·34; loss of lead, 12% on 15,269 lb.=1 ton at $96, grand total, $727·24, or 5·5c. per fine ounce of gold recovered.

Roughly speaking, the cost of acid treatment is about 24c. per ounce of fine gold recovered. A cyanide plant producing 2,500 oz. of fine gold per month would save approximately $4,800 per year in the cost of refining, besides gaining about $1,440 from the elimination of by-products, in which gold has to be sold at a discount, and from losses in handling. The lead smelting process has shown an increased recovery from the same slime, of 10% and even more, as compared with the acid process. In one trial for the Village Main Reef Gold Mining Co., the smelting process gave 11% higher recovery than three acid-treated lots; in another trial 10% more; although the reason for this has not yet been carefully investigated, the evidence is too important to be ignored. The large differences have been attributed to the incomplete mixture of the slime and fine zinc in order to insure that in taking equal parts for the comparative tests there will be equal quantities of gold in each, but if that were the case the acid treatment would sometimes give higher recovery than the smelting, a result, however, that has not once been obtained. The use of lead acetate in large quantities which has become necessary in precipitating the very large volume of dilute solution from the slimes plants, has caused trouble in the acid treatment owing to the danger of introducing lead into the bullion. This trouble disappears with the smelting method. It is also true that the very poor and bulky precipitate from the slimes boxes are costly to treat by the acid process, but readily treated cheaply by the smelting process. Recently, Alfred James stated that the loss from the ordinary clean-up as practiced in the Rand amounts to from 1 to 6% of the total output.

E. H. Johnston and W. A. Coldecott[15] used MnO_2 as an oxidizer in refining precipitates, although niter has a higher theoretical power, yet at the temperature of fusion MnO_2 is the most efficient. It also does not corrode the crucibles so readily. The average charge was: 100 parts slimes, 20 to 35 parts borax glass, 20 to 40 parts MnO_2, 15 to 40 parts of sand. Very high-grade bullion was reduced by this method. P. S. Tavener, however, states that the fineness of the bullion is obtained at the expense of the silver, which the manganese dioxide tends to drive into the slag.

Treatment of Concentrates.—C. M. P. Wright[16] describes the treatment of raw concentrates by percolation as practiced at Choukpazat gold mines in Burma. The concentrates contain from 30 to 40% of sulphides, and from 60 to 70% of coarse sands. The sulphides consist mainly of iron pyrite; but 5% consist of franklinite, galena, chalcopyrite, and a little altaite. The franklinite carries 7 oz. gold, the chalcopyrite and iron pyrite from 0·9 to 2 oz. gold, and the galena practically none, the average value of the concentrates is 1·82 oz. gold

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[15] *Journal of the Chemical and Metallurgical Society of South Africa*, Vol. III., p. 21, July, 1902.

[16] "Cyaniding Concentrates by Percolation." A paper read before the Institution of Mining and Metallurgy, November, 1902.

per ton. The concentrates are treated first with a plain water or alkaline wash, followed by a weak solution wash 0·10 to 0·12% cyanide, and then nine washes of 0·3% cyanide. The contents of the vat are then turned over, and are treated until for two successive days the effluent solution runs 0·26% cyanide, when the treatment is considered complete. Then follow two washes from the strong sump, 0·25% cyanide, and two weak washes, 0·07%, finally one or two wash waters. From 17 to 20 tons of concentrates are treated per month. The time of treatment is 24 days, and the extraction is 84%. The zinc boxes are made up at the commencement of the treatment and left untouched to the end, all solutions passing through the box as they come from the percolating vat. The precipitates that pass a 30-mesh screen carry nearly as much silver as gold, those that remain on a 30-mesh screen carry practically no silver, but much copper. All the zinc in the box becomes copper coated almost immediately on being put to use. The method of treating the precipitates is as follows: Careful cold acid treatment is followed by a thorough washing and drying in enameled basins, and fluxing the slimes below 30-mesh size with 27% borax, 18% sand, 13% soda, 10% niter. The slimes above 30-mesh size are fluxed with 45% borax, 27% sand, 22·5% soda and 16% niter. The slags run about 8 oz. gold per ton and contain no shot. The bullion from the fine slimes is from 560 to 600 fine, and from the coarse slimes from 500 to 540 fine. The detailed cost of treating 89 tons of concentrates was: Pumping, 13·5c.; supervision, 86c.; labor, 11c.; cyanide (5·12 lb.), $1·345; zinc (0·85 lb.), 7c.; reduction, assaying and sundries, 59c. Total, $3·12 per ton. The tailings assayed 0·25 oz. of gold per ton.

Herbert K. Scott,[17] in his paper on "The Gold Fields of Minas Geraes, Brazil," mentions the success obtained in treating concentrates by the cyanide process at various mines in the State of Minas Geraes, Brazil. At the Moro Velho mine, concentrates from strakes consisting of pyrrhotite, pyrite and mispickel are treated by an "oxygen process," which is a modified cyanide process embracing agitation and aëriation. The Passagem mine of the Ouro Preto Gold Mining Co. in the same district, after experimenting with the same class of material with a modified cyanide process with good results, will replace barrel chlorination of the concentrates by cyaniding. At the Faria mines, near Honoria Bicalho, on the Central Railway of Brazil, the pulp from the batteries passes over amalgamated plates, and into two spitzlütten, which separate out the heavy concentrates. The tailings overflow from the spitzlütten pass to two spitzkasten, which separate the sands from the slimes. The sands and the concentrates are treated separately by percolation, and the slimes by the filter press process. Johnson presses are being used. An extraction of 90% is obtained on the sands, and 55% on the slimes.

At the Sao Bento mines, near Santa Barbara, oxidized siliceous ores are crushed by Blake crushers and Gates rolls to pass a screen of 0·15-cm. opening. An extraction of 86·6% is obtained.

Commercial Potassium Cyanide.—According to A. Whitby[18] the difference in composition of the salt sold as "98% potassium cyanide," is considerable.

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[17] A paper read before the American Institute of Mining Engineers, May, 1902.

[18] A paper read before the Chemical and Metallurgical Society of South Africa, Dec. 20, 1902.

Five samples from four distinct sources were analyzed with the following result:—

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Potassium	6·5	30·5	30·8	45·6	....
Sodium	41·0	23·9	23·1	11·4	47·5
Cyanogen	39·4	38·8	37·7	40·4	51·2
Carbonate (CO_3)	7·5	3·0	4·7	0·3	Trace.
Undetermined	5·6	3·8	4·3	2·3	1·3
KCN and NaCN	78·0	85·6	83·5	94·8	98·7

The object of the analyses was to show how the present system of purchasing cyanide left the manufacturers a wide margin for impurities. For instance, No. 1 contained by calculation 13% of sodium carbonate and 5% of other impurities. No. 5 shows what a commercial sodium cyanide ought to be. It is very easy for the manufacturer to comply with existing conditions, and yet supply the consumer with many things he can do without.

No. 3 is heavily charged with alkaline sulphides, but it was used extensively without complaint about its effectiveness; while laboratory tests may show alkaline sulphide to be injurious, in working solution they are rendered harmless by precipitation as zinc sulphide. Alkaline carbonates are beneficial in increasing the alkalinity of the solution. The cyanates act the same way, in becoming eventually transformed into carbonates. Summarizing, the facts are as follows: The mills use a mixture of sodium and potassium cyanide nicely adjusted to 98% KCN, leaving room for extensive adulteration. The effectiveness of the mixed cyanide being accepted, it would be desirable to adopt the use of a sodium cyanide, demanding an efficiency of at least 50% cyanogen. Or if a potassium cyanide is to be used a limit should be set for the sodium cyanide present in order to control the amount of inactive bodies. For the analyses, 10 g. of cyanide were dissolved in 500 c.c. of water, this solution being used for all tests. For the determination of carbonate and cyanogen freshly prepared solution must be used. For carbonates, from 50 to 100 c.c. of the solution are taken, and a few drops of ammonia and a solution of calcium nitrate in slight excess added. The precipitate is filtered rapidly, and washed with hot water containing a little ammonia. The precipitate is ignited to oxide, weighed and calculated to carbonic acid. The cyanogen is determined in the usual way with silver nitrate. For the determination of the alkalies, 50 c.c. were evaporated with a slight excess of hydrochloric acid, taken up again with a few c.c. of concentrated acid, and again evaporated. For more accurate work it would be necessary to remove heavy bases by dissolving the residue in water made slightly alkaline with ammonia, and passing hydrogen sulphide through to remove traces of lead and iron present. Should calcium be present the treatment must be followed by the addition of a little ammonium oxalate, filtered, and the solution again rendered slightly acid by hydrochloric acid, and evaporated to dryness, gently ignited and weighed. For the purpose of these experiments it was found sufficient merely to evaporate to dryness with acid, as even the most impure samples gave mere traces of insoluble residue. The total chloride was then estimated with decinormal silver nitrate solution, and the ratio of potassium to sodium determined by the indirect method.

According to R. W. Moore,[19] of 80 samples of commercial potassium cyanide imported into the United States, only 24 contained no sodium cyanide, while 50 contained from 10 to 54% of sodium cyanide, averaging 22%, it being evident that much of the cyanide used in the process is a mixture of sodium and potassium cyanide. Under the Dingley tariff, potassium cyanide is admitted under a duty of 12·5%, which is one-half that on chemical salts. The question came up for the Board of General Appraisers as to what duty is to be paid on a mixture of sodium and potassium cyanides, and the decision reached was that the mixture should be admitted as potassium cyanide.

Treatment of Cupriferous Gold Ores.—Louis Janin, Jr.,[20] discusses the treatment of cupriferous gold ores by the cyanide process. Three methods are advocated which have in view the entire or partial elimination of the copper and the consequent protection of the potassium cyanide. They are:—

1. Leaching by sulphuric acid preliminary to cyanide treatment.
2. Scrymgeour's method of dissolving copper minerals in a solution of potassium cuprocyanide, containing no free potassium cyanide.
3. Bertram Hunt's method of leaching with an ammoniacal cyanide solution.

While many copper minerals are soluble in sulphuric acid, this method has serious drawbacks in that it may have a very high consumption of acid if lime and magnesian carbonates are present in the ore. There is also a tendency for the ore to cement and pack in the tanks after the acid treatment. A neutralizing agent such as a caustic soda solution must follow the acid treatment, otherwise the consumption of cyanide will be more even than when treating the original ore before acid treatment. Burnt lime, as ordinarily employed, will not penetrate the ore mass to neutralize the acid. The acid process is then a three-stage process. 1. Leaching the ore with dilute sulphuric acid. 2. Neutralizing the acid remaining with caustic soda. 3. Treatment with cyanide solution.

Scrymgeour's method depends upon the property of potassium cuprocyanide to dissolve copper in certain minerals. The cuprocyanide is obtained by heating the ore with dilute cyanide solution. When the cuprocyanide solution has dissolved the maximum of copper in the form of sub-cyanide the excess of copper is precipitated electrolytically. Then the ore is ready for the ordinary treatment with dilute cyanide solution. The method is a two-stage one employing separate electrolytic precipitation vats, and separate storage tanks.[21]

Bertram Hunt's method is very simple, and essentially a one-stage process. It depends upon the protective influence of ammonia as well as its solvent action for copper, the ammonia and cyanide being employed in the same solution. It is known that the double salt of copper and potassium cyanide has a solvent action on gold. It is not so well known that the cyanides of gold, silver and copper, and other base metals are soluble in ammonia. When a solution of cupric oxide is dissolved in ammonia containing less cyanide than will combine with the copper, then an alkali cupricyanide is formed which exerts a solvent action on the gold equal to the cyanide itself.

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[19] *Journal of the Society of Chemical Industry*, Vol. 21, p. 892.

[20] *Engineering and Mining Journal*, p. 816, Dec. 20, 1902.

[21] See also *Engineering and Mining Journal*, Aug. 17, 1901, and THE MINERAL INDUSTRY, Vol. X., pp. 851 and 852.

In treating ores by the Hunt process the strength of solution in ammonia is varied according to the copper content and the condition in which the copper is found. Comstock tailings containing cupric oxide, originally introduced into the ore as copper sulphate in the amalgamation treatment, use as high as 8 lb. of ammonia per ton.

The strength of the solution in cyanide was 1 lb. per ton. The consumption of cyanide was 0·6 lb. per ton. The tailings treated assayed $1·45 in gold and 3·05 oz. in silver, and the residues from the treatment assayed 25c. in gold and 1 oz. in silver. On other material, perfect extraction was attained on the gold and 85·09% on the silver. The high extraction is probably due to the energetic oxidizing power of the cupric oxide dissolved in ammonia. The solution employed on the Comstock tailings is higher than would be used ordinarily, owing to the solubility of the copper in this case, which would rarely occur in an ore where the copper was native.

At the cyanide plant of the Brooklyn Mining Co. at Dale, San Bernardino County, Cal., a complex ore is treated containing lead carbonate, copper bearing pyrite, and copper in various conditions notably as silicate. This last named mineral being soluble in cyanide, caused a loss of from 7 to 8 lb. of cyanide per ton by the ordinary treatment. An addition of 6 lb. of ammonium chloride per ton to a 0·15% cyanide solution brought the consumption down to 1 lb. cyanide per ton. From 7 to 8 lb. of burnt lime are added per ton of ore, and the ammonium chloride is added directly to the cyanide solution in the stock tanks. The solution was allowed to remain in contact with the ore for 12 hours, then draining and washing was continued for about 6 days. Any salt of ammonia may be used instead of aqua ammonia, provided lime or some alkali is added to the ore. If the ore contains ferrous salts these should be removed by adding the ammonia solution and an oxidizing agent previous to adding cyanide.

At Dale, ordinary zinc box precipitation is used, which presents no difficulties, although the product is low grade, $3,500 to $7,000 in value per ton, if acid were used in the clean-up the richness of the product could be doubled. On the whole, however, electrolytic precipitation is preferable. In Hunt's process, the use of peroxidized lead anodes and aluminum cathodes is advisable. The lead anodes are peroxidized in a solution of potassium permanganate before use. A current density of 3 amperes per sq. ft. is employed. Lead anodes alone gradually become peroxidized, and when the current density rises above 1 ampere per sq. ft.—reaction occurs with the formation of basic lead carbonates and lead cyanides. The gold, silver and copper are not precipitated as an adherent coating on the aluminum, but fall as a sludge.

Hunt's ammonia cyanide process has the following advantages:—

1. It makes amenable to the cyanide process ores not before treated.
2. In cases where the consumption of cyanide is high it may be reduced by employing the process.
3. It is a simple process, compared to processes which aim to accomplish the same results, and hence is more economical.
4. The cost of the reagents employed is not high compared to the cost of

cyanide, part of the cost in some cases may be made up by the value of the copper recovered.

5. Unlike the acid treatment, calcareous ores are amenable to the process.

6. There is no limitation to the copper content of the ores which can be treated economically under local conditions, though with high-grade copper ore a plant would have to be installed for ammonia recovery.

It presents a good field for oxidized copper-gold tailings or ores, and possibly may be extended to pyritic ores.

Important Patents Issued during the Year.—Several patents have been granted during the year, of which some may in time have an important bearing on the cyanide process.

A patent has been issued to Ed. D. Kendall, of Brooklyn, N. Y., for the electrolytic recovery of precious metals dissolved in cyanide solutions. The gold-bearing cyanide solution is filtered through a mass of hard fragmental carbon pocketed around the porous cup of an electrolytic cell, and connected as the cathode of a 15-volt current. A carbon plate as anode is placed in the porous cup and immersed in a solution of caustic alkali. The cyanogen set free collects in the caustic alkali solution of the anode, and the precious metals are deposited in a pulverulent form throughout the mass of the cathode. After the deposition of the gold, the two compartments are emptied of their solution, a silvered carbon plate rubbed with graphite replaces the former carbon anode plate, the current is reversed and a strong solution of potassium cyanide is permitted to flow through the cell, successively through the anode and cathode compartments in the order named. The gold is redissolved from the former cathode and deposited in reguline form on the silvered carbon plate now forming the cathode. The idea was first suggested by Dr. Pfleger in 1895, and further developed, and its advantage pointed out by Prof. S. B. Christy.

United States Patent No. 687,258, for the recovery of cyanide from waste and foul solutions, has been issued to William Orr, of Salt Lake City, Utah, and controlled by the Gold & Silver Extraction Co. of America. The quantity of potassium cyanide and potassium-zinc cyanide is determined in the waste solution; the waste solutions are then run into a suitable tank, and the proper quantity of fused zinc chloride added to precipitate all the cyanogen as zinc cyanide. The solution is then separated from the precipitate by decantation or filtering, after which a solution of alkali hydrate is added to dissolve the zinc cyanide. The correct quantity of potassium or sodium sulphide is then added to precipitate the zinc, which is separated, the solution then being again ready for use.

Miscellaneous.—According to Wm. J. Sharwood[22] selenium is found in the precipitates from the cyanide process and may come from the presence of the silver and copper selenides in the ores, both of which are slowly soluble in potassium cyanide, as potassium seleno-cyanide, KCNSe, from which zinc precipitates selenium. If, however, the selenium is found in the precipitate after treatment with sulphuric acid, the selenium probably came from the acid, being precipitated from it by the zinc.

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[22] *Engineering and Mining Journal*, p. 683, Nov. 22, 1902.

According to T. L. Carter,[23] cyanide solutions carrying gold which have become useless and foul from long standing, may be treated to recover the gold as follows: Sufficient zinc chloride is added to precipitate the gold as a fine gray powder, and the whole allowed to filter through sand to catch the gold. The sand can then be used in the fluxing of precipitates.

A. F. Crosse[24] describes two methods for the assay of cyanide solution as follows:—

1. Pour 500 c.c. of solution into an evaporated dish, put under a hood with a good draft, add nitric acid until the solution shows an acid reaction, boil for 15 minutes, then add 0·5 g. of silver dissolved in nitric acid, filter and fuse the filter paper with the precipitate, as usual with litharge and flux, and then cupel the lead button.

2. Take 500 or 1,000 c.c. of solution, add an excess of copper sulphate, acidify with sulphuric acid, filter and fuse the precipitate with litharge and flux, and cupel the lead button.

Cyanide Poisoning.—The Victorian Mines Department[25] has issued instructions printed on linen, for posting in cyanide works, which give directions how to proceed in cases of cyanide poisoning in the absence of medical assistance. The credit for the work is due to Dr. Martin, of Melbourne University, and Mr. H. Jenkins, the Government Metallurgist. In a case of poisoning, everything depends on prompt action, for the chances of recovery are very small after the lapse of a very few minutes if a fatal dose has been taken. The first step is to neutralize the rapid poison by the antidote, and then to empty and wash out the stomach as soon and completely as possible. The antidote consists of two solutions, sealed up in bottles, and a sealed powder. One bottle contains 7·5 g. of ferrous sulphate dissolved in 30 c.c. of water; the other 1·5 g. caustic soda dissolved in 300 c.c. of water. The powder consists of 2 g. magnesia put up in a sealed tube. There should also be a gag for the purpose of opening the clenched mouth of the unconscious person, and a stomach tube that can be passed through the gag into the patient's stomach. If the patient is still conscious he must drink the antidote at once; if not a small gag is inserted in the patient's mouth to prevent the stomach tube from being bitten off, and the tube passed down his throat into the stomach. The antidote is then poured down the tube and is followed by some water. If the patient has been able to swallow the antidote the stomach tube is inserted at this time, the patient being placed in a reclining position, and half a pint of water poured down the tube. Before all this descends into the stomach the funnel is lowered to get it to act as a siphon, and to empty the stomach as completely as possible. This is repeated several times in order to wash out the stomach. If the tube is not at hand every endeavor must be made to induce vomiting after the administration of the antidote. When the stomach has been emptied and washed steps must be taken to bring about artificial respiration if the patient is in a state of collapse. This is done as in the cases of partial drowning or suffocation.

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[23] *Engineering and Mining Journal*, p. 211, Feb. 8, 1902.

[24] *Journal of the Chemical and Metallurgical Society of South Africa*, May, 1902.

[25] *Australian Mining Standard*, May 29, 1902.

Cyanide Patent Decisions.—In an action in Queensland, Australia, the chief justice of that State, upheld the validity of the MacArthur-Forrest cyanide patents. The patents have also been successfully maintained in New Zealand and Victoria. In West Australia and New South Wales the courts have held that there was either no novelty or that the specifications were too broad. In the United States, the matter has never been really brought to trial. In the suit against the Mercur Co., of Utah, the latter compromised by agreeing to pay a small royalty. In Mexico and other Spanish-American countries the patents hold good. In South Africa, under the Republic, the patents were declared invalid, but as the Transvaal is now a British colony under the patent laws of the mother country, the patent which is good in England will probably be declared good in the Transvaal, and will raise interesting questions of royalty to be paid. The patents have at most but a few years to live in the different countries, and it is questionable whether in view of the broad lines of the process renewals will be granted.

By a decision of the United States Circuit Court of Appeals, and held as final, zinc dust is admitted free according to paragraph 482, Act of 1897.

CYANIDING SULPHO-TELLURIDE ORES.

BY PHILIP ARGALL.

THE successful use of bromo-cyanide in the treatment of the unroasted sulpho-telluride ores of Western Australia has attracted quite a little attention in the United States, more particularly, perhaps, from those having mining interests in Cripple Creek, Colo. The very fact that sulpho-telluride ores can be treated without roasting, appeals at once to the small producer, who immediately sees a method for reducing his ore to bullion without the use of the usual cumbersome and often expensive roasting plant.

The method of working the Western Australian ores in the raw state, by means of fine grinding and subsequent treatment with bromo-cyanide, is known as the "Diehl" process (see preceding pages of this volume), apparently now established as an economic and commercial success in the treatment of Kalgoorlie ores. I herewith propose to compare this process of cyaniding with the roasting method as heretofore practiced on the ores of Cripple Creek.

The Kalgoorlie ores contain a large quantity of calcium and iron carbonates, together with a small quantity of magnesia. Estimating the latter component as $CaCO_3$, Mr. H. Knutsen gives the following approximate analysis of three samples: Insoluble, 57·98%, 59·61%, and 76·91%; $FeCO_3$, 19·29%, 13·94%, and 12·11%, and $CaCO_3$, 22·55%, 26·73%, and 9·18%.

The sulphur appears to have been neglected in the analysis. Mr. Alfred James, however, gives as a typical analysis of these ores: SiO_2 about 50%, Fe 10%, Al_2O_3 5 to 20% or more, MgO 1 to 5%, S 3 to 7%, Cu 0·1 to 0·3%, Pb trace, Zn 0·02%. As trace, Sb 0·02%, Te 0·03 to 0·1%, and $CaCO_3$ 6 to 17%. Ores of this character after roasting when the solutions reach them form a lime-iron cement which sets hard in the tanks and greatly interferes with, and often prevents, the percolation of the solutions through the charges. For this reason early attempts at leaching the roasted ores at Kalgoorlie were far from successful; furthermore, these Australian ores, while containing an appreciable quantity of free gold in a comparatively granular condition, still require to be ground very fine in order to obtain a high rate of extraction; the fine grinding produced troubles in the subsequent handling of the slime, and led to the early introduction of filter presses, which soon became standard in the cyanide practice of Western Australia.

One of the most successful combination processes for reducing the sulphotellurides ores of Kalgoorlie is briefly outlined as follows: Crushing dry to about 30-mesh size, roasting in mechanical furnaces, fine grinding and pan amalgamation in dilute cyanide solutions, separating the sands from the slimes, treating the latter in the filter presses and the former in tanks, or, as an alternative, reducing the ore under treatment to such a fine state of division that it is all successfully treated in the filter presses, thereby abolishing the leaching in the tanks. According to Mr. Alfred James, the Kalgoorlie sulphide ores yield, without roasting, from 50 to 70% extraction when treated by agitation with ordinary cyanide solutions. My experiments on Cripple Creek telluride ore gave almost identical results; in fact the lowest extraction on 30-mesh size raw ore that I have observed is 54%. It is perhaps permissible to state that fuel is quite expensive in Kalgoorlie, and water may be said to command famine prices, from which it is evident that roasting is at a disadvantage, costing, it is said, on those low tenor sulphur ores, from $1 to $3 per ton, while power costs from 70 to 90c. per horse power per day. Under these conditions, a wet process for working the ore in the raw state has at least a fair show.

The use of the halogen cyanides as accelerators in the cyanide process was discovered and patented by Dr. Gaze in 1892, and in February, 1893, a cyanide mill near Reefton, N. Z., used chloro-cyanide in the solutions; but owing to difficulties in precipitation, the process was soon abandoned. In 1894 Messrs. Sulman & Teed, of London, patented a bromo-cyanide process, and to these gentlemen is due the credit of applying bromo-cyanide to the direct treatment of telluride ore. It is well known that cyanogen in the semi-molecular or nascent state has a powerful action on gold, that bromo-cyanide itself has but little if any solvent power on gold, but when added to a cyanide solution, it not only liberates a molecule of cyanogen from the latter, but also contributes its own cyanogen, thus: $KCN+BrCN=KBr+2CN$.

Bromo-cyanide must be considered as a cyanogen liberator, and it is no doubt through the intense chemical activity of the nascent cyanogen thus liberated that the tellurides are attacked, at least to the extent of setting free part of their contained gold. Briefly, the combination bromo-cyanide process evolved by Dr. Diehl is as follows:—

(1) Stamping the raw ore with or without amalgamation, as may be found expedient.

(2) Separating the heavy minerals from the gangue by concentration.

(3) Roasting the concentrates and returning the roasted tellurides to the batteries for amalgamation, or selling the concentrates to the smelters.

(4) Sliming all the tailings from the concentrators so the material will pass a 200-mesh screen.

(5) Agitating this fine pulp for at least 24 hours in cyanide solutions, to which a solution of bromo-cyanogen is added from time to time.

(6) Filter pressing the agitated slimes.

The Diehl process is fully described by Mr. H. Knutsen[1] in a very able and interesting paper from which the following comparative data of costs are taken. The process is in use at one property alongside a roasting plant, both treating the same class of ores; in the roasting plant two-thirds of the ore is treated in filter presses and one-third in leaching tanks, while in the Diehl all the ore must be filter pressed.

In the roasting process, 3,411 tons were treated, which yielded 5,287 oz. of bullion and no concentrates, while with the Diehl process 5,888 tons were treated, yielding 5,201 oz. of bullion and leaving 3,819·47 oz. in the concentrates. If the concentrates represent but 0·5% of the ore, as reported, then practically 42% of the value of the crude ore is locked up in about 30 tons of concentrates. These latter are treated at the smelting works. A summary of expenditure per ton of ore treated during August, 1901, is given in the subjoined table.

	Roasting Process.		Diehl Process.	
	s.	d.	s.	d.
Superintendence	1	5·051	1	0·013
General stores and charges	1	4·306	1	7·466
Electric light	1	4·561	1	2·514
Assay, retorting and smelting	1	9·036	1	6·075
Fuel	9	2·548	3	5·746
Water	3	5·046	3	2·347
Compressed air	1	4·254	2	0·209
Filling and emptying vats	1	2·564	...	.....
Labor, general	1	1·978	1	10·618
Engine driving and firing	0	11·479	0	7·662
General repairs	3	3·058	2	3·224
Screens, shoes and dies	...	.....	0	0·340
Elevating	...	.....	0	3·481
Cyanogen bromide	...	.....	4	0·046
Potassium cyanide	8	0·277	2	9·596
Zinc	3	2·418	2	2·227
Filling and emptying presses	1	8·253	2	6·171
Filter cloth	0	4·736	0	3·098
Chemicals	0	1·049	0	1·001
Firing roaster	1	2·958	...	.....
Agitation	1	2·723	...	.....
Royalty	...	.....	1	9·196
Totals	37	4·295	32	9·030

Taking the difference in fuel cost between the two processes, and adding the expense of firing the roaster, the approximate cost of roasting is found to be 6s. 11·7600d. The cost of bromo-cyanide is 4s. per ton of ore treated; to this, the royalty for the use of the process should be added, and a total of 5s. 9·24d. is obtained as an offset to the roasting, which shows 1s. 2·5d. in favor of the Diehl process. It was claimed that the same quality of ore went to both plants, but the Diehl gave a return amounting to 3s. 8d. per ton more than that from the roasting process. This comparison appears to me to be somewhat favorable to the Diehl process, if, indeed, a strict comparison of the costs of the rival processes was intended: for example, the capacity of the roasting plant appears to be about 60% of that of the Diehl, yet the cost for supervision, engine driving, etc., is about 50% greater for the smaller plant. It is in the final products of the plants, however, that the most unfair comparison creeps in; the roasting process produces all its yield in bullion, while the Diehl leaves about 42% of the bullion content of the ore in the form of high-grade concentrates, which can neither be handled nor roasted without loss of metal. There is also an additional smelting

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[1] *Proceedings of the Institution of Mining and Metallurgy*, 1902, London; see, also, THE MINERAL INDUSTRY, Vols IX. and X.

charge for extracting the values from the concentrates that is apparently not included in the foregoing expense table. Furthermore the roasting plant is not credited with flue dust or sweeps, and one cannot believe that the roasting of ores of this character would be attempted without the usual equipment of dust flues and settling chambers.

In a newer Diehl plant the concentrates, amounting to about 5% of the ore treated, are roasted and returned to the batteries for amalgamation, the pulp from the raw as well as from the roasted ores mingling together are treated in agitators for 24 hours with cyanide and bromo-cyanogen solutions. The final tailings are said to "average from 1 to 2 dwt. gold per ton, no matter whether the original ore contained 1 oz. or 4 oz. gold per ton." The consumption of chemicals is given at about 3 lb. KCN and 1·25 lb. BrCN per ton of ore. The working cost is summarized as follows: Milling, 4s. 0·59d.; concentration, 1s. 7·19d.; treatment, concentrates, 1s. 4·08d.; extraction, 17s. 1·02d.; total, 24s. 0·88d.

The bromo salts alone amount to 5s. per ton of ore treated. It will be noticed that bromo-cyanide is not depended on to break up the gold tellurides completely, hence these minerals are first concentrated out as far as is possible, and afterward roasted to set the gold free for amalgamation. In the next place, a tailing approaching $2 in value can scarcely be considered a satisfactory termination of such an elaboration of processes. Yet it is extremely interesting to know that such good work can be accomplished by a wet process, or at least one that eliminates from 80% to 95% of the roasting usually found necessary in treating sulpho-telluride ores. Such a process will have a great future in places where roasting is expensive, either through lack of fuel, or the high sulphur content of the ore; provided that in either case, the bromo-cyanide will extract the values.

The sulpho-telluride ores of Cripple Creek are virtually altered granites, phonolites, and andesites, containing slightly more silica and considerably more iron and sulphur than the original rocks, but on the whole practically of the same chemical composition. Tellurium and fluorite are little more than traces in the ores received at a custom works which contain but little carbonate, and when roasted, exhibit no tendency to harden or set in the tanks unless an excess of lime has been added. Ordinarily a good extraction can be obtained on roasted ores crushed no finer than 30-mesh size (0·017-in. opening). The sulphur content of the ores varies from 1% to 7%, and may be said to average approximately 3%. These ores are quite easily roasted, and the entire process of roasting and cooling would vary in cost from 30c. to 50c. per ton, depending on the sulphur content and on the arrangement of the roasting plant. About four years ago, I made a complete estimate of the cost of cyaniding Cripple Creek ores at a proposed new works to be erected at Cañon City. The works were designed to treat 500 tons of ore per day, to be later enlarged to 750, or even 1,000 tons, provided the ore market justified the increase. I had intended to use the roasting process with some important modifications and improvements which were developed during my experience at the works of the Metallic Extraction Co., and tested to finality on a working scale at that plant. The estimate of the actual cost of milling the ore, extracting the values, and marketing the bullion on a basis of treating 500 tons per day, worked out to $1·75 per ton of ore. The proposed new method of treatment not only substantially reduced the working cost, but gave also an increased extraction over that attained at the old plant.

On the strength of this discovery and on the improvements that could be made in a new plant, a site for the proposed works was selected near Cañon City, and the Florence & Cripple Creek Railroad extended a branch into that city to accommodate the plant; however, before the new road was completed both the Metallic Extraction Co.'s works and the railroads were under option for sale, and were subsequently sold, which caused the scheme for the cheap milling of Cripple Creek ores to fall through, and with it, for a time at least, the prospect of treating $5 ores at a profit to the miner.

It is true that those results have not been attained in practical working on a commercial scale, but, nevertheless, there is no question as to their accuracy or of the fact that Cripple Creek ores can be roasted and cyanided in a modern up-to-date plant of 500 tons daily capacity at a cost of $1·75 per ton. But one need not enter into the question of the total cost of cyaniding Cripple Creek ores in order to compare the Diehl with the roasting process now in use. I believe the following will suffice:—

Diehl Process.	Cost.		Roasting Process.	Cost.	
Bromo-cyanogen and royalty	$1·00		Roasting	$0·50	
Fine grinding	·50		Tank work	0·25	
Filter press work and agitation	1·25		Total	——	$0·75
Total	——	$2·75	Difference in favor of the roasting process		$2·00

Assuming the cyanide consumption to be the same in each case, it is evident that the cost of bromo-cyanide, plus grinding from 30-mesh size to 200-mesh size, plus filter press work, plus concentration, would have to aggregate less than $1 per ton before the Diehl process could compete successfully with the roasting process in the treatment of Cripple Creek sulpho-telluride ores. Therefore, the latter process must prevail at Cripple Creek, as, in my opinion, it will ultimately prevail at Kalgoorlie.

THE TREATMENT OF SULPHO-TELLURIDE ORES AT KALGOORLIE.[1]

BY W. A. PRICHARD AND H. C. HOOVER.

Introductory.—The Kalgoorlie field, the mines of which practically are limited to one square mile, has during the eight years since its discovery, to the end of 1902, produced gold to the value of £14,873,982. The feverish requirements of the London stock markets, into whose hands fell the development of these fabulous deposits of refractory ore, coupled with the universal inexperience in dealing with ores of this class, resulted in a number of serious blunders in metallurgical treatment.[2] There has been expended in metallurgical works on this square mile over $8,000,000, much of which has been devoted to the acquirement of experience. Some companies are now operating their second or third plants, and, on the other

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[1] *Engineering and Mining Journal*, Aug. 1, 1903.

[2] Admirable detailed discussion of the practice on the Great Boulder Proprietary, by Mr. G. M. Roberts, appeared in the *Monthly Report* of the Kalgoorlie Chamber of Mines for July, and of the Diehl Process by Dr. Knutzen in the *Proceedings of the Institution of Mining and Metallurgy* for 1902.

hand, more conservative companies continue to operate ill-adapted machinery at a high working cost or are only treating selected portions of their ore, with the use, in many cases, of unsuitable machinery such as yields them a low extraction. Some companies continue to hand-pick ores—incidentally to pick the eyes out of the mine—and ship to smelters, while awaiting the final demonstration of the best treatment process. Although obtained at the expense of much costly experimentation and of much high priced advice, both good and bad, the treatment practice in the hands of the progressive companies to-day compares most favorably with that of any other mining center working refractory ores.

The Kalgoorlie field possesses many disadvantages, aside from its refractory ore, in the total absence of natural fresh water, in being limited as to supply of fuel, in being saddled with high freights, high import duties, high cost of living, and consequently high wages, all of which have resulted in a very high state of efficiency and ingenuity in the conservation of water, power, labor and material.

The ores are a siliceous impregnation of the country rock, itself a diabase, and therefore, aside from the state of mineralization, presents a great difficulty in the large percentage of slimes produced—both from oxidized and unoxidized material. In the sulphide ores the gold occurs, in a minor proportion, free, but in richer ores it is intimately associated with tellurides and iron sulphides. The ore also contains considerable amounts (from 4 to 8%) of iron carbonate.

In some mines the tellurides occur in more or less definite shoots, so that the most refractory ores can be separately treated, and in all mines the refractory character increases with the values, *i.e.*, proportion of tellurides. The percentage of free gold varies from 10% in the Oroya Brownhill to 30% in the Ivanhoe, and the average contents of the ores treated varies from 15 dwt. in the Lake View to 2 oz. of gold in the Oroya Brownhill. The percentage of concentrates varies from 4 to 10%. The percentage of slimes in the sulphide ores varies with the mine, and of course with the character of treatment, but the inherent slimes, crushing wet through say 20-mesh screen, would probably average 50% in the eastern mines and somewhat less to the west, the Ivanhoe showing a minimum.

The ores near the surface were oxidized, and in these ores the treatment, except for the heavy proportion of slimes, was a matter of no especial difficulty by ordinary milling, amalgamation and cyanide. Most of the oxidized ores have now been exhausted. The oxidation extended as far down as 200 ft.

The distinctive feature of Kalgoorlie practice is that all ores are now reduced to a slime for final treatment, but this has been developed in two general and distinctly different lines, with excellent results in both cases. First: Wet milling of the ores, concentration and roasting of concentrates and treatment of tailings by grinding to slimes the entire product and treating with cyanide or bromo-cyanogen, and, second, by dry crushing, roasting the entire product, grinding to slimes and treating roasted residues by cyanide. Other methods have been tried, but not with commercial success. The two successful processes have been applied with wide variations as to detail, owing to the unsettled state of opinion existing at the time of constructing the nuclei of the present plants.

The wet milling process is usually referred to as the "Diehl Process," and it is in use at the Oroya Brownhill, Lake View Consols and Hannan's Star mines.

The other form of treatment, which usually goes by the name of the "Roasting Process," is in use on the Great Boulder Proprietary, Great Boulder Perseverance, Associated Gold mines, Kalgurli, South Kalgurli, and Great Boulder Main Reef. The Ivanhoe mine, whose output ranks fourth on the field, is not yet completely equipped for treating the whole of its ore, nor for securing the most efficient extraction. The working cost is the lowest on the field, but the work is incomplete. The Golden Horseshoe mine, whose output ranks second, is in the same position but with the highest cost. The line of development on both these mines is, however, toward wet crushing by stamps, amalgamation of free gold, concentration and incomplete treatment of tailings being secured by ordinary cyanide and filter press treatment. In both these mines, the richest telluride ores are either mined separately or sorted, and then treated either by smelting or in a small roasting plant. Neither mine has yet solved the problem, *i.e.*, efficient extraction.

Diehl Process.—The essential metallurgical features of this process in its best development are given on pp. 335 and 336 of this volume.

In the Lake View mill, stamps of 1,100 lb. are used, and, as prior to concentration coarse crushing is advantageous, an average duty of 5 tons (of 2,240 lb.) is obtained. Of the product 38% (slimes) will pass 150-mesh screen. If the fineness be increased to 55% slime, the duty is lowered to 3·5 tons, but sliming is secured more economically in the tube mills and, therefore, furnishes a second reason why the high mill duty is desirable. After concentration, the sands are separated in spitzkasten, and run into the tube mills filled with flint cobbles. From these mills, all tailings which will pass the outlet spitzkasten join the slimes from the entrance spitzkasten, and the sands return again to the tube mill. The slimes pass to closed agitators, where bromo-cyanogen is introduced, the period of agitation being about 24 hours. The slimes are then introduced either by pumps or montejus to the filter presses, for recovery of solutions, and the gold precipitated therefrom in the usual way.

The concentrates are amalgamated and then roasted in Edwards or Merton furnaces, the residues being treated by plain cyanide. For roasting concentrates but little fuel is needed, the sulphides furnishing much of the required heat. It has been found in treating concentrates that a much larger tonnage can be roasted when a considerable portion of coarse sand is included with the concentrates. The inclusion of coarse sand with the concentrates has the advantage of throwing more gold, sulphides and tellurides into the concentrates, thereby decreasing the consumption of cyanide and bromo-cyanogen in the slimes treatment. A close concentration, though unnecessary, is very desirable in the bromo-cyanogen process, and it is found, as stated above, that in practice the amount of cyanide and bromo cyanide required to recover the gold from the tailings increases with the amount of concentrates remaining in them when the slimes are treated. The difficulty is both mechanical and chemical. There is still a further advantage where royalty is paid on gold recovered by bromo-cyanogen, the cost for royalty is reduced by throwing more gold into concentrates. At the Lake View Consols over 50% of gold is obtained from the concentrates.

In the case of the Oroya Brownhill, the concentrates were returned to the battery after roasting, being amalgamated prior to concentration, and considerable economy will result in introducing the Lake View method of separate treatment. The average assay of tailings from Oroya North Block and Brownhill ore on the Oroya Brownhill for five months is 3·1 dwt. per ton, the average yield of the ore being 37·1 dwt. per ton fine gold, showing an actual extraction of 92·3% per ton. The average on the Lake View Consols for the same period is 1 dwt. 14 grains, the yield being 14 dwt. 12 grains on an extraction of 90%, and in this case the irreducible minimum in tailings somewhat affects the extraction.

The Hannan's Star is an adapted mill, crushing dry in the first instance is not the best development of the process, yet the extraction averages about 91 to 92%.

Roasting Process.—The essential features of this process are: (1) Breaking in gyratory breakers. (2) Dry crushing in Griffin or Krupp ball mills. (3) Roasting in Edwards' or Merton's, or other furnaces, to oxidize sulphides and tellurides. (4) Amalgamation and sliming in pans. (5) Separation of sands and regrinding in pans. (6) Agitation of slimes with cyanide. (7) Recovery of solution from slimes by filter pressing. (8) Precipitation of gold by zinc shavings.

In dry grindings, with either Krupp ball mills or with Griffin mills, fine rock-breaking is essential, and it is usually conducted in two stages. For rock breaking, gyratory crushers are universally favored in all processes, as the hardness and unfriability of the Kalgoorlie ore makes it unsuitable for ordinary jaw crushers. In the grinding stage Krupp ball mills, Nos. 4, 5, or 8, or Griffin mills, are used. The No. 5 ball mill most commonly used, has a capacity of about 25 tons, when 66% (slimes) will pass a 150 (linear) mesh screen. One Griffin mill has a capacity of about 30 tons per day, of which from 70 to 80% will pass a 150-mesh screen. All dry mills work most successfully on ores containing under 3% of moisture, and should much more exist, drying is necessary.

In roasting, Edwards, Merton or Holthoff-Wethey furnaces are used, with wood fuel, and in one case a combination of wood and coal-generated gas is used, the introduction of gas largely increasing the capacity of the furnace. The hot ore is then introduced into a mixer, where it is puddled with return solutions from the spitzkasten. The pulp then passes to the amalgamating pans or mills.

Of the gold in roasted ores, 50% is recoverable by amalgamation; about the same proportion of gold as is recovered from the concentrates in the Diehl process.

The percentage of slimes is much greater in the product from dry crushers than by wet crushing, hence in the roasting process much of the sliming has been done prior to the second grinding operation, which in the roasting process takes place in the Wheeler type of pans. After grinding and amalgamating, the remaining sands are separated by spitzkasten and clarified by spitzlutten. The sands are returned to the same or other pans for regrinding, and excess water is returned to the mixers. The slimes are led to agitation vats, where the cyanide solutions are introduced and agitation is continued for about 24 hours. The mechanical part of agitation is identical in both processes, as is filter pressing, and is also the subsequent treatment of solutions, but in the roasting process ordinary cyanide is used. The Great Boulder Proprietary shows an extraction of about 90% on ores averaging between 27 and 30 dwt. fine gold. The Great Boulder Perseverance shows an extraction of 88 or 89% on ores of similar grade.

Comparative Results.—The extraction secured by the two processes on ore of the same grade shows a difference of from 1 to 3%, generally in favor of the Diehl method. However, much depends upon the efficiency of the individual plant. In initial expenditure, the advantage lies on the side of the Diehl process, largely owing to the more limited outlay on roasting and appliances and less cost of erection. In working expenditure the advantages on the side of the Diehl process are: (1) Preliminary breaking in one stage. (2) Cheaper crushing wet. (3) By concentration the product necessary to roast is less than 5% of the total ore against 100% in the roasting process. (4) Less cost of maintenance and wear and tear. The advantages of the roasting process are: (1) Less cost in chemicals. (2) No royalties. The other operations fairly well compensate each other, and it seems that the Diehl process should have, under equally efficient management, about 2s. 6d. or 60c. per ton the advantage in costs.

Working Costs.—Working costs are difficult of comparison even on so limited a field as Kalgoorlie. The factors bearing on comparative costs are not wholly the efficiency of management or the process in use. In the first instance, there is a great difference of volume in ore treated at different plants, and consequently an increased cost per ton in smaller mills from fixed charges, and decreased cost in larger mills by the range of supervision of each employé. Moreover, the hardness of the ore varies greatly, not only in different mines, but in the same mine; in general, it increases toward the southern end of the field. The consumption of chemicals varies with the richness of the ore. Besides these factors, the cost of water varies considerably; some mines obtain a portion from their own property, others are compelled to purchase all that they use.

The Oroya Brownhill and Lake View Consols mines, using the Diehl process, represent two extremes of conditions. Oroya Brownhill treats an average of about 4,000 tons per month of ore averaging over 2 oz. per ton, being one of the smaller mines as regard tonnage, and the richest in character of ore treated. The Lake View treats about 7,500 tons per month of an average value of about 14 dwt., this being the lowest grade sulphide ore treated. The costs include all charges except general management.

	Oroya Brownhill.	Lake View Consols.
	Shillings.	Shillings.
Milling	3·38	3·61
Concentrating	1·81	2·17
Treatment of concentrates	15·81	10·45
Total	21·00	16·23

For the month of May the Oroya Brownhill costs were further reduced by 1s. 6d. or 36c. per ton, to 19s. 6d. or $4·68.

Of mines using the roasting process, the working costs of the Great Boulder Proprietary, treating about 9,400 tons per month, and the Great Boulder Perseverance, treating between 11,000 and 12,000 tons per month, not including general management, but including superintendence of the plant, as given in their annual report for 1902, are 23s., or $5·52, for the former, and 22s., or $5·50, for the latter. Some reductions have been effected since that date, and the costs of the latter mine are given at 19s. 6d. or $4·68 for May.

GRAPHITE.

BY JOSEPH STRUTHERS.

THE production of crystalline graphite in the United States during 1902 amounted to 4,176,824 lb., valued at $153,147, as compared with 3,967,612 lb., valued at $135,914 in 1901. As in previous years, the greater part of the output was obtained from the mines in the Ticonderoga district, New York, although the mines at Chester Springs, Chester County, Pa., and at Stockdale, Clay County, Ala., contributed largely to the production, and small quantities were derived from the mines near Dillon, Mont., and in Remington County, South Dakota. The production of amorphous graphite in the United States during 1902 was 4,739 short tons, valued at $55,964, as compared with 809 short tons, valued at $31,800, in 1901. Under this head is included the so-called graphitic anthracite of Rhode Island and the Baraga graphite of Michigan, the latter in reality being a carbonaceous schist. The greater part of the output was derived from Wisconsin, followed by Rhode Island, Michigan, South Dakota, New Mexico and Wyoming, in the order named. In addition to the production stated above, there has been considerable activity in developing graphite mines in Wyoming and North Carolina, and about 1,000 tons of graphite ore have been mined and are awaiting treatment. The total quantity of artificial graphite manufactured in the United States during 1902 was 2,358,828 lb., valued at $110,700, as compared with 2,500,000 lb., valued at $119,000, in 1901. In the following table, which shows the annual production, imports and consumption of graphite from 1898 to 1902, inclusive, the refined crystalline product is given in pounds, the amorphous product in tons, and the artificial product in pounds.

THE PRODUCTION, IMPORTS, EXPORTS (*a*) AND CONSUMPTION OF GRAPHITE IN THE UNITED STATES.

Year.	Refined Crystalline Graphite.						Amorphous Graphite.		Artificial Graphite.	
	Production.		Imports.		Consumption.		Production.		Production.	
	Pounds.	Value. (*b*)	Pounds.	Value.	Pounds.	Value.	Tons. 2,000 lb.	Value.	Pounds.	Value.
1898	1,647,679	$32,385	30,199,680	$743,820	31,847,359	$826,205	1,200	$11,400	185,647	$11,608
1899	3,682,608	145,304	41,586,000	1,990,649	45,218,608	2,135,953	1,080	8,240	405,870	32,475
1900	4,108,052	164,122	32,298,560	1,389,117	36,401,612	1,553,239	1,045	8,640	860,750	68,860
1901	3,967,612	135,914	32,029,760	895,010	36,997,372	1,067,921	809	31,800	2,500,000	119,000
1902	4,175,824	153,147	40,857,600	1,168,554	45,034,424	1,322,401	4,739	55,964	2,358,828	110,700

(*a*) The exports of graphite from the United States amounted to 12 long tons, valued at $834, in 1901 and 3 tons, valued at $365, in 1902. (*b*) Nominal.

In the trade the mineral graphite is classified into "crystalline" and "amorphous," the former constituting the finer grades used chiefly for the manufacture of fire-resisting products, in lubrication, in electrotyping, etc., while the latter is of inferior quality and suited only for foundry facings, paint, stove polish, and similar purposes. Some of the amorphous product, however, especially that from Bavaria and Mexico, is utilized also in the manufacture of pencils and in electrotyping work. The bulk of the supply of the best grades of crystalline graphite continues to be derived from Ceylon, which furnishes at present about 80% of the total consumption of the United States. The graphite is imported direct by steamer in packages of 600 lb. net weight each. The ore is sorted and graded into four products, which in the order of value are: Lump, chip, dust and sweepings. The lump and the chip varieties are used chiefly in the manufacture of graphite crucibles and lubricants, as well as for electrical purposes, while the dust and the sweepings are utilized mainly in the manufacture of foundry facings, stove polish and greases. The consumption of crystalline graphite in the arts and manufactures is approximately as follows: Crucibles, 55%; stove polish, 15%; foundry facings, 10%; paint, 5%; all others, 10%. The last-named division includes powder, glazing, electrotyping, steam packing, pencils, and various minor uses. In spite of the development of the manufacture of artificial graphite by the electric furnace, the need for the natural graphite has increased very largely in recent years, due to the growth of the iron and steel industries, the largely increased use of copper and its alloys, the development of electrical machinery, which calls for graphitized products, and the increased need for special lubricants. During 1902 the United States supplied from domestic ores but little more than one-tenth of the total consumption of natural graphite for the year.

(Much of the information in the following technical review of the progress of the graphite industry in the United States during 1902 has been contributed by Mr. William F. Downs.) Interest in the search for good graphite properties continues, and although no new fields have been reported, much exploration work has been done, and the producing mines have been more carefully examined for available ore. The continued high price of graphite and the increased demand for "American flake" are the principal reasons for the recent activity. For many years a prejudice existed against American flake graphite, which was only removed in the late nineties by the enforced use of all grades of graphite resulting from the scarcity and very high price of the well-known grades. Manufacturers finally came to the conclusion that the value of graphite for any purpose depended upon purity and physical condition, and not upon the geographical location of the deposits. A foreign demand exists for American flake graphite, although at present the domestic consumption is so great as to exclude exports. The market for graphite from low-grade disseminated flake ores has caused the question of concentration to be more carefully studied than ever before. Operative plants have changed or improved their methods, and new processes are to be introduced in plants under construction. Two new features in concentration are worthy of special notice; one, the use of petroleum vapor which is rapidly absorbed by graphite and permits the flakes to be more readily separated by flotation from the gangue, and the second, the drying (heating) of the ground product before separation, whereby the flakes of graphite are floated on the surface of the water and removed, the gangue being carried along with the outflowing stream. The consumption of crucible graphite and other high grades continues to increase, due principally to the activity in the metal trades. The use of graphite paints for the protection of steel structures has also been greatly expanded, although for this purpose both natural and artificial amorphous graphites are used. The severe duty required of lubricants in large power plants has increased the demand for graphite, which substance, on account of its lubricating properties and preservative action on metal is generally recognized as most desirable. Despite the acknowledged superiority of graphite for this purpose, the consumption has not been largely increased for two reasons—one the difficulty of getting a strictly pure product, and the second the difficulty in feeding the dry powder to the place of service. These questions are being solved mainly by the demand for a "high duty" lubricant and numerous devices have been patented for the forced feed of dry graphite. During the past year an invention has been developed which solves the question of the feed of graphite without changing the usual lubricator equipment of an engine. The principle is based on the suspension of graphite in oil, and the lubricant is patented and sold under the trade-mark of "Lubriphite."

In the manufacture of graphite products the graphite is used in a ground state. The larger concerns do their own grinding, and a few of the smaller ones purchase the graphite in a ground condition. The principal manufacturers of graphite articles, classified as to products, are given in the subjoined list:—

Crucible Manufacturers and Grinders.—Joseph Dixon Crucible Co., Jersey City, N. J.; J. H. Gautier & Co., Jersey City, N. J.; Robt. Taylor Crucible Co., Callowhill Street, Philadelphia, Pa; Bridgeport Crucible Co, Bridgeport, Conn; R. B. Seidel & Co., Philadelphia, Pa.; Ross & Co., Philadelphia, Pa.; Taunton Crucible Co., Taunton, Mass.; Crucible Steel Co. of America, Pittsburg, Pa.; Tacony Crucible Co., Tacony, Pa.; McCollough & Dalzell, Pittsburg, Pa. (Ahrenburg & Co., crucible makers).

Grinders.—Allen Graphite Co., Talladega, Ala.; Philadelphia Graphite Co., Philadelphia, Pa.; United States Graphite Co., East Saginaw, Mich. (mines in Mexico).

Paint Manufacturers.—Detroit Graphite Co., Detroit, Mich.; Wisconsin Graphite Co., Pittsburg, Pa.

Stove Polish Manufacturers.—Rising Sun Stove Polish Co., Canton, Conn.; Enameline Stove Polish Co., Passaic, N. J.; Nickel Plate Stove Polish Co., Chicago, Ill.

Foundry Facing Manufacturers.—S. Obermeyer Co., Cincinnati, O.; Hill & Griffith, Cleveland, O.; J. W. Paxton, Philadelphia, Pa.; E. D. Ranson, Troy, N. Y., American Facing Co., New York, N. Y.; T. P. Kelly, New York, N. Y.: Brown Bros., Springfield, Mass.

Grease and Lubricant Manufacturers.—Ilsey, Doubleday & Co., New York, N. Y.; J. S. McCormack & Co., Pittsburg, Pa.; The Lubriphite Co., Jersey City, N. J.

Dealers.—Standard Graphite Co., New York, N. Y.; Pettinos & Bros., South Bethlehem, Pa.

REVIEW OF PROGRESS IN THE GRAPHITE INDUSTRY DURING 1902.

Alabama.—The Allen Graphite Co., at Stockdale, Clay County, increased its output of flake graphite during 1902, and two new companies have been formed to develop graphite properties in other parts of the State. A deposit of graphite is reported near Taylorsville, Alexander County.

Massachusetts.—The graphite mines of the Massachusetts Graphite Co., near Sturbridge, Worcester County, has been in course of development during the year, a few small shipments of the crystalline product being made to consumers to test the quality of the product.

Montana.—The Crystal Graphite Co. has been developing its graphite deposit near Dillon, Beaverhead County. Two small adits were started on the outcrop, but at a short distance the vein became almost perpendicular in dip and the work on them ceased. Later, an adit was started on the side of the mountain to intercept the vein at a depth of 65 ft., and at the close of the year it had been extended a distance of 135 ft., which is calculated to be within a few feet of the deposit. Shipments of the product have been made to crucible manufacturers to test its quality. Work will be resumed early in 1903, and if the deposit proves of sufficient value a mill will be erected near the mine.

New Mexico.—Exploratory work was done during 1902 at the graphite properties, eight miles southwest of Raton, Colfax County, which are now under the control of the Standard Graphite Co., of New York, and an output of 65 short tons of high-grade amorphous graphite was shipped to Moosic, Lackawanna County, Pa., for manufacture into paint and foundry material. A 60-ft. adit was driven on the vein of graphite and 15 pit shafts and facings exposed the deposit at various points. The district about Raton is underlain with bituminous coal, the seams of which vary in thickness from 3 to 7 ft. In the portion where the graphite is found, a layer of lava in the form of a laccolite has intruded itself above the coal seam, and by its heat has metamorphosed the coal to graphite which assumed a columnar form. The graphite is of the amorphous variety, and contains a portion of the silica which was originally associated with the coal. The vein of graphite approximates a horizontal position, and varies in width from 3 in. to 2 ft. In many places the graphite is free from rock, but containing an intimate mixture of silica. Generally the graphite occurs in a clear, clean vein although a part of it is often mixed with rock. The graphite vein is cut through by canyons, and can be traced for a considerable distance on opposite sides of a large mesa. In one canyon three tunnels varying in length from 10 to 60 ft. have been driven on the vein, each showing the occurrence of the graphite to be continuous.

New York.—There are numerous limestone deposits in Essex and neighboring counties which carry graphite distributed through the mass, or in small lenses of very rich ore. While a large number of these deposits have been, and are being developed and promoted, the only ones of promise are those operated by the Joseph Dixon Crucible Co., which is running an adit to tap the rich lenses in its old mine on the Lead Hill, back of Ticonderoga, and a similar deposit worked by the Columbia Graphite Co., on Warner Hill, between Ticonderoga and Crown Point. At the close of the year, development work had not proceeded far enough to prove the value of either of these deposits.

The Joseph Dixon Crucible Co. continues to operate its mines and mills at Graphite and at Hague, on Lake George, although the latter plant was closed down about the last of the year for the purpose of prospecting the deposit. Unlike its mine at Graphite, which has been worked continuously since 1880, the Hague vein seems to have been a line of weakness during the geological upheavals, and the ore and wall rocks near the surface are very much pulverized, so that while the ore carries a good percentage of graphite, the production is small, simply on account of the fineness of the flake. It is probable that when the workings are extended in depth, the graphite will be found in coarse flakes in the unaltered rocks unless the faulting has occurred along the vein throughout its course.

The prospect developed by the Gray Brothers, between Ticonderoga and Schroon was secured by the Ticonderoga Graphite Co., which was organized for the purpose of working this deposit. A well designed 10-stamp mill has been erected and operations begun late in the year. While the production has been very much below the paper figures, the company seems to have a good chance for ultimate success, because the flake is coarse and the deposit is wider than any yet opened in the State. A much larger plant with economical mining should handle this ore with a profit.

Practically no milling has been done at Pottersville, in Warren County. A shaft has been extended to a depth of 150 feet, and the vein is reported to be of fair quality and width in the drift near this level.

It is probable that all the valuable mines that will be opened in this section will be found in the graphitic quartzite, as the lenticular shaped ore bodies in the limestone have, without exception, proved uncertain. A very large low-grade deposit of graphitic quartzite was found by Prof. J. F. Kemp on the east shore of Lake George about 3 miles back of Hulett's Landing. A peculiar feature of this deposit is the fact that the hanging wall is a very large eruptive dike. As in the Hague mine, the vein seems to have been a line of weakness. The flake of this deposit is very small and of too low grade to be of any value. It is probable this is the continuation of the deposit that is found at a lower level on the west shore of South Bay, a large arm of Lake Champlain, near Whitehall.

North Carolina.—The graphite mines near Graphiteville, McDowell County, have been developed to some extent during the year and about 800 tons of ore have been mined. The ore is stated to be partly amorphous and partly crystalline, the amorphous variety being of such a character that it may be utilized in the manufacture of pencils, foundry facings, paint, etc. The completion of the works of the company has been interrupted by litigation.

Pennsylvania.—The Philadelphia Graphite Co., at Chester Springs, Chester County, produced the greater part of the output of graphite in this State during 1902. The Federal Graphite Co., at the same locality, is equipping its plant with a magnetic concentrator of the roller type for the removal of the greater part of the ferruginous impurities, the balance being extracted by a special treatment with hydrochloric acid. The material as it comes from the concentrator is added to an acid bath, agitated for four hours with live steam, and allowed to remain in the acid for 25 hours additional. It is then thoroughly washed to remove all traces of acid and dried, which yields a flake product stated to be equal in quality to the Ceylon chip graphite. The Pennsylvania Graphite Co., formerly operative in Berks County, has made no production since 1899.

Rhode Island.—The Rhode Island Graphite Co. has continued to operate the amorphous graphite mine near Providence. The graphite occurs mostly in the nature of pockets, although it is also found in two or three fissure veins. During the latter part of 1902 the grade of the product reached as high as from 65 to 70% C. It is of interest to note that in connection with the development of the graphite deposit, a vein of semi-anthracite coal has been opened up.

Washington.—The graphite deposits in this State, owned by the Shelbyville Consolidated Mining Co., have been abandoned, as the material could not be mined with profit.

Wisconsin.—The Wisconsin Graphite Co. is installing a complete modern mining plant at Steven's Point, and has added four large re-grinding machines at its works in Pittsburg, Pa. The product is amorphous graphite reported to assay in some specimens as high as 74% C. It is manufactured into paints, lubricants and paste.

Wyoming.—The principal graphite deposits are located at Hallock Canyon, near Laramie, Albany County, and are now operated by the Copper Cliff Mining Co.

WORLD'S PRODUCTION OF GRAPHITE. (IN METRIC TONS.)

Year.	Austria	Canada	Ceylon. (*d*)	Germany.	India.	Italy.	Japan.	Mexico	Russia.	Spain.	Sweden	United States. (*b*)	Totals.
1897	38,504	396	19,275	3,861	61	5,650	204	907	(*a*)	(*a*)	99	450	69,311
1898	33,062	1,107	78,509	4,593	22	6,485	346	1,857	98	10	50	824	125,006
1899	31,819	1,105	29,037	5,196	1,518	9,990	55	2,305	29	(*a*)	(*e*) 545	1,648	80,962
1900	33,663	1,743	19,168	9,248	1,858	9,720	94	2,561	(*c*)	(*a*)	84	1,799	79,938
1901	29,992	2,005	22,707	4,435	2,530	10,818	(*c*)	762	(*c*)	(*a*)	(*f*) 56	1,894	74,694

(*a*) Not reported in the government statistics. (*b*) Crystalline graphite. (*c*) Statistics not yet published. (*d*) The figures for 1897, 1899 and 1900 are exports; the enormous production in 1898 as reported in official government publications is not reflected in the exports for that year, which amounted to 24,849 metric tons. (*e*) Of this quanity 500 tons were crude product. (*f*) The production of crude graphite during 1901 was 1,727 metric tons, valued at $1,634.

Australia.—During 1901, 350 long tons of graphite were mined at Undercliff, in Wilson's Downfall Division, New South Wales. The deposit averages 2 ft. in width. Efforts have been made to develop a second graphite property in the same district.

Canada.—The production of graphite in Canada during 1902 was 1,095 short tons, valued at $28,300, as compared with 2,210 short tons, valued at $38,780 in 1901—in both years the output was derived mainly from the Black Donald mine. at Brougham, Renfrew County, Ont. The following companies are interested in graphite mining, although not all were numbered among the producers during 1902: *New Brunswick*—Canada Paint Co., near St. John Station. *Ontario*—Ontario Graphite Co.; Brougham & Globe Refining Co., Port Emsley. *Quebec*—Calumet Mining & Milling Graphite Co., Calumet; North American Graphite

Co., Buckingham; Walker Mining Co., Buckingham; and Grenville Graphite Co., Grenville, (formerly Keystone Graphite Co.).

An interesting improvement in the principles of wet concentration of graphite ores has been successfully applied at the mill of the North American Graphite Co. at Buckingham, Quebec, by the use of a wet separator designed by H. H. P. Brumell, which treats the dried or heated ore by flotation upon, rather than by immersion beneath, the surface of the water.

THE GRAPHITE INDUSTRY IN CANADA DURING 1902.

BY W. E. H. CARTER.

THE erection of a graphite refinery at the Black Donald mine, in Renfrew County, owned by the Ontario Graphite Co., was begun late in 1901, and water power on the Madawaska River, two miles away, was developed to supply electrical energy for the works and mine. Treatment of the ore commenced in July, 1902. At the same time, the graphite property in North Elmsley Township, Lanark County, first operated some 40 years ago, was again taken up and actively developed by the Globe Refining Co. This mine is owned by Rinaldo McConnell, of Ottawa, and is situated about seven miles southeast of Perth. A refinery has been erected two miles farther east, beside a small water power on the River Tay, at which operations were started toward the close of the year. Several other graphite deposits have undergone preliminary development during 1902, but the work accomplished has not been sufficient to form a proper estimate of their value. The graphite bodies, both in Ontario and Quebec, are closely associated with the Archæan crystalline limestone, and the mineral occurs in three forms, *viz.:* amorphous, crystalline and flake. The only known large deposit of amorphous granite exists at the Black Donald mine, although other prospects are reported to carry this variety; while the crystalline graphite is confined to the Quebec district, and occurs in small veins associated with deposits of the flake variety. The most generally distributed form is the flake graphite, which is much more valuable than the amorphous, and inferior to the crystalline only in that the latter occurs as practically pure carbon, whereas the flake is disseminated through a gangue or matrix, from which it must be separated, its quality, therefore, depending upon the efficiency of the concentration process.

At the Black Donald mine the ore occurs in a vertical vein traversing crystalline limestone and is composed mainly of amorphous graphite; the flake variety is found, however, in small stringers and pockets, as well as in the schistose walls, which are several feet thick. The total carbon content amounts to about 65%, of which about 45% is amorphous and 20% flake, the remaining gangue being composed of limestone and occasional seams and pockets of chlorite, locally called "mica." The vein is unusually uniform in character from wall to wall, and has a very uniform graphite content. There are locally enriched areas of amorphous graphite containing as high as 80% C. Low-grade bodies of flake also occur which, taken as a whole, seldom exceed 25% C, and a maximum size of flake of about 8-mesh. The ore chute has been found to increase steadily in width from 16 ft. at the eastern outcropping, to 26 ft. underground at the extremity of the west drifts, about 400 ft. away. The graphite in the walls gradually decreases as the more solid country rock is reached, and when the rock contains less than 15% C it is not mined, as at the present time this percentage is considered to be the minimum quantity for profitable treatment in the refinery.

Owing to the similarity in the specific gravity and the size between the flake and chlorite, the particles of the latter in the gangue cannot be separated entirely from the graphite in the process of concentration, and they contaminate the flake graphite product to such an extent as to reduce seriously its value for the manufacture of crucibles, for which it is chiefly used. In consequence, those portions of the deposit carrying chlorite are sorted out, together with the richer portions of the amorphous graphite, to form a product containing not less than 50% C that is shipped in the lump form for foundry facing purposes. The intermixed gangue is not seriously detrimental to this use.

The refinery, which has a capacity of 15 tons of ore per day, uses a wet process of concentration with large buddles. All of the material but the tails is dried either in an electric-heated or ordinary fire-heated revolving cylinder, sized, and then ground between millstones, which pulverize the gangue and amorphous graphite and merely polish the flake. After grinding, the product is passed through a series of revolving screens of gradually decreasing mesh, by which four sizes of flake are separated out, then a mixed flake and amorphous grade, and finally four or more sizes of amorphous graphite. The first flake is the coarsest and cleanest product, running about 10-mesh size and 96% C; the remaining grades of flake decrease in size, but all are over 90% pure. The amorphous grades are in powder form and carry from 54 to 62% C. The limestone remaining with the graphite after buddling pulverizes more readily than the graphite and in the screening separates out from the graphite as dust.

This mine is exceptional, both as regards uniformity and quality of the graphite and size of the deposit. Since the erection of the refinery practically all the ore may be converted into valuable products, chief of which are the grades of flake for use in the manufacture of crucibles.

At the McConnell mine, operated by the Globe Refining Co., the graphite occurs along several mineralized zones or veins traversing the crystalline limestone. These zones occur along parallel or intersecting lines, and are somewhat lenticular in character. They lie nearly vertical, are from 8 to 30 ft. wide, and have been traced along the strike for more than several hundred feet. The graphite is entirely in flake form disseminated through the limestone, but the average carbon content is much less than that of the Black Donald mine. The refinery process also differs, including some new features of treatment which seem likely to prove successful. After coarse crushing and drying the ore is reduced to a fine size and screened several times to remove a considerable proportion of the limestone gangue as dust. A cleaner separation of the intermixed rock is effected by concentrating in pneumatic jigs, and the concentrates are then ground in a series of millstones. The polished and enriched flake discharged from the last stone undergoes wet buddling in small vats, which finish the work of concentration, after which the graphite is again dried, preparatory to the final grading in revolving screens into two or, when desired, more sizes, the coarsest being from 15 to 20-mesh size. On account of the low content of carbon in the crude ore, this elaborate scheme of concentration has been adopted in order that the saving should be as high as possible. The flake product is of high grade suitable for crucible stock. The capacity of the McConnell refinery is from 15 to 20 tons of ore per day.

A third property called the Allanhurst mine situated in the township of Denbigh has been opened up quite lately by J. G. Allan, of Hamilton, Ont. A quantity of ore has been taken out and shipped to Hamilton, where it is used for foundry facings. It is proposed to develop the property on a more extensive scale.

ARTIFICIAL GRAPHITE.

The manufacture of artificial graphite, both crystalline and amorphous, continues in the hands of the sole producer, the International Acheson Graphite Co. of Niagara Falls, N. Y., which reported an output during 1902 of 883,591 lb. of graphitized electrodes and 1,475,237 lb. of granular or powdered graphite, making a total of 2,358,828 lb. valued at $100,700, as compared with the total of 2,500,000 lb. valued at $119,000 in 1901. The production and value of artificial graphite from 1897, the year of the inception of the industry, to 1902 are given in the subjoined table:—

PRODUCTION AND VALUE OF ARTIFICIAL GRAPHITE FROM 1897 TO 1902, INCLUSIVE.

Year.	Pounds.	Value.	Unit Value per Pound.	Year.	Pounds.	Value.	Unit Value per Pound. (a)
			Cents.				Cents.
1897..........	162,882	$10,149	6·2	1900..........	860,750	68,860	8·0
1898..........	185,647	11,608	6·2	1901..........	2,500,000	$119,000	4·75
1899..........	405,870	32,475	8·0	1902..........	2,358,828	110,700	4·69

(a) The decrease in the unit value of the total production from 8c. per lb. in 1899 and 1900 to 4·69c. per lb. in 1902 was due largely to the increased proportion of the amorphous variety produced.

Artificial graphite is manufactured in the electric furnace, the two products being known as graphitized electrodes, and artificial graphite. In the former the ordinary electrode, which is composed of a mixture of petroleum, coke, pitch and a carbide-forming material (silica or iron oxide) is submitted to the intense heat of an electric arc furnace and the whole graphitized, furnishing a product possessing special qualities. For the production of the so-called "artificial graphite," anthracite coal is heated in the electric arc furnace and the impurities eliminated, the ash being reduced in some cases to as low as 0·5%. Graphitized electrodes are used in electrolytic processes for the production of caustic soda, and of chlorine and metals in chloride solution; also in electrometallurgical processes, such as the production of calcium chloride, the electric smelting of copper and iron ores, and the manufacture of various iron alloys. The artificial graphite in the form of grains and powders is used chiefly in the manufacture of paint, dry batteries and commutator brushes, although a considerable quantity is used in the manufacture of lubricants, in electro-plating work and in certain chemical processes which require a carbon of exceptional purity.

Pure graphite has many advantages, such as high electrical conductivity, great resistance to chemical action, and absence of the property of occluding gases which is possessed more or less by all forms of amorphous carbon. Natural graphites of the necessary purity for work of this kind are so expensive that in most cases the price is prohibitive. Within the last year artificial graphite has been used successfully as a lubricant for high-grade work, and experiments have been made with artificial graphite for coating the grains of high explosives, the spontaneous ignition of which is supposed to result from a static charge of electricity on the grains, causing a spark which detonates the powder. By coating the grains with graphite the formation of the static charge is prevented.

The production of graphite electrodes, as stated by F. A. J. Fitzgerald,[1] was not as large in 1902 as in the previous year, due to the fact that there were fewer new electrochemical works equipped. Graphitized electrodes have certain valuable properties which cause them to be used in preference to electrodes of amorphous carbon, these properties being the resistance of the electrode to oxidization when heated in the air, high electrical conductivity, and the ease with which they can be machined. According to H. Moissan, amorphous carbon is consumed when heated in oxygen at from 370° to 385° C., whereas it requires a temperature of 660°C. to burn artificial graphite. On account of the higher electrical conductivity of the artificial product, the cross section of the electrodes need only be one-third to one-fourth that required when the amorphous carbon variety is used, thereby exposing less surface to be oxidized. By the use of a screw thread to attach the electrode to the conducting wire a better contact can be made and new pieces can be attached from time to time to a partially consumed electrode, or the residual parts of old electrodes connected and used as a new electrode, so that none of the electrode is wasted. Slabs of material can also be dovetailed together to form partitions or boxes. The specific resistance of the artificial material is 0·00032 ohms per cu. in., or about one-fourth that of amorphous carbon. The following table[2] shows the results of experiments made with amorphous carbon and graphite electrodes in actual electrometallurgical work:—

Sieves.	Number, Size and Kind of Electrodes Used in Each Terminal.	Total Current in Amperes.	Current Density Amperes per Square Inch.	Average Hours Run.	Average Length Consumed.	Number of Runs.	Relative Weight Consumed per Hour.
A.....	Four—4 in. x 4 in. x 24 in. Amorphous carbons.	4,000	62·5	8	12 in. to 14 in.	4	1·000
B.....	Four—4 in. x 4 in. x 24 in. Acheson graphite.	4,000	62·5	33	12 in. to 14 in.	4	0·250
C....	Four—2 in. x 4 in. x 24 in. Acheson graphite.	4,000	125·0	32	12 in. to 14 in.	15	0·125
D.....	Four—2 in. x 4 in. x 30 in. Acheson graphite.	4,000	125·0	95	22 in. to 24 in.	15	0·074

The electrodes in all cases were ranged side by side touching each other.

E. G. Acheson has patented[3] a new method of graphitizing electrodes, by subjecting them to the high temperature of an electric furnace. The electrodes are placed in piles separated from one another by spaces filled with a "material having a lower coefficient of electrical conductivity" than the electrodes. The current is then passed through the mass with the result that most of the heat energy is developed in the material in the spaces between the electrodes. The

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[1] *Engineering and Mining Journal*, March 28, 1903, 484.

[2] C. L. Collins, *Transactions of the American Electrochemical Society*, I., No. 1, p. 53, 1902.

[3] United States Patent No. 701,758, June 17, 1902.

advantage of this method is that large furnaces can be used and the electrical resistance kept sufficiently high to avoid currents of very high amperage.

E. G. Acheson has also patented[4] a process of making graphite which consists in introducing into an electrical furnace a mass of amorphous carbon and a volatilizable material capable of forming a carbide, and by the action of the metallic vapors on the amorphous carbon at the high temperature of the electric furnace to change it to graphite. Carbon is placed in a furnace and mixed with a metallic compound, such as ferric oxide, and extending from one end of the furnace to the other is a core composed of carbon rods or plates which acts as a conductor for the current. On passing the current through the furnace the petroleum cake is heated to a high temperature, the iron oxide is reduced and the vapor of metallic iron acts on the amorphous carbon, converting it into graphite.

Borchers and Moegenburg[5] found that the conversion of amorphous carbon into graphite in the electric furnace, is greatly accelerated if metals or metallic compounds are present which are able to form dissociable carbides. A relatively small quantity of aluminum was found to be effective for this purpose.

Analytical Determination of Graphite in Ores.—According to A. G. Stillwell[6] graphite can be determined by the absorption method for carbon, the apparatus consisting of a generator flask, KOH and H_2SO_4 bulbs, and necessary guard bulbs. From 0·25 to 1 g. is heated to redness to expel organic matter, treated with dilute HCl (1:1), filtered through a Gooch crucible, using ignited asbestos as filtering medium, and washed. The contents of the crucible are placed in the generator flask with 15 c.c. of a saturated solution of chromic acid, and 75 c.c. of concentrated H_2SO_4 are then added slowly to the agitated contents of the flask, which is finally heated over a low flame. From the increase in weight of the KOH bulb, the quantity of graphite in the sample can be calculated. Blank tests must be run on the chromic acid, and the result deducted in each determination. The fire and acid treatment may be dispensed with, if there is no organic matter or carbonate present.

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[4] United States Patent No. 711,031, Oct. 14, 1902.

[5] *Zeitschrift fuer Elektrochemie*, Sept. 25, 1902.

[6] *Journal of the Society of Chemical Industry*, XXI., June 16, 1902, 779.

GYPSUM.

THE production of gypsum in the United States continued to increase greatly during 1902, although statistics of production during this year are not now available. The production during 1901 was 659,659 short tons, valued at $1,577,493.

PRODUCTION OF GYPSUM IN THE UNITED STATES. (*a*) (IN TONS OF 2,000 LB.).

States.	1900.	1901.	States.	1900.	1901.
California	*e* 3,500	3,550	Oregon	450	(*d*)
Colorado	4,000	*b* 17,394	South Dakota	750	(*d*)
Ind. Ter. and Oklahoma	16,975	(*d*)	Texas	42,000	(*f*)
Iowa	92,201	*c* 213,419	Utah	2,247	(*d*)
Kansas	*e* 90,000		Virginia	10,885	15,236
Michigan	150,000	185,150	Wyoming	2,995	(*g*)
Montana	325	(*d*)	Other States	....	105,345
New York	42,874	119,565			
Ohio	25,000	(*d*)	Total	484,202	659,659

(*a*) Statistics reporting the amount quarried. (*b*) Includes Wyoming. (*c*) Includes Texas. (*d*) Included in Other States. (*e*) Estimated. (*f*) Included with Iowa and Kansas. (*g*) Included with Colorado.

GYPSUM IMPORTED INTO THE UNITED STATES. (IN METRIC TONS.)

Year.	Ground or Calcined.			Unground.			Value of Manufactured Plaster of Paris.	Total.
	Quantity.	Value.	Per Metric Ton.	Quantity.	Value.	Per Metric Ton.		
1898	3,021	$18,500	$6·12	168,723	$181,364	$1·09	$40,979	$240,843
1899	3,317	19,250	5·80	199,724	220,608	1·10	58,073	297,926
1900	3,159	19,179	6·07	213,239	229,878	1·08	66,473	315,530
1901	3,156	19,627	6·22	238,971	238,440	0·99	68,603	326,670
1902	3,706	23,225	6·27	277,027	284,942	1·03	52,533	360,700

PRODUCTION OF GYPSUM IN THE PRINCIPAL COUNTRIES. (*a*) (IN METRIC TONS.)

Year.	Algeria. (*b*)	Canada.	France. (*b*)	Germany. (*c*)		Greece.	India.	United Kingdom	United States.
				Baden.	Bavaria.				
1897	36,750	217,392	2,004,339	40.702	26,158	51	8,187	184,287	272,493
1898	37,337	198,908	2,115,261	28,037	25,688	83	3,390	199,174	285,644
1899	39,950	221,862	1,807,454	29,419	29,727	81	6,546	215.974	333,891
1900	46,875	228.713	1,950,222	26,331	35.484	129	4,415	211,486	439,265
1901	44,025	266,605	2,385,633	28,188	3,581	671	(*d*)	204,045	598,529
1902	(*d*)	301,229	(*d*)	(*d*)	31.701	*Nil.*	(*d*)	172,219	....

(*a*) From official reports of the respective countries, except the statistics for the United States. (*b*) A part of the product is reported as plaster of Paris. In converting this to crude gypsum it has been assumed that the loss by calcination is 20%. (*c*) Prussia is a large producer of gypsum, but there are no complete statistics available. (*d*) Statistics not yet available.

Deposits of gypsum have been found near Sunset, Kern County, Cal., but have not yet been developed. A Tacoma gypsum company has bought a gypsum deposit on Freshwater Bay, Wash., and will erect a refining plant at Tacoma which is to have a yearly output of 15,000 to 20,000 tons of plaster of Paris and fertilizer. The gypsum deposit is said to be 70 ft. wide and 1,000 ft. long, and a tramway 3,500 ft. long is being built to convey the mineral from the quarries to the barges which will transport it to Tacoma.

GYPSUM AND GYPSUM CEMENT PLASTER INDUSTRIES IN KANSAS DURING 1902.

BY ERASMUS HAWORTH.

DURING the year 1902, the gypsum cement plaster industry in Kansas, and adjoining states and territories, was conducted about the same as in previous years. No changes whatever were made along technological lines, neither were there any new companies or new mills built, excepting one at Blue Rapids, Kan., mentioned later.

The changes in ownership, which occurred late in 1901 and early in 1902, were reported in THE MINERAL INDUSTRY, Vol. X., pp. 375, 376. As there set forth, the United States Gypsum Co. purchased nearly all the mills in Michigan, Iowa, New York, Oklahoma, and quite a number in Kansas.

At the present time there are nine companies doing business in Kansas, namely: United States Gypsum Co., with head offices in Chicago; American Cement Plaster Co., Salina Cement Plaster Co., Great Western Cement Plaster Co. and the Blackwell Cement Plaster Co., all with offices in common at Lawrence, Kan.; Samson Cement Plaster Co. at Burns; Ætna Cement Plaster Co., with offices at Kansas City, Mo.; Best's Keen Cement Plaster Co., at Medicine Lodge, and the Electric Cement Plaster Co. at Blue Rapids.

The United States Gypsum Co. has one mill at Hope and one at Blue Rapids, the old time Fowler's mill at the latter place being closed, as is also the Roman Cement Plaster Co.'s mill at Spring Valley, which was bought by this company. The American Cement Plaster Co. now owns but one mill which is in operation, a mill at Watonga, Blaine County, Oklahoma. The Salina Cement Plaster Co. has a mill at Longford, Kan., and also one at Acme, Tex. The Great Western Cement Plaster Co. has one mill at Blue Rapids, Kan. The Blackwell Cement Plaster Co. has a mill about six miles northeast of Blackwell, Oklahoma. The Samson Cement Plaster Co. is still doing a prosperous business at Burns, Kan. The Ætna Cement Plaster Co., with a mill a few miles from Dillion, Kan., has been in operation only a part of the time. A new company recently organized under the name of the Electric Plaster Co. has built a new mill at Blue Rapids, Kan., and bids fair to be a strong company in the future.

During the past year Oklahoma has had three gypsum mills in operation, those at Watonga and Blackwell, already mentioned, and a new one at Ferguson, owned by the Ruby Cement Plaster Co. The Indian Territory has but one mill, the old one at Marlow, at present owned by the Acme Cement Plaster Co. There are but two companies doing business in Texas, the Acme Co., which has a mill at Acme, and the Salina Cement Plaster Co., above mentioned, with offices at Lawrence, Kan., which also has a mill at Acme. During 1902 the Acme Cement Plaster Co. purchased and enlarged the gypsum plaster mills at Wyoming, which gives them an additional mill for the far Western trade.

Two kinds of gypsum are used by the various mills above mentioned, the ordinary rock gypsum and the fine grained gypsum earth. In Kansas all the mills at Blue Rapids, the one at Hope, and the one at Medicine Lodge use rock gypsum. The Blackwell Co. also owns some rock gypsum at Blackwell, Oklahoma, although at present they are using the gypsum earth variety. All the other mills of

Kansas, Oklahoma, Indian Territory, Texas, and the one at Laramie, Wyo., use the gypsum earth. This variety of gypsum produces a dark colored plaster, due to impurities, commonly spoken of as the "brown coat." It is employed to put on what corresponds to the first two coats of the old-fashioned lime mortar, and must be followed by a white coating of plaster made from rock gypsum, or from white lime.

The gypsum business was quite healthy during 1902, large sales were made, and fair prices were realized.

Canada.—In 1901 there was only one factory in operation in Ontario, that of the Alabastine Co. of Paris, Ltd., which manufactured calcined plaster, cement wall plaster and alabastine from gypsum mined near Caledonia. A factory for making "wood fiber," a mixture of gypsum, sand and wood fiber, has been established at Toronto. Most of the gypsum mined in Canada is shipped to New York to be milled.

France.—The greater portion of the gypsum used for agricultural purposes was produced by the Department of Seine-et-Oise, the rest being divided among 24 departments. Plaster from gypsum was made in 36 departments, about 70%, however, was produced in the departments of Seine-et-Oise, Seine, and Seine-et-Marne, the greatest deposits being at Montmaitre.

According to F. A. Wilder[1] the following cements containing gypsum are unusually hard, uniform in structure, set slowly and permit the addition of coloring matter without loss of strength. In hardness, they stand half way between Portland cement and stucco. Keene's cement is a slow setting alum plaster manufactured from unground gypsum, preferably of a white variety, which is burned at a red heat, then immersed in an alum solution, burned again at a red heat and then finely ground. If mixed with 20% water, it has a tensile strength of 70 lb. and a crushing strength of 800 lb. per sq. cm. Parian cement consists of 44 parts calcined gypsum and 1 part calcined borax. The gypsum is saturated with a borax solution and burned at a red heat. It sets slowly and dries in 5 or 6 hours. Scagliola is a mixture of finely burned plaster and limewater, which is made into slabs for wall decorations. Gypsum heated to 1,000°F. and then coarsely ground is called estrick gypsum. This material when allowed to settle slowly, protected from draft and heat, becomes exceedingly hard, and is especially recommended as a floor material.

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[1] *Engineering and Mining Journal*, Aug. 30, 1902.

IRON AND STEEL.

BY FREDERICK HOBART.

THE iron and steel trades of the United States during 1902 showed a demand and a production which exceeded the record figures of 1901. Moreover, large as the production was, it did not come up to the demand, and the output of the furnaces had to be supplemented by imports to an extent which has not been equaled for many years.

Iron Ore.—The production and consumption of iron ore for a series of years is given in the subjoined table:—

IRON ORE MINED AND CONSUMED IN THE UNITED STATES. (IN TONS OF 2,240 LB.)

District.	1899.	1900.	1901.	1902.
Lake Superior, shipments to furnaces	18,251,804	19,095,398	20,589,237	27,571,121
Southern States, shipments to furnaces	4,800,000	5,100,000	4,767,667	4,850,000
Other States, shipments to furnaces	2,240,000	1,758,000	2,530,575	2,215,000
Total mined in United States	25,291,804	25,917,398	27,887,479	34,636,121
Add decrease in stocks at Lake Erie docks	....	....	45,007	....
Add importations	674,082	897,793	966,950	1,165,470
Total	25,965,886	26,815,185	28,899,436	35,801,591
Deduct increase in stocks at Lake Erie docks	750,000	690,000	....	1,214,591
Deduct exportation	40,665	51,460	64,703	88,445
Total consumption	25,175,221	26,073,725	28,834,733	34,499,555

The increase in ore was somewhat higher in proportion than that in pig iron. It is probable that stocks at furnaces were greater at the end of 1902 than at the opening of the year, but there is no way of ascertaining these exactly. Making allowance for the different value of ores, it appears that over 75% of the iron produced in the United States is made from Lake Superior ores. For the Lake region accurate statistics of production have been kept for a long period, chiefly owing to the enterprise of the Cleveland *Iron Trade Review*. The statement of output of ore by ranges for four years past is as follows:—

PRODUCTION OF LAKE SUPERIOR IRON ORE BY RANGES, 1899 TO 1902. (LONG TONS.)

Range.	1899.	1900.	1901.	1902.
Marquette range	3,757,010	3,457,522	3,254,680	3,858,010
Menominee range	3,301,052	3,261,221	3,605,449	4,627,594
Gogebic range	2,795,856	2,875,295	2,938,155	3,663,484
Vermillion range	1,771,502	1,655,820	1,786,068	2,084,263
Mesabi range	6,626,384	7,809,535	9,004,890	13,342,840
Total	18,251,804	19,059,398	20,589,237	27,571,121

The Marquette range is wholly in Michigan, the Menominee and Gogebic ranges are partly in Michigan and partly in Wisconsin, and the Vermilion and Mesabi ranges are in Minnesota. Details of the movement will be found on a following page.

The shipments from the United States Steel Corporation's mines in 1902 amounted to 16,174,473 tons, or 58·6% of the whole. This is apart from 325,440 tons shipped by the corporation from the Pewabic mine, in which the Carnegie Co. has a one-half interest, but it includes the 6,882 tons shipped from the Iron Ridge mine of the Illinois Steel Co. in Wisconsin. This mine is remote from the Lake Superior ranges and has never been included in Lake Superior statistics. The total shipments from the Pewabic mine were 530,291 tons.

The base prices for Lake ores, for the season of 1903, have been fixed as follows: Mesabi Bessemer.—Basis, $4 per ton, f. o. b. lower lake ports; guarantee, 63% Fe, 0·045% P, 10% H_2O.

Mesabi Non-Bessemer.—Basis, $3·20 per ton, f. o. b. lower lake ports; guarantee 60% Fe, 12% H_2O.

Divided into three classes, according to structure, as follows: Difference between first and second class, 15c. per ton, and differential between second and third class 10c. per ton, or a total of 25c. per ton between first and third class. Guaranteed upon Longyear 58% Fe and 10% H_2O, making the latter ore $3·16 per ton, f. o. b. lower lake ports. The classes are arranged as follows:

First Class.—Stevenson, Wallace, Admiral, Pearce, Cass, La Belle, Elba, Fray, Biwabik, Butler, Steese, Hale, Kanawha, Longyear, Morrow, Croxton, Leetonia. La Rue, Kinney, Top Brown, Atlas, Cypress, Grant, Laura, Winifred, Victoria, Shilling Columbia, Columbia, Franklin, Leonard.

Second Class.—Commodore, Union, Petit, Malta, Sparta, Corsica, Minorca, Lincoln, Jordan, Beaver, Albany.

Third Class.—Mahoning and Vulcan.

Old Range Bessemer.—Basis, $4·50 per ton, f. o. b. lower lake ports; guarantee, 63% Fe, 0·045% P, 10% H_2O.

Old Range Non-Bessemer.—Basis, $3·60 per ton, f. o. b. lower lake ports; guarantee, 60% Fe, 12% H_2O.

These prices are substantially the same as for 1902. Less than 35% of the Lake ore is now sold, however, the balance being mined directly by the companies which use it.

Imports of iron ore, other than from Cuba in 1902 included 209,485 tons from Canada, chiefly from the Michipicoten Range on the northern shore of Lake Superior; and 11,000 tons from Newfoundland. The balance was principally Spanish ore, though some cargoes were received from Algeria and Greece, and one cargo from Venezuela.

The following companies shipped iron ore to the United States in 1902: The Juragua Iron Co., Ltd., 221,039 gross tons; the Spanish-American Iron Co., 455,105 tons; the Cuban Steel Ore Co., 23,590 tons; total shipments, 699,734 tons. The Cuban Steel Ore Co. went out of business at the end of the year and its mines are closed. No iron ore was shipped from Cuba in 1902 to any country other than the United States.

Pig Iron.—Complete statistics of iron and steel production in the United States have been compiled by the American Iron & Steel Association under the supervision of Mr. James M. Swank. In the following notes the figures from Mr. Swank's report have been freely used.

The production of pig iron, classified according to fuel used, has been as follows:—

PIG IRON PRODUCTION ACCORDING TO THE FUEL USED. (IN LONG TONS.)

Fuel Used.	1898.	1899.	1900.	1901.	1902.
Bituminous, chiefly coke	10,273,911	11,736,385	11,727,712	13,782,386	16.315,891
Anthracite and coke	1,180,999	1,558,521	1,636,366	1,668.808	1,096,040
Anthracite alone	22,274	41.081	40,682	43,719	19,207
Charcoal	296.750	284,766	339.874	390,147	378,504
Charcoal and coke	....	....	44,608	23,294	11,665
Total	11,773,934	13,620,703	13,789,242	15,878 354	17,821,307

Another classification is that according to the purposes for which the iron is used. In this form the production is given in the subjoined table:—

PIG IRON PRODUCTION. (IN LONG TONS.)

Kind of Iron.	1900.		1901.		1902.	
	Tons.	%	Tons.	%	Tons.	%
Foundry and forge iron	4,517,437	32·8	4,541,250	28·6	5,176,568	29·1
Bessemer pig	7,943,452	57·6	9,546,798	60·4	10,393,168	58·3
Basic pig	1,072,376	7·8	1,448,850	9·1	2,038,590	11·4
Spiegeleisen and ferromanganese	255,977	1·8	291,461	1·9	212,921	1·2
Totals	13,789,242	100·0	15,878,354	100·0	17,821,307	100·0

It is remarkable that there should have been such a large increase in production in 1902, when there were serious adverse conditions to contend with, chiefly inadequate transportation facilities, resulting in a short supply of coke and iron ore and the banking for longer or shorter periods of many furnaces. The anthracite coal strike also interfered with the activity of some Eastern furnaces. Its effect upon production was greater than the actual shortage of fuel would warrant, owing to the consequent disturbance of business, and the withdrawal of bituminous supplies from their usual consumers. The United States made more pig iron in 1901 than Great Britain and Germany combined, and in 1902 more than these two countries and Belgium combined. Stocks of pig iron unsold in the hands of manufacturers, or under their control, at the close of 1902, and not intended for their own consumption amounted to 49,951 tons, as compared with 70,647 tons at the close of 1901 and 442,370 tons at the close of 1900, being only about two days' output.

The total number of furnaces in blast on Dec. 31, 1902, was 307, as compared with 266 on Dec. 31, 1901, and 232 on Dec. 31, 1900.

Of the 17,821,307 tons of pig iron produced in 1902 the five largest producing States were: Pennsylvania, 8,117,800 tons; Ohio, 3,631,388; Illinois, 1,730,220; Alabama, 1,472,211, and Virginia, 537,216 tons.

The subjoined table gives the production of pig iron by States in 1901 and 1902, in the order of their prominence in 1902:—

States—Long Tons.	1901.	1902.	States—Long Tons.	1901.	1902.
Pennsylvania	7,343,257	8,117,800	New Jersey	155,746	191,380
Ohio	3,326,425	3,631,388	West Virginia	166,597	183,005
Illinois	1,596,850	1,730,220	Michigan	170,762	155,213
Alabama	1,225,212	1,472,211	Kentucky	66,468	110,735
Virginia	448,662	537,216	North Carolina and Georgia	37,333	32,315
New York	283,663	401,369	Connecticut	8,442	12,066
Tennessee	337,139	393,778	Massachusetts	3,386	3,360
Maryland	303,186	303,229	Texas	2,273	3,095
Wisconsin and Minnesota	207,551	273,967			
Missouri, Colorado and Washington	203,409	269,930	Total	15,878,354	17,821,307

All the above-named States, with the exception of Massachusetts and Michigan, made more pig iron in 1902 than in 1901.

The consumption of pig iron in the last five years is approximately shown in the subjoined table, the comparatively small quantity of foreign pig iron held in bonded warehouses not being considered. Warrant stocks are included in unsold stocks:—

ANNUAL CONSUMPTION OF PIG IRON IN THE UNITED STATES, 1898-1902. (IN TONS OF 2,240 LB.)

Pig Iron.	1898.	1899.	1900.	1901.	1902.
Domestic production	11,773,934	13,620,703	13,789,242	15,878,354	17,821,307
Imported	25,152	40,393	52,565	62,930	625,383
Stocks unsold Jan. 1	874,978	415,333	68,309	446,020	70,647
Total supply	12,674,064	14,076,429	13,910,116	16,387,304	18,517,337
Deduct stocks Dec. 31	415,333	68,309	446,020	73,647	49,951
Also exports	253,057	228,678	286,687	81,211	27,487
Approximate consumption	12,005,674	13,779,442	13,177,409	16,232,446	18,439,899

It will be observed that while the increased production of pig iron in 1902 over that of 1901 was 1,942,953 tons, the increased consumption was 2,207,453 tons. The increased consumption in 1901 over that of 1900 was 3,055,037 tons, but the consumption in 1900 was actually less than that in 1899.

For two years past the Association has collected additional statistics, grading the iron made into nine classes. The subjoined table shows the classification made and the quantities produced:—

PIG IRON PRODUCTION BY GRADES. (IN LONG TONS.)

Grades.	1901.	1902.
Bessemer and low-phosphorus pig iron	9,596,793	10,393,168
Basic pig iron made with mineral fuel	1,548,850	2,038,590
Forge pig iron	639,454	833,093
Foundry pig iron	3,548,718	3,851,276
Malleable Bessemer pig iron	256,532	311,458
White and mottled and miscellaneous grades	87,964	172,085
Spiegeleisen	231,823	168,408
Ferromanganese	59,639	44,573
Direct castings	8,583	8,656
Total	15,878,354	17,821,307

Of the total production of pig iron in 1902 more than 58% was Bessemer and low-phosphorus, as compared with over 60% in 1901; 21·6% was foundry, as compared with 22·3% in 1901; over 11%, was basic, as compared with 9% in 1901; 4·6% was forge, as compared with over 4% in 1901; 1·19% was spiegeleisen and ferromanganese, as compared with 1·8% in 1901; and 1·7% was malleable Bessemer, as compared with 1·6% in 1901. The production of white and mottled and of miscellaneous grades of pig iron amounted to less than 1% in both years. Castings made direct from the furnace did not amount to 0·1% in either year.

In 1902 the production of low-phosphorus pig iron, which is chiefly used by manufacturers of acid open-hearth steel, was for the first time definitely ascertained. It amounted to 164,246 gross tons, and was made by four States, namely, New York, New Jersey, Pennsylvania, and Tennessee.

The number of furnaces out of blast at the close of 1902 was 105. Many of these furnaces were only temporarily banked because of the inability of their owners to obtain a supply of fuel. At the close of 1901 there were 140 furnaces out of blast.

The limestone consumed for fluxing purposes by the blast furnaces of the United States in the production of 17,821,307 tons of pig iron in 1902 amounted to 9,490,090 tons. The average consumption of limestone per ton of all kinds of pig iron produced was 1,192·8 lb. in 1902, as compared with 1,196·5 lb. in 1901 and 1,205·6 lb. in 1900. The consumption by the anthracite and bituminous furnaces was 1,207·7 lb. per ton of pig iron made and by the charcoal and mixed charcoal and coke furnaces it was 527·9lb. A number of the Southern furnaces use dolomite in preference to limestone; this dolomite is included in the limestone mentioned above. One small furnace, in Maryland, uses oyster shells as flux.

The *Iron Trade Review,* of Cleveland, has prepared, from the figures of the American Iron and Steel Association, an interesting table, showing the percentage of the total pig iron output made in each State for 1902, compared with that for 1900 and 1890. The figures are as follows:—

	1890.	1900.	1902.
Maine	0·0	....	....
Massachusetts	0·1	0·0	0·0
Connecticut	0·2	0·1	0·1
New York	3·6	2·1	2·3
New Jersey	1·7	1·2	1·1
Pennsylvania	48·0	46·2	45·5
Maryland	1·6	2·1	1·7
Virginia	3·2	3·6	3·0
North Carolina and Georgia	0·3	0·2	0·2
Alabama	8·9	8·6	8·3
Texas	0·1	0·1	0·0
West Virginia	1·4	1·2	1·0
Kentucky	0·5	0·5	0·6
Tennessee	2·9	2·6	2·2
Ohio	18·5	17·9	20·4
Indiana	0·2	....	....
Illinois	7·6	9·9	9·7
Michigan	2·5	1·2	0·9
Wisconsin and Minnesota	2·4	1·3	1·5
Missouri	1·0	1·1	
Colorado	0·2		1·5
Oregon and Washington	0·1	....	
Total	100·0	100·0	100·0

The output of the two chief States—Pennsylvania and Ohio—is further given by districts, as follows:—

	1890.	1900.	1902.
Pennsylvania:			
Lehigh Valley	7·9	4·0	2·9
Schuylkill Valley	5·9	3·2	2·9
Upper Susquehanna Valley	2·0	1·0	0·0
Lower Susquehanna Valley	5·5	3·9	3·0
Juniata Valley	2·1	0·9	1·1
Shenango Valley	6·5	5·8	7·0
Allegheny County	14·5	22.6	23·9
Miscellaneous Bituminous	3·4	4·7	4·7
Charcoal	0·2	....	....
Total Pennsylvania	48·0	46·2	45·5
Ohio:			
Hanging Rock Bituminous	1·0	1·8	1·8
Mahoning Valley	5·4	7·3	8·1
Hocking Valley	0·9	0·4	0·2
Lake Counties	....	3·6	4·8
Miscellaneous Bituminous	6·0	4·8	5·4
Hanging Rock Charcoal	0·3	0·1	0·1
Total Ohio	13·5	17·9	20·4

On the changes shown the *Iron Trade Review* comments as follows: "It is somewhat surprising to note that much of the movement of the decade from 1890 to 1900 has been almost reproduced in the short space of two years. It is not a result which would have been expected on purely theoretical grounds. Last year was one which kept in operation furnaces located in districts, which only figure in abnormal times. When the next depression strikes the trade we may expect radical changes to be shown up by our method of comparison. But for the present we would hardly expect that the State of Virginia, for example, should produce a smaller percentage of the total production in 1902 than in 1900, or even in 1890, but such is found to be the fact. And the same movement is found with West Virginia, Tennessee and New Jersey. Every one of these States produced more pig iron in 1902 than in either 1900 or 1890, and their relative decline is shown only by a comparison of percentages.

"Interest will, of course, center on the large iron States. We find that the great State of Pennsylvania, which made 48% of the pig iron production in the United States during 1890, and declined to 46·2% in 1900, experienced a further drop to 45·5% in 1902. Looking at the districts, however, the decline is easily located in the eastern part of the State. The upper Susquehanna Valley has about dropped out, while the lower has kept about even as to tonnage. The Lehigh, Schuylkill and Juniata valleys have slightly decreased their actual tonnage, and greatly decreased their proportion.

"Against these declines in the eastern part of Pennsylvania, there have been almost proportionately large advances in the western part, using Lake ores entirely. Allegheny County, which made 14·5% of the country's production in 1890, made 23·9% in 1902. The tonnage was more than tripled in 12 years, while the country scarcely doubled its tonnage. The Shenango Valley increased its relative importance in the same period, in less degree.

"In Ohio, the Mahoning Valley and the Lake counties increased their relative proportion in a substantial way, and made the whole State more important relatively.

"Alabama, which has shown an increasing pig iron production, lost slightly in relative importance from 1890 to 1900, and lost as much more in the two following years. In 1890 the State made 8·9% of the country's production, in 1900, 8·6%, and in 1892, 8·3%.

"Broadly speaking, practically every item in the table indicates (1) that the districts using Lake Superior ores are increasing their relative importance in a most marked manner, the change being noteworthy in so short a period of comparison as two years; (2) the districts using local ores are either only holding their own as to actual tonnage or are declining. It requires no prophetic eye to read from this record, based on exceptionally prosperous years, that these latter districts will not so well stand the strain of adversity.

"From 1900 to 1902 the following districts showed increases in actual tonnage: Connecticut, New York, Schuylkill Valley, Juniata Valley, Shenango Valley, Allegheny County, Maryland, Virginia, North Carolina and Georgia, Alabama, West Virginia, Kentucky, Tennessee, Hanging Rock (Ohio), Mahoning Valley, Lake counties (Ohio), Illinois, Wisconsin and Minnesota and Missouri, Colorado, Oregon and Washington. Of these 19 there were only 10 which showed an advance in relative production, the important ones being the Mahoning Valley and the Lake counties in Ohio, and the Shenango Valley and Allegheny County in Pennsylvania.

"From 1900 to 1902 the following districts showed declines in tonnage of production: Lehigh Valley, Upper and Lower Susquehanna valleys, Texas, Hocking Valley and Michigan.

"The Upper Susquehanna Valley practically dropped out in 1902, through the removal of the local interest to Buffalo, N. Y."

Steel.—The production of steel in the United States is given in the subjoined table:—

PRODUCTION OF STEEL IN THE UNITED STATES. (IN TONS OF 2,240 LB.)

Kinds.	1898.	1899.	1900.	1901.	1902.
Bessemer	6,609,017	7,586,354	6,684,770	8,713,302	9,138,363
Open-hearth	2,230,292	2,947,316	3,402,552	4,656,309	5,687,729
Crucible, etc.	93,548	128,500	131,250	103,984	121,158
Total tons	8,932,857	10,662,170	10,218,572	13,473,595	14,947,250
Total metric tons	9,075,783	10,832,765	10,382,069	13,689,945	15,186,406

The increase in Bessemer steel in 1902 was 6·8%, while that in open-hearth steel was 22·2%; the increase in the total output of all kinds of steel was 12·2%. In part, the small increase in Bessemer steel was due to a local and temporary cause; but the gain in open-hearth steel was a substantial one, both in quantity and in proportion to the total.

The comparatively small increase in Bessemer steel was due to the closing down of the Lackawanna Steel Co.'s plant at Scranton; while the new works of that company at Buffalo were not yet completed.

The application of the different kinds of steel continued practically the same as heretofore. Rails continue to be made of Bessemer steel almost exclusively, and it is also used for bars and merchant steel very largely; while the open-hearth steel is used for structural material, shapes and sheets. It may be noted, however, that the latest rail mill built—that at Ensley, Ala.—uses basic open-hearth metal. That plant, however, made very few rails last year, having been completed near the close of the year.

It is worth noting also that the greater part of the additional output of open-hearth steel is from the basic furnaces. Of the steel made last year in the open-hearth furnace 79·1% was basic and 20·9% acid steel; the proportions in 1901 being 77·7% and 22·3% respectively. The Bessemer, or converter, production continues to be practically all acid steel, and the basic converter does not come into use here. The proportions of acid and basic steel made are shown in the following table:—

	Acid.		Basic.		Total.
	Tons.	%	Tons.	%	Tons.
Bessemer	9,306,471	61·6	....	....	9,306,471
Open-hearth	1,191,196	7·9	4,496,533	29·7	5,687,720
Crucible	125,000	0·8	....	....	125,000
Totals	10,622,667	70·3	4,496,533	29·7	15,119,200
Totals, 1901	9,854,602	73·1	3,618,993	26·9	13,473,595

The increase last year, as compared with 1901, in acid open-hearth steel was only 14·7%, while that in basic steel was 24·2%. This increase will be augmented by the extension of steel making in the South, where several new plants are being erected and others are contemplated. All of these will naturally make basic steel.

The figures given, emphasize the movement of several years past, and again show that the open-hearth process is growing in importance in this country. This is further shown by the fact that nearly all the new steel plants are open-hearth furnaces. The only important new Bessemer plant now under construction is that of the Lackawanna Steel Co. at Buffalo; and that is not wholly an addition to the converter capacity, since it takes the place of the smaller plant at Scranton, which the company dismantled last year.

Finished Iron and Steel.—The production of all kinds of Bessemer steel rails by the producers of Bessemer steel ingots in 1902 was 2,876,243 gross tons, as compared with a similar production in 1901 of 2,836,273 tons, in 1900 of 2,361,921 tons, and in 1899 of 2,240,767 tons. The maximum production of Bessemer steel rails by the producers of Bessemer steel ingots was reached in 1902, but the increase in that year over 1901 amounted to only 40,020 tons, or 1·4%. As compared with 1887, 15 years ago, the increase in 1902 in the production of Bessemer rails amounted to only 831,474 tons, or 40%, while during the same period the increase in the production of Bessemer ingots amounted to 6,202,330 tons, or almost 211%.

With the exception of the Lackawanna plant at Scranton, which was dismantled in 1902, all the Bessemer rail mills were operated nearly to their full capacity in that year, the demand for steel rails being greater than the supply all through the year. Some interruption to the utmost possible activity of the Bessemer rail mills in 1902 was also caused by the inability of the railroads to deliver raw materials promptly to the blast furnaces.

To the above total for 1902 must be added 59,099 tons of Bessemer rails made in the same year from purchased blooms and from re-rolled and renewed Bessemer steel rails, making a grand total for 1902 of 2,935,392 tons of Bessemer steel rails. Twenty plants rolled or renewed Bessemer steel rails in 1902.

The production of open-hearth steel rails in the United States in 1902 was 6,029 tons, as compared with 2,093 tons in 1901 and 1,333 tons in 1900. The maximum production of open-hearth rails was reached in 1881, when 22,515 tons were made. The rails rolled in 1902 were made in Pennsylvania and Alabama, the latter producing over five-sixths of the total quantity made. The production of iron rails in 1902 was 6,512 tons, all made in Pennsylvania, Alabama, Ohio, and California, and all weighing less than 45 lb. to the yard. In 1901 the production of iron rails was 1,730 gross tons, as compared with 695 tons in 1900, 1,592 tons in 1899, and 3,319 tons in 1898. Adding the open-hearth and iron rails produced in 1902 to the Bessemer steel rails made in that year gives a grand total for 1902 of 2,947,933 tons of all kinds of rails, the largest production ever attained in one year, as compared with a total production of 2,874,639 tons in 1901, 2,385,682 tons in 1900, 2,272,700 tons in 1899, and 1,981,241 tons in 1898.

The production of open-hearth steel rails may be expected to show a large increase in 1903, owing to the active operation of the Ensley plant of the Tennessee Coal, Iron & Railroad Co., which makes rails from basic open-hearth steel.

The following table gives the production of all kinds of rails in 1902 according to the weight of the rails per yard. Street rails are included in the total production of rails, but the quantity made in each year can no longer be given separately.

Kind of Rails—Long Tons.	Under 45 Pounds.	45 Pounds and Less than 85.	85 Pounds. and Over.	Total. Long Tons.
Bessemer steel rails	253,167	2,037,063	645,162	2,935,392
Open-hearth steel rails	2,206	3,821	.....	6,029
Iron rails	6,512	.....	.....	6,512
Total for 1902	261,887	2,040,884	645,162	2,947,933
Total for 1901	155,406	2,225,411	493,822	2,874,639
Total for 1900	157,531	1,626,093	602,058	2,385,682
Total for 1899	133,836	1,559,340	579,524	2,272,700
Total for 1898	123,881	1,404,150	453,210	1,981,241
Total for 1897	88,896	1,223,435	335,561	1,647,892

The increase in the production of rails weighing under 45 lb. to the yard from 1897 to 1902 was 172,991 gross tons, in rails weighing 45 lb. and less than 85 lb., 817,449 tons, and in rails weighing over 85 lb., 309,601 tons.

The total production of all kinds of iron and steel rolled into finished forms in the United States from 1898 to 1902 is given below:—

Year.	Iron and Steel Rails.	Bars, Hoops, Skelp, and Shapes.	Wire Rods.	Plates and Sheets, except Nail Plate.	Cut Nails. Gross Tons.	Total. Gross Tons.
1898	1,981,241	3,941,957	1,061,683	1,448,301	70,188	8,514,370
1899	2,272,700	4,996,801	1,036,398	1,903,505	85,015	10,294,419
1900	2,385,672	4,390,697	846,291	1,794,528	70,245	6,487,448
1901	2,874,639	5,685,479	1,365,934	2,254,425	68,850	12,349,327
1902	2,947,933	6,583,545	1,574,293	2,665,409	72,936	13,944,116

The production of wire nails in the United States in 1902 amounted to 10,982,246 kegs of 100 lb., as compared with 9,803,822 kegs in 1901, an increase of

1,178,424 kegs, or over 12%. In 1900 the production amounted to 7,233,979 kegs, in 1899 to 7,618,130 kegs, in 1898 to 7,418,475 kegs, in 1897 to 8,997,245 kegs, in 1896 to 4,719,860 kegs, and in 1895 to 5,841,403 kegs. The total production of cut nails in 1902 was 1,633,762 kegs of 100 lb. each, as compared with 1,542,240 kegs in 1901, an increase of 91,522 kegs, or almost 6%. In 1886 the maximum production of 8,160,973 kegs was reached. In 1902 the production of wire nails exceeded that of cut nails by 9,348,484 kegs, in 1901 by 8,261,582 kegs, in 1900 by 5,660,485 kegs, in 1899 by 5,713,790 kegs, in 1898 by 5,846,254 kegs, and in 1897 by 6,890,446 kegs.

One branch of iron manufacture has almost ceased to exist. In 1902 there were no forges in operation in the United States for the manufacture of blooms and billets directly from the ore. In 1901 the blooms and billets so made amounted to 2,310 gross tons, as compared with 4,292 tons in 1900, 3,142 tons in 1899, 1,767 tons in 1898, 1,455 tons in 1897, 1,346 tons in 1896, 40 tons in 1895, 40 tons in 1894, 864 tons in 1893, and 2,182 tons in 1892. All the ore blooms produced since 1897 were made by the Chateaugay Ore & Iron Co., of Plattsburgh, New York, at its Standish Iron Works, which were, however, idle in 1902.

The iron blooms produced in forges from pig and scrap iron in 1902, and which were for sale and not intended for the consumption of the makers, amounted to 12,002 gross tons, as compared with 8,237 tons in 1901, 8,655 tons in 1900, 9,932 tons in 1899, 6,345 tons in 1898. All the pig and scrap blooms made in forges from 1895 to 1902, and intended to be for sale, were made in Pennsylvania and Maryland.

The United States Steel Corporation.—As the United States Steel Corporation, the organization of which was noted and described in THE MINERAL INDUSTRY, Vol. X., now produces over 50% of the pig iron manufactured in the United States, and over 60% of the steel and finished products, its report for 1902 constitutes an important part of the history of the iron trade for the year. An analysis of this report is given in the following pages and contains very full information as to the operations of the company. It covers the calendar year 1902.

The balance sheet, summed up and reduced to its closest possible analysis, shows assets and liabilities as below:—

Common stock	$508,302.500	
Preferred stock	510,281,100	
Stocks of subsidiary companies	215,914	
		$1,018.799,514
Bonds, U. S. Steel Corporation	$301,059,000	
Obligations of subsidiary companies	69,285,878	
		$870.344.878
Sinking and other special funds		29.698,993
Current accounts and liabilities		49,826,252
Surplus fund		77,874,597
Total liabilities		**$1,546,544,234**
Properties owned and improvements		$1,328,446,343
Sinking fund and miscellaneous		8,263,784
Inventories, material on hand		104,390,845
Accounts, bills and collectable assets		60,280,140
Cash on hand		50,163,172
Total assets		**$1,546,544,234**

To put it briefly, the company has, in capital stock, $1,018,799,514, on approximately half of which it has agreed to pay 7% yearly, before the other half can receive anything; it has $370,344,878 in obligations constituting liens on part or all of its property; it has $29,698,933 in special funds intended to retire those liens or to replace property worn out or destroyed; while the remainder of $127,418,831 constitutes the working capital held in hand to carry on its enormous operations, without friction. The iron ore mined by the corporation from its mines in the Lake Superior region was as follows, in long tons:—

	Tons.	Per Cent.
Marquette Range	1,487,870	9·3
Menominee Range	2,675,754	16·7
Gogebic Range	2,064,492	12·8
Vermillion Range	2,057,537	12·8
Mesabi Range	7,778,026	48·4
Total	16,063,179	100·0

These shipments were 58·3% of the total ore output of the Lake region last year. For the current year the proportion will be higher, as the Steel Corporation has acquired additional holdings.

The coke produced was 9,521,567 tons. The coal mined from the corporation's mines, and not used in the production of coke, was 709,367 tons. This would make a total of approximately 15,000,000 tons mined by the company. This shows that the hold of the company upon the coal supply is much less extensive than that upon the output of iron ore. The company must have bought a large quantity of coal from outside parties last year. Of the coke, however, its works produced nearly 38% of the total output of the country last year. It must be remembered, however, that nearly all of the coke last year came from the Connellsville district, which is a region now on the decline.

The production of steel ingots at the various works was as follows last year:—

	Long Tons.	Per Cent.
Bessemer steel	6,759,210	69·4
Open-hearth steel	2,984,708	30·6
Total	9,743,918	100·0

This total is 64·4% of the total output of steel ingots in the United States last year. It shows that the United States Steel Corporation must have bought a large quantity of pig iron from outside interests.

The production of the corporation's blast furnaces last year was: Pig iron, 7,802,812 tons; spiegeleisen, 128,265 tons; ferromanganese, 44,453 tons; total, 7,975,530 tons. This was 44·8% of the total output of pig iron in the United States. The proportion—as with iron ore—will probably be greater this year, in view of the new furnaces completed, and those bought by the corporation. If the spiegeleisen and ferromanganese are taken separately, it is found that the corporation's output was 81·1% of the total production in the United States.

The subjoined table shows the total quantity of finished products made; in this table the item of billets and blooms shows only the quantity shipped and sold to others in that form, and does not include billets made and afterward converted into other products in the company's mills:—

	Long Tons.	Per Cent.
Billets and blooms sold and shipped	782,637	9·5
Rails	1,920,786	23·4
Merchant steel, bars, shapes, etc.	1,254,560	15·3
Plates	649,541	7·9
Sheets and tin-plates	783,576	9·6
Wire and wire products	1,122,809	13·7
Wire-rods	109,330	1·3
Tubes and pipes	744,062	9·1
Axles	136,787	1·7
Spikes, bolts, nuts, etc.	42,984	0·5
Rail-joints and angle-bars	139,954	1·7
Structural work (Am. Bridge Co.)	481,029	5·9
Miscellaneous	29,177	0·4
Total finished products	8,197,232	100·0

Only 9·5% of the steel made was sold in the comparatively crude form of billets. The table shows the wide range of products made in the company's various mills.

The tonnage of unfilled orders on the books at the close of 1902 equaled 5,347,253 tons of all kinds of manufactured products. At the corresponding date in preceding year the orders booked equaled 4,497,749 tons. In many of the classes of heavier products, like rails, plates and structural material, practically the entire capacity of the mills is sold up until nearly the end of the year 1903.

The income account for the year—condensed as far as possible—may be given as follows:—

Gross sales and earnings	$560,510,479
Rentals and miscellaneous	3,128,971
Interest on investments and receipts from companies controlled	5,426,452
Total receipts	$569,065,902
Manufacturing cost and operating expenses	$411,408,818
Selling, general and transportation expenses	13,202,399
Taxes, discounts and current interest	4,299,494
Rentals and interest, subsidiary companies	6,846,427
Total expenses	$435,757,138
Net earnings	$133,308,764
Depreciation and replacement funds, regular	$14,150,325
Depreciation and replacement funds, extraordinary	10,000,000
Interest on U. S. Steel Corporation bonds	15,187,850
Sinking fund on Corporation and subsidiary bonds	3,664,064
Total charges	$43,002,239
Net balance for stock	$90,306,525
Dividends paid, 7%, on preferred stock	$35,720,178
Dividends paid, 4%, on common stock	20,332,690
Total dividends	$56,052,868
Undivided profits, to surplus	$34,253,657

Had all the net earnings shown been applied to dividends, they would have been sufficient to pay 10·74% on the common stock. The sum available for dividends was 15·84% of the gross receipts. In this case it is impossible to make any close averages of production; it may be stated, however, that the gross sales and earnings showed approximately $68·37 per ton of finished steel product, and the total receipts $69·42 per ton. The manufacturing expenses were $50·19, and the total expenses $53·16 per ton.

The report states that "the actual expenditures for ordinary repairs and maintenance included in operating expenses were $21,230,218. It cannot be stated, however, that this specific sum was taken out of the net earnings for the year, because in the manufacturing and producing properties the expenses for repairs and maintenance enter into and form a part of production cost. And as the net earnings of such properties are stated on the basis of gross receipts for product shipped, less the production cost thereof, the income for the year is charged with outlays for repairs and maintenance only to the extent that the production during such period was actually shipped. But as the shipments in 1902 equaled practically the year's production, approximately the entire amount of the expenditures in question has been deducted before stating the net earnings as above."

The report states, in brief, that the physical condition of the properties has been fully maintained during the year, the cost of which has been charged to current operations. The amount expended during the year for maintenance, renewals and extraordinary replacements aggregated $29,157,011. Of this amount $7,926,793 was for extraordinary replacements, the bulk of the same ($6,978,230) being in connection with the manufacturing properties. The ordinary maintenance and repairs aggregated $21,230,218, of which $16,099,218 was spent on the manufacturing properties and $3,544,654 on the railroad properties; remainder scattering.

From the organization of the corporation, April 1, 1901, to Jan. 1, 1903, the amount of bonds and mortgages paid and retired by all the companies, including bonds purchased for sinking fund, was $6,384,759; bonds and mortgages issued for new property acquired, $3,456,660; net decrease, $2,928,099.

The unsecured obligations of the subsidiary companies, consisting of purchase money obligations, bills payable and special deposits, were reduced during the fiscal year 1902 by $13,652,368, and during the entire period from April 1, 1901, to Dec. 31, 1902, by $27,700,339. The funds for said payment were provided entirely from the surplus net earnings; no new capital or bonded or other liability has been created in lieu thereof, although practically all of such payments might properly be funded, as the liabilities were those of the subsidiary companies prior to or at the time of organization of the United States Steel Corporation for the acquirement of additional property or for moneys borrowed, which were in turn used for purchase of property and construction expenditures.

As shown by the balance sheet, the amount of these liabilities outstanding on Dec. 31, 1902, is $17,377,468, as follows: Purchase money obligations, $6,689,419; bills payable, $6,202,502; special deposits, $4,485,547.

The expenditures made during the year by all the properties and charged to property account equaled, less credits for property sold, the total sum of $16,586,532. These outlays were made for the completion of construction work at manufacturing properties under way when the United States Steel Corporation was organized, also for necessary additions and extensions authorized since its organization, for the acquirement of additional ore and coal property, the opening and development of new mines and plants, for additional equipment and facilities demanded by the growing requirements of the business of the transportation properties, to secure material reduction in cost of manufacture, transportation of raw and unfinished material, and distribution of finished products, etc.

The outlays as above are classified by properties as follows: Acquirement of stocks of subsidiary companies, $258,473; manufacturing properties, $9,743,126; ore properties, $1,971,542; coal and coke properties, $2,043,169; transportation properties, $2,741,653; total, $16,757,963. Against this there was a credit of $171,430 on miscellaneous properties sold; leaving a net outlay of $16,586,533, as above.

The average number of employés in the service of all properties during the entire year was 168,127. The aggregate amount paid for salaries and wages of employés was $120,528,343.

One of the most important points to be considered in the trade in 1902 was the course of the United States Steel Corporation as to the extension of its operations. During the greater part of the year the corporation was quiet in this direction, and little was heard of any further additions to its properties, its apparent policy having been simply to round out and complete the works which it already owned, particularly by the addition of blast furnace capacity. It will be remembered that the number of blast furnaces owned by the big corporation on its first organization was not sufficient to supply its steel works with pig iron, and the consequence was that heavy purchases of pig iron had to be made from time to time. This outside buying was chiefly done from the Bessemer Steel Association, the organization of the blast furnace operators of the Mahoning and Shenango valleys, in western Pennsylvania and Ohio. Apparently the corporation did not intend to enlarge the number of its plants or possibly postponed any such action until the settlement of the litigation in which its proposed issue of $250,000,000 in bonds was involved. In December, however, there was a sudden change in this respect, and it was announced that the corporation had purchased the property of the newly formed Union Steel Co., which was a consolidation of the Union Steel Co., which, during the year, had been constructing blast furnaces and steel works at Donora, near Pittsburg, and of the Sharon Steel Co., which owned comparatively new works of the best modern types at Sharon, Pa. The purchase included the transfer of all the property and assets of the Union Co., comprising, besides the works above mentioned, large interests in iron ore on the Menominee and Mesabi ranges, in the Lake Superior region, and also a large working capital which had been provided by the stockholders. The price paid was $45,000,000, payment being made in bonds secured by mortgage upon the properties turned over. It may be said that there were special reasons for the acquisition of these properties. In the first place they gave the corporation an important addition to its blast furnace capacity. Beyond that, however, they put an end to the prospect of a serious competition in the wire and nail trades, and strengthened the United States Steel Corporation on a side where it had been particularly weak, and open to attack. The result in this direction will probably be the closing of some of the older works of the company and the transfer of a portion of the wire business of the Donora and Sharon mills. Beyond the points mentioned, however, a strong motive for the purpose is found in the ownership of the iron ore properties, but to this point reference is made elsewhere.

Another purchase reported in December was that of the property of the old Troy Steel Co., located at Breaker Island, on the Hudson River, near Troy, N. Y. This property, which had been operated for a number of years with various fortunes, but which had been idle for several years past, included three blast furnaces having a yearly capacity of 160,000 tons of pig iron, with rolling mill for structural material, merchant steel and sheets and a basic Bessemer steel plant, for a long time the only one of the kind in the United States. This property was sold early in 1902 to parties who incorporated a new company known as the Troy Steel Products Co., and announced plans for starting up the mills and adding tin-plate and wire mills. This project, of course, came to an end with the sale. The furnaces when in operation used magnetic ores from the neighborhood of Crown Point, and Port Henry, on Lake Champlain, making a basic pig. The chief object of this purchase is that the plant provides blast furnaces, and can furnish basic iron for the open-hearth steel furnaces of the big wire works at Worcester, Mass. The Bessemer plant has been given up and the mill machinery transferred to other works.

A deal which was closed just after the end of the year was the purchase of the important interests on the Mesabi iron range, owned by the Hill or Great Northern Railroad interest. From the beginning, it has evidently been the intention of the United States Steel Corporation to control the Lake Superior iron ore deposits and no opportunity has been lost of strengthening its hold upon them. The purchases made by Mr. Hill were intended chiefly to give the traffic of the mines held to the Eastern Minnesota road, owned by the Great Northern Co., and this object was quite as well secured by a contract with the United States Steel Corporation as by the actual ownership and operation of the mines. In this connection it may be well to mention the fact that there were a good many transactions in iron properties in different parts of the United States made during the year. Most of these were completed in a quiet, not to say secret way, and in most of them the actual purchasers remained more or less a mystery. Under these circumstances, it is not at all out of the way to surmise that the United States Steel Corporation was back of many of these transactions, and that its ultimate object in them is to control the iron ore output of the country.

IMPORTS OF IRON AND STEEL, 1899—1902. (IN LONG TONS.)

Article.	1899.	1900.	1901.	1902.
Pig iron, spiegeleisen, and ferromanganese	40,398	52,565	62,930	625,383
Scrap iron and scrap steel	10 925	34,481	20,130	109,510
Bar iron	19,791	19,685	20.792	28,844
Iron and steel rails	2,134	1,448	1,905	63,522
Hoop, band, or scroll iron and steel	663	165	2,974	3,362
Steel ingots, billets, structural steel, etc	12,601	12,709	8,163	289,318
Sheet, plate, and taggers' iron and steel	7,043	5,143	5,621	7,156
Tin plates	58,915	60,386	77,395	60.115
Wire rods, iron and steel	·17,964	21,092	16,804	21,382
Wire, and articles made from wire	2,363	1,848	4,129	3,468
Anvils	240	223	251	203
Chains	188	260	198	576
Total	173,220	209.955	221.292	1,212,889

Imports and Exports.—The results of the enormous home consumption in 1902 were apparent in a diminution of exports and an increase in imports. The demand and prices at home made it difficult to compete with Great Britain and Germany in foreign markets; while large quantities, especially of pig iron, scrap and steel billets, were absorbed by our manufacturers.

The preceding table, compiled from the reports of the Bureau of Statistics of the Treasury Department, gives the quantities of leading articles of iron and steel imported into the United States in the four calendar years 1899, 1900, 1901 and 1902.

The total imports of iron and steel, including machinery, cutlery, firearms, etc., for which weights are not obtainable, amounted in foreign value to $41,468,826 in the calendar year 1902, as compared with $20,395,015 in 1901, $20,443,911 in 1900, and $15,800,579 in 1899, an increase in 1902 as compared with 1901 of $21,073,811, or over 100%. Of the pig iron imported in recent years a large part was spiegeleisen and ferromanganese, which pay duty as pig iron, but in 1902 there was a great increase in the importations of foundry and Bessemer pig iron.

The following table, also compiled from the reports of the Bureau of Statistics of the Treasury Department, gives the exports of leading articles of iron and steel in the calendar years 1899, 1900, 1901 and 1902:—

EXPORTS OF IRON AND STEEL, 1899—1902. (IN LONG TONS.)

Article.	1899.	1900.	1901.	1902.
Pig iron	228,678	286,687	81,211	27,487
Scrap and old, for remanufacture	76,663	40,328	14,199	9,411
Bar iron	10,898	18,299	17,708	22,249
Band, hoop, or scroll iron and steel	2,869	2,976	1,561	1,674
Bars or rods of steel not wire rods	30,429	81,366	27.397	9,300
Steel wire rods	16,992	10,652	8,165	24,618
Billets, ingots, and blooms	25,487	107,385	28,614	2,409
Cut nails and spikes	9,974	11,168	9,302	7,170
Wire nails	33,517	27,404	18 778	26,580
All other nails, including tacks	2,076	1,812	1,806	2,244
Iron plates and sheets	6,196	9,381	6,900	3,434
Steel plates and sheets	50,635	45,534	28,923	14,866
Iron rails	6,442	5,874	901	211
Steel rails	271,272	356,245	318,055	67,455
Structural iron and steel	54.244	67.714	54.005	58,859
Wire	116,317	78,014	88,288	97,848
Total	942,689	1,154,284	700,857	370,805

The total exports of iron and steel, which include locomotives, car wheels, machinery, castings, hardware, saws and tools, sewing machines, stoves, printing presses, boilers, etc., amounted in the calendar year 1902 to $97,892,036, as compared with $102,534,575 in 1901, $129,633,480 in 1900, $105,690,047 in 1899, $82,771,550 in 1898 and $62,737,250 in 1897. The exports of iron and steel more than doubled in value from 1897 to 1900, but there was a shrinkage in 1901 as compared with 1900 of $27,098,905, or more than 20%. In 1902 there was a further shrinkage, but it was not so pronounced as in 1901, owing to the advance in prices.

The exports of agricultural implements, whch are not included above, amounted in the calendar year 1902 to $17,981,597, as compared with $16,714,308 in 1901, $15,979,909 in 1900, $13,594,524 in 1899, $9,073,384 in 1898, and $5,302,807 in 1897.

Technical Changes.—Technical progress in this country during 1902 was confined mainly to the construction of larger furnaces; to increased intensity of production; to improvements in the handling of ore, fuel and other material; and to dispensing with manual labor as far as possible by the introduction of machinery. The new furnaces constructed in Pennsylvania and Ohio were of the largest type, capable of providing 500 tons of iron daily, and were all furnished with machinery of the latest type. In the Southern district a few old furnaces were rebuilt and a few new ones constructed. These were generally of a smaller class, running from 100 to 150 tons of iron a day, although they were also furnished with improved machinery. The leaner ores of the South do not lend themselves so readily to fast driving and high production as do the Lake Superior ores, which now form the staple supply of the Pittsburg furnaces.

Increased attention is being paid to the saving of by-products and the utilization of material, hitherto considered as waste. Thus the quantity of slag from basic furnaces used in the manufacture of cement is increasing rapidly, as will be shown by the figures given elsewhere in this volume in the article on "Slag Cement." The manufacture of bricks and paving blocks from slag has also been undertaken in several places. The use of by-product coke is increasing, and the design of nearly all the new blast furnaces includes the construction of a block of by-product ovens. This is found to be of great advantage, not only on account of the actual saving, but also because the furnace secures the immediate control of its own coke supply.

One very important source of waste, however, still attracts but little attention in this country. With on exception, to be noted later in this section, the only method in which the waste gases from the blast furnace are utilized in the United States is for the heating of the blast stoves and occasionally for raising steam in boilers. A notable exception is found in the new plant of the Lackawanna Steel Co., at Buffalo, where gas engines aggregating 3,500 H. P. are being installed, to be driven by blast furnace gas. These engines are furnished by the De La Vergne Co., of New York. They will be used chiefly to generate electric power by which the machinery of the plant will be operated.

The Talbot continuous steel process is now being tried experimentally abroad, where its operation has excited a good deal of controversy. It has not yet been put in use anywhere in the United States, except in the original plant at the Pencoyd works. There has been some extension in the use of the Tropenas and other small converters and in the making of steel castings direct from the furnace. The use of casting machines at blast furnaces is becoming quite general, and, in fact, their operation is essential with furnaces of the very large capacity which are now quite common.

The fact that comparatively few improvements have been made was quite natural. A period when business is extremely active and furnaces, converters and mills are driven to their full capacity, is not a time when ironmasters can stop to make experiments, or to introduce new machinery, which is not absolutely necessary. The tendency is to postpone matters to a more convenient season.

THE IRON AND STEEL MARKETS IN 1902.

The consumption of iron and steel in the United States continued throughout 1902 to be on a scale altogether unexampled in history. In fact, the year seemed to be the culmination of a continued period of prosperity. The continuance of good crops for several years, coupled with comparatively short crops in Europe, created a demand abroad for our agricultural products, which brought into the United States an enormous amount of money, and furnished people with funds for building and for investment in enterprises of various kinds, thereby creating a demand for material which showed no signs of slackening during the year. Building in all of the large cities was on an enormous scale, and there was a continuance of the tendency shown for several years to increase the use of iron and steel in building construction. The railroad demand which was at one time considered the chief factor in the iron trade, is now of much less relative importance than formerly, although the quantity actually consumed by the railroads has largely increased during the year. The general prosperity of the country enabled the railroads to make renewals very freely, and to enter on many schemes of improvement and new construction in order to enable them to handle traffic more conveniently and more cheaply. This involved the use of large quantities of new rails, bridge steel and the like, while new equipment also absorbed additional quantities. The new railroads built in the United States during 1902 amounted, according to a statement prepared by the *Railroad Gazette*, to 6,024 miles, which is the largest report made for more than eight years past. Notwithstanding the large quantity of steel required for this purpose, it was very much less than that taken for renewals for new sidings and additional tracks on the more important lines. The construction of electric railroads also was very active during the year, and the material required with these enterprises formed a large item of the demand. Girder rails which are generally used for these roads, in fact, were turned out by the rail mills to an extent never before reached.

Almost immediately after the opening of 1902 the rush for material began, and by the end of January the capacity of blast furnaces and rolling mills was pretty fully taken up for the first half of the year. At the same time, the rail mills were completely filled for the year, and some important orders from Mexico and South America, which were offered here, were refused, owing to the inability of the makers to fill them, and went finally to English and German mills. All through the first part of the year the demand continued large, and in February a new and more special pressure for foundry iron began. It seemed as though a number of the larger consumers had up to that time either been doubtful as to the continuance of high pressure conditions in the trade, or had been too confident of their supplies, for in that month a number of them came into the market to an extent which for the time being threatened general demoralization. The immediate pressure, however, was averted for the time by offers of Scotch and Middleboro iron from Great Britain and of German pig, while at the same time a number of large contracts were made which filled the order-books of the furnaces for the third quarter, and in some cases went into the fourth quarter of the year.

Under ordinary conditions this state of affairs would have resulted in a sharp rise of prices, and it is quite possible that this might have been carried to an extent which would for the time being have acted as a check upon consumption. The policy which the United States Steel Corporation had announced in 1901 was, however, strictly adhered to. That company refused to make more than a very slight advance in its quotations, and its influence on this point served to steady the market, and to compel the minor producers to hold back. Later in the year there were advances made to a certain extent under the form of premiums paid for early deliveries of material, but these affected only a portion of the trade, and could hardly be accepted as constituting a general advance. The United States Steel Corporation, through its control of a considerable portion of the Lake Superior mines, succeeded also in preventing any advance in the prices of Lake ore, which were fixed just before the opening of navigation on about the same figures that prevailed in 1901, and which were maintained at those figures throughout the year. The schedule of prices was $4·25 per ton, delivered on dock at Lake Erie port, for Bessemer old range; $3·25 for non-Bessemer old range, and Bessemer Mesabi, and $2·75 for non-Bessemer Mesabi. The United States Steel Corporation, through its control of a large number of Lake vessels, succeeded also in fixing the basis of rates on the Lakes, which during the year showed less variations than for a number of years previously, but this point of the subject is fully treated in our local reports below.

Production at the blast furnaces continued during the early part of the year at a high point, and the blowing in of several new furnaces with large outputs increased the total. Later in the year the railroad difficulties affected production to a considerable extent by preventing the free delivery of coke and compelling furnaces to bank or to restrict their output. This introduced a certain element of irregularity, and reports from the furnaces were closely watched throughout the trade. By the middle of the year imports of foreign iron had begun to attain considerable proportions. The total was, of course, small in comparison with our home production, but it exceeded the quantity imported in any previous year. These imports undoubtedly had a good effect in constituting the market, and in assuring the consumers that they could, if necessary, secure supplies of pig iron and steel billets from abroad, in case our own works were unable to furnish them.

In June a disturbance appeared in the strike of the blast furnace workers in western Pennsylvania, the consequences of which threatened to be serious. This strike, however, was quickly settled, and did not affect the production to any considerable extent, as had been feared. By the end of June the furnace and mill capacity had been pretty well taken up for the balance of the year, a condition probably never before known at so early a date. No producers of importance were able to accept orders after that time for delivery in 1902, except in a few special lines. In some grades of sheets, in wire and in tin plate, it was evident that the capacity of the United States to absorb the material have been overestimated, and in those branches particularly, there was more or less competition among the independent producers and the mills controlled by the United States Steel Corporation. This served to keep down prices to some extent, and also to prevent the premiums for early deliveries which prevailed in most other branches of the trade. Railroad and building enterprises which had not contracted for material before this time were compelled to postpone construction until a more convenient season. Railroads were generally able to secure the supplies they needed it some shape or other, but, trolley enterprises and new building suffered considerably. In structural steel especially, some large purchases were made during the latter half of the year from middlemen or others who held contracts with the mills, and in these cases a considerable advance upon the current quotations was paid.

During the last half of the year conditions remained the same. The history of the trade was a continual struggle to secure material, and to keep up with contracts for delivery, and the position was complicated by the fact that the railroads were handling an unprecedented amount of traffic in all directions, so that annoying delays and blockades were frequent. Fuel, ores and other raw materials did not reach furnaces and mills, and they were unable to clear their yards of finished material for which consumers were waiting. It is only justice to say that the leading railroad lines made every effort to put an end to this condition of affairs, and to handle their traffic as promptly as possible, but most of them seemed to have underestimated probable demands, and from every quarter there came complaints of shortage of cars and motive power. It can hardly be said that there was any improvement in this direction up to the end of the year.

Alabama.[1]—The conditions in the Birmingham iron market, including the entire iron region of Alabama and the adjacent States, were extremely active throughout the year. Production was on an unexampled scale. Not a single iron company in Alabama failed to make money in 1902. These profits have not all appeared in dividends, as a large part of the money was wisely expended in improving the properties and accumulating a good working surplus. Not only was all the iron produced during the year sold, but, in fact, many of the companies closed the year with a shortage on their contract deliveries. This was not due so much to any trouble at the furnaces as to the ore shortage which, during the last three months of the year, considerably embarrassed the iron manufacturers. Moreover, nearly every blast furnace in this section has nearly, if not quite all its product for the first half of 1903 under contract. A great deal more could have been sold for later deliveries, but many of the furnaces were unwilling to take orders running beyond June, believing that they did better by adhering to this course.

The closing quotations for pig iron were as follows: No. 1 foundry, \$21@\$22; No. 2 foundry, \$20@\$21; No. 3 foundry, \$18·50@\$19·50; No. 4 foundry, \$17@\$18; gray forge, \$16·50@\$17; No. 1 soft, \$21@\$22; No. 2 soft, \$20@\$21. Prices for the first half of the year will not fall below \$20 for No. 2 foundry. All deliveries on old contracts at lower prices have now been worked off and there is little doubt that the average realized by Alabama blast furnaces during 1903 will be at least \$18, taking all grades into account.

The rolling mills in the Birmingham district were actively employed throughout the year, and nearly all of them closed the year with large orders on hand for 1903. Foundries and machine shops in the district did also exceedingly well. At the Ensley steel plant work was good. The completion of the rail mill will require a large quantity of steel, especially as the plant had orders for rails well

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[1] By L. W. Friedman.

through 1903. The steel, wire rod and nail mills had no room for complaint over conditions during the year.

New production continued to come forward. The Tennessee Coal, Iron & Railroad Co. completed an additional stack at the Alice Furnace, while the Alabama Consolidated Coal & Iron Co. started a new stack at Gadsden. Rising Fawn Furnace, owned by the Georgia Coal & Iron Co., which had been dismantled for several years, was rebuilt as a coke furnace, and put in blast. Projects for several new furnaces were started, and arrangements made to build at least three additional stacks.

Ohio.[2]—Cleveland in 1902 strengthened its position as a distributing market for a large section of the Central West, remaining the center from which was directed the movement of iron ore from the Lake Superior region. Sales of iron ore and the chartering of vessels to carry the product down the lakes, developed later in 1902 than in any season for some time past. The opening of spring found iron ore producers still undecided as to a price policy for the season. The old range operators demanded a stable list of prices, and felt that they ought to obtain a better price for their product in view of its increasing scarcity. The Mesabi producers were strongly inclined to advance prices and make a general grab for all they could get; at the same time they showed a desire to increase profits by bearing Lake freights. It was generally believed that the time had come for an ore pool to regulate prices and output. A general survey of the field, however, soon showed this idea to be impracticable. The old range men therefore accepted the price of the previous year, $4·25 for Bessemer grades, while the Mesabi range men put up their price on Bessemer Mesabi $0·50 to $3·25, and on non-Bessemer Mesabi to $2·75, non-Bessemer old range taking the same price as Bessemer Mesabi. While there was no agreement as to prices the individual announcement of each company was on this basis, and it lasted through the year.

Prices having been settled, heavy buying began. Despite supposed stocks of ore in the East, some furnaces in that region bought largely, a conservative estimate of the quantity taken being between 2,500,000 tons and 3,000,000 tons. Sales to Eastern consumers continued through the year, and as many were on the continuous contract plan, with material to be distributed through several years, it is extremely difficult to say just how much ore was sold there for 1902 consumption.

Last spring the vessel interests headed by J. C. Gilchrist, the biggest independent vessel owner, made a vigorous stand for an 80c. Lake freight rate from Duluth to Ohio ports, with a commensurate rate from the other shipping ports, thus opposing the allied ore shippers headed by the United States Steel Corporation. The latter concern learned that one of its larger competitors had been able, through the influence of M. A. Hanna & Co., to make a 75c. rate in 1901, which carried provisions for 1902 as well. The supply of tonnage indicated that 1902 was to be a season of low rates, and the United States Steel Corporation did not like to be worsted by a competitor. The result was that while some shippers paid 80c. on about 1,500,000 tons of ore, the great bulk was chartered under contract at 75c.

The season opened with going rates identical with contract rates, and prospects

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[2] By George H. Cushing.

of a fight over going rates through the year. Some vessel interests refused to handle anything but wild ore rather than take the proposed smaller rates; unfortunately for them the season opened early. Almost the entire fleet of the United States Steel Corporation was in operation by April 10, before contract rates for the season had been determined. The outside vessel men had hoped that boats would not start before May 1. The sudden opening of navigation and the movement of 1,500,000 tons of ore before the vessel men expected any ore to be delivered at all, upset plans generally. In round numbers it has been figured that the amount of ore handled over Lake Erie docks was 22,640,000 tons, as compared with 17,014,000 tons for the season of 1901, an increase of 5,626,000 tons. The quantity which remained on the docks Dec. 1, 1902, was 7,074,250 tons, as compared with 5,859,653 tons on Dec. 1, 1901, an increase of 2,214,597 tons. In 1902 most of the boats made an average of 20 trips for the season, whereas the lowest average heretofore was about 22 trips, a decrease of 11%. Had the car shortage been responsible for vessel delays the quantity of ore moved from the lake docks to furnaces would not have shown such an abnormal percent. of the total increase handled. The quantity of ore moved shows that the railroads did extraordinary work. Ore shippers had no reason to complain of lack of cars or poor dock equipment. In one instance a new automatic unloader handled 5,600 tons in five hours and 15 minutes, 92% of the cargo being taken out automatically. Nor can blame for delays be placed on dock conditions since the entire year was free from labor difficulties.

The hard coal strike immediately threw vessels loading anthracite at Buffalo and Erie to the bituminous shipping ports. These boats not finding their usual number of up-bound cargoes began going back to the head of the lakes light and rushing down ore. The result was a general congestion at lower lake docks, which lasted nearly all summer. The expected importations of ore from the Michipocoten ore fields in Ontario were estimated at 1,000,000 tons. Instead they perhaps have reached 200,000 tons, an increase of 60,000 tons, or 10 cargoes, over 1901. The increased demand for ore in Canada, the partial failure of some projects there and the inferior grade of the ore may have had something to do with keeping down importations.

The following table, prepared by the Cleveland *Iron Trade Review,* shows the performances of docks at the head of the lakes:—

	1901.	1902.	Changes.
Escanaba	4,022,668	5,413,704	I. 1,391,036
Marquette	2,354,284	2,595,010	I. 240,726
Ashland	2,886,252	3,553,919	I. 667,667
Two Harbors	5,018,197	5,605,185	I. 586,988
Gladstone	117,089	92,375	D. 24,714
Superior	2,321,077	4,180,568	I. 1,859,491
Duluth	3,437,955	5,598,408	I. 1,160,453
Total by lake	20,157,522	27,039,169	I. 6,881,647
Total, all rail	431,715	500,000	I. 68,285
Total shipments	20,589,237	27,539,169	I. 6.949,932

The following tables show the quantity handled over Lake Erie docks, and those remaining there in stock on Dec. 1, the close of the navigation year:—

IRON ORE RECEIPTS AT LAKE ERIE PORTS. (IN TONS OF 2,240 LB.)

Port.	1901.	1902.	Changes.
Toledo	798,298	1,087,571	I. 289,273
Sandusky	33,017	165,556	I. 132,539
Huron	431,311	520,646	I. 89,335
Lorain	721.662	1,442,417	I. 720,755
Cleveland	3,831,060	4.873.818	I. 1,042,258
Fairport	1,131,776	1,538,744	I. 356,968
Ashtabula	3,981,170	4,796,805	I. 815.635
Conneaut	3,181,019	4,300,801	I. 1,119,282
Erie	1,379,377	1,717,268	I. 337,891
Buffalo & Tonawanda	1,475,386	2,256,798	I. 781,412
Total	17,014,076	22,649,424	I. 5,635,348

IRON ORE ON LAKE ERIE DOCKS, DEC. 1. (IN TONS OF 2,240 LB.)

Port.	1901.	1902.	Changes.
Toledo	254,196	310,023	I. 55,827
Sandusky	47,384	95,175	I. 47,791
Huron	231,501	232,764	I. 1.263
Lorain	195,863	328,304	I. 132.441
Cleveland	1,378,060	1,500,604	I. 122,544
Fairport	710,590	824,236	I. 113,646
Ashtabula	1,769,145	1,967.136	I. 197,991
Conneaut	604.106	673,679	I. 69,573
Erie	470.718	722,966	I. 252,248
Buffalo	198,100	319,367	I. 121,267
Total	5.859,663	7,074,254	I. 1,214,591

The proportion of direct shipments of ore to furnaces over the Lake Erie docks was very large. Shipments to furnaces between May 1 and Dec. 1 aggregated 18,423,364 tons, compared with 14,204,596 tons in 1901, 11,613,773 tons in 1900, 11,765,158 tons in 1899 and 9,058,829 tons in 1898. It will thus be seen that the direct shipments more than doubled since 1898. The shipments to furnaces during the navigation season above referred to are determined in this way: First, we have the quantity of ore on Lake Erie docks before the opening of navigation on May 1, last, 2,848,194 tons; add to this the receipts of the season just closed, 22,649,424 tons, and the total is 25,497,618 tons; deduct the amount now on dock, 7,074,254 tons, and we have 18,423,364 tons as the amount that was forwarded, either direct or from dock, to the furnace yards. It is understood, of course, that the difference between the output of 27,039,169 tons from the mines and the receipts of 22,649,424 tons at Lake Erie ports, is ore that went to places other than Lake Erie ports, principally to the furnaces at South Chicago.

Pig Iron.—The revulsion against the highest prices during 1901 had spent itself by Jan. 1, 1902, and a gradual advance set in, which continued for nearly six months. Then the market began to show runaway tendencies. On Jan. 1 basic iron was selling for $15·75, Bessemer iron was bringing about the same price, while foundry grades were selling at $16·50. Material was scarce and deliveries very slow. By Jan. 15 Bessemer producers were refusing $16, while the Southern furnaces advanced their prices from $11@$12, Birmingham, and got a good deal of business from this territory. By the end of the month the outlook was bad for small consumers of foundry iron, who depended upon the open market to supply immediate needs.

The basic producers, who had been expecting higher prices to counteract a long suspension of operations, began about Feb. 1 to sell iron for the future, evidently believing that the top had been reached. They sold iron for third-quarter delivery at the market price of $17·50, Valley furnace. Before the first week in February had passed one furnace announced that it had sold up its entire supply of foundry iron for the year at current prices of $16·50 for No. 1 foundry, Valley furnace. Such an announcement, however, seldom means more than two-thirds of the possible output, the remaining one-third capacity being reserved to accommodate old customers, to provide against emergencies or to obtain possibly higher prices.

The business for the year was mostly done before March 1, and the worst operating conditions of the first nine months came during the time the sales were being made. Early in March there was a slight setback on account of floods, which temporarily crippled railroads. The increasing demand for pig iron advanced prices to $17·50 for No. 2 foundry, with premiums for immediate shipment. Toward the end of the month Bessemer and basic producers began to show signs of parting company. The basic producers justified their grab-all policy by saying that they had to make up for the long idleness of their stacks. Bessemer producers began to try to curb the grasping market spirit, and the Bessemer Association held for $16, with basic producers demanding $17, Valley furnace. The beginning of May found foundry iron commanding $20 in the valleys. The quantity of foundry iron sold at this price for early delivery was very small. The strike of the hard coal miners did not affect the pig iron trade for a month, but the demand of furnace workmen in the Mahoning and Shenango valleys, and at some furnaces in Southern Ohio and the Pittsburg district for an 8-hour day instead of one of 12, with no change in wages, caused a strike of a week's duration early in June. It was settled by a 10% increase in wages. Demand was now so near supply that an order for 100 tons of foundry iron had to be divided among three furnaces in the South, the price paid being $16·50, Birmingham. For immediate shipment foundry iron was bringing $22·50, and an offer of $20 for Bessemer iron in this market failed to get a carload. This represented conditions up to July. Foundry prices were up to $21 for third quarter delivery with Bessemer holding at $21·75. When the strike was over and the men returned to work with a 10% advance in wages, the Bessemer and basic producers found trouble ahead, production began to decline and consumers to suffer. There was a demand for material for delivery during 1902, and the first quarter of 1903. Bessemer iron for first quarter delivery sold at $16·50.

The strike of the miners in the Pocahontas district and the resulting coke shortage shut down 12 furnaces in the Southern Ohio district and some near Pittsburg district. By August foundry iron for immediate shipment commanded $24@$25, with buyers eager to get it, and by September sales of foundry grades were developing for the first quarter of 1903. Prices for immediate shipment climbed higher and higher, until foreign producers were able to ship to the Mahoning and Shenango valleys and the Pittsburg district. Early in October foreign iron began to arrive, and to the end of the year the needs of the market not supplied by contracts were met very largely by importations from Scotland and Nova Scotia. The demand for foundry iron advanced prices to $27@$28 for immediate delivery. The shortage in car supply was so bad during October that some stacks were idle 10 days out of the 30, and the supply of coke shortened until in November some furnaces were idle 20 days out of 30. It was evident that furnaces would have to carry over into 1903 the greater part of many orders taken for delivery during 1902, and that deliveries on such contracts will hang on, most likely, until April 1 of the new year. The remarkable season of 1902 closed with foundry iron sold up for the first half of 1903, with some sales made into the third quarter, the first half prices being $23, Valley furnace, and those for the second half being $21, Valley furnace. Members of the Bessemer Association sold up their material for first quarter delivery in 1903. The non-association furnaces sold Bessemer for the first half and a good deal for the second half at $23 prior to July 1, and $21 after that date. During the year 25 new furnaces were started in this region tributary to the Lake Superior ore supply, each of which will produce, on the average, 400 tons of pig iron daily.

Bar Iron and Steel.—The year opened with bar iron weak at 1·50c. Pittsburg. Bessemer steel bars were 1·50c., with the usual $2 difference for open-hearth. There was an advance the first week in February to 1·60c. for bar iron, while steel bars remained unchanged. By March 1 the bar iron mills had forced prices up to 1·70c. The result was an establishment of a price of 1·60c., Pittsburg, for Bessemer, with open-hearth bringing 1·70c., Pittsburg. Early in May bar iron rose to 1·80c., where it remained for the summer. Billets became scarce, but after a while producers of Bessemer steel bars began to substitute them for iron bars and the situation was relieved. Shortly after tin-plate mills suspended operations, throwing a good many steel billets upon the open market. Between Bessemer steel bars on one side and the competition of Bessemer billets on the other, the bar iron producers after Aug. 1 found some difficulty in marketing their product at a profit. It was later in the season before any reduction was made, and mills intimated that prevailing market quotations might be shaded on very choice specifications, but the nominal prices established in May of 1·80c. for bar iron and 1·60c., Pittsburg, for Bessemer, and 1·70c., Pittsburg, for open-hearth, prevailed at the end of December.

Sheets.—Prices started in 1902 at 3·10@3·25c. for No. 27, the basis for the other gauges. The first week of January showed that stock men were preparing for a coming rush. Prices advanced sharply by Jan. 15, the sheet sales being on the basis of 3·35@3·50c. for No. 27, out of stock, with mill sales at a lower price. Selling continued active through February and well into March. By March 15 jobbers demanded and received 3·40@3·55c. for No. 27. Prices again advanced, and before April 1, No. 27 was quoted at 3·45@3·50c., out of stock. In this trade as well as in many others, probably the greater part of the business for the year was done at moderately low prices. By May 15 producers of sheets began to feel the general shortage of steel. In March a convention of the sheet mills, independent of the United States Steel Corporation, had determined to send a representative abroad. W. F. Bonnell, of Cleveland, was chosen and spent three months in England, Germany and Belgium looking for material. An order was placed and imports began about the middle of June. It looked for a while as if outside mills would have to suspend because the United States Steel Corporation would not release billets and sheet bars. With importations of material the home market eased up considerably, and there has been no such shortage since.

To the end of the year there was a marked difference between the heavier and the lighter grades, the heavier indicating a buoyant demand for material while the lighter grades showed indications of overproduction. By July 15 the smaller mills which were looking for business were reported cutting prices, but there was no open cutting till September, then the market dropped and struck what seems to be the bottom price for material out of stock as the January basis, of 3·10@3·20c. for No. 27 was re-established. The question arose with the cut in prices whether the United States Steel Corporation was not trying either to drive its smaller competitors out of business or force them into a combination where they could be more easily controlled. Many such producers, not able to have their own mines, blast furnaces, steel mills and rolling mills, are at the mercy of producers of billets and bars. The year was one of policy making, and during it the policy of making the supply of material at all times equal to the needs but not in excess of them, was introduced.

Plates and Structural Material.—The year hardly showed a waver in the heavy steel trade. It opened with large stocks of both structural shapes and plates on hand. Early buying was heavy and continued good all spring, with no distress until April. Jobbers by Feb. 15 were getting 2·25c. for all grades, with demand rather brisk. The March floods hampered the steel mills considerably, and lessened production for a couple of weeks. The demand for shapes increased, and prices began to range between 2·25c. and 3c. out of stock. By the latter part of March speculators thought to get a lead on the future by buying heavily, but the mills gave immediate notice that no material should be sold to speculators on any pretext whatever. This policy was followed through the year. By May 1 the structural consumers began to inquire abroad for material, and it seemed as if ship building in some of the lake yards would have to await the arrival of foreign steel. Under such conditions the smaller mills got restless. They could not see how they were to be helped by conservative prices, and were inclined to break away from the old quotation of 1·60c., Pittsburg. They began to talk premiums, particularly on plate, the demand for which was very heavy. The mills in this territory were sold up for months ahead, and Eastern mills were sold pretty well up to the limit of their capacity. The latter part of May saw the smaller structural mills breaking away from the larger ones on prices for spot shipment. The larger mills had very little to sell, but sold what they could at 1·6c., Pittsburg, the old price. The Eastern structural mills jumped prices to 2·25@3c. for spot shipment, offering considerable quantities. This brought mill and job sales to the same level. By the second week of June the plate pool had been suspended, and the smaller mills refusing to be governed by the conservative price policy, were selling for what the market would stand. They began to demand 1·80c. and 1·90c. at the mill, while the mills in this territory producing structural shapes began to ask 1·90c. at the mill. It is perhaps fortunate that most of the business for 1902 was done before this premium policy was adopted, although the small mills had all they could do to supply home needs at the higher price.

About July 15 importations began and helped out smaller consumers a great deal. The market settled, structural steel bringing 2·50@3c. out of stock, or from the smaller mills, with both sheared and universal mill plates bringing 2·50c., out of stock, and 2@2·10c. at the mill. When the readjustment of prices came in December the smaller mills asked 2c. for plates, while the jobbers asked 2·25c. for sheared and 2·50c. for universal. Jobbers held for 2·25c. for structural and smaller mills in some instances dropped to 2·75c. The year ended with the large structural mills sold up for the first three quarters of 1903, and plate mills sold up for the entire year.

Steel Rails.—The 1902 price policy of steel rail mills was decided early in the fall of 1901 and before the close of that year almost the entire output for 1902 was sold. The year 1902 was about half over when sales for 1903 delivery began, and were heavy until the latter part of the year. The price was the same as the previous year, $28 at the mill for standard sections. The only fluctuation in prices came about Oct. 15, when there was some demand for light rails, and prices of such rails went to $38@$42 for immediate shipment.

Pennsylvania.[3]—The policy of the Steel Corporation to prevent prices from soaring to an abnormal figure with every increase in demand was successfully carried out, and as a result the iron and steel market was steady and substantial throughout the year. Buyers had more confidence than in former years, and orders for extended future delivery were freely placed. Before the end of the first quarter the mills had business on the books insuring steady operation for months ahead and the furnaces soon were filled up for the second quarter. The tonnage for the year just closed was greater than any previous year in the history of the iron and steel industry, prices and profits were more satisfactory, but deliveries were extremely aggravating. Pig iron production would have been much heavier but for the shortage of coke. The fact that the railroads were wholly unable to handle the freight offered despite the increased facilities by heavy additions to rolling stock and improved equipment, indicate an unprecedented business. Building operations were delayed, although the material needed was ready, but could not be shipped. The furnaces suffered greatly during the last half, as it was impossible to get the full requirements of coke, and as a result a heavy tonnage booked for shipment during 1902 was carried over into this year. Mills were affected by a shortage of iron, and at times by a scarcity of coal. The plants of the United States Steel Corporation, except tin-plate and sheet mills, in the Pittsburg and Youngstown districts, were kept in constant operation throughout the year, only closing for brief periods for necessary repairs.

The only weakness in the market was in sheets, tin-plate and wire products. Reductions in price were found necessary by the United States Steel Corporation in order to secure business. This condition of affairs, however, was due to the excessive producing capacity in these lines. The demand was greater than the previous year, but in 1902 many new independent plants were put in operation. Before the opening of the second half there was a heavy overproduction in tin-plate and many mills were forced to close. In order to keep its plants in operation the American Tin-Plate Co. succeeded in getting a wage concession from the workers and went after the rebate export trade. A cut in prices from $4 to $3·60

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[3] By S. F. Luty.

a box also was made, but it was late in the year before enough business was secured to warrant the starting of all of the idle mills. Wire products were cut in price $7 a ton, and the plants all were operated steadily. In sheets a cut of $5 a ton was found necessary to insure business for the mills, many of which had been shut down for lack of orders. The independent plants were not closed by these cuts, as most of them had contracts taken at favorable prices, and had fully provided for the raw material required. While the conditions in these lines appear to have been unsatisfactory the business done, it is estimated, was much heavier than in former years.

The apparent dullness in tin-plate, sheets and wire was almost lost sight of in the tremendous business done in structural material and other finished steel products. Every plant in this district was crowded with orders throughout the year, and a heavy business was booked for this year's delivery, insuring continuous operation up to July 1. Some high prices were paid for finished steel products during the last half, but the official price was maintained at all times by the leading interests. Business accepted at these figures, however, was for extended delivery. The accompanying table of prices for the year merely gives the rates quoted, and does not record the prices paid, as it would be impossible to satisfactorily show the fluctuations on orders for prompt shipment. The ruling price was quoted in every instance, but premiums over these rates were paid on urgent orders, and they varied from $2 to $8 a ton on structural material, steel bars and plates.

AVERAGE PRICES PER TON OF IRON AND STEEL IN PITTSBURG DURING 1902.

	Jan.	Feb.	Mch.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Bessemer pig iron	$16·75	$17·00	$7·50	$20·75	$22·00	$22·25	$22·25	$22·50	$23·00	$24·00	$23·75	$23·50
Foundry No. 2	16·50	17·00	19·00	20·75	21·50	22·00	23·00	23·00	23·00	23·50	23·50	23·25
Gray forge	16·00	16·50	18·00	19·75	20·25	20·50	21·00	21·25	21·50	21·00	21·00	21·00
Bessemer steel billets	27·00	30·00	31·00	32·00	32·50	33·50	32·50	31·00	31·00	30·00	30·00	30·00
Sheets No. 28	3·10	3·10	3·10	3·10	3·10	3·00	3·00	3·00	3·00	2·75	2·75	2·75
Tank plate	1·60	1·60	1·60	1·60	1·60	1·60	1·60	1·60	1·60	1·60	1·60	1·60
Steel bars	1·50	1·55	1·60	1·60	1·60	1·60	1·60	1·60	1·60	1·60	1·60	1·60
Steel rails	28·00	28·00	28·00	28·00	28·00	28·00	28·00	28·00	28·00	28·00	28·00	28·00
Wire nails	2·00	2·05	2·05	2·05	2·05	2·05	2·05	2·05	2·00	1·90	1·85	1·85
Cut nails	2·05	1·95	1·95	2·05	2·05	2·05	2·05	2·05	2·05	2·05	2·05	2·05
Ferromanganese, domestic	52·50	52·50	52·50	52·50	52·50	52·50	52·50	52·50	52·50	52·50	52·50	52·50

Importations of steel and pig iron were heavy during the last half, and it would be difficult to give a correct estimate of the tonnage. Prices in most instances were about equal to the rate for the home product. Less Southern iron was received in this district than in former years, indicating that prosperous conditions were not confined to the Pittsburg district alone. The railroads were entirely responsible for the curtailment of the production of pig iron. Furnaces in the Mahoning and Shenango valleys were forced to bank during the last four months of the year, and a number were blown out on account of a shortage of coke. The coke supply was adequate and fully 1,000,000 tons were stocked in the yards during the last half, the railroads being unable to furnish the cars needed to transport it to the furnace. Blast furnaces in the Pittsburg district were not so severely affected, but the production would have been greater had conditions been better. Two furnaces were added to the Carrie group early in the second half, and in December one was added to the Edgar Thomson group.

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The freight congestion became so great in November that a tie-up of all industries was threatened. By extraordinary efforts the blockade was relieved, but transportation facilities were not up to requirements. If the mills in this district had been forced to depend entirely on the railroads for coal they could not have been operated as satisfactorily as they were. Most of the mills have facilities for obtaining a coal supply from the rivers which are always navigable this side of the Davis Island dam in the Ohio River. The Monongahela River Consolidated Coal & Coke Co. was able to operate its mines continuously and ship coal to the mills. The Pittsburg Coal Co., the railroad coal combination, estimates that production last year was curtailed fully 20%, by the inability of the railroads to handle the freight offered. This company was short over 1,000,000 tons on its contracts at the close of the year, and in addition was forced to reject many large orders.

The year opened with Bessemer pig iron selling at $16·75, and large contracts were placed with the merchant furnaces, the United States Steel Corporation taking 150,000 tons from the Bessemer Furnace Association. Severe weather in February crippled the railroads and interfered with shipments, and although the association had fixed the price at $16·75, buyers forced prices up. The demand for foundry iron was remarkable, and before the end of February there was scarcely any difference in price for all grades of pig iron. Sales of foundry iron were made at prices above Bessemer. Late in March buying of foundry iron for 1903 delivery began, and $19 was the price paid. Furnaces were sold up for the first half before April 1. The United States Steel Corporation made a contract with the Bessemer Furnace Association in April for 300,000 tons of Bessemer iron for delivery in the fourth quarter of 1902 and the first quarter of 1903 at $16·50, Valley furnaces. This price was not duplicated during the rest of the year. The strike of blast furnace workers which began on June 1 for the establishment of a three-turn instead of a two-turn system continued for a week, and production was curtailed fully 50,000 tons. A compromise was made with the strikers, and an advance of 10% in wages was granted. During the last half no sales of Bessemer pig iron were made for 1902 delivery at less than $22, and some sales were made above $24. As high as $25 was paid for foundry iron, and the minimum price of gray forge for the last half was $21.

The demand for steel was heavy in the first quarter, and in April large orders began going abroad, and importations of steel continued throughout the year. Heavy orders for structural material were placed in January. Early in March the mills were forced to refuse business, except for late delivery, and premiums of $5 a ton for prompt shipment were freely paid. An effort was made by some manufacturing interests to advance the price of structural material and plates early in the year, but the United States Steel Corporation objected, and the official price announced in January remained unchanged all year. The steel rail production for 1902 was sold up before May 1 at the fixed price of $28 a ton. The demand was heavy, and relaying rails found a ready market at $29 and $30. The flood on March 1 entirely closed or affected most of the mills in the Pittsburg district. All flood records were broken in getting the mills ready for operation after the waters had receded, and some were started within 24 hours.

The labor troubles of last year were not of a serious character. Strikes of structural iron workers, machinists and of steel melters in the crucible steel works were soon settled by granting advanced wages to the men. The iron workers in the union rolling mills of the country got two advances. The puddlers' pay was increased from $5·50 to $5·75 a ton in January, and the finishers got an increase of 2%. In July the puddlers were given $6 a ton rate, and the finishers an additional 2% increase. This was due to the heavy demand and advanced prices in bar iron. These high wages continued for the remainder of the year.

The Union Steel Co. and the Sharon Steel Co. were consolidated in November, and in the following month the merged company was taken over by the United States Steel Corporation. The St. Clair Furnace Co. and the St. Clair Steel Co., with plants at Clairton, were consolidated, and operated as the Clairton Steel Co. by the Crucible Steel Co. of America.

The beam and plate associations met in December, renewed the agreements for another year and reaffirmed prices.

IRON AND STEEL PRODUCTION OF THE WORLD.

The pig iron production of the world in 1902 is shown in the following table, the figures being reduced to metric tons, to facilitate comparisons:—

PIG IRON PRODUCTION OF THE WORLD. (IN METRIC TONS.)

Year.	Austria-Hungary.	Belgium.	Canada.	France.	Germany.	Italy.	Russia.
1898	1,266,388	979,755	69,248	2,525,100	7,215,927	12,887	2,241,290
1899	1.323,999	1.036,185	95,582	2,578,400	7,160,208	19,218	2,708,749
1900	1,311,949	1,161,180	87,612	2,714,298	7,549,655	23,990	2,895,036
1901	1,300,000	765,420	248,896	2,388,828	7,785,887	25,000	2,807,972
1902	1,335,000	1,102,910	324,670	2,427,427	8,402,660	24,500	2,566,000

Year.	Spain.	Sweden.	United Kingdom.	United States.	All Other Countries,	Total.
1898	229,754	531,766	8,819,968	11,962,817	545,000	36,418,900
1899	266,885	467,727	9,572,178	13,838,634	625,000	39,722,560
1900	289,788	526,868	9,008,046	14,009,870	625,000	40,196,892
1901	294,118	528,875	7,977,459	16,132,408	635,000	40,889,358
1902	278,000	524,400	8,653.976	18,008,448	615,000	44,557,991

The three chief iron-producing countries—the United States, Great Britain and Germany—turned out last year 79% of the world's production of pig iron, as compared with 74% in 1901. The United States alone made 40% of the total in 1902, as compared with 39% in 1901.

The steel production of the world for five years past is shown in the subjoined table, the figures being given also in metric tons:—

STEEL PRODUCTION OF THE WORLD. (IN METRIC TONS.)

Year.	Austria-Hungary.	Belgium.	Canada.	France.	Germany.	Italy.	Russia.
1898	605,500	567,728	22,288	1,174,000	5.734,307	87,467	1,095,000
1899	1,127,104	729,820	22,852	1,240.000	6,290,434	108,501	1,821,898
1900	1,145,654	655,199	23,954	1,565.164	6,645,869	115,887	1,880,260
1901	1,142,500	596,670	26,501	1,425,351	6,394,222	121,300	1,815,000
1902	1,143,900	776,875	184,950	1,635,300	7,780,682	119,500	1,780,250

Year.	Spain.	Sweden.	United Kingdom.	United States.	All Other Countries.	Total.
1898	112,605	263,700	4,639,042	9,075,783	855,000	23,732,720
1899	117,650	273,454	5,080,000	10,832,765	400,000	27,543,318
1900	144,355	300,586	5,130,800	10,382,069	400,000	28,842,294
1901	122,954	269,897	5,096,301	13,689,173	405,000	31,084,869
1902	124,000	283,500	5,102,420	15,136,406	412,000	36,479,783

The three chief producing countries furnished 82%, and the United States alone 42% of the total in 1902, as compared with 81% and 44%, respectively in 1901.

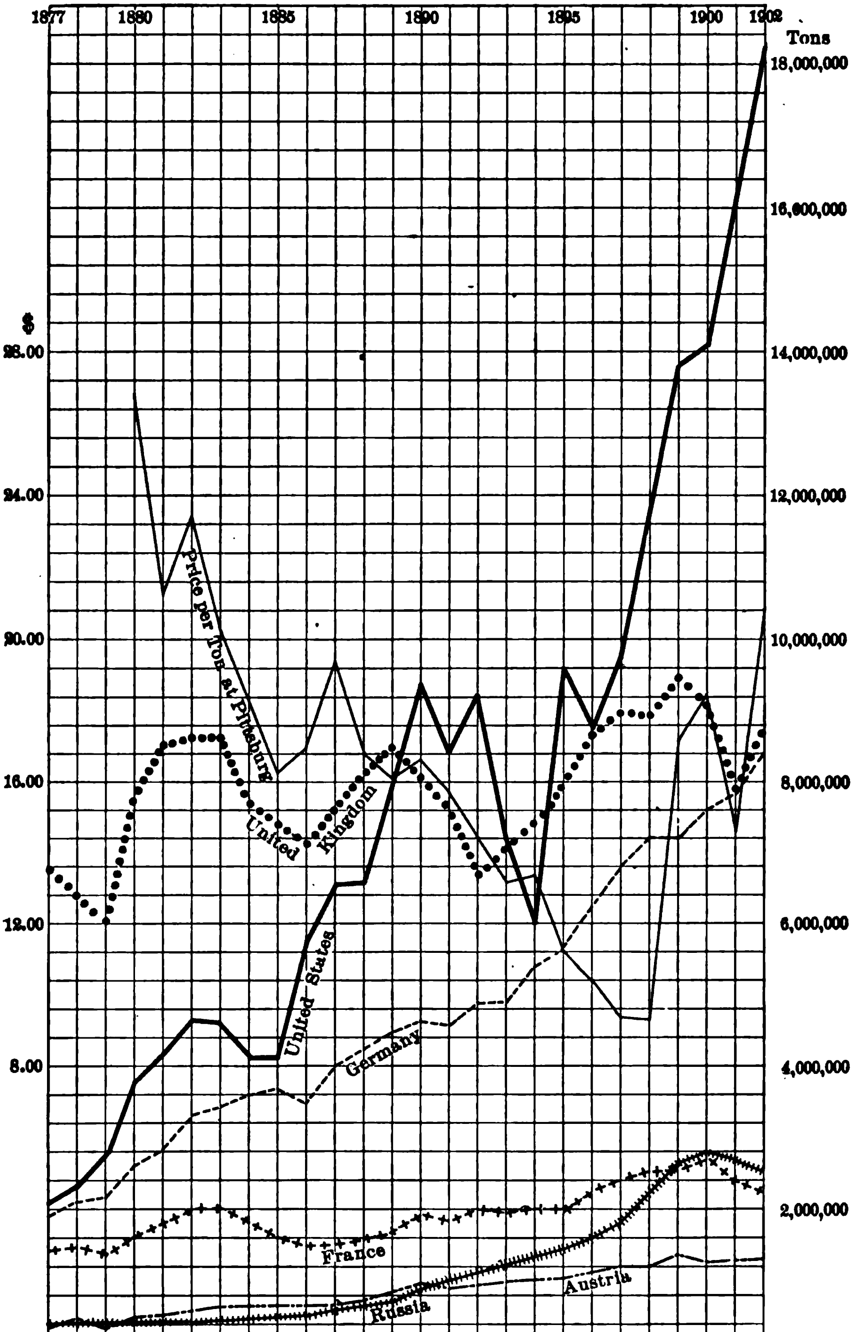
An increasing proportion of the world's pig iron output is, each year, converted into steel. In 1902 the steel production reached the highest point ever reported, being more than 80% of that of crude iron.

Austria-Hungary.—The production of iron and steel showed small increases—35,000 tons in pig iron, but only 1,400 tons of steel. Finished iron is not reported. The Austrian industry is an ancient one, iron having been produced in Bohemia and Moravia, as well as in Hungary, as far back as Roman times, and throughout the Middle Ages. The Austrian metallurgists are progressive, however, and some of the works are as perfectly equipped, and as admirable in their mechanical arrangements, as any in Europe. This is more especially true of the plants of Donawitz, Kladno, Teplitz, and Witkowitz. At the two latter the basic process of steel manufacture was installed at an early period of its history. At Donawitz there is now in operation one of the finest blast furnace plants in Europe. The works of the Prague Eisen-Industrie Gesellschaft, at Prague, are identified with the origin of the Bertrand-Thiel process of steel making. Of late years the old Alpine plants of the Montan Gesellschaft have been largely reconstructed and some of them have been improved out of existence.

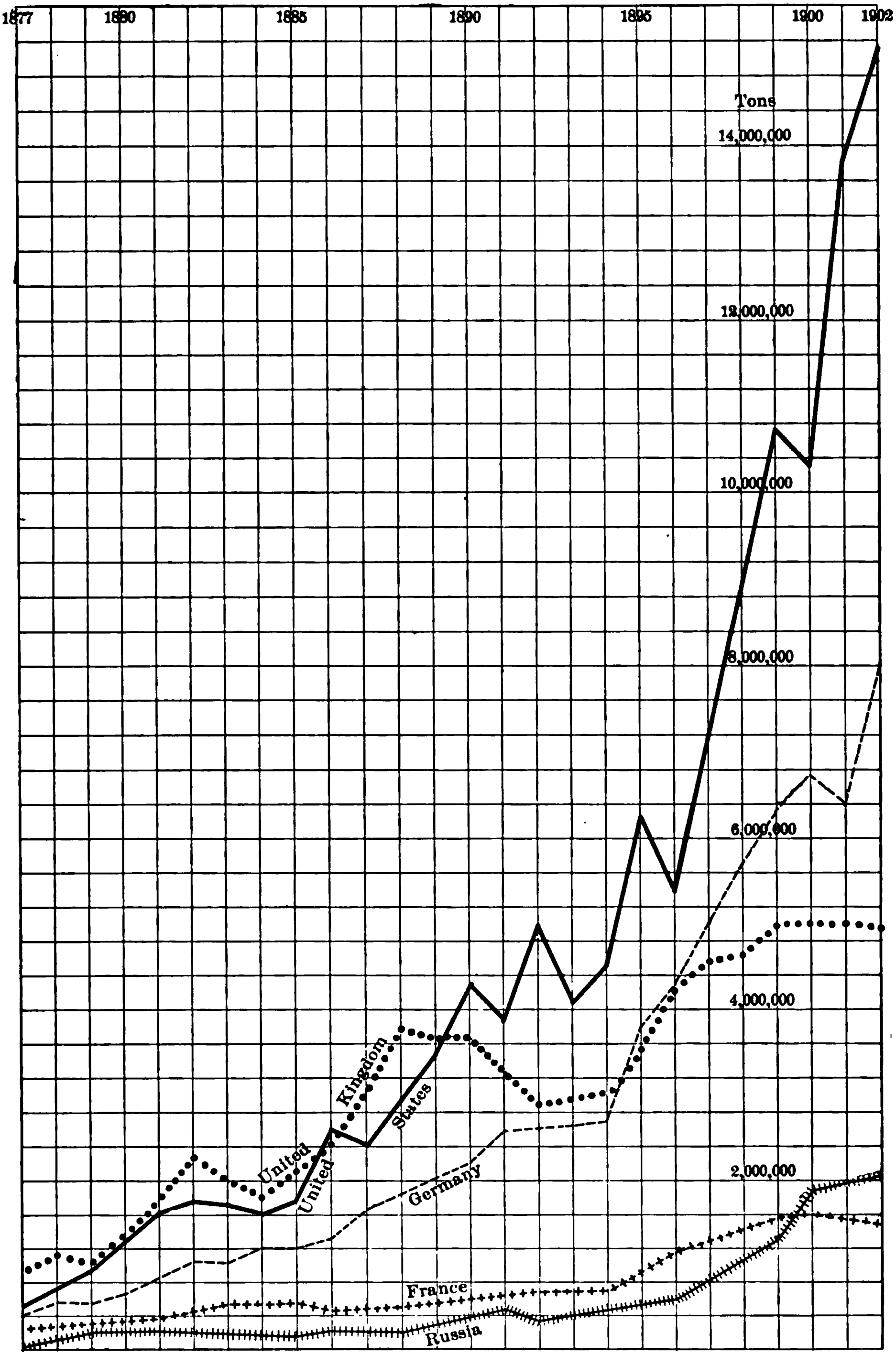
According to Ritter von Tunner, the Austro-Hungarian Empire has been well to the front in the adoption and development of modern steel-making processes. Styria and Carinthia, among Continental countries, were the first to adopt and improve the Bessemer process. The open-hearth furnace was first tried in Styria, and cast steel was first produced from a Siemens open-hearth furnace at Kappenberg, in the same region, while the Neuberg works was the first to produce steel by the direct process.

The iron industry of Austria-Hungary is mainly a home business, and it does not profess to compete with the great international movement of products characteristic of the trade of Great Britain, the United States, Germany, and Belgium. The Austrian iron works naturally export chiefly to the nearest markets, which are the other countries on the Danube, but they have also to some extent done an export business with Russia and Italy. The most remarkably situated works from this point of view are the blast furnaces at Trieste, which are constructed largely along American lines, with a thoroughly modern equipment, and which, importing iron ores from Spain and coke from the north of England, compete with both German and British works in outside markets.

Since Bosnia and Herzegovina became Austrian dependencies, those provinces have shown a development of the iron industry, which in 1901 was represented by 122,569 tons of iron ore, 39,296 tons of pig iron, 18,120 tons of steel ingots, and



THE PRODUCTION OF PIG IRON IN THE PRINCIPAL COUNTRIES OF THE WORLD IN METRIC TONS.



THE PRODUCTION OF STEEL IN THE PRINCIPAL COUNTRIES OF THE WORLD IN METRIC TONS.

16,500 tons of finished iron. Seven new furnaces are being built in Bosnia; they are of small size and will use charcoal as fuel.

Belgium.—The production of pig iron during 1902 showed a considerable improvement over that of the previous year. The outputs being as follows:—

	1901.	1902.	Changes.
	Metric Tons.	Metric Tons.	Metric Tons.
Foundry iron	92,700	108,560	I. 15,860
Forge iron	166,955	256,435	I. 89,480
Steel pig	505,765	737,915	I. 232,150
Totals	765,420	1,102,910	I. 337,490

The average number of furnaces in blast in 1902 was 33, showing an output of 33,422 tons per furnace. Belgium has adhered to the puddling furnace more closely than any other country, except Great Britain. The production of wrought iron in all forms in 1902 was 377,910 metric tons, chiefly in bars, angles and plates. The production of steel ingots was 776,875 metric tons, as compared with 526,670 tons in 1901, showing an increase of 250,275 tons, or nearly 48%. The output of finished steel in 1902 was 755,880 tons. The large increase over 1901 was due mainly to a great improvement in the export trade.

The future of the Belgium iron trade is not altogether clear. Iron ore supplies are already derived largely from abroad, while the cost of coal is increasing, as the upper seams have largely been exhausted and deep mining is necessary. The Belgium industry has prospered largely because the labor supply has been abundant, and wages generally low. Both in coal mining and in the iron trade, however, there has been much discontent recently, and some serious strikes have taken place. It appears that increases in labor cost, as well as in fuel costs are imminent. As the iron industry depends largely upon foreign buying, in which sharp competition must be met, the situation is a serious one. At the same time, Belgium iron-masters are generally alert and progressive, and have shown themselves ready to take every advantage, not only in trade, but also in a technical way. Thus the John Cockerill Co., at Seraing, was a pioneer in the utilization of waste gases from blast furnaces. Its machine shops are now the largest manufacturers of blowing and other engines for the conversion of such gases into power.

Canada.—The iron and steel industry in Canada has advanced rapidly in recent years, chiefly owing to the developments in Nova Scotia. The works at Sault Ste. Marie, from which so much was expected, are not yet in full operation.

The total production of pig iron in 1902 amounted to 319,557 long tons, against 244,976 tons in 1901 and 86,090 tons in 1900. In the first half of 1902 the production was 157,804 tons and in the second half it was 161,753 tons, a gain of only 3,949 tons. Of the total product in 1902, 302,712 tons were made with coke and 16,845 tons with charcoal. A little over one-third of the total product was basic pig iron, namely, 107,315 tons. The Bessemer pig iron made amounted to about 9,000 tons. Spiegeleisen and ferromanganese have not been made since 1899. The total production of steel ingots and castings in Canada in 1902 was 182,037 long tons, as compared with 26,084 tons in 1901, an increase of 155,953 tons. Bessemer and open-hearth steel ingots and castings were made in each year. Almost all of the open-hearth steel reported in 1902 was made by the basic process.

The large increase in the production of steel in Canada in 1902 over 1901 was caused by the starting up of the new open-hearth steel plant of the Dominion Iron & Steel Co., Ltd., at Sydney, Cape Breton, N. S., which first produced steel on Dec. 31, 1901, and of the new Bessemer plant of the Algoma Steel Co., Ltd., at Sault Ste. Marie, Ont., at which steel was first made on Feb. 18, 1902. The latter company has two 6-ton Bessemer converters, which were operated for a few months in 1902, producing in all 44,537 long tons of ingots. The company has also a rail mill which first made Bessemer steel rails on May 5, 1902, and which also ran for a few months in that year, producing 32,878 long tons. In addition this company also produced 1,236 long tons of other rolled products in 1902. The Dominion Iron & Steel Co. produced 99,425 long tons of basic open-hearth steel ingots and castings and 86,424 tons of blooms, billets, and slabs, but it made no steel rails. The Dominion Iron & Steel Co. obtains a large part of its ore supply from its mines at Bell Island, Newfoundland. Its chief fuel is coke, made from Cape Breton coal, in by-product ovens.

France.—The iron trade in France was comparatively quiet during 1902, though some recovery was shown from the depression of 1901. The chief improvement in demand was in material for new electric installations. Marine work was very quiet during the year, and export trade rather light.

The production of pig iron, as officially reported is given in the subjoined table:—

Fuel.	1901.	1902.	Changes.
	Metric Tons.	Metric Tons.	Metric Tons.
Coke	2,361,657	2,399,156	I. 37,499
Mixed coke and charcoal	10,167	14,716	I. 4,549
Charcoal	16,999	13,555	D. 3.444
Total	2,388.823	2,427.427	I. 38,604

The manufacture of charcoal-iron is now carried on only at a few furnaces in the departments of Haute-Saône, Landes and Pyrénées-Orientales.

The production of finished iron in all forms is reported as follows:—

	1901.	1902.	Changes.
	Metric Tons.	Metric Tons.	Metric Tons.
Puddled	347,798	401,272	I. 53,474
Refined in charcoal forges	5,457	5,580	I. 123
From scrap	213,900	218,974	I. 5,074
Total	567,155	625,826	I. 58,671

A few charcoal forges still survive, most of them in the Landes and Pyrénées-Orientales. The wrought iron output was in the following forms: Bars, shapes and merchant iron, 572,541 tons; plates, 52,965 tons; rails, 320 tons.

The production of steel ingots was as follows:—

	1901.	1902.	Changes.
	Metric Tons.	Metric Tons.	Metric Tons.
Bessemer	816,677	1,014,934	I. 198,257
Open-hearth	608,674	620,366	I. 11,692
Totals	1,425,351	1,635,300	I. 209,949

The official reports do not distinguish between basic and acid steel; but the larger part of the steel is made by the acid process. The production of finished steel is reported as follows:—

	1901.	1902.	Changes.
	Metric Tons.	Metric Tons.	Metric Tons.
Bars and merchant steel	614,018	653,931	I. 39,913
Plates	269.908	276,287	I. 6,379
Rails	291,528	301,434	I. 9,906
Totals	1,175,454	1,231,652	I. 56,198

The finished steel produced during 1902 is classified as follows: Converter steel, 682,814; open-hearth, 517,408; puddled steel, 12,041; cemented, 1,005; crucible steel, 12,715; made from scrap and old steel re-worked, 5,670; total, 1,231,652 metric tons.

Little was done during the year in the way of new works. Some additions were made to the forges of St. Etienne. Schneider et Cie. nearly completed the building of a large blast furnace plant at Cette, near Marseilles. It will use chiefly Algerian ores, from Mokta-el-Hadid and Beni-Saf. The location, on the Mediterranean seaboard, is for the purpose of receiving those ores at a low rate. Development work has proceeded steadily on the large body of minette ores discovered two years ago close to the German frontier.

Germany.—The iron trade of Germany in 1902 showed some recovery from the depression, which marked it in 1901, which was due rather to an increased export business than to any improvement in the foreign trade.

The pig iron production, including Luxemburg, as reported by the German Iron & Steel Union, was as follows:—

	1901.		1902.		Changes.
	Metric Tons.	%	Metric Tons.	%	Metric Tons.
Foundry iron	1,512,107	19·4	1,619,275	19·3	I. 107,168
Forge iron	1,356,794	17·4	1,206,550	14·3	D. 150,244
Bessemer pig	464,086	6·0	387,384	4·6	D. 76,702
Thomas (basic) pig	4,452,950	57·2	5,189,501	61·8	I. 736,551
Totals	7,785,887	100·0	8,402,660	100·0	I. 616,773

Spiegeleisen and ferromanganese are included with forge pig, under the old German classification. The total increase in 1902 over the preceding year was 7·9%. The production for 1902 was the largest ever reported in one year, except that for 1900, which was 8,422,842 metric tons.

Imports of pig iron into Germany in 1902 were light, amounting to 143,040 tons, compared with 267,503 tons in 1901; a decrease of 124,463 tons, or 46·4%. The exports, on the other hand, showed a large increase, the total for 1902 being

347,256 tons, compared with 150,448 tons in 1901; an increase of 196,808 tons, or 130·8%. Most of this increase was due to a demand from the United States. Iron and steel products of all kinds, outside of pig iron, showed a large increase also, the total exports in 1902 being 2,961,764 tons, compared with 2,196,794 tons in 1901; an increase of 764,970 tons, or 34·8%.

The imports and exports of iron ore for the year were as follows:—

	1901.	1902.	Changes.
	Metric Tons.	Metric Tons.	Metric Tons.
Imports	4,370,022	3,057,408	D. 412,619
Exports	2,389.870	2,868,068	I. 478,198
Net imports	1,980,152	1,089,335	D. 890,817

The imports were chiefly from Spain and Sweden. The exports were chiefly minette ores from Luxemburg, which went to France.

The steel production in 1902 was as follows:—

	Acid.		Basic.		Total.	
	Metric Tons.	%	Metric Tons.	%	Metric Tons.	%
Converter ingots	341,885	4·4	4,888,054	62·8	5,229,939	67·2
Open hearth ingots	129,724	1·7	2,304,495	29·6	2,434,219	31·3
Direct castings	46,387	0·6	70,187	0·9	116,524	1·5
Totals	517,996	6·7	7,262,686	93·3	7,780,682	100·0
Totals, 1901	465,040	7·3	5,929,182	92·7	6,394,222	100·0

The Thomas, or basic, converter retains its strong hold upon the German steel manufacture. The gain, both in pig iron and steel was made in the second half of the year. During that period considerable sales of basic pig and of steel were made to the United States.

Italy.—The production of pig iron in Italy is small, but there is a considerable output of steel made from imported pig iron. The iron is chiefly from Great Britain. The Ferris steel works, the largest and most important in the country, is making arrangements to absorb several smaller concerns. An effort is being made to consolidate and work some of the old iron mines in Piedmont, where a considerable industry formerly existed in the manufacture of charcoal iron. It failed, partly on account of the exhaustion of fuel supplies, and partly because, as depth increased, the cost of mining iron ore became too great for the limited capital available.

Russia.—The iron industry of Russia suffered from severe depression throughout the year. The industrial crisis, which began in 1901, continued unabated, and matters were further complicated by the approaching completion of the Siberian Railroad, and the consequent curtailment of orders for rails and other material.

In a recent paper on the iron trade of South Russia, read before the Iron and Steel Association, Mr. A. P. Head threw much interesting light on the conditions under which this industry is carried on; computed at 45·5% of the total output, the finished material supplied for railway purposes, and assigned to merchant bars, sheets, and girders, 37·2% of the remainder.

The iron ore supplies of Russia are exceedingly miscellaneous. Until quite lately the workings were on a very small scale. In 1890, for example, the official returns showed that ores were mined from 536 mines or quarries, and 195 lakes, 180 of the latter being in Finland and 15 in North Russia. The total output of iron ore from these 731 workings was under 1,900,000 tons, so that the average output was only about 2,600 tons. In more recent years, however, attention has been concentrated on the more productive sources of supply, and Krivoi Rog, Blagodat, and other deposits are worked on a scale of some magnitude. Brown iron ore is the staple source of supply, followed in the order of volume by red hematite and magnetic iron ore.

The iron industry of Russia is still carried on under somewhat primitive conditions in most of the leading districts apart from the south. As recently as 1885 there were 195 blast furnaces available, and these produced a total of about 500,000 tons of pig iron, of which all but 10% was produced by charcoal fuel. In the following decade this condition had considerably altered, although charcoal pig iron continued to be the staple. In 1880, about 55% of the blast furnaces in the country were worked with cold blast, but in 1890 the proportion was 32%, and at the present time it is probably not more than 16%.

Spain.—Although Spain is a large producer of iron ore, the metallurgical industry is of only moderate proportions. There was little change in the industry during 1902. The total exports of iron ore in 1902 were 7,546,512 metric tons; this figure compares with 6,637,613 tons in 1901, and 7,823,270 tons in 1900. Approximately 70% of these exports is shipped to Great Britain.

Sweden.—According to Dr. Richard Akerman the output of pig iron in Sweden during 1902 for the year was 524,400 metric tons. All of this iron was made with charcoal as fuel. The quantity of blooms produced from pig iron in charcoal hearths was 183,600 tons. The steel production for the year was 283,500 tons of ingots, of which 193,300 tons were made in open-hearth furnaces, while 85,200 tons were Bessemer or converter steel. The exports of iron and steel for the year included 73,296 tons of pig iron, 20,380 tons of charcoal blooms, 8,148 tons of steel ingots and 174,013 tons of bar iron and steel. The exports of iron ore in 1902 reached a total of 1,719,293 metric tons.

The Swedish iron-masters are turning their attention more and more to the manufacture of steel. Exports of iron blooms and bars have been decreasing, as open-hearth steel has been coming into use for many of the purposes for which Swedish iron was formerly thought to be necessary.

United Kingdom.—The statistics for the iron and steel trade are compiled by the British Iron Trade Association, and are in somewhat different form from those of the United States.

The supply of iron ore for the British furnaces was as follows:—

	1901.	1902.	Changes.
	Long Tons.	Long Tons.	Long Tons.
Ore mined in Great Britain	12,266,790	13,426,217	I. 1,159,427
Ore imported	5,548,888	6,341,272	I. 792,384
Total	17,815,678	19,767,489	I. 1,951,811

This would indicate an average consumption in 1902 of 2·33 tons of ore per ton of pig made; or an average of a little under 43% iron in the ore. The imported ore was higher in iron than that mined in Great Britain. The chief source of the ore imported was Spain, from which country 5,309,733 tons were received. From Greece there were 335,824 tons; Algeria, 215,632; Italy, 182,053; Sweden, 167,083; Newfoundland, 91,617; France, 66,172; Portugal, 17,223. No other country contributed any considerable quantity. The total imports of manganese ore were 233,333 tons, as compared with 192,654 tons in 1901; an increase of 40,679 tons. The chief sources of these imports were: Russia, 112,706 tons; India, 43,093; Brazil, 41,986; Turkey, 12,263; Chile, 11,938; Greece, 8,322 tons.

The total production of pig iron in 1902 was 8,517,693 tons, which compares with 7,851,830 tons in 1901, showing an increase of 665,863 tons. The product was classified as follows:—

	1901.	1902.	Changes.
	Long Tons.	Long Tons.	Long Tons.
Forge and foundry	3,597,994	3,727,294	I. 129,300
Hematite	3,267,684	3,683,148	I. 415,464
Basic	794,787	922,218	I. 127,431
Spiegel and ferromanganese	191,365	185,033	D. 6,332
Total	7,815,830	8.517,693	I. 665,863

In the British classification, hematite corresponds to our Bessemer, or low-phosphorus pig. The consumption and disposition of the pig iron made in 1902 is estimated by the Association as in the table below. In this, imports and exports of iron and steel in all forms are reduced to their approximate equivalent in pig iron, which is taken as the general basis:—

		Long Tons.
Pig iron made		8,517,000
Imported as pig		227,000
Imported in other forms		1,244,000
Total supplies		9,988,000
Exported as pig	1,103,000	
Exported in other forms	3,557,000	4,660,000
Home consumption		5.328,000

The distribution of the home consumption is estimated as follows, also reduced to terms of pig: Ship building, 1,200,000 tons; merchant iron and steel, 1,108,000; foundry purposes, 1,000,000; machinery, 700,000; railroad material, 450,000; tools, hardware and the like, 450,000; tin plates, 220,000; naval and military purposes, 200,000 tons. The number of blast furnaces active in 1902 was 354, showing an average make of 24,061 tons each.

The statistics for wrought, or puddled, iron are not complete. The make of puddled bar was reported at 998,278 tons during 1902 as compared with 974,385 tons in 1901, an increase of 23,893 tons. English makers have adhered to wrought iron, more than in any other country, and a large quantity of shapes and plates is made of wrought iron.

The total production of steel in 1902 was 5,022,067 tons, an increase of

6,023 tons over that of 1901. The production for five years is shown in the subjoined table:—

STEEL PRODUCTION IN GREAT BRITAIN. (IN LONG TONS OF 2,240 LB.)

Variety.	1898.	1899.	1900.	1901.	1902.
Open-hearth	2,806,600	3,030,251	3,156,050	3,290,791	3,083,288
Bessemer	1,759,386	1,825,074	1,745,004	1,606,253	1,825,779
Crucible	100,000	122,000	131,000	119,000	113,000
Total	4,665,986	4,977,325	5,032,054	5,016,044	5,022,067

An analysis of the steel production in 1902, omitting crucible steel, is as follows, the figures being in long tons:—

	Acid.		Basic.		Total.	
	Long Tons.	%	Long Tons.	%	Long Tons.	%
Open-hearth	2,676,508	54·5	406,780	8·3	3,083,288	62·8
Bessemer	1,157,180	23·6	668,599	13·6	1,825,779	37·2
Totals	3,833,688	78·1	1,075,379	21·9	4,909,067	100·00

For the first time in several years the figures show an increase in the proportion of Bessemer steel. The Bessemer, or converter, metal was largely used for rails, of which 903,216 tons were made last year. The open-hearth process is preferred to the converter; and years ago the output of open-hearth steel exceeded that of Bessemer. The number of converters and steel furnaces shows very little change in 1902, the new ones constructed having been mainly to replace older apparatus worn out. Very much the same thing may be said of the blast furnaces—the new blast furnaces mainly replace old ones. They generally show some increase in capacity, but less than in this country, for the British iron-maker has never favored the very large furnaces, such as are found at the later works in this country.

The condition of the British trade in 1902 was very much more satisfactory than in the preceding year. The year 1901 was a period of depression, owing partly to a decrease in the home demand for iron and steel, and still more to the crisis in Russia, Germany and other European countries. The British trade depends largely upon export, and in 1902 there was an important revival in the foreign demand. In part, this was due to improved conditions abroad, and in part also to the fact that the United States, absorbed in its own huge home demand, practically withdrew from foreign markets, while it also purchased a very considerable quantity of British iron. The trade showed greater steadiness, with fewer variations in prices, than for a number of years past. It presented, however, one anomaly, and that is a decline in prices of finished iron and steel, accompanied by an advance in the average selling value of pig. Manufacturers also found prices higher for iron ores and coke, and these were not offset by a small reduction in the rate of wages for labor. The various branches of manufacture in which iron and steel were used were generally prosperous, with the exception of the shipbuilding business, which forms a very important section of the British trade; in this business there was less work than for several years past. To some extent, however, this was offset by the heavy demand for rails and other railroad material for export.

The extent to which foreign business affects the British trade is shown by the fact that while Great Britain last year exported about 11% of its total make of pig iron, the proportion of the finished iron and steel sold abroad was over 35%. The total exports for 1902 are estimated as equivalent to 4,660,000 tons of pig iron; of which, however, only 1,103,000 tons were exported in the form of pig, the remainder being in the various kinds of finished iron and steel.

Other Countries.—Mexico may be expected to appear as a producer in 1903. The large works of the Compañia Fundidora de Hierro y Aciero at Monterey was put in operation near the end of 1902. This plant is equipped to make pig iron, castings, open-hearth steel, rails and plates. The ores and fuel used come from Mexican mines.

In Japan little progress has been made. The large Government works, to which reference has been made in previous reviews, have so far been only moderately successful. The chief difficulty appears to be in securing suitable supplies of iron ore.

In China, the development of the great iron deposits located by American and European engineers, which was interrupted by the Boxer insurrection, has been resumed only on a very small scale. The uncertainty of affairs in the Empire has prevented any new work.

In India important concessions for prospecting, and for mining iron ores have been granted to a wealthy Parsee firm, Tata & Co., of Bombay, and serious work has been undertaken.

Iron Ores in Sweden and Norway.—According to a recent report to the British Iron Trade Association, Sweden and Norway appear to be destined to play a more important part than they have hitherto done in furnishing the iron ores called for by Germany, Britain, Belgium and other countries. that require to supplement home supplies from foreign sources. The iron ores of Swedish Lapland are being more rapidly developed every year, and, together with those of Gellivara, will in 1903 furnish to other European countries nearly 2,000,000 tons. Provision is, however, being made by the increase of railway and shipping facilities, and otherwise, to greatly increase the present output, and as the total available supply has been computed at over 400,000,000 tons—much of it, however, of inferior grades—there is no doubt scope for a vast increase of the present foreign trade. In Norway the chief iron ore property taken in hand up to the present time is that of Dunderland, which is being exploited by a British company, of which Sir David Dale is chairman. This company has yet to prove the entire suitability of the Dunderland ores to ordinary iron making requirements. There appears to be a degree of uncertainty attached to the ultimate outcome of the use of the Edison, or other analogous concentration process that has to be adopted to prepare an exceptionally refractory ore for British blast furnaces. Estimates have been made that the Dunderland ore can be put on board ship for about 72c. per ton.

NOTES ON PROGRESS IN IRON AND STEEL METALLURGY DURING 1902.

BY FREDERICK HOBART.

ELECTRIC FURNACES.—With regard to the metallurgy of iron and steel, the electric furnace occupies only a modest place in this branch of industry, and it is doubtful whether the manufacture of iron and steel on the same vast scale in the regions where it is now carried on under most favorable conditions could possibly be obtained by the use of the electric furnace.

Reduction of Iron Ores.—Although the reduction of iron ores by electricity has formed the subject of a practical study by Mr. Keller,[4] the results of which will be described further on, it may be stated at once that the use of electricity as a reducing agent is only practicable from an economic point of view, first, when it is a question of manufacturing special qualities of iron from pure ore delivered at the works on favorable terms; secondly, when it is desired to foster an iron and steel industry in a country hitherto undeveloped in this respect, into which all the coal must be imported, where iron ore of good quality abounds, and where natural sources of power are available in the immediate neighborhood of the ore deposits.

General Conditions of the Economic Possibility of the Electric Reduction of Iron Ore.—In a few words, and without going into detail, it will be useful to sketch briefly the relations between the principle of manufacture and the possibility of the reduction of ore by electric methods. The author has determined experimentally that one kilowatt-year utilized in an electric reducing furnace is capable of yielding about four tons of steel-making pig iron. If, therefore, the cost of one kilowatt-year equals K, the expenditure in electric energy per ton of iron smelted will equal K÷4. Adding to this cost of 350 kg. of coke necessary for the reduction of one ton of iron, the expenditure representing the electric energy absorbed and the fuel requisite for reduction will be equal to

$$\underset{\text{(energy)}}{\frac{K}{4}} \quad + \quad \underset{\text{(reduction)}}{350 \text{ kg. coke.}}$$

On the other hand, as is well known, about 1,000 kg. coke are required for the production of one ton of pig iron in the blast furnace, and assuming for the moment that the labor, maintenance and sundry accessory expenses are the same in either case, and that the cost of supplying the blast balances the cost of the electrodes, which is approximately exact; and further, that the price of coke at the electric station is 28s. per ton, while at the iron works it is only 16s., then the cost of production in both cases will be the same on the assumption that

$$\frac{K}{4} + \frac{28\text{s.} \times 350 \text{ kg.}}{1{,}000} = 16\text{s.}$$

which gives a value for K equal to 25s. 6d. In a general way, therefore, the reduction of iron ore by electricity in a country possessing metallurgical works and equally good conditions of transport throughout is only theoretically practicable if the ore can be obtained on equal terms, and if the cost of the kilowatt-year does not exceed 25s. 6d. It is true that this latter condition is capable of realization

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[4] Paper read at the June (1903) meeting of the Iron and Steel Institute, London.

and has been realized in several electric installations operated by water power, but bearing in mind that the scale of production of an electric furnace is less than that of blast furnaces, and that on this account establishments equipped for electric working would be of less capacity, the working expenses being also proportionately higher, it does not appear as if the reduction of iron ores, so far as the smelting of ordinary pig iron is concerned, will ever enter the sphere of practice in any European electric works. This conclusion is the more absolute the higher the cost is of the kilowatt-year and the cheaper the coal is. Thus, in Great Britain, for instance, where coal is cheap and the cost of the kilowatt-year is very high, the adoption of electric smelting of iron is totally impracticable. Nevertheless, with a pure ore at a moderate price available at an electric generating station run by water power, it would be of interest to undertake the smelting in an electric furnace on account of the extreme purity which would be attainable in the product.

There remains one peculiarity to be noted with regard to the reduction of iron ore in the electric furnace. In the use of the system to be described later in this section, in which neither the hearth nor the walls are electrically of importance, not only can these be either acid or basic, but the melting hearth can be so arranged that the proportion of carbon in the finished product is greatly reduced, and the metal when run off is not an ordinary pig iron, but a very hard steel, having already been subjected to a considerable fining process.

The Establishment of an Electrometallurgical Iron Industry in Countries Possessing no Iron Industry.—There are still many countries in which the conditions would favor the adoption of an electrometallurgical industry, where coal is scarce, but where, on the other hand, an abundance of good ore and water power are available. Brazil, Chile, New Zealand, and others come within this category. Mr. Keller is now engaged upon a scheme for the installation of an important electrometallurgical establishment in Brazil for the production of pig iron and steel. The importance of such an industry will be appreciated when it is stated that in Brazil alone the annual consumption of iron is 60,000 tons, and that this quantity is compulsorily limited by the high price of the imported iron and steel.

The following are the data on which the above-mentioned scheme is based: A concession has been granted by special law to the syndicate of a waterfall which has a fall of 114 ft., and is capable of supplying in the season of minimum flow, a force of 25,000 H.P. The work of confining the fall within channels has been contracted for under penalty for the sum of $500,000. The cost of one-horse power per year is therefore $2. Calculating that the amortization of these works, and also that of the hydraulic and electric plant, will be effected in 10 years' time, the cost of production of one kilowatt-year in such an installation will be less than $10. The iron ore averages 65% Fe, and is of remarkable purity, the cost, delivered at the furnace, being reckoned at $2·50 per ton. The price of good English coke amounts to $12 per ton. The conditions are therefore entirely favorable for such an enterprise, and in the light of the comparison previously drawn it is likely that Brazil will develop into a highly interesting field of operations for the electrometallurgy of iron and steel.

Mr. C. Vattier, who has been commissioned by the Chilean Government to undertake an industrial tour in Europe, has kindly furnished the particulars relating to the conditions in Chile, which in many points resemble those obtaining in Brazil. Here, too, no iron industry has ever been established, but an abundance of rich iron ore and numerous waterfalls exist, one of which has already been surveyed, and it is estimated that the cost of a kilowatt-year will not exceed $6. The price of English coke delivered in these districts is $20 per ton. Then applying the equation previously given, assuming that coke blast furnaces were in existence in Chile,

$$100 = \frac{K}{1} + 35,$$

or,

$$K = \$52.$$

From this it is clear that coke blast furnaces can never be established in Chile while, on the other hand, there is every likelihood that in the near future electric furnaces will be installed. New Zealand also, with its excellent magnetic ores, which form the sand of the shore, and with considerable waterfalls occurring near the sea in the course of the rivers flowing down from Mount Egmont, affords a good field for the electrometallurgy of iron.

Steel Obtained from the Reduction of Iron Ores.—The manufacture of steel direct from the ores is subject to the same economic conditions which govern the operation of smelting pig iron. The possibility of obtaining superior qualities by means of the electric fining process nevertheless affects the economic aspect of the question. The cost of the electric energy, the basis of the whole process, no longer forms the principal factor in the cost of production. About 1·10 kilowatt-years are necessary for melting and fining of one ton of steel; and even if the motive power is supplied by a steam engine, the expenditure of electric energy will approximately amount to 32s. per ton of steel. This outlay, resulting under the least favorable conditions of generating power, can scarcely form an obstacle to the fining of steel of superior quality by the electric method.

After thus elucidating the general conditions under which the electrometallurgy of iron and steel appears possible, it may be permitted to describe the following experiments undertaken by Mr. Keller several years ago. The manufacture of iron and steel was divided into two quite distinct phases, the reduction and the melting of the raw metal being effected in a primary furnace working continuously, and the fining of the metal being carried out in a secondary furnace working intermittently. The latter was placed at a lower level than the former, and received the metal direct as it was run off from the primary reducing furnace.

The conditions essential to ensure efficiency in the working of the furnace are, first, sufficient power available for treating a considerable mass. Secondly, continuity in working. To comply with these conditions the author adopted the plan of focusing the heat at several points encircling the mass of raw materials. By Mr. Keller's arrangement the use of an acid or a basic lined wall is optional. The furnace hearth is constructed in the same manner as an open-hearth furnace. The melting chamber of the furnace is surmounted by a shaft of brickwork containing the ores, fuel, and fluxing materials, which are charged in from the top.

As soon as the furnace is started, charging begins until it is full. The four electrodes are regulated separately, a matter which is easily acccomplished within a few minutes after lighting up. The reduction of the metal and the fusion at first take place on the hearth only, but after working some time the materials contained in the upper part of the furnace become sufficiently heated to enter into reaction. From this period onwards the reduction is no longer confined to the lower part of the furnace, that is to say, to the melting zone, but it begins to take place throughout the whole shaft of the furnace, which is kept constantly full. The gases collect in the upper part, and are drawn off into a chamber where they are burnt, the heat of combustion being utilized in various ways, as for drying the ores.

After some hours the crude metal is run off into the fining furnace, which is previously heated up preparatory to receiving it, and contains already a certain quantity of molten metal. As soon as the slag begins to flow from the tapping hole, the stopper is inserted and the current is then suitably regulated in the now fully charged furnace, in order to maintain the heat and to begin the process of decarburization. At the moment of tapping the metal from the primary furnace, the charge in the latter sinks, and the electrodes, which had been slightly raised to permit of regulating the pressure of the current, are again lowered and return to their original position. The charging of materials then recommences.

The slags from the upper furnace are drawn off through special tapholes provided in the sides of the furnace, and the metal and slag are run off at regular intervals, the working being controlled in the ordinary way by the examination of the contents as they issue from the furnace. A metal is thus obtained absolutely uniform in composition and capable of being readily fined. When the lower fining furnace is fully charged the molten metal is diverted into a second furnace, while the fining of the crude metal proceeds in the former.

The method of electric distribution is similar to that already described, but while the primary reducing furnace is constantly maintained full, the fining furnace contains only molten metal and the substances necessary for completing the elimination of the non-metals. The surface of the bath is at a sufficiently low level to permit of taking samples during working. Although the electric distribution is the same in both furnaces, the method of electric working is totally distinct, for while in the reducing furnace a low pressure of from 25 to 30 volts for each focus is employed, the fining furnace is worked with a pressure of from 50 to 75 volts for each focus. It is important, therefore, in fining that the electrodes are not plunged in the slag, otherwise, on account of the oxidizing nature of the latter, their ends are rapidly burnt away, and owing to the contact with the slag the iron oxide contained therein is reduced, and particles of carburized metal become entangled, which delays, and even renders impossible, the finding of the metal bath beneath the layer of slag.

The elevation of the electrodes for a given capacity of furnace or for a given slag is determined by their distance apart, and by the pressure employed. For a given distance apart it is, therefore, necessary, in order to avoid all contact between the electrodes and the bath of metal, to employ a somewhat high pressure.

The top of the fining furnace is closed in by a reverberatory crown, and openings are provided for the introduction of the additions and for taking samples. These operations could be facilitated by mounting the furnace upon trunnions and tipping it like a Bessemer converter.

The temperature is easily controlled during fining by the adjustment of the electrodes. It can be increased to a point far above the temperature of the open-hearth furnace converter, or crucible furnace, and it is even possible to obtain a heat sufficient to volatilize the iron. By the process of electric fining, reactions can, therefore, be produced which are impossible in the open-hearth. The decarburization should be effected preferably with the aid of metallic oxides, in particular with iron oxide. If a blast is employed a rapid waste of the electrodes ensues; further, the oxygen of the air-blast, after burning the greater portion of the more oxidizable elements, of which carbon is the chief, then reacts upon the iron, forming particles of iron oxide, which, being disseminated throughout the mass, rapidly change its quality. On the other hand, the oxygen of the iron oxide, being in stable combination, is only freed by the energetic reducing action of the carbon. The ore process, therefore, appears to be that which is best applicable to the electric open-hearth. The dephosphorization and desulphurization of the metal bath are also facilitated by the character of the source of heat. The elimination of sulphur can be effected without difficulty owing to the ease with which a reducing action is promoted.

The final additions are made, as in the ordinary process. The only point to be noticed in regard to these is the economy which can be effected in the case of rare metals by the prevention of loss due to their oxidation while making the additions.

NEW BLAST FURNACES.—The following is a list of new blast furnaces begun in 1902, which are expected to be put into blast during 1903:—

One of the two furnaces of the Buffalo & Susquehanna Iron Co., at Buffalo, N. Y.; Wharton Furnace No. 3 at Wharton, N. J.; Palmerton Furnace of the New Jersey Zinc Co., building at Palmerton, Pa., to make spiegeleisen; the furnace of the Rochester & Pittsburg Coal & Iron Co., at Falls Creek, near Du Bois, Pa.; two furnaces of the Sharon Steel Co., at South Sharon; two furnaces at Donora, Pa., of the Union Steel Co.; the third stack of the St. Clair Furnace Co., at Clairton, Pa.; No. 2 Furnace of the Low Moor Iron Co., at Low Moor, Va.; Tuscaloosa Furnace of the Central Iron & Coke Co., at Tuscaloosa, Ala.; Gadsden Furnace of the Alabama Consolidated Coal & Iron Co., at Gadsden, Ala.; the first of a series of furnaces which the Alabama Steel & Wire Co. is to build at Gadsden, Ala.; the new furnace of the Cleveland Furnace Co., at Cleveland, Ohio; the new furnace of the South Chicago Furnace Co., at South Chicago; the Zug Island Furnace of the Detroit Iron & Steel Co., at Detroit, Mich., and the furnace of the Lookout Mountain Iron Co.

During the year 1904 there will be completed the following stacks on which work is now progressing:—

The second furnace of the Buffalo & Susquehanna Iron Co., at Buffalo, N. Y.; Nos. 3, 4 and 5 furnaces of the Lackawanna Steel Co.; the fourth furnace at the Ohio Works of the Carnegie Steel Co., at Youngstown, Ohio; No. 3 Furnace at

New Castle, Pa., of the Carnegie Steel Co.; No. 5 Eliza Furnace of the Jones & Laughlin Steel Co., at Pittsburg, Pa.; No. 3 Furnace of the National Tube Co., at McKeesport, Pa.; the new Franklin Furnace of the Cambria Steel Co., of Johnstown, Pa.; the two new furnaces at Lorain, Ohio, for the Lorain plant of the Illinois Steel Co.; the two new stacks of the Cherry Valley Iron Co., at West Middlesex and at Leetonia, Ohio; the second furnace of the La Belle Iron Works, at Steubenville, Ohio; the new Ensley Furnace of the Tennessee Coal, Iron & Railroad Co., at Ensley, Ala., and Furnace F of the Colorado Fuel & Iron Co., at Pueblo, Colo. The addition of these new plants will more than compensate for the falling off of old works incapable of producing iron economically.

THE BLAST FURNACE AS A POWER PLANT.—Mr. Edward A. Uehling[5] sums up the possibilities of the utilization of blast-furnace gases as follows:—

"Although the application of blast furnace gas, to internal combustion engines, is of comparatively recent date, its practicability has already been demonstrated on a commercial scale. A large number of such engines, varying from 50 to 1,200 H.P., the majority over 500 H.P., are to-day in successful operation in Europe, Germany being far in the lead.

"From a large number of tests it has been found that from 20 to 30% of the heat energy contained in the gas can be realized in effective power. It has been found that 1 lb. of blast furnace gas generates 1,283 B. T. U. Now since 2,545 units are equivalent to one horse power and taking the average efficiency of the blast furnace gas engine at 25% we find that 2,545÷12+7·93 lb. of gas are required per horse-power hour. Deducting from the total weight consumed in heating the blast and dividing by the weight per H.P. hour, the horse power per ton of iron produced per hour is found to be 1,097·76 H.P.

"The power legitimately required to operate the plant should be below 200 H.P. per ton of iron per hour; but since labor saving machines are continually being added, to be on the safe side, 250 H.P. should be allowed for blowing engines, pumps for all necessary purposes including cooling water for gas engines, for handling the raw material and product for lighting the plant, etc., there still remains 1,097·76—250=847·76 H.P. for sale or available for other useful work, for every ton of iron produced per hour.

"The average rate of production of pig iron in the United States for three months in 1902 was 1,493,691 tons per month, 49,790 tons per day and 2,078 tons per hour; hence if the wasteful steam power plants were replaced by internal combustion engines at all the furnaces there would be available a surplus of 847·76×2,078=1,761,645 H.P.

"The importance of the blast furnace as a source of power as well as the efficiency of the gas engine as a prime mover, are perhaps even more vividly brought out by the following fact, than by the colossal figures of available power shown above: If the coke consumed per ton of iron was burned direct under steam boilers and the steam generated all used to produce power in steam engines, an efficiency of 1·82 lb. of fuel per horse power hour must be realized in order to produce an equal power to that obtained from the gas engine from

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[5] *Stevens Institute Indicator.*

the same weight of coke charged into the blast furnace even after deducting the gas required to heat the blast.

"When the fact is considered that it is quite the exception to depend upon blast furnace plants for any surplus power, that on the contrary in the majority of plants thousands of tons of coal are fired under the boilers to assist the gas in producing the necessary steam for the wasteful blowing engines and pumps in a still more wasteful boiler plant, and compare this with the actual power possibilities of the blast furnace it is somewhat surprising that so little has been done in this direction in America.

"The path of economy does not lie in the direction of compounding steam cylinders, or increasing the heating surface of the steam boiler plant. Money thus spent, unless it be for temporary purposes, is more or less completely wasted.

"A modern blast furnace plant should not only have no fuel expense for its own power requirement, but should have a surplus of power of at least 800 H.P. for every ton produced per hour for sale which in the majority of localities could be made the source of a handsome revenue.

"To realize this condition, the first and most imperative step is to wash the gas thoroughly, the second is to replace the steam engines by internal combustion engines. A good beginning to utilize the power stored in blast furnace gas, as herewith demonstrated, is being made by the Lackawanna Steel Co., at its new works near Buffalo, where blast furnace gas engines aggregating 40,000 H.P. are now being installed."

LEAD.

By Joseph Struthers, D. H. Newland and Henry Fisher.

The production of all varieties of domestic lead in the United States during 1902 showed a slight increase over the production in 1901. The grand total of soft, desilverized and antimonial leads produced from both domestic and imported ores and refined from imported base bullion in 1902 amounted to 388,140 short tons, as compared with 392,393 short tons in 1901. The totals of desilverized, soft and antimonial leads in short tons, derived from domestic ores in 1902 and 1901 were respectively as follows: Desilverized, 199,615, 211,368; soft, 70,424, 57,898; antimonial leads, 10,485, 10,656 (includes production from foreign sources); total domestic leads, 280,524, 279,922.

PRODUCTION AND CONSUMPTION OF LEAD IN THE UNITED STATES. (IN SHORT TONS.)

Year.	Stock of Refined, Jan. 1. (a)	Produced from United States Ores.				Imported in Ores and Bullion.	Total Supply.	Consumed.	Exported in all Forms.	Stock of Refined, Dec. 31. (a)
		Desilverized.	Soft.	Antimonial. (b)	Totals.					
1898....	31,161	169,364	50,468	8,643	228,475	89,209	348,845	246,989	78,168	23,688
1899....	23,688	171,495	40,508	7,877	217,065	76,423	317,196	215,662	74,944	26,590
1900....	26,590	221,278	47,923	9,906	279,107	114,397	425,824	258,896	100,288	66,640
1901....	66,640	211,368	57,898	10,656	279,922	112,471	458,083	304,274	100,026	53,733
1902....	53,733	199,615	70,424	10,485	280,524	107,616	441,873	(c) 360,139	80,467	(c) 55,000

(a) Includes lead in bond, which amounted to 4,700 tons at the end of 1902. 16,618 tons at the end of 1901. 21,190 tons at the end of 1900 11,320 tons at the end of 1899 and 7,845 tons at the end of 1898. (b) The entire production of antimonial lead is entered as of domestic production, although part of it is of foreign origin; it is, however, impossible to separate this in the statistics; owing to this inability the division of the American production between antimonial and desilverized is not quite accurate, though the error is not important. (c) Estimated.

The decrease of 11,753 short tons in the production of desilverized lead during 1902 was a continuation of the retrograde movement begun in 1900, a year in which the stock carried over was very large, compared with the stocks in previous years. The decrease in the production of desilverized lead, however, was practically offset by the increase in the production of soft lead, which amounted to 12,526 short tons and, including the slight decrease in the production of antimonial or hard lead (a minor proportion of which is of foreign origin) gives a total production of desilverized lead and soft lead from domestic sources and antimonial lead amounting to 280,524 short tons in 1902, an increase of only 602 short tons over that of the previous year.

Colorado.—The production of lead in Colorado during 1902 was 53,152 short tons, valued at $4,325,484, as compared with 74,056 short tons, valued at $6,419,131 in 1901. The production by principal counties for the two years, as reported by the Hon. Harry A. Lee, is given in the subjoined table:—

County.	1901.		1902.	
	Short Tons.	Value.	Short Tons.	Value.
Clear Creek	1,945	$168,601	1,641	$133,556
Hinsdale	3,705	328,898	3,107	252,888
Lake	28,180	2,442,629	19,725	1,605,228
Mineral	5,260	455,932	4,646	878,065
Ouray	3,952	342,590	2,181	178,423
Pitkin	16,875	$1,419,364	12,487	$1,016,185
San Juan	7,736	670.607	3,850	313,308
Others	6,813	600,515	5,565	452,881
Total	74,056	$6,419,131	53,152	$4,325,484

The value of the production of the smelters and mills of the Leadville district during the calendar year 1902 amounted to $9,468,544, divided as follows: gold, $1,302,680; silver, $3,051,195; lead, $1,694,410; copper, $303,409; spelter, $3,103,448; and manganese, $8,400. The quantities of ore produced were: oxidized iron ores, 285,494 tons; sulphides, 281,558 tons; zinc ore, 85,699 tons; siliceous ores, 72,215 tons; carbonate ores, 22,730 tons. The American Smelting & Refining Co. reports a production of 50,484 short tons of lead from Colorado ores. The Yak Tunnel has been sunk to a depth of 1,400 ft., and at the 1,300-ft. level, a new ore body was found. An arrangement has been made with the Ibex Co. by means of which the Yak Tunnel proposes to drain the Ibex property, and to prospect it at this level. The independent smelting plant of the Ohio & Colorado Smelting & Refining Co., at Salida, has been completed, and is reported to be smelting from 600 to 700 tons of ore daily, yielding about 30 tons of lead bullion; a roasting plant has been added to the equipment. The Midas mine was a steady producer. No ore was shipped from the Greenback mine for several months during the latter part of 1902, owing to the failure of the owners and the smelter combination to arrive at a satisfactory agreement; the mine is prepared, however, to ship from 300 to 400 tons of ore a day. The Small Hopes mines have been operated upon lease, and in addition to the shipment of a large quantity of ore, development work has been actively carried on.

The bulk of the ores produced in the Leadville district is in the form of fluxing iron ores, which renders the miner dependent upon the rates allowed by the smelter consolidation. The Philadelphia smelter at Pueblo has been closed, due in part to a diminution of Colorado ores and in part to the cessation of shipments of Utah ores, which have been diverted to the new smelting plant at Murray, near Salt Lake City. The utilization of low grade silver-bearing zinc ores promises to be an important factor in the future of the State, and two small concentrating plants have started to work near Denver, and the American Smelting & Refining Co. has installed a small zinc plant at Pueblo, which if successful will be followed by the erection of similar plants elsewhere, so as to act as feeders to the central smelters under the control of the company.

The successful operation of the mills of the A. Y. & Minnie, the A. M. W. and other mining companies, has done much toward the solution of the treatment of the low grade zinc-lead sulphide ores of the Leadville district. A large mill has been completed for the Resurrection mine and several others are in contemplation for 1903. The American Smelting & Refining Co. has installed new roasting furnaces, and has purchased the pyritic smelter of the Boston Gold-Copper Co. which will be enlarged to treat low grade ores of the Leadville district—a problem that has been a serious one for mining companies for some time past.

The zinc situation has been materially improved during the year, and a steady market has been secured in Kansas and Colorado as well as abroad. The United States Reduction & Refining Co. is enlarging its plant at Cañon City by the erection of a new crushing and sampling mill and an additional bag house having a capacity of 6,000 bags. This company is treating a large quantity of zinkiferous material mainly from the Moyer mine.

Several new shafts have been sunk at Fryer Hill on the extension of old bonanza ore shoots and the properties of the Fryer Hill Mines Co. have been successfully drained at a cost of $55,000, which will admit of the handling of large bodies of low grade ores in the old workings.

Idaho.—The quantity of lead produced by smelting the output of the lead-silver ores in the Cœur d'Alêne district during 1902 amounted to 74,739 short tons, as compared with 68,953 short tons in 1901, and the yield in silver from this source was 4,489,549 oz. in 1902, as compared with 3,349,533 oz. in 1901. The statistics of lead and silver production in this State are based on returns received direct from the producers with an allowance of 6% for loss of lead and 2% for loss of silver in smelting the ores. The ores in the Cœur d'Alêne district are of low grade, and are mechanically concentrated to a product which averages in composition about 50% lead and 30 oz. silver per ton. The chief producers during 1902 in the order of output were: The Bunker Hill & Sullivan Mining & Concentrating Co., Cœur d'Alêne Development Co., Larson & Greenough, Empire State-Idaho Mining & Developing Co., Frisco Consolidated Mining Co., Ltd., The Mammoth Mining Co. and the Standard & Hecla Mining Co. Comparatively little new work was done in this district during the year beyond the ordinary prospecting and development necessary to keep the mills supplied with ore. The Empire State-Idaho Co., owning the Tiger-Poorman mine at Burk and the Last Chance mine at Wardner, has made arrangements to have electric power transmitted by wire from the plant operated by water power at Spokane Falls, Wash., over 100 miles distant, a notable development of the use of electricity in mining; the chief work at the mines was the completion of the Kellogg tunnel to the main stopes, a distance of 12,000 ft. through which the ore is carried to the concentrators by electric tramway thus supplanting the use of the aerial wire rope tramway extending over the town of Wardner 2·5 miles in length. This tramway has been one of the show features of the camp for several years. The mining industry of the Cœur d'Alêne district has been well described by J. B. Finlay in an illustrated paper read before the meeting of the American Institute of Mining Engineers, May, 1902. In September, 1902, an agreement was made between the miners of the Cœur d'Alêne district, the American Smelting & Refining Co. and the railroad companies by which the rail rates for freight have been reduced to $2·50@$3 per ton, the miners receiving the entire benefit of the reduction in rates and the American Smelting & Refining Co. agreeing to take 12,000 tons of ore and concentrates per month.

The discovery of a 22-ft. vein of silver-lead ore was reported at the Idaho-Centennial mine early in 1902. The company operating this property proposed to install an air compressor and a concentrating plant for the low grade ore, and to ship the high grade ore to the smelter at Everett, Wash. At the Riverview mine at Bayshore, Custer County, a body of high-grade silver-lead ore, 40 ft. wide, has been struck. An incline has been sunk 110 ft. which shows high values along its entire length. This mine was formerly a large producer, but had not been operated for several years, and its reopening in 1902 was due to the approach of the New Salmon River Branch Railway of the Oregon Short Line Railroad. Another mine which has been opened on account of the extension of the railroad is that of the Portland Mining Co. in Shoshone County. This mine has been closed since 1893. The Oregon Railroad & Navigation Co. has completed a branch line from Kingston to Delta, a distance of 33 miles. The company owns the Silver Tip, Sitting Bull and Tuscumbia lead and silver properties near Delta. In the Thunder Mountain district, Idaho County, the Hidden Treasure Mining Co. has acquired the Hidden Treasure and Belle of Thunder Mountain claims.

Iowa.—There was a material falling off in the production of lead ores in this State during 1902. The output amounted to 247,900 lb., valued at $5,761, as compared with 600,000 lb., valued at $13,800 in 1901. All of the lead ores produced were smelted by Wm. G. Watters of Dubuque, who treats as well ores from other States. The total output of lead in the State from all sources amounted to 1,061,000 lb., valued at $42,440, as compared with 1,500,000 lb., valued at $49,000 in 1901. The demand for lead ruled firm, but that for zinc was indifferent, as none was offered. There has been considerable development work on lead properties, and the outlook is quite promising for an increased production during 1903. The average yield of the lead ores treated amounted to approximately 70% lead.

Kansas.—According to the report of State Labor Commissioner Lee Johnson, the formation of a purchasing company to handle the entire output of lead and zinc ores from Kansas was contemplated. This company was to receive the production from the various mines, and to sell it to the smelters, the purpose being to maintain a uniform price, and if necessary to sell any surplus production outside the State, but on the advance of the price of ore, the plans were not put into effect. The average monthly price of lead ore was $21 in January, which rose to $21·75 in February, fell to $20·75 in May and rose to $25·75 in December, making the average for the year $23·11. The only change in the mining practice in 1902 was the use of buckets of 1,000-lb. capacity instead of 500-lb., and of heavier cables and hoisting engines. Very few mills were built, but many were moved to new localities, most of them to the southwestern Missouri district. The use of the Wilfley table has also become more general. There are 192 mills in the State with a crushing capacity of 19,350 tons daily. The entire output of lead and zinc in ores during 1902 was 78,518,600 lb., valued at $1,216,431, as compared with an output valued at $1,413,948 in 1901.

The only smelter reporting a production in 19Q2 was at Galena, operated by the C. V. Petraeus Smelting & Manufacturing Co., capitalized at $50,000. This smelter was completed about the middle of the year and shipment from the plant was made in August, 1902, and during the last four months of the year several million pounds of soft lead were produced.

Missouri.—The mining district of southwestern Missouri, embracing St. Francois, Madison and Washington counties, experienced a prosperous year in 1902. A new discovery of lead ore has been reported on a farm two miles east of Liberty, Lake County, and the property has been leased by operators from the Joplin district. An important discovery has been made of large bodies of lead and zinc ores at Lehigh, Jasper County. The St. Louis & San Francisco Railroad will build a branch road from Carl Junction to the new field. The Federal Lead Co., owning mines at Flat River, has completed its smelting works at Alton, Ill., and will handle the lead ore from the new producers in Illinois and Missouri who are not equipped with smelting plants and formerly shipped the ore to the East, as the public smelter at St. Louis could not treat the entire output. The Scotch hearth system is used for the first treatment of the ores, and the slag is resmelted in water-jacketed furnaces. A shaft house of the St. Joe Lead Co. was destroyed by fire in December, 1901, but the machinery was not seriously damaged, and was in operation again within a month. During the year the company added a blast furnace to its Herculaneum plant, increasing the number to five. A large Gates crusher was installed in the place of several small Blake crushers, and extensive trestles were built, so that the ore, coke and flux can be handled more readily. In 1903, the company introduced compressed air locomotives in its underground workings to replace the mule system. A 50% dividend was divided among the stockholders of the company, and the capital was increased from $3,000,000 to $6,000,000, of which $2,250,000 will remain in the treasury and $3,750,000 be issued. The Doe Run Lead Co. sunk a new shaft during 1902, and at a depth of 450 ft. it opened a new 6-ft. ore body. This company also declared a 50% dividend, and increased its capital from $1,000,000 to $1,500,000. The Desloge Consolidated Lead Co. completed its No. 4 shaft, which is 325 ft. deep, in four months' time. In 1903, machinery was added, so that the capacity of the plant of 600 tons of ore daily was increased to 1,000 tons. New railroads were constructed in the Joplin district. The output of this district during 1902 was 31,615 short tons of lead and 262,545 tons of zinc, valued at $9,430,790. The average monthly price of lead ore per 1,000 lb. was as follows: January, $21; February, $21·75; March, $21·60; April, $21·75; May, $22; June, $22·31; July, $23; August, $24·50; September, $24·50; October, $24·17; November, $24·94; December, $25. In May a severe storm damaged the mills in the Joplin district. Several new companies were formed and capitalized at high figures, while others were recapitalized.

Montana.—The production of lead in Montana during 1902, according to B. H. Tatum of the United States Assay Office, Helena, amounted in value to $332,747. The lead smelting plant of the American Smelting & Refining Co. at smelter near Great Falls, which was closed down in April, 1901, continued inoperative during 1902, and while it has not been dismantled a large part of the machinery and equipment has been shipped to other plants of the company. At the plant at East Helena, labor troubles caused a shut-down during May, June and a part of July, which reduced the tonnage of ore smelted during the calendar year to 11,000 tons monthly. The bag houses erected to collect the dust from the blast furnace gases, did not prove a success owing to the character of the ores treated, as the gases produced during the smelting destroyed the bags too rapidly. This system was replaced with a long steel flue which cools the gases and facilitates the deposition of the material held in mechanical suspension and aids, as well, the condensation of the metallic values contained in the gases in a volatilized condition.

Nevada.—The Rocco-Homestake mine of White Pine County, in 1902 produced ore to the value of $46,925. Of the gross earnings of the company $12,236 were expended for labor, $6,545 for freight between the mines and railway terminus, and $19,511 for freight between railway terminus and Salt Lake, the smelting center. It is estimated that 5,000 tons of ore have been developed on the property, which will average 70·1% Pb and 21·4 oz. silver per ton.

New Mexico.—Three smelting plants were in operation during the year at Cerillos, Magdalena and Silver City, and the construction of the pyritic smelter at Lordsburg was completed. A large portion of the ores produced in this State is treated at the El Paso smelter in Texas. The chief producers of lead ores were the mines in the Magdalena Mountains and at Cooks Peak.

Tennessee.—According to the report of R. A. Shiflett, Chief Mine Inspector, the quantity of lead contained in the lead ores produced in this State during 1902 amounted to 500 short tons, valued at $2,000. There were 18 men employed in this industry throughout the year.

Texas.—In July, 1901, the silver-lead smelting plant at El Paso, was destroyed by fire, and April 15, 1902, the furnaces of the new works were blown in. There are seven lead blast furnaces rated at from 200 to 250 tons charge per day, and three copper blast furnaces, each with a daily capacity of from 250 to 300 tons. The furnaces are fed from a 6-ton charge car, which is moved along the ore, flux and fuel bins by means of an electric motor, and, after having received its charge, is raised 38 ft. by a 15-ton hydraulic elevator to the top of the furnaces, where it travels over them to the charging openings. As the copper furnaces are lower than the lead furnaces, the charges for them are first dropped into hoppers from which they are discharged into the furnaces. Crude Beaumont (Texas) oil is used in the roasting and boiler departments. The power plant is equipped with seven boilers, representing a total of 1,250 H.P., and four blowers of a capacity of 30,000 cu. ft. per minute direct connected to three tandem compound condensing Corliss engines. The sampling works, briquetting machinery, pumps, hoists, motor cars, etc., receive power from a central electric plant.

Utah.—The production of lead by counties, as reported by B. H. Tatum, United States Assay Office, Helena, Mont., is given on the following page.

The blast furnace of the new smelting plant of the American Smelting & Refining Co. at Murray, nine miles south of Salt Lake City, was blown in during the early part of the summer of 1902. The works are built on a horizontal plane. There are, however, two drops, one of a few feet from furnace house floor to the slag yard level to furnish the room necessary for the matte settling boxes, and the other along the entire slag yard to furnish dumping ground for the slag. The works have three divisions—the crushing and roasting department, the smelting department and the power department. The roasting department has two steel buildings, one for hand reverberatory furnaces and the other for the Brückner cylinders. The hand reverberatory furnaces have neither fusing nor sintering-hearths. The raw ore is brought on an overhead track, dumped into the hoppers of the furnaces, and the roasted ore is dropped into cars running on a depressed track serving the row of furnaces. At the end of the track is an incline. The cars are drawn up the incline, and then over a horizontal track running over a row of brick bins into which their contents are dumped. The fire boxes have step grates fed from above with coal, and closed ash pits. Ventilation and light are furnished by a large opening in the roof of the building; the floor is of concrete laid on a bed of broken slag. The general arrangement of the Brückner plant as regards handling of ore and coal, is similar to that of the hand reverberatory plant. The smelting department contains eight blast furnaces, 48×160-in. section at the tuyeres. A furnace has 10 tuyeres on a side, entering the centers of the cast iron jackets, which are 16 in. wide and 6 ft. high. The furnaces are fed mechanically. The ore and fluxes arrive on trucks and discharge onto the ore beds and into the elevated flux bins respectively. The charges are made up on the furnace house level, dumped into the feeding cars which are hoisted on two inclines to a transfer carriage running over the tops of the furnaces. The base bullion is removed from the siphon taps on the furnace house level, slag and matte are tapped into settling boxes from which the waste slag overflows in Nesmith single bowl waste slag pots, which are hauled by a small locomotive to the edge of the dump and poured. The sculls and foul slag are returned and dumped into the hopper of a continuous inclined pan conveyor, delivering into a steel cylinder lined with brick, which is placed behind the furnace house near the place where the charges are made up. The slag is drawn off through chutes when needed. The matte is tapped from the settling boxes into suitable receivers and allowed to cool on the dump. The dust flue extending behind the furnace house is arranged to allow the discharge of the flue dust into cars running on a depressed track. This blast furnace flue connects with the main flue which is built of concrete laid in expanded metal stretched over steel frames. Parts of the main flue can be cut out by steel dampers to admit of cleaning. The draught for the roasting and smelting departments is furnished by a stack 20 ft. in diameter and 225 ft. high. The power department contains eight boilers provided with American stokers, two cross compound horizontal Allis-Chalmers (Dixon) blowing engines, two direct connected generators and a machine shop.

County.	1902.		County.	1902.	
	Short Tons.	Value.		Short Tons.	Value.
Beaver	2,511	$204,876	Tooele	1,976	$160,779
Juab	10,183	824,644	Others	431	35,065
Salt Lake	1,629	132,534			
Summit	38,625	3,143,300	Total	55,805	$4,500,698

Separate from the three main divisions are the sampling and flue dust briquetting mills.

The new smelting plant of the United States Mining Co., at Bingham Junction, was put in commission in October, 1902. At first, mechanical charging of the furnaces was adopted which, however, did not meet with success, and a return was made to the common practice of charging by hand. The capacity of the plant is 1,000 tons of ore per day, and ores are purchased in order to mix advantageously with the ores of the United States mine at Bingham and the Centennial-Eureka mine at Tintic, both owned by the company. The entire holdings and rights of the Utah Consolidated Gold Mining Co., of England, operating the Highland Boy mine and smelter at Bingham, have been transferred to the Utah Consolidated Mining Co., of New Jersey. The Uncle Sam Consolidated Mining Co. owning the Uncle Sam and Humbug mines at the north end of the Tintic range in Juab County, is shipping about 300 tons of ore per month, the ore being mainly silver-lead. The Uncle Sam ore carries about 1 oz. silver to every 20 lb. of lead, and the Humbug ore about 1 oz. silver to every 10 lb. of lead. The gangue is quartz and lime. The ore also carries from $1 to $10 in gold. A 50-ton concentrating mill is to be erected. The Gilmore Mining Co. of Texas district, in Idaho, is developing its property. It has 700 ft. of tunnel in cross-cutting and drifting on its various shoots of ore. It is shipping ore every two weeks, and will ship concentrates also from its jigging plant, which has already been erected. A ton of concentrates is obtained from 3 tons of crude material, the concentrates assaying 65% lead and about 40 oz. silver. The capacity of the jigs is 14 tons of ore daily. Hoisting works and ventilating tubes are to be installed.

LEAD PRODUCTION OF THE WORLD. (*a*) (IN METRIC TONS.)

Year.	Australasia. (*c*)	Austria.	Belgium.	Canada.	Chile. (*d*)	France.	Germany.	Greece.	Hungary.
1897	....	9.680	17.023	17.698	370	9.916	118,881	16,486	2,527
1898	67.000	10.840	19,830	14.477	18	10,920	132,742	19,198	2,305
1899	87,600	9.736	15.700	9.917	171	15,981	129,225	19,059	2,166
1900	87,100	10,650	16,365	28.654	14	15.210	121.513	16,395	2,030
1901	90,000	10,161	18.760	23,542	455	21,000	123,098	17,644	2,029

Year.	Italy.	Japan.	Mexico.	Russia.	Spain.	Sweden.	United Kingdom. (*b*)		United States.	Totals.
							Foreign Ores.	Domestic Ores.		
1897	22,407	1,787	71,687	450	169,216	1,480	13,812	26,988	179.369	699,167
1898	24,543	1,705	71,443	241	198,392	1,559	23.239	25,761	207.271	798.615
1899	20,543	1,989	84.656	322	184,007	1,606	17,571	23,929	196,938	820,873
1900	23,763	1,877	63,827	221	176.600	1,424	10,738	24,762	258,204	854.407
1901	25,796	1,806	94,194	250	169.294	988	19,639	20.361	258,944	892.955

(*a*) The statistics for Austria, Belgium, Canada, France, Germany, Hungary, Italy, Japan, Russia, Spain and Sweden are from the official reports of the respective governments except where otherwise noted. Those for Greece are based on the authorities given under the general table of mineral production of Greece in a subsequent part of this volume. Those for the United States are from data collected by THE MINERAL INDUSTRY. Those for the United Kingdom as specified in note *b*.

(*b*) The production of lead in the United Kingdom is given in two columns. One gives the amount of lead derived from domestic ores, the yield of which is calculated at 95%, as reported in the official British blue books. The other column gives the production of lead in the United Kingdom from foreign ores smelted there. These figures, which are not reported in the official blue books, are obtained by deducting the production of British lead from the total output of the lead smelters of the United Kingdom as stated in the *Statistische Zusammenstellungen über Blei, Kupfer, Zink und Zinn* of the Metallurgischegesellschaft, Frankfort-on-the-Main.

(*c*) From the *Statistische Zusammenstellungen* of the Metallurgischegesellschaft, Frankfort-on-the-Main These figures comprise only the lead exported to Europe and America. (*d*) Exports.

PRODUCTION, IMPORTS, EXPORTS AND CONSUMPTION OF LEAD IN THE CHIEF COUNTRIES OF THE WORLD. (IN METRIC TONS.)

		Aust'a-Hungary. (*a*)	Belgium. (*b*)	France. (*c*)	Germany. (*d*)	Italy. (*e*)	Russia. (*f*)	Spain. (*g*)	United Kingdom. (*h*)	United States. (*i*)
1900	Production	12,680	16,365	15,210	121,513	23,763	221	176,600	35,500	253,204
	Imports	8,091	58,141	70,857	70,252	3,257	20,000	*Nil.*	198,416	103,780
	Totals	20,771	74,506	86,067	191,765	27,020	20,221	176,600	233,916	356,984
	Exports	393	46,566	718	18,825	5,018	*Nil.*	153,939	17,764	90,638
	Consumption	20,378	27,940	85,349	172,940	22,002	20,221	22,661	216,152	266,346
1901	Production	12,090	18,760	21.000	123,098	25,796	250	169,294	40,000	253,944
	Imports	11,033	....	59,051	52,886	2,926	22,550	*Nil.*	221,549	102,033
	Totals	23,123	....	80,051	175,984	28,722	22,800	169,294	261,549	355,977
	Exports	68	....	648	20,820	4,463	*Nil.*	151,993	18,426	90,520
	Consumption	23,055	....	79,403	155,164	24,259	22,800	17,301	243,123	265,457

(*a*) From *Statistisches Jahrbuch des K. K. Ackerbau Ministerium* and *Magyar Statisztikai Evkönyv*.

(*b*) Production from *Statistiques des Mines, Minières, Carrières, et Usines Métallurgiques*. Imports and exports from *Annuaire Statistique de la Belgique*. Not available for 1901.

(*c*) From *Statistique de l'Industrie Minérale*.

(*d*) Production, imports, and exports from *Statistisches Jahrbuch für das Deutsche Reich*.

(*e*) From *Rivista del Servizio Minerario*.

(*f*) From *Sbornik Statisticheskikh Svedenie o Gornozavodskoi Promyshlennostie Rossie v Zavodskom Godu*, St. Petersburg.

(*g*) From the *Reports of the Comision Ejecutiva de Estadistica Minera*. Imports and exports from the *Revista Minera de Espana*.

(*h*) Production from statistics of the Metallurgischegesellschaft, Frankfort-on-the-Main. Imports and exports from Board of Trade returns.

(*i*) The statistics of production are those collected by THE MINERAL INDUSTRY; those of imports and exports are from the reports of the Bureau of Statistics, Washington.

LEAD MINING IN FOREIGN COUNTRIES DURING 1902.

Algeria.—The production of argentiferous lead ore during 1901 amounted to 1,614 metric tons, valued at $21,916, as compared with 222 metric tons, valued at $6,382 in 1900. A discovery of a deposit of lead ore has been reported at the Oum Teboul mines, near Bona.

Austria-Hungary.—The Bleiberger-Bergwerks Union, owning mines in Illyria, produced during 1902 in the Bleiberg district, 2,617 metric tons of lead ore, 4,348 tons of leady ore and 3,335 tons of zinc ore. The average content of metal in the ores produced was, Pb 4·9% and Zn 3·9%. The mines at Meiss produced 3,484 metric tons of lead ore, 4,695 tons of leady ore, and 104 tons of calamine. There were also 130 metric tons of lead ore produced at Eisenkappel, and 77 tons of lead ore at Windisch-Bleiberg. In Hungary, the Ärar district produced the entire output of lead ore during 1901 from the following named mines: Felsö-Biberstollen, 628 metric tons; Felsöbánya, 1,407 metric tons; Kapnik, 274 metric tons; Oradna, 135 metric tons, and Oláhláposbánya, 34 metric tons.

Australia.—In the Broken Hill district all the mines except the Broken Hill Proprietary, Block 10, Central and South, suspended operations during 1902, owing to the depressed metal market. The total tonnage of ore produced in the year is estimated at 253,409 long tons, containing approximately 132,548 tons lead, 6,165,226 oz. silver, 29,432 tons zinc and 15 oz. gold. The ore is valued approximately at £2,202,311, while the value of the lead content is estimated at £1,481,224. Consequent upon the low prices ruling for silver and lead, increased efforts were made by the companies to effect economies in mining, to improve the methods of treating the refractory ores, and to find a means of utilizing the waste products, as a result a degree of success was achieved in solving the various problems. The Broken Hill Proprietary Co., Ltd., during the fiscal year ending Nov. 30, 1902, treated 263,659 tons of ore yielding 64,676 tons soft lead, 427 tons antimonial lead, 5,477,143 oz. silver and 2,935 oz. gold. Of the 643,587 tons of ore raised, 85,235 tons were obtained from open-cut, and 558,352 tons from underground workings. The gross profits for the year amounted to £155,061, which, after deducting £42,364 for depreciation of various plants, yielded a net profit of £102,697. For construction the sum of £32,424 was expended, and two dividends of £48,000 each were paid. The balance at the end of the fiscal year was £550,091. Experiments with the "Huntington-Heberlein" process having been satisfactory, a plant to carry on this process, which consists in delivering the roasted concentrates in a lumpy condition to the furnaces instead of first briquetting them, has been completed, and it is believed that this will materially strengthen the earning power of the company by increasing the recovery of the metallic content of the ore. The results obtained with the magnetic concentrator have not been sufficiently satisfactory to justify the erection of a working plant. Eight furnaces are in operation at Port Pirie, one of which has been converted into a circular furnace, and is under trial. During the fiscal year 243,655 tons of ore, concentrates, etc., were smelted, with an average yield during the first half-year of 18·81% Pb and 18·71 oz. silver per ton, and during the second half-year of 21·71% Pb and 19·69 oz. silver per ton. The refinery treated 47,721 tons of silver-lead bullion, yielding 4,644,366 oz. fine silver, 2,935 oz. fine gold, 46,046 tons soft lead and 427 tons antimonial lead. In addition to the ore smelted at Port Pirie, a quantity of concentrates was sold, the total output amounting to 64,676 tons lead and 5,349,426 oz. silver. The Broken Hill Proprietary Block 10 Co., Ltd., for the year ending Sept. 30, 1902, treated 85,672 tons crude ore yielding 15,968 tons concentrates containing 10,297 tons lead and 545,588 oz. silver. The expenditures during the half-year ending Sept. 30, 1902, amounted to £46,387, the income to £46,494, the net profit to £1,284; the profit and loss account was increased to £17,810. There were 46,401 tons lead ore and 403,836 tons zinc ore on hand at the end of the fiscal year. Magnetic separation is being tried on the ore, but the results are still unsatisfactory. A new power plant is being erected and a new mill will be built in January, 1903. In the concentrating plant several alterations have been made, greatly increasing its efficiency.

The Sulphide Corporation, Ltd., during the fiscal year ending June 30, 1902, milled 251,056 tons of ore, assaying 18% lead, 19·5% zinc and 11·8 oz. silver, which yielded 50,753 tons of lead concentrates containing 45,444 tons lead, 49,344 tons zinc and 2,964,263 oz. silver. In addition 463 tons of concentrates were produced by re-treatment of 2,627 tons of slimes from the old dump. The magnetic separation plant, which was completed in October, 1901, can handle 3,000 tons of middlings per month. During the year 11,372 tons of these middlings were treated, yielding 5,336 tons of concentrates containing 2,094 tons zinc, 729 tons lead, and 74,204 oz. silver. The results are so satisfactory that a plant will be erected to increase the output of zinc concentrates. It will be used to treat

700,000 tons of zinkiferous by-product now lying on the dumps, which contains approximately 4,822,000 oz. silver, 38,600 tons lead, and 163,500 tons zinc.

Bolivia.—The exports of Bolivia through the port of Antofagasta, Chile, during 1900 included 182 metric tons of bar lead, valued at $36,453, and 4,807 metric tons of silver-lead, valued at $961,473. During 1901 the export of silver-lead only is reported, which amounted to 538 metric tons, valued at $365,457. (Value quoted in Chilean currency.)

Canada.—(By Samuel S. Fowler.)—The mining of lead ores in Canada has been virtually confined to British Columbia, all of the producing mines being within the limits of the Kootenays, in the southeastern corner of the Province. Mining has been possible only because of the silver content of the ores; the ratio of silver to lead in West Kootenay lead ores exceeding 2 oz. to 1%, and in East Kootenay a little less than 1 oz. to 1% of lead.

Prior to 1892 slightly more than 500 tons of lead ore had been mined, and the industry began as the result of the Slocan discoveries in the autumn of 1891. A little later, important discoveries were made in East Kootenay, which have since become of great importance. According to the reports of the Minister of Mines of British Columbia, the lead production of the Province during the last decade has been as follows:—

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
	Short Tons.		Short Tons.		Short Tons.		Short Tons.
1892..........	404	1895.........	8,238	1898.........	15,847	1901.........	25,792
1893..........	1,068	1896.........	12,100	1899.........	10,981	1902.........	11,268
1894..........	2,831	1897.........	19,420	1900.........	31,679		
						Total......	139,578

In 1899 many of the Slocan mines were closed for a long time because of strikes consequent upon the introduction of an eight-hour law. During 1900 and 1901 the output increased rapidly because of the effect of relatively high prices of lead in London, and the operations of one large concern in East Kootenay. In 1902 the effect of low prices of both lead and silver was to make the continuance of the industry financially impossible, or at least unprofitable, except at some of the smaller and richer properties.

In 1900 the smelters bought British Columbia lead ores only at the London quotation for soft Spanish, less $14 per ton, and in 1901 and 1902, less $20 per ton. In 1902 the average price received by the miner was about $1·40 per 100 lb., as compared with the Cœur d'Alêne (Idaho) miner, who received (chiefly from the American Smelting & Refining Co.) $3·50 per 100 lb. metallic lead, equivalent to 1·5c. per lb. lead produced therefrom in the large and highly protected American market. That market has not been open to the Canadian miner for three years, because of the sufficient American production. Whatever Canadian lead has been sent into the States during the last three years has been smelted or refined there in bond, excepting about 10%, and whatever advantage has been gained from this exception has gone to the refiner rather than the miner.

The Canadian market for lead in all forms amounts at present to from 14,000 to 15,000 short tons per annum. About 3,500 tons is used in metallic form, the balance chiefly as paint material. The present tariff relating to lead and lead products imported into Canada, was framed before the lead industry existed, and provides for a duty of 15% on pig and 5% on corroded lead, less in each instance one-third, if the import is of British origin. Such duties are not sufficiently protective to be of use to the British Columbia miners, who, driven by a return to normal prices for lead, are compelled either to go out of business or seek such changes in the tariff as will result not only in giving the miner a higher average price for his lead, but will tend as well to the establishment of corroding works within the Dominion. In seeking an increase of duty rather than any other form of assistance, the miner is looking forward to the results of the great industrial expansion which is taking place and to the consequent increase of the home consumption, of which he rightly thinks, he should have some of the benefits, as against the interests of the Mexican who now supplies most of the Canadian lead trade through American channels.

During 1902 more than 80% of the lead ores and 75% of the lead content of them was smelted, either at Trail or Nelson. Without these local smelters, the mining of much of the very low-grade Rossland ore, (which is used as dry ore by the Trail plant) and of practically all of the dry silver ore output of the Province, would be impossible. The dry-ore miner should therefore take an active interest in the affairs of the lead miner. Shortage of coke supplies, due to strikes at the coal mines, and shortage of lead ores, because of low prices, necessarily rendered lead smelting operations very unsatisfactory, each plant running only one furnace during most of the year. Electrolytic refining of lead (which is described under the caption "Recent Improvements in Lead Smelting," given later in this section), was successfully established at the experimental plant of the Canadian Smelting Works, at Trail, from which during the second half of the year, 876 short tons of lead were produced and sold in Canada.

Chile.—The export of silver-lead from Chile during 1901 amounted to 441 metric tons valued at $197,396 (Chilean currency).

France.—The production of lead ore during 1901 amounted to 20,650 metric tons, chiefly derived from the Pontpéan mine in Ille-et-Vilaine, which contributed 11,000 tons of silver-lead ore and 4,600 tons of zinc blende. Other silver-lead mines are in the departments of Hautes-Pyrénées, Aveyron, Tarn, Ariège and Drôme.

Germany.—The production of lead ore in Germany in 1902 was 167,855 metric tons ($3,359,000), as compared with 153,341 metric tons ($3,535,250) in 1901. The output of lead was 140,331 metric tons ($7,837,250) and litharge 4,197 metric tons ($258,250), as compared with 123,098 metric tons ($8,058,250) and 4,101 metric tons ($282,000) respectively in 1901. In 1902, the output of the Verein fuer die Berg-und Huettenmaennischen Interessen in Aachener Bezirk was 32,938 tons of lead ore and 60,486 tons of pig lead. The average price obtained for the lead was $5·57 per 100 kg. During 1902 the output of lead ore in Silesia amounted to 52,757 metric tons, valued at $971,327, and of lead, 30,240 metric tons ($1,709,862), and of litharge 2,119 metric tons ($122,623). The production of lead ore in the Bonn district during 1902 was 63,703 metric tons.

Italy.—The ore deposits in the Iglesias district, Sardinia, occur either as veins or as caverns and beds, the former being found exclusively in schists and the latter in limestone. In general, the veins strike N.E.-S.W., and dip toward the north; they range in width up to 5 ft. and even greater, and are filled with argentiferous galena, blende and calamine. The galena is rich in silver as compared with the cavern and bedded deposits, and the silver sulphide present appears to occur also in the gangue which is chiefly quartz and calcite, although fluorite and barite also are present. The most important vein deposits are at Montevecchio and Gennamari-Ingurtosu, others are at San Giovanni, Su Zurfuru, Marganai, Nebida, San Benedetto, Malacalzetta and Montenuovo. The cavern and bedded deposits contain chiefly galena and calamine with occasional cerussite and blende. At Malfidano, calamine alone occurs, while at Monteponi, galena poor in silver is present also. The cavern and bedded deposits occur almost always near the contact between limestone and Silurian schists, and ores of this class are worked at Monteponi, San Benedetto, Nebida, Seddas Modizzis, Marganai and Malfidano, of which the first and last named rank among the most important mines in Italy. The production of lead ore in the Iglesias district during 1899 was 30,599 tons, as compared with 33,353 tons in 1898, and of zinc ore 127,714 tons in 1899, as compared with 113,585 tons in 1898. There were produced, also, small quantities of silver, antimony, manganese and iron ores, and about 25,000 tons of coal per annum. The number of workers in the lead and zinc mines in 1899 was 13,003. A small quantity of lead ore is smelted on the Island, 1,917 tons of soft lead having been exported in 1899, but by far the greater part of the output is shipped to the mainland of Italy for reduction. A little zinc ore also is smelted at home, but the greater part is treated at Belgium and France, 83,484 tons having been sent to the former, and 25,000 tons to the latter in 1899.

Mexico.—(By James W. Malcolmson. See also under the section devoted to gold and silver, elsewhere in this volume.)—The advance of the lead mining industry in Mexico is largely due to the United States import duty of 1·5 c.'U. S. currency, per pound on lead, thereby keeping Mexican lead ores in the country. Numerous local smelters have been built up on account of this tax, and the domestic smelters now handle perhaps 75% of all the ore mined in the country. Toward the end of 1902 steps were taken to reopen the numerous lead mines of the American Smelting & Refining Co., which had been closed on account of the low price of lead and the destruction of the El Paso smelting works by fire. The American Smelting & Refining Co. and its ally the Guggenheim Exploration Co. now own or control lead mines in the States of Santa Bargara, Parral, Monterey, Sierra Mojada, Velardeña, and Chihuahua, and are still energetically examining producing properties with a view to purchase. The Compañia Metalurgica Mexicana and its allied organizations, the Mexican Lead Co. and Montezuma Lead Co., pursues the same policy. It owns lead mines in the States of Sombrerete, Sierra Mojada, Santa Barbara, Monterey, San Pedro, Concepcion de Oro and other points. The new Torreon lead smelter of the Compañia Metalurgica de Torreon, which commenced operations in 1902, owns the Voladora lead mine in Monterey and the Americana mine at Terrazas, Chihuahua. This plant of four furnaces, smelting 12,000 tons of ore per month, made a profit of $700,000 in 1902 on a capitalization of $2,500,000.

Chihuahua.—In Santa Eulalia, near Chihuahua City, American capitalists took over the Potosi mine at the end of 1901, and have opened it up through the adjoining Santo Domingo property, at a depth of 1,300 ft., with extraordinary success. The Santo Domingo and Potosi silver-lead ore bodies are larger than any developed lead carbonate deposits in Leadville, but the silver assays are lower. The adjoining mines of the Hearst Estate and the American Smelting & Refining Co. also contain very large quantities of carbonate ore. Two narrow gauge railroads are at present unable to handle the output of lead ores from this camp. Discoveries of lead carbonate ores at Terrazas, 40 miles north of Chihuahua City seem to be important. Along the Conchos River, low grade silver-lead ore deposits are being reached by the Kansas City, Mexico and Orient Railroad, which will probably be available during 1903. At Santa Barbara the Guggenheim Exploration Co. has opened up in the Tecolotes mine an ore body carrying silver-lead sulphides. The crushed ore is screened, classified and passed over Wilfley tables, saving 90% of the lead. Gas producers are successfully used in the power plant. The Montezuma Lead Co., operating in the same camp has built a large concentrator using jigs. At Naica, near Santa Rosalia, high grade basic silver-lead ores have been mined in large quantity. An enormous ore body was found in the San Pablo mine of the Mexican Lead Co., but a serious fall interfered with operations. The mine is now in running order again. The production from the Axtec and Carbonate mines of the Monterey Smelting & Refining Co. is only limited by the necessities of that plant. During 1902 the Zaragoza silver-lead mine has been acquired and operated by the Guggenheim Exploration Co.

Coahuila.—Operations in the Sierra Mojada mines which usually produce very large quantities of silver-lead carbonates were very much reduced on account of the fire at the El Paso smelting works. The properties are now being reopened and more than 10,000 tons of ore are being shipped per month. The fire in San Salvador mine burned throughout the year. This mine contains considerable native sulphur, and over 30,000,000 ft. of lumber in square sets. There is no water available. The blowing in of the Torreon smelter stimulated mining considerably in the southern part of the State, and the Norias de Bajan, Cerralvo and Cuatro Cienegas silver-lead camps have been operated steadily.

Durango.—The Compañia Minera de Penoles at Mapimi is the most prosperous enterprise in the State. During 1902, 171,000 metric tons of ore were mined, producing 92,000 kg. of silver and 24,000 metric tons of lead. The quantity of ore produced at present exceeds 500 tons per day. The ore is found as a series of irregular pipes in Cretaceous limestone which have been explored to a depth of 2,300 ft. The ore bearing zone is developed by a number of main levels from which horizontal diamond drill-holes are run out on each side, 16 ft. apart and 200 ft. long. The whole area is grid-ironed. Thirty electric hoists are used in underhand stoping, varying from 1 to 50 H.P., and this method of development has proved to be the most successful in the opening up of ore reserves. This company pays $125,000, Mexican currency, in dividends per month.

Nuevo Leon.—This State produces 200,000 tons of lead carbonate ore per year. All the ore carries silver. The mines are located in parallel ranges, 20 miles apart, on the East Coast range of the Sierra Madre Mountains. The principal deposits are Villaldama and Montañas, and the Mitre, Volador, Aztec and

Carbonate mines in the Mitre Mountains of the same range. All these deposits are similar in character, the ore horizon being practically the same. The outlook for 1903 is good, but the sulphide zone has not yet been reached, and some doubts are expressed as to its importance.

Portugal.—The exports of lead ore in 1902 amounted to 1,723 metric tons, valued at $17,250, as compared with 328 metric tons, valued at $10,200 in 1901.

Spain.—The exports of lead ore in metric tons from the different districts of Spain during 1902 were as follows: Adra, 134; Agulas, 4,151; Garrucha, 4,005 ($160,200); Linares, 37,000; Mazarron, 5,897. There were also exported 1,443 metric tons of bar lead from Adra, 9,980 metric tons ($598,800) of pig lead from Almeria, 37,803 metric tons of silver-lead and 21,095 metric tons of soft lead from Carthagena, 6,808 metric tons of silver-lead from Portman, 5,643 metric tons of silver-lead from Garrucha, 52,000 metric tons of pig lead from Linares and 23,893 metric tons from Mazarron. Of the exports from Carthagena, 35,916 tons of soft and silver-lead were shipped to the United Kingdom, and 18,013 tons to France, the rest going to Belgium, Germany and Italy. There were shipped to Carthagena, 2,150 tons of lead concentrates from Australia, and 453 tons from Algeria. There were 2,325 metric tons of silver-lead ore imported into Mazarron. The output of the Mazarron lead mines in 1902 was approximately 34,650 tons of silver-lead ore, as compared with 37,950 tons in 1901. In this district some of the mines have attained a depth of 500 ft. The mines in operation are the Impensada, Triumfo, Santa Ana, Fuensanta, San Carlos, San José, Talia, Santa Isabel, Aurora, San Antonio and Usurpada. Of these, the first three are operated by the Compañia de Aguilas, the Santa Isabel by the Compañia de Escombrera-Bleyberg, and the rest by single individuals. In 1902 the Impensada mine produced 8,400 long tons, and the Santa Ana 9,000 long tons of silver-lead ore. The poorest ore from these mines assayed 46% Pb, and the richest 70%. The silver assayed from 2·20 oz. to 3·80 oz. per ton. The production of silver-lead ore and blende in the districts of Alcaracejos, Posadas and other districts of the Province of Cordoba was 15,593 tons, valued at 2,432,952 pesetas. The British lead works in the city of Cordoba smelted 7,921 tons of lead ore and obtained 5,724 tons of pig lead. The French works at Peñarroya smelted 40,000 tons of lead ore, and obtained 26,000 tons of pig lead and 1,382,637 oz. of silver. The Linares Lead Mining Co., Ltd., operating the Pozo Ancho and Las Quinientos mines at Linares, reports for the semester ending June 30, 1902, the sale of 1,892 tons of lead which realized £21,859, 70 tons of carbonate ore for £271, and a stock on hand valued at £32,776. Its expenditures amounted to £52,103, leaving a profit for the half-year of £1,897. The Compañia de Aguilas, capitalized at 15,000,000 pesetas, and owning lead mines at Mazarron, Almagrera and Azuaga, produced during 1902, 22,769 metric tons of silver-lead ore. The Real Compañia Asturiana de Minas for the year 1902, reports a net profit of 4,309,547 pesetas, of which 4,301,365 pesetas were realized from its mines, and the remainder from interest. During the year the company produced 33,031 tons of calamine, 4,253 tons of galena, 55,160 tons of charcoal, 21,502 tons of zinc, 3,516 tons of lead and 1,669 kg. of silver.

Turkey.—Silver-lead ore is mined in Balia in the Karassi district, and in

Kara-Aidin, by a Turkish corporation capitalized at $290,000, which employs 500 to 600 men. The corporation is the only concern in Turkey using electricity for power. The annual production averages from 4,000 to 6,000 tons of metal assaying 82% lead and from 1·25 to 4% silver.

THE LEAD MARKETS IN 1902.

THE year opened with the same quotations as ruled at the end of 1901, 3·85@3·95c., St. Louis, and 3·95@4c., New York, but at the end of January, the American Smelting & Refining Co. raised its prices 10c. per 100 lb. all around, and also gave notice that in future orders for prompt shipment would be executed only at 2·5c. per 100 lb. extra. This was done in order to induce consumers and dealers to cover their requirements ahead, and to carry part of the available supplies which had accumulated at the refining works. Consequently, quotations quickly advanced to 3·95@4·05c., St. Louis, and 4·05@4·10c., New York, and have ruled at these figures ever since, with but small variations. It proved impossible to bring about the same high range of values as that of the previous year (the average for 1902 is about 0·25c. per lb. lower than for 1901), owing to the danger of foreign lead being imported, even with a duty of 2·125c. per lb. This was due to the fact that the European markets have been very much depressed on account of bad business abroad and the constant fear of a deluge of exports from the United States in the event of an advance. While the consumption of lead in the United States has been very heavy—the demand for electrical purposes, cables, etc., especially, showing a large increase—and while the stocks existing at the end of 1901 have practically disappeared, it was necessary, in order to bring about the existing state of affairs, to have recourse to the same expedients as those of last year, *i.e.*, to curtail the production of ores and export certain quantities of domestic lead to Europe. This, naturally entailed a heavy sacrifice, which, however, to a large degree, came out of the pockets of the ore producers, as they were being paid for their lead only on the basis of 3·5c. per lb. Furthermore, it is reported that in some cases royalties were being paid for quantities not mined, in order to pacify some of the recalcitrant miners. There has also been a tendency on the part of the Trust to centralize the smelting of ores and the refining of lead bullion by closing down some plants and diverting material to others. Some of the steps taken will probably have a beneficial effect in the future, in spite of the inclination in some quarters to decry these efforts. But looking at the matter broadly, there are a good many which will tend to discourage mining and prospecting operations in a large number of camps, and in that respect they are certainly a detriment and setback to the industry in general. However, with the energy and enterprise characteristic of the American mining industry and the people therein engaged, there is no doubt but that in the course of time, ways and means to a solution of this most difficult problem will be found. The only producing center which benefited very largely by the continued high values is Missouri, where considerable strides forward have been made, resulting in a very heavy output.

AVERAGE MONTHLY PRICES OF LEAD PER POUND IN NEW YORK.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug	Sept.	Oct.	Nov.	Dec.	Year
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1898	3·65	3·71	3·72	3·63	3·64	3·82	3·95	4·00	3·99	3·78	3·76	3·76	3·78
1899	4·18	4·49	4·37	4·31	4·44	4·43	4·52	4·57	4·58	4·58	3·70	4·64	4·47
1900	4·68	4·68	4·68	4·68	4·18	3·90	4·08	4·25	4·35	4·35	4·58	4·35	4·37
1901	4·35	4·35	4·35	4·35	4·35	4·35	4·35	4·35	4·35	4·35	4·35	4·15	4·33
1902	4·000	4·075	4·075	4·075	4·075	4·075	4·075	4·075	4·075	4·075	4·075	4·075	4·069

London.—The year commenced with fair quantities being offered from America and Australia, and the nearest price at opening was £10 5s. for foreign, English offering at about 2s. 6d. more. This level brought out rather more demand, and caused a steady advance to £11, closing at about 5s. reduction from this figure. February commenced with renewed purchases by consumers and a fair speculative inquiry, values consequently improving to £11 15s. and remaining steady until the end of the month, eventually closing at £11 12s. 6d.@£11 15s. cash. March found the market very dull, and prices remained about £11 10s. for soft foreign, until late in the month, when they receded to £11 7s. 6d. In April, a better demand was established from home consumers and from Germany, especially for early delivery, and this caused an advance to £11 15s., which was well maintained. May opened at £11 12s. 6d.@£11 15s. for foreign, but owing to heavy arrivals, prices had a tendency to weaken, and just at the end of the month some of the English desilverizers made free sales, causing a speedy fall to £11 for both English and foreign. The low level at the beginning of June soon attracted buyers, and when it was found that offerings were not so plentiful there was a quick rally to £11 7s. 6d. for foreign, English being held for a fraction more, but before the month was out 2s. 6d. to 5s. per ton was lost. July opened with a steady demand, which was met without prices being raised, and when trade became quieter toward the end of the month values declined to £11 for soft foreign. August was very dull, and consumers remained apathetic, the market remaining dull, with practically no alteration in price. September began with a flat tone, owing to heavy Australian arrivals, which caused a fall to £10 15s. per ton. At this level consumers showed more desire to buy against their requirements, and prices rallied to £11, eventually dropping to £10 15s. again. Early in October cable makers booked good orders and covered their lead requirements, and this served to keep prices steady until the end of the month, when owing to large arrivals values became once more depressed and fell to £10 12s. 6d. November opened with business at the last named figure, but a good inquiry was forthcoming, and prices improved to £10 10s. 3d. A cessation of buying, however, combined with rather freer offerings from the Continent, again depressed the market, and the nearest values at the beginning to December were £10 12s. 6d. for soft foreign and £10 15s. for English. During the early part of the month there was quite a good demand, especially from cable makers, and this, coupled with some speculative buying, soon raised prices to £11 for foreign. Later, a somewhat easier tendency prevailed, and the year closed with Spanish lead at £10 17s. 6d.@£10 18s. 9d., with £11@£11 1s. 3d. quoted for English lead.

WHITE LEAD, RED LEAD, LITHARGE AND ORANGE MINERAL.

The aggregate production of lead pigments during 1902 was considerably greater than in 1901, the increase being distributed among all varieties except red lead and orange mineral, of which much smaller outputs are reported.

The production of white lead in oil during 1902 was 179,473,588 lb., valued at $9,755,197, as compared with 154,606,670 lb., valued at $8,978,441 in 1901, an increase in quantity of 24,866,978 lb. and in value of $776,756. The production of dry white lead in 1902 amounted to 49,841,821 lb., valued at $2,222,975, as compared with 46,966,945 lb., valued at $2,274,212 in 1901, which shows an increase in quantity but a decrease in value.

The production of red lead during 1902 was 23,338,252 lb., valued at $1,262,712, as compared with 26,206,096 lb., valued at $1,448,550, showing a decrease in quantity of 2,867,844 lb. and in value of $185,838.

The production of litharge during 1902 amounted to 25,510,690 lb., valued at $1,299,443, as compared with 18,913,036 lb., valued at $979,586 in 1901, an increase in quantity of 6,597,654 lb. and in value of $319,857.

There were produced 1,933,521 lb. of orange mineral, valued at $138,349 during 1902, as compared with 2,174,727 lb., valued at $224,667 in 1901, showing a decrease in quantity of 241,206 lb. and in value of $86,318.

The detailed statistics of the production and imports of the various lead pigments are given in the subjoined tables:—

UNITED STATES: PRODUCTION OF RED LEAD, WHITE LEAD, LITHARGE AND ORANGE MINERAL.

Year.	Red Lead.		White Lead. (*a*)		Litharge.		Orange Mineral.	
	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.
1898..........	9,160	$916,000	98,172	$9,391,738	7,460	$710,192	658	$88,937
1899..........	10,199	1,070,895	103,466	10,812,197	10,020	1,032,060	928	139,200
1900..........	10,098	1,050,192	96,408	9,910,742	10,462	1,067,124	825	100,650
1901..........	13,103	1,448,550	100,787	11,252,653	9,460	979,586	1,087	224,667
1902..........	11,669	1,262,712	114,658	11,978,172	12,755	1,299,443	967	138,349

(*a*) Includes both dry and in oil.

UNITED STATES: IMPORTS OF RED LEAD, WHITE LEAD, LITHARGE AND ORANGE MINERAL.

Year.	Red Lead.		White Lead.		Litharge.		Orange Mineral.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1898..........	682,449	$25,780	506,739	$24,334	56,417	$2,021	795,116	$37,745
1899..........	1,021,573	43,812	584,409	30,211	55,127	3,614	1,141,387	58,242
1900..........	549,551	25,532	456,872	28,366	77,314	2,852	1,068,793	61,885
1901..........	485,467	19,870	384,673	21,226	49,306	1,873	977,644	52,409
1902..........	1,075,839	37,383	506,423	25,320	88,115	2,908	997,494	49,060

In addition to the products stated in the foregoing table, the United States Reduction & Refining Co. at Cañon City, Colo., reported during 1902 an output of 4,000 short tons of "zinc-lead," valued at $225,000 as compared with 2,500 short tons, valued at $150,000 in 1901. This pigment is a mixture of oxidized compounds of zinc and lead made by an oxidizing smelting of lead and zinc ores in a blast furnace of special design. There were also produced by the Picher Lead Co. of Joplin, Mo., 4,736 short tons of "sublimed lead," valued at $449,611.

This special pigment, which is sometimes classed as a white lead, consists essentially of a mixture of lead sulphate and lead oxide, obtained in the special smelting of lead ores, whereby this material is produced in addition to metallic lead. It can hardly be called a by-product, as the furnace operations are conducted so as to yield a larger rather than a smaller output of the volatilized material.

A comparison of the statistics of domestic production and imports plainly shows the gradual displacement of the imported lead pigments by those of domestic manufacture. The subjoined table shows that the difference in price between white lead in oil and pig lead in New York in 1902 was $1·405, as compared with a difference of $1·36 in 1901. Against this must be set the difference in the price of linseed oil, which varied from 47c.@68c. per gal. in 1902, and from 50c.@82c. per gal. in 1901. The price of linseed oil at the beginning of 1901 was 56c. per gal.; it sold as low as 50c. in September, and reached the highest point of the year, 82c., in July. Beginning with 58c. in January of 1902, the price advanced until it reached 68c. in June, and then declined until 47c. was reached in October, closing the year at 47c. The market price for pig lead in New York during 1902 opened at 4·125c. and closed at 4·225c. The former price was maintained until Jan. 25, when it rose to 4·225c., and continued at this quotation for the remainder of the year.

ANNUAL AVERAGE PRICE AT NEW YORK OF CORRODING PIG LEAD AND WHITE LEAD IN OIL.

Year.	Corroding Pig Lead.	White Lead in Oil.	Difference.	Year.	Corroding Pig Lead.	White Lead in Oil.	Difference.
	Per 100 Lb.	Per 100 Lb.	Per 100 Lb.		Per 100 Lb.	Per 100 Lb.	Per 100 Lb.
1893..........	$3·73	$6·03	$2·30	1898..........	$3·79	$5·08	$1·29
1894..........	3·28	5·26	1·98	1899..........	4·53	5·35	0·82
1895..........	3·28	5·05	1·77	1900..........	4·55	5·57	1·02
1896..........	3·03	4·90	1·87	1901..........	4·51	5·87	1·36
1897..........	3·64	5·00	1·26	1902..........	4·22	5·62	1·40

Progress in the Manufacture of White Lead during 1902.

By Parker C. McIlhiney.

During 1902 the white lead industry has not undergone any marked changes as far as the processes by which the product is manufactured are concerned. The great bulk of the product is still made by the old Dutch process, but the constant efforts made by inventors who are attracted by the magnitude of the business as a field for new processes, are resulting in the periodical introduction of new methods of manufacture, most of which, it is true, are tried and found wanting in one way or another, but out of which the valuable features are gradually absorbed by their successors in the field.

The tendency of invention in this country in recent years as judged by the processes successfully introduced has been toward the modification of the undesirable features of the Dutch process rather than the introduction of processes designed to supplant Dutch white lead by the products of precipitation processes, products having the same chemical composition as Dutch lead, but somewhat different physical properties, and requiring on this account a more elaborate and expensive introduction to the purchasing public. The year under review has not been marked by the advent of any new processes which have as yet attained comnercial importance. As noteworthy factors in the production of white lead there are now, in addition to the Dutch process, the Carter and the Bailey processes, both of which aim at the production of the same kind of lead as the Dutch, and the Dahl process under the management of W. J. Matheson & Co., which makes quick process lead by a precipitation method. The Gabel process aims to produce Dutch lead, and may become commercially important.

The Gabel process differs from the Dutch process in that the lead instead of being cast into buckles is shaved up into thin strips in a planer, the shavings being from 0·0625 in. to 0·25 in. wide and 0·01 in. thick. These shavings are filled into the pots which are so arranged that there is a free passageway for gases through a series of pots arranged one on top of the other, the bottoms of the pots being gratings which simply hold the mass of lead shavings in place. The grating in the bottom of each pot is surrounded by a rather deep channel which is filled with acetic acid. The pots when charged with lead and acid are placed in a wooden building provided with a double floor, the inner floor being perforated with a large number of holes to allow the carbon dioxide and air admitted through the space between the two floorings to enter the stack. A steam boiler is provided and both the steam from it and the carbon dioxide produced by the combustion of the fuel (coke) are allowed to enter the stack. The carbon dioxide is washed with water and freed from sulphur by passing through a dry purifier charged with iron oxide. The building in which the corrosion takes place is provided with windows through which the progress of the operation can be observed. The claim is made for the process, that the operation of converting the metallic lead into white lead is under perfect control, as all the elements of temperature, proportion of oxygen and proportion of carbon dioxide are changeable at will. It is also claimed that on account of the mechanical condition of the metallic lead, the time of corrosion is reduced to a third of that required for the Dutch process; also, that on account of the absence of tan-bark the lead produced is of better color than Dutch lead.

The manufacture of orange mineral of high grades has been commenced by the firm of Dahl & Ferguson, in New York, using Matheson's quick process lead as a starting point. The process is carried on in a reverberatory furnace fired with fuel oil. Quick-process lead is well adapted for the manufacture of orange mineral on account of the same peculiarities of physical condition which operate to limit its general use as paint.

Taking the history of recent years as a guide, it seems safe to predict that, first, the greatest technical developments in the manufacture of white lead may be looked for in some process which imitates the mechanics and chemical reactions of the Dutch process, and brings acetic acid, oxygen, and carbon dioxide into contact with metallic lead simultaneously; the Carter, Bailey, and Gabel processes, being examples of different means of attaining this result; and second, that the quick processes of which the Dahl is a type, and in all of which the characteristic feature is the separation of the solution of the lead as a soluble salt and the precipitation as insoluble basic carbonate into two distinct operations, will in all probability have a restricted but certain growth and will supply the users of white lead for other purposes than as white paint.

Recent Improvements in Lead Smelting.

By H. O. Hofman.

Introductory.

New Publications.—M. W. Iles has published a book entitled, "Lead Smelting, the Construction, Equipment and Operation of Lead Furnaces, and Observations on the Influence of Metallic Elements on Slags and the Scientific Handling of Smoke."[1] The author has given his experience in practical work, which is not easy to summarize, as facts more than principles are discussed. In order to appreciate its value the reader must be somewhat familiar with the details of lead smelting practice.

Distillation of Lead.—Kahlbaum, Roth and Siedler[2] distilled metallic lead in vacuo as Schuller[3] had done before them. The crystals they obtained appear to be combinations of octahedra and hexahedra, with octahedra prevailing.

Market Lead.—O. Mühlhauser[4] examined samples of sheet lead of E. W. Blatchford & Co., Chicago, of the Raymond Lead Co., Chicago, and of a St. Louis firm, and found that they contained 0·07%, 0·15% and 0·11% impurities respectively. The author compares these Mississippi valley leads with brands from German zinc-desilverizing plants, which contain 0·008% and 0·045% impurities, and draws inferences unfavorable to American brands of lead. The editor of the *Berg- und Huettenmaennische Zeitung,*[5] calls the author's attention to the differences that exist between American "chemical" and "corroding" leads.

Corrosion of Lead Service Pipes by Water.—The investigations by the Massachusetts Board of Health carried on in 1897-98[6] were continued in 1899 and 1900,[7] and confirmed the former conclusions that drinking water must contain considerable carbonic acid to dissolve lead to an extent which would render it harmful. It was also found that iron oxide, which is always contained in ground water, being deposited in the service-pipes had an appreciable action upon lead. Furthermore, that the greater the hardness of the water as compared with its content of free carbonic acid, the smaller was the corroding effect upon lead.

F. Clowes[8] experimented upon the action of distilled water upon lead, and obtained results differing from those of the Massachusetts Board of Health in regard to the effects of oxygen and carbonic acid. He found that in vacuo or in an atmosphere of hydrogen, lead was not attacked by distilled water. When oxygen was present, the lead was readily attacked; carbonic acid alone had a very slight effect, and its presence in water containing oxygen even interfered with the corrosive effect of oxygen. The action of oxygen was rapid at first, some hydroxycarbonate being formed which in part went into solution. The idea that bacteria were necessary to start the corrosion was disproved, as heated lead was corroded by boiled water as quickly as under ordinary conditions. The

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[1] Published by Wiley & Sons, New York, 1902.

[2] *Zeitschrift fuer Anorganische Chemie*, 1902, 29, 267-271; *Berg- und Huettenmaennische Zeitung*, 1902, 296

[3] *Wiedemann's Annalen*, 1883, 18, 319.

[4] *Zeitschrift fuer Angewandte Chemie*, 1902, 758; *Berg- und Huettenmaennische Zeitung*, 1902, 428.

[5] 1902, 546.

[6] THE MINERAL INDUSTRY, 1900, IX., 439.

[7] *Massachusetts Board of Health Report*, 1900, 487; *Engineering News*. Oct. 9, 1902.

[8] *Engineering*, Nov. 7, 1900.

presence of certain salts seemed to protect the lead, especially sulphates, less so carbonates and free carbonic acid. The effect of lime was found to be doubtful; if sufficiently concentrated it might even increase the corrosion.

Melting and Boiling Points.—Lodin[9] volatilized galena in a current of nitrogen at a temperature of 860°C.; galena melts at 935°C.

J. Guirochant[10] investigated the resistance of various metallic sulphides to the passage of the electric current, and gives the following melting and boiling points: Lead sulphide melts at 1,015°C., boils at 1,085°C.; tin sulphide melts at 1,000°C., boils at 1,090°C., and iron sulphide melts at 925°C.

Lead-Tellurium Alloys.—The freezing points and microstructure of lead-tellurium alloys were investigated by H. Fay and C. B. Gillson,[11] who prepared a series of seventeen alloys containing from 2 to 95% tellurium. The results are given in detail under the caption "Review in the Progress of Metallography during 1902," elsewhere in this volume.

Lead Ores of Southeast Missouri.[12]—Galena concentrates of Bonne Terre and Flat River carry small quantities of copper, some of which enters the lead produced in smelting. Thus a sample of crude lead showed 0·2% copper which, by liquating and poling was reduced to 0·02%. An analysis of a carload of concentrates gave Pb 62·10%, Cu 0·61%, Fe 3·33%, CaO 5·85%, MgO 3·08%, SiO_2 1·39% and silver 1·3 oz. per ton. Lime and magnesia are present as carbonates; which show the concentrates to contain $CaCO_3$ 10·45% and $MgCO_3$ 6·78%; and with the SiO_2 1·39% give 18·62% gangue. Iron and copper are present as pyrite and chalcopyrite, respectively.

Importation of Lead Ores.[13]—The decision of the Board of General Appraisers[14] in the case of lead ores and base bullion imported into the United States in bond, is to be contested.

Sampling Ores.—P. Johnson[15] describes the sampling mill which he built for the British Columbia Copper Co.'s smelting plant at Greenwood, B. C. The mill, 75 ft. long by 65 ft. wide by 58 ft. high, has a daily capacity of 1,000 tons ore, and is driven by a 100-H.P. engine. Fig. 1 represents a vertical cross section through the plant. The ore to be sampled is collected in an upper row of six bins (each 50 ft. long), some distance from the mill. From these the ore is discharged into scoop-cars of from 1 to 1·25 tons capacity, brought to the mill and dumped into the No. 5 Gates crusher, set to crush to a size of from 3 to 5 in. Lumps larger than 11 in. in diameter have to be broken by sledging. The crusher discharges the broken ore in the first Johnson sampler, making from 6 to 7 r. p. m., and cutting out 10% for the first sample, while the rejected ore goes into first ore bin. The sample is delivered into No. 2 Gates crusher, crushing to a size of from 0·75 to 1·25 in., and discharging into the second Johnson sampler, which makes 9 r. p. m., and cuts out three 20%

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[9] *Comptes rendus*, 1895, 20. 1164.

[10] *Comptes rendus*, 134, 1224; *Zeitschrift fuer Electrochemie*, 1902, 8, 889; *Engineering and Mining Journal*, Dec. 27, 1902.

[11] *Transactions of the American Institute of Mining Engineers*, XXI., p. 586.

[12] *Engineering and Mining Journal*, Apr. 26, 1902.

[13] *Ibid.*, Dec. 21. 1902.

[14] THE MINERAL INDUSTRY, 1901, X., 424.

[15] *Engineering and Mining Journal*, Apr. 12, 1902.

samples. The discard passes into second ore bin. The sample is spouted into the boot of the elevator, raised 55 ft., and discharged through a chute into the No. 0 Gates crusher, set to crush from 0·25- to 0·5-in. sizes. This delivers the ore into the third Johnson sampler, making 12 r. p. m., taking three 20% cuts per revolution, which are discharged onto the sloping feed-table, while the rejected ore goes into the ore bin, 1. The table feeds the ore into the hopper of a pair of 10×16-in. Reliance rolls, which reducing to 0·125 in., discharges into the fourth Johnson sampler of the same size as the third. This cuts out 20% as final sample, and delivers it through an 8-in. pipe into a sample buggy, which takes it to the finishing room, containing sample-grinder, bucking-plate, etc. The rejected part is returned to the ore bin.

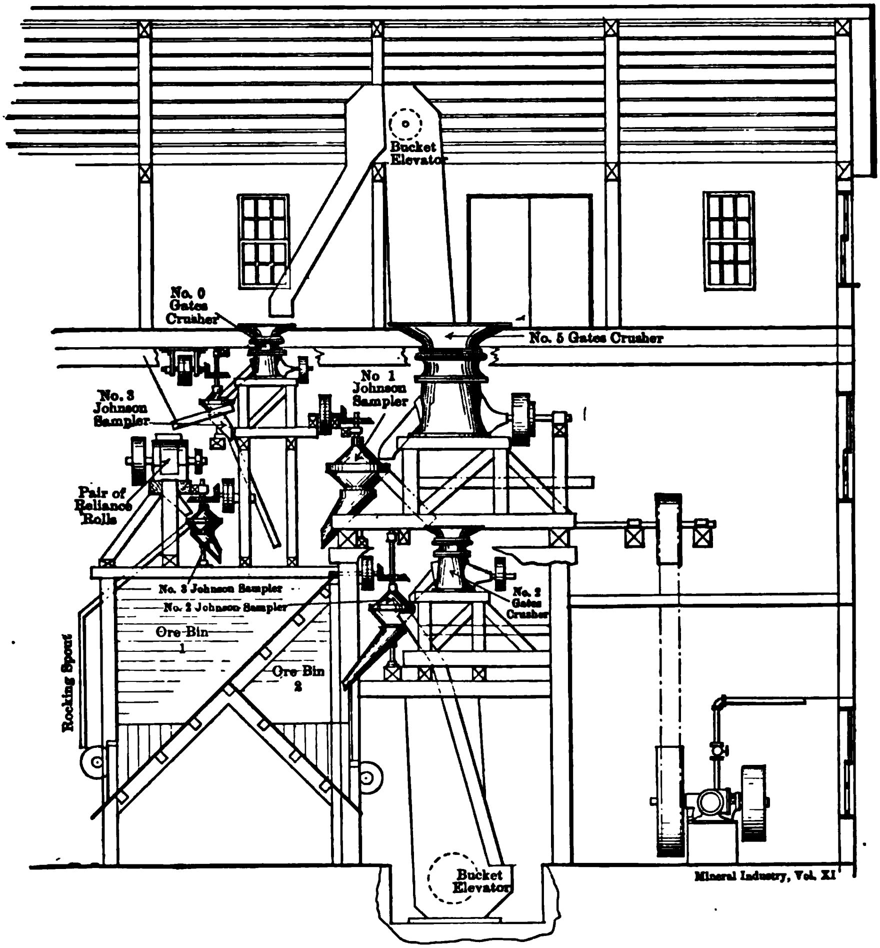

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FIG. 1.—SAMPLING MILL OF THE BRITISH COLUMBIA COPPER CO., AT GREENWOOD, B. C.

This mode of sampling furnishes $\frac{1}{10} \times \frac{1}{5} \times \frac{1}{5} \times \frac{1}{5} = \frac{1}{1250}$ part, which in small shipments would not give enough material for the finishing room. In the latter case the first sampler is not rotated, but so placed that all the ore delivered into the first crusher passes through its sample-spout into the second crusher. Thus $\frac{1}{5} \times \frac{1}{5} \times \frac{1}{5} = \frac{1}{125}$ part of the ore instead of $\frac{1}{1250}$ part will go to the finishing room. In the same manner the second sampler may be cut out, when $\frac{1}{25}$ part of the whole will form the final sample.

The Johnson sampler, as shown in Fig. 2, consists of three parts; a top cone *c* attached to a revolving shaft, an inverted cone S_1 with opening *O*, and diverting spout *t* bolted to the top cone, and a rejecting spout enclosing the bottom of the inverted cone. The stream of ore coming down the spout from the crusher passes into the rotating inverted hopper S_1 excepting when the opening *O* comes under the spout, when the tongue t_1 deflects the stream into the sample-spout. The segmental area of the opening is 10% of the entire circumference. If the removable lid *l*, be taken off and a tongue put in its place, a 20% sample of the whole will be obtained.

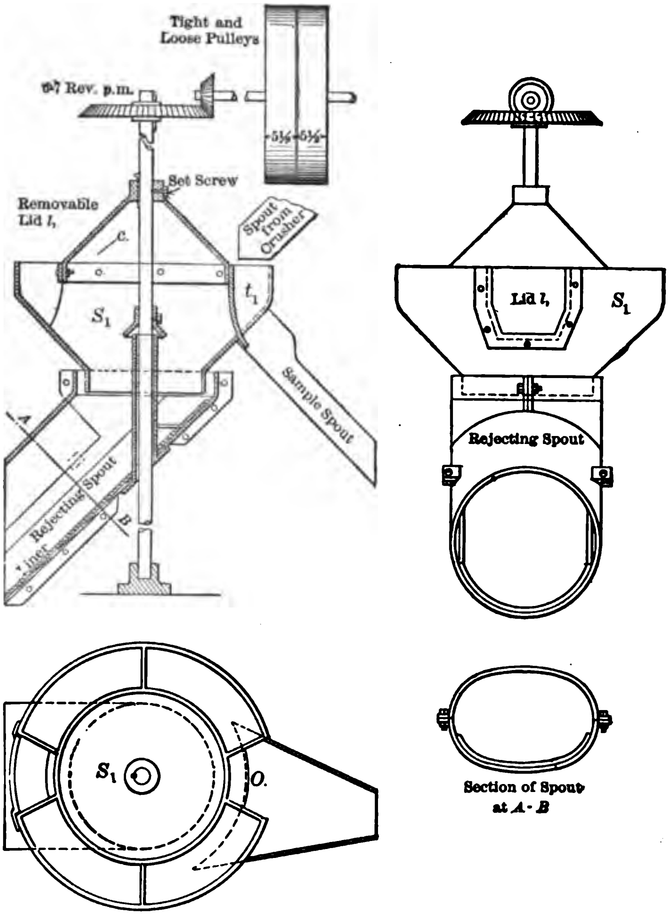

FIG. 2.—THE JOHNSON SAMPLER.

The smaller-size samplers have three openings instead of the single one *O*, shown in the illustration.

In the British Columbia Copper Co.'s works, two men draw the ore from the bins into the buggies, two men do the tramming, and two weigh the ore, dump it into the crusher and break up lumps when necessary; one man attends to the mill proper; 2 or 3 men take the ore from both sets of ore bins to the smelter mixer-bin.

The mill has sampled over 100,000 tons of ore; many lots were check samples on the work done by other parties. Examples of the work done are subjoined:—

Sample.	No. of Lot.	Size of Lot. Tons.	Copper Wet Method. %	Gold Oz. per Ton.	Silver Oz. per Ton.	Analysis.				
						Insoluble	SiO_2.	Fe.	CaO.	S.
a.........	1	22	6·60	0·04	1·01	51·6	33·6	14·8	4·1	10·9
b.........	1	22	6·40	0·03	1·25					
a.........	2	65	6·10	0·12	1·80	54·2	52·0	12·6	3·8	Tr.
b.........	2	65	6·15	0·12	1·70					
a.........	3	110	3·85	0·01	2·17	37·4	29·5	16·7	17·8	6·4
b.........	3	110	3·80	0·01	2·20					
a.........	4	150	1·70	0·145	0·34	42·1	38·0	23·2	13·1	2·4
b.........	4	150	1·70	0·150	0·33					
a.........	5	27	1·70	0·52	1·30	50·1	37·5	19·3	3·4	12·0
b.........	5	27	1·68	0·48	1·39					
a.........	6	33	0·90	0·15	0·41	30·4	33·1	26·5	Tr.	18·6
b.........	6	33	0·98	0·14	0·42					
a.........	7	60	0·88	0·20	0·45	34·7	29·6	26·7	Tr.	18·3
b.........	7	60	0·90	0·18	0·44					
a.........	8	17	0·00	0·74	5·60	90·2	89·5	3·3	Tr.	1·2
b.........	8	17	0·00	0·72	5·62					
a.........	9	30	0·00	0·36	2·00	93·0	91·7	2·3	Tr.	0·7
b.........	9	30	0·00	0·34	1·90					
a.........	10	110	0·00	0·29	9·70	84·5	82·1	4·2	Tr.	3·3
b.........	10	110	0·00	0·27	9·60					
a.........	11	17	0·00	0·04	25·70	63·7	63·1	10·1	Tr.	11·0
b.........	11	17	0·00	0·04	26·40					

The Sampling Mill,[16] in Park City, Utah, is erecting a 500-ton automatic mechanical sampling plant, designed by J. B. Fleming. The ore unloaded into the mouth of a breaker is crushed to 1·5-in. size, and elevated to the top of the building; it then passes through a mechanical sampler (name not given), which cuts out 25% as a sample, while the rejected ore goes to the shipping bins. The sample is reduced to 0·75-in. size by a pair of 36×12-in. rolls, passes through a second sampler, where again 25% is cut out; the discard goes to the shipping bin elevator, while the reduced sample passes through a second set of rolls 30×10 in. Reduction of sample in quantity and correspondingly in size is repeated four times, when a final sample of 600 lb. from 250 tons of ore is collected in one of two small bins above the sample-grinder. The finishing-work is carried out in the usual way.

The Foster-Coolidge sampling machine,[17] shown in Fig. 3 with discard-chute detached and reversed, takes out as a sample the whole of a stream of ore at short intervals. It consists of a cast-iron base, to which is bolted a frame of four cast-iron pipes joined at their tops by cast-iron cross-pieces; the pipes are stiffened by four braces. Beneath the top of the frame are two pairs of grooved rollers from which are suspended two oscillating angle-iron frames guided at the bottom by two pairs of short pieces of pipe. Cross-irons carrying cast-iron hoppers and dividers are riveted to the frames; the hoppers are bolted to the

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[16] *Mining and Scientific Press*, Sept. 6, 1902.

[17] United States Patent No. 694,784, March 4, 1902; *Mining and Scientific Press*, June 21, 1902.

front-irons, the dividers to the back-irons. The frames are attached by means of connecting rods to two eccentrics, which are driven by a 3-in. belt on a 14-in. pulley, and make 150 oscillations per minute. The length of stroke is so adjusted that the hopper shall discharge the entire content alternately into the sample- and the discard-channel of the dividing trough. The ore, crushed to pass a 1-in. ring, is fed through the 4-in. pipe at the top; it strikes the oscillating hopper, where it is mixed and dropped alternately into the sample- and discard-channels of the rapidly-moving divider. The discard gliding down the discard-channel is delivered into the top-opening of the discard-chute, while the sample gliding down the sample-channel, strikes the lower end and falls through the opening in the bottom into the second hopper, and thence into the second divider, where the operations are repeated, and so on down through the third and fourth hoppers and dividers, the final sample being delivered into a sample-chute extending through the cast-iron base. The power required to drive the machine is small. The sampler is 7 ft. 3 in. high and occupies a floor-space 5 ft. 10 in.×2 ft. 9 in. Its capacity per hour is said to be from 25 to 30 tons of ore or matte.

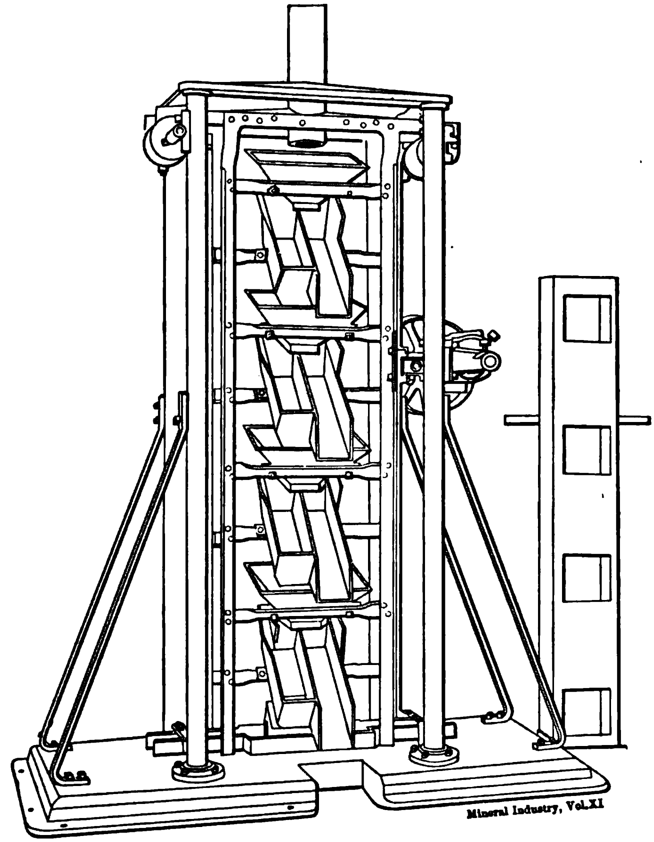

FIG. 3.—THE FOSTER-COOLIDGE SAMPLER.

P. Argall[18] has published a paper on sampling and dry-crushing, details of which are given in the "Review of Ore Dressing," later in this volume.

Assay-Balances.—The Denver Balance Co.[19] has brought out two new portable balances. Style S is designed for the prospector and is sensitive to 0·00002 g. ($\frac{1}{50}$ mg.), style R, intended for assayers, weighs accurately to 0·00001 g. ($\frac{1}{100}$mg.).

Assay-Furnaces.—C. S. Batchelder[20] has patented a two-muffle furnace, enclosed by iron sheathing with an asbestos backing and a fire-brick lining. The muffles have asbestos doors fitted to admit air at the sides, and are provided also with peepholes.

A. C. Calkins[21] has patented an assay furnace consisting of a muffle (with openings front and back, to be opened and closed independently), and a crucible space on either side. The three parts are to be heated from the same fire-place, and the products of combustion carried off by a main flue, which also collects other gases from the muffle and crucible-heating spaces. Another patent[22] was granted to him in October, 1902.

Cupels.—T. L. Carter[23] sounds a note of warning to assayers who are in the habit of purchasing their cupels, advising them to test a new lot for absorption before use. In one lot he found the loss in gold by absorption to be 10%; also that the percentage of loss by cupellation of a silver-gold alloy differed from that of gold alone.

J. Vogle[24] advocates the use of a kaolin cupel with a blow-pipe to finish the cupellation of a lead-button containing a very small quantity of gold. The cupel material is prepared by triturating kaolin with water, pouring off the slime into a flat dish, and allowing it to settle. Enough kaolin is taken to furnish a 2-in. layer of sediment, when most of the moisture has been evaporated. The moist cake is divided into 2-cm. squares, which when fully dried and burnt, form the cupels. A lead button is cupelled in the usual way until it is reduced to 1-mm. diameter; it is then transferred to the kaolin cupel and finished with the blow-pipe, with an addition of borax if necessary. In cupelling, the litharge combines with the kaolin and forms a small pit. In order that the button shall assume the globular form desired for measurement, the bead is moved from the pit and finished on another part of the cupel. Standards for comparison are made by beating out pure gold, weighing strips 0·9 mg., 0·08 mg., etc., wrapping them in strips of lead foil of the same size, melting them down on charcoal, and then cupelling on the kaolin cupels.

Assay of Lead Ores.—J. L. Charles[25] recommends the use of potassium cyanide as flux for the assay of lead ores, and advocates the following method of procedure: ram into the crucible 10 g. KCN, pour in the charge (ore, 10 g., and KCN, 30 g. well mixed), cover it first with 5 g. KCN, then with a 0·25- to 0·5-in. layer of salt. Colorado lead works generally lose some of the lead values in assaying. The following are common charges: ore, 10 g., mixed with sodium bicarbonate, 15 g.; potassium carbonate, 10 g.; argols, 7 g. or

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[18] *Institution of Mining and Metallurgy*, 1901–02, [10, 234.

[19] *Mining Reporter*, Oct. 9, 1902.

[20] United States Patent No. 712,636, Nov. 4, 1902.

[21] United States Patent No 696.548, Apr. 1, 1902.

[22] United States Patent No. 711,554, Oct. 21, 1902

[23] *Engineering and Mining Journal*, May 17, 1902.

[24] *Mining and Scientific Press*, July 19, 1902.

[25] *Mining Reporter*, Aug. 14, 1902.

flour 5 g.; borax glass 3 g., sprinkled on top, and salt cover, nails as needed. Fusion is started at a low heat, which is gradually raised. The fusion should be completed in from 35 to 40 minutes. Another flux is: sodium bicarbonate, 125 g.; potassium carbonate, 162 g.; raw borax, 63 g.; flour, 51 g. With much calcium and barium oxide, more borax is added. Nails are always used.

With ores high in antimony, the author prefers to determine lead volumetrically by the molybdate instead of using a dry method, for which Ricketts recommends: ore, 10 g., sodium or potassium carbonate, 35 g., niter, 1 g., salt cover; the charge to be fused 20 minutes at a good heat, then cooled slowly for 10 minutes, and finished at a high heat in 10 minutes. The idea is that part of the antimony will be taken up by the flux, part will be volatilized, and very little only will be taken up by the lead.

O. J. Frost[26] modified the common method for assaying galena concentrates from northern Idaho (Pb from 40 to 60%), by dropping 10 g. KCN into the crucible about five minutes after complete fusion of the charge, and then heating for 15 minutes. With the use of KCN overheating must be avoided, as there is danger of the charge boiling over. The following table of comparative results is of interest:—

Without KCy.	With KCy.	Wet Assay (Molybdate Method).	Without KCy.	With KCy.
%	%	%	%	%
44·6	45·5	45·56	52·9	53·57 and 53·55
49·9	50·4	50·40	49·2	50·28 and 50·19
55·6	56·2	56·32	45·5	45·9 and 45·88
....	55·62 and 55·51	55·87 and 55·68	46·6	47·2 and 47·22
57·4	58·27 and 58·00		45·8	46·58 and 46·32
56·5	57·56 and 57·45		48·2	49·04 and 48·98
56·0	56·44 and 56·76		45·3	46·12 and 45·95
60·4	60·85 and 60·92		45·7	46·18 and 46·27

I. C. Bull[27] has investigated the determination of lead in ores. Six different ores containing as leading lead-bearing minerals galena (two), cerussite (two), sulphuret-galena-sphalerite (one), and galena-stibnite (one), were assayed for lead in the dry way, gravimetrically by the lead sulphate and lead chromate methods, electrolytically by the lead peroxide method, and volumetrically with the ammonium molybdate (D. H. H. Alexander), the oxalic acid and potassium permanganate, potassium dichromate, potassium ferrocyanide, and lastly with the original and modified methods of Koenig. The influence that antimony, bismuth, barium, strontium and calcium have on the volumetric methods were also determined.

The data tabulated show that the dichromate method is liable to give results that are too high; the same is the case with Koenig's method, though to a less degree. The ferrocyanide and molybdate (Alexander's) methods are preferable to the other two. The results obtained are shown in the tables given on the next and following pages of this section.

The results in the table show that the molybdate or Alexander's method, the dichromate or back titration method with either ferrous salt or sodium thiosulphate, the Koenig and the ferrocyanide methods give concordant results.

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[26] *Engineering and Mining Journal*, May 17, 24, 1902.

[27] *School of Mines Quarterly*, 1902, 23, pp. 348–366.

RESULTS OBTAINED BY VARIOUS METHODS OF DETERMINATION.

		Ferrocyanide.					Dichromate Ferrous.					Koenig's.					Alexander's.				
Antimony.	Lead taken, mg.	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
	Impurity added, mg.	25	50	100	200	400	25	50	100	200	……	25	50	100	200	400	50	50	100	120	200
	Metal obtained, mg.	300	300	300	300	300	313	342	351	405	……	300	300	300	300	300	300	300	300	300	300
	Percent error in terms of lead.	0	0	0	0	0	+4·1	+12	+14	+36	……	0	0	0	0	0	0	0	0	0	0
Bismuth.	Lead taken, mg.	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
	Impurity added, mg.	25	50	100	200	400	25	50	100	200	400	25	50	100	200	400	25	50	100	200	400
	Metal obtained, mg.	300	301	304	305	306	310	323	349	421	563	300	300	300	300	300	300	300	300	300	300
	Percent error in terms of lead.	0	+·3	+1·3	+1·6	+1·8	+3	+7	+13	+28	+46	0	0	0	0	0	0	0	0	0	0
Barium.	Lead taken, mg.	300	300	300	300	300	300	300	300	300	310	300	300	300	300	300	300	300	300	300	300
	Impurity added, mg.	12	25	50	100	200	12	25	50	100	200	12	25	50	100	200	12	25	50	100	200
	Metal obtained, mg.	301	302	305	306	306	320	337	371	402	461	310	314	330	352	368	298	295	277	256	244
	Percent error in terms of lead.	+·3	+·6	+1·6	+1·8	+6·8	+6·6	+10·9	+19	+25	+53	+3·2	+4	+9	+14	+18	−·6	−1·6	−6	−10	−15
Strontium.	Lead taken, mg.	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
	Impurity added, mg.	25	50	100	200	400	25	50	100	200	400	25	50	100	200	400	25	50	100	200	400
	Metal obtained, mg.	300	300	300	300	300	306	311	323	342	356	320	334	414	494	560	300	300	297	289	283
	Percent error in terms of lead.	0	0	0	0	0	+1·8	+3·5	+7	+12	+16	+6	+10	+33	+39	+46	0	0	−1	−3·6	−5·9
Calcium.	Lead taken, mg.	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
	Impurity added, mg.	25	50	100	200	400	25	50	100	200	400	25	50	100	200	400	25	50	100	150	200
	Metal obtained, mg.	300	300	300	300	300	306	305	313	323	351	300	304	352	450	520	300	300	300	300	300
	Percent error in terms of lead.	0	0	0	0	0	+·9	+1·6	+4·1	+8·2	+14	0	+1·3	+14	+33	+42	0	0	0	0	0

In the preceding table are brought together the data showing to what degree antimony, bismuth, barium, strontium and calcium interfere with the resuits of the above-mentioned four volumetric methods.

RESULTS OBTAINED BY VARIOUS METHODS OF DETERMINATION.

Number of Ores.	Fire Assay.	Lead Sulphate Method.	Lead Chromate Method.	Electrolytic Method.	Alexander's Method.	Koenig's Method.	Oxalate Method.	Dichromate: Ferrous" Method.	Dichromate "Hypo" Method.	Ferrocyanide Method.
	%	%	%	%	%	%	%	%	%	%
I.....	76	78·68	78·71	78·73	78·74	78·60	77·54	78.71	78·76	78·67
	....	78·62	78·68	....	78·82	78·64	77·60	78·78	78·78	78·65
II.....	37	37·20	37·28	37·35	37·41	37·38	36·71	37·32	37·33	37·31
	....	37·26	37·30	....	37·44	37·40	36·62	37·38	37·37	37·29
III.....	9	10·76	10·77	10·80	10·80	10·58	9·92	10·78	10·80	10·90
	....	10·74	10·74	....	10·83	10·62	9·98	10·72	10·76	10·86
IV......	24·7	18·40	18·45	18·58	18·47	18·46	17·54	18·46	18·50	18·44
	Base Metal,	18·43	18·40	....	18·51	18·42	17·65	18·44	18·45	18·48
V......	26·7	27·25	27·28	27·32	27·44	27·24	26·28	27·31	27·26	27·25
	....	27·21	27·20	....	27·35	27·56	....	27·27	27·32	27·18
VI.....	37·8	38·50	38·47	38·60	38·66	38·60	37·33	38·46	38·57	38·65
	....	38·54	38·50	....	38·58	38·68	....	38·52	38·60	38·58

Assay of Lead in Slags.—Svoboda[28] worked out the following wet method for the determination of lead in blast-furnace slags: Place 10 g. finely pulverized slag in a covered beaker, add 10 c.c. water, stir, add quickly while shaking, 50 c.c. conc. hydrochloric acid, dilute with 30 to 40 c.c. water, and boil until free from hydrogen sulphide. Add carefully potassium chlorate to peroxidize the salts, remove excess of chlorine by boiling, filter through a large folded filter into a beaker holding 1,500 c.c., and wash three times with boiling water. Return filter with residue to original beaker, boil with water, filter through second folded filter, using the same funnel as before (the filtrate to be run into the first filtrate), and wash two or three times with boiling water. The residue is free from lead, all the lead having gone into solution. Add to the filtrate 20 g. granulated zinc (free from lead), allow to stand over night, then filter and wash three times with cold water. Transfer filter with precipitated lead and residual zinc to a beaker, add nitric acid to dissolve lead and zinc, transfer to a 250-c.c. flask, cool, fill to the mark and filter. Take 200 c.c. of the filtrate (=8 g. slag) add 25 c.c. dilute sulphuric acid (1·4), and when the lead sulphate has settled out, add 70 c.c. absolute alcohol, and allow to stand over night. Then filter through a Gooch crucible, wash with 30%, then with 100% alcohol, and finally with ether, dry at 150°C., cool and weigh. The lead sulphate thus obtained is as a rule C. P. If there is any doubt, dissolve it in concentrated ammonium acetate, wash and again weigh the crucible. In order to obtain check results, the lead dissolved by ammonium acetate was precipitated as lead sulphide, and weighed as such. Results obtained are tabulated below:—

Per Cent. Lead from	First Set. Sample No.										Second Set. Sample No.						Third Set. Sample No					
	1	1a	2	3	4	5	6	7	8	8a	9	10	11	12	13	14	9	10	11	12	18	14
Lead Sulphate..	3·30	3·09	3·39	3·66	3·73	4·19	1·93	....	1·83	1·64	2·39	4·79	2·51	2·41	2·58	2·73	2·51	4·68	2·66	....	2·39	3·01
Lead Sulphide...	3·36	3·14	3·50	3·69	3·78	4·30	2·03	1·74	1·83	1·66	2·29	4·78	2·59	2·42	2·57	2·76	2·54	4·74	2·76	....	2·43	3·09

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[28] *Oesterreichische Zeitung fuer Berg- und Huettenwesen*, 1902, 588.

Silver-Gold Assays.—Prost and Boveroulle[29] compared the crucible and scorification assay methods for silver using argentiferous blende and galena concentrates with from 70 to 75% lead. Crucible assays were made with iron crucibles in a pot-furnace. Two charges were used: (1) ore 20 g., sodium carbonate 30 g., dehydrated borax 17 g., argols 4 g., sodium carbonate cover 10 g.; (2) same as above, only 15 g. litharge were mixed into the charge. Scorification charges were made up of ore 5 g., granulated lead 25 g., cover granulated lead 25 g., dehydrated borax 0·5 g. The scorifiers were placed at the back of the muffle, brought to a cupelling temperature at the front, the muffle door was closed, the fire urged for 15 or 20 minutes, the door opened, and the scorification carried on until the lead buttons were covered; then borax was added, the fire again urged, and the charges poured. The results are summarized in the subjoined table:—

Ore.	Crucible Assay,				Scorification in Assay.		Difference.	
	With Litharge. Grams Ag per Ton of Ore.	Number of Assays Made.	Without Litharge. Grams Ag per Ton of Ore.	Number of Assays Made.	Grams Ag per Ton of Ore.	Number of Assays Made.	Grams Silver.	% of Total Silver in Favor of Scorification Assay
Blende I.......	887	3	....	....	895	3	8·0	2·02
Blende II......	644	3	....	....	684	4	42·0	6·12
Galena I.......	....	....	899	3	921	7	22·5	2·23
Galena I.......	901	2	....	....	921	7	20·5	2·22
Galena II......	2,285	2	....	....	2,323	5	38·0	1·63
Galena II......	....	....	2,284	2	2,323	5	39·0	1·67
Galena III.....	2,491	2	....	....	2,618	5	127·0	4·85
Galena III.....	....	....	2,481	2	2,618	5	136·5	5·22
Galena IV......	2,926	2	....	....	3,001	5	75·0	2·49
Galena IV......	....	....	2,936	2	3,001	5	65·0	2·16
Galena V......	3,112	3	....	....	3,160	6	48·0	1·50
Galena V......	....	....	3,126	2	3,160	6	34·0	1·07
Galena VI......	6,915	1	....	....	7,070	2	155·0	2·19
Galena VI......	....	....	6,969	1	7,070	2	101·0	1·55

Alderson,[30] in discussing the assaying of base silver ores, advocates the use of the crucible method. He also recommends the following charge for roasted ore:—

Sodium bicarbonate, 20 g.; borax, 0·5 A.T.; litharge, 1·5 A.T.; silica (glass through 20-mesh screen), 20 g.; argols, 2 g. Each of these components equals in volume one teaspoonful. He considers a preliminary roast an unnecessary operation (occupying too much time), as an addition of niter acts more quickly, and gives results that check satisfactorily. With an ordinary base ore, he takes 0·5 A.T., uses the charge given above except that he leaves out the argols, increases the litharge to 2 A.T., and adds 10 g. niter. If the base ore contains very little gangue, he increases the litharge to from 2·5 to 3 A.T., the silica to 30 g., and the niter to 15 g. In order to avoid a preliminary assay for determining the reducing power, he makes a rough pan test.

An editorial[31] describes briefly a method for assaying coppery lead ores.[32]

W. G. Perkins[33] advocates the assay of silver and gold-bearing coppery materials in the crucible. The charges are to be made up with a large quantity

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[29] *Revue Universelle des Mines*, 1901, 56, 220.

[30] *Mining and Scientific Press*, Apr. 19, 1902.

[31] *Ibid.*, June 14, 1902.

[32] See The Mineral Industry, X., 1901, 419, under P. R. Roberts.

[33] *Transactions of the American Institute of Mining Engineers*, 31, 912.

of litharge that is to carry the copper into the slag, with sufficient silica to have 1 part silica to 16 parts litharge, also the necessary oxidizing or reducing agents to obtain a button weighing 16 g. The fusions carried out in the muffle will give the best results when starting with the muffle fairly red; in 30 minutes this becomes a bright red, when the charge is kept in the furnace 10 minutes longer. The slag obtained will pour well, and when allowed to solidify will show when broken, lead, copper and iron silicate on the outside edge, gradually passing into crystalline litharge toward the center. If the furnace is too cool the slag will be crystalline, and shots of lead are liable to remain in the crucible; if too hot, the slag corroding the crucible will show cavities which may retain lead. In making up the charges, it is important to know the content of copper, silica, iron, and sulphur of the ore, and the effects of the fluxes: 1 g. flour will reduce 10 g. lead; 4% sulphur, 16 g.; 4% antimony, 3 g.; 4% arsenic, 6 g.; and 1 g. potassium nitrate will oxidize 4 g. lead. The quantity of litharge used will depend, besides silica to be slagged, upon the impurities to be fluxed. With low-grade ores (from 2 to 4% copper), 5 A.T. litharge will be added to 0·5 A.T. ore; with matte (from 48 to 60% copper), 8 A.T. litharge will be charged with 0·1 A.T. matte. For example, an ore of the composition copper 5·4%, silica 29·4%, iron 28·2%, lime 13·1%, sulphur 15·8% may be taken. Being rich in copper, 0·25 A.T. will be weighed out so as not to make the charge too large. This will require 8 A.T. litharge, 0·5 A.T. sodium and potassium carbonates, 18·3 g. silica, and 4 g. potassium nitrate. The author always uses a salt cover having found the results to be more satisfactory than with borax. Arsenic and antimony interfere with the method only when together they exceed 4% in quantity.

W. H. Kauffman[34] investigated the losses in silver in cupelling; he varied the quantities of silver and lead taken, the kind of cupel, and studied the effects of copper. The cupels were of three kinds: water cupels, potash cupels and borax cupels. In the first, 3,000 g. bone ash were moistened with 393 c.c. water; in the second, 60 g. pearl ash were dissolved in the water; in the third, 20 g. borax. The results obtained are given in the subjoined tables, each assay-figure being the average of several determinations.

Water Cupels.

Silver Charged.	Silver Lost.	Lead Charged.			
		5 Grams.	10 Grams	15 Grams	20 Grams
Mg.	Per Cent.	%	%	%	%
25		2·14	2·63	2·69	2·09
50		1·48	2·28	2·14	1·86
100		1·30	1·61	1·68	2·12
200		0·86	1·94	1·40	1·74

Potash Cupels.

Silver Charged.	Silver Lost.	Lead Charged.	
		10 Grams	25 Grams.
Mg.	Per Cent.	%	%
25		2·38	2·48
50		2·10	2·25
100		1·82	1·98
200		1·29	1·46

Borax Cupels.

Silver Charged.	Silver Lost.	Lead Charged.	
		10 Grams.	25 Grams.
Mg.	Per Cent.	%	%
25		2·43	2·44
50		1·96	2·37
100		1·42	2·12
200		1·17	1·76

Water Cupels.

Silver Charged.	Copper Charged.	Silver Lost.	Lead Charged.	
			10 Grams.	25 Grams
Mg.	Mg.	Per Cent.	%	%
100	20		1·61	1·82
100	50		1·80	1·99
100	100		1·87	2·01

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[34] *Engineering and Mining Journal*, June 14, 1902.

The conclusions drawn are: (1) the percentage-loss in silver is greater with small than with large quantities of silver; (2) with 10- and 15-g. lead buttons the loss in silver is smaller than if the buttons weigh 25 g., and greater if the weight goes down to 5 g. (25-mg. silver buttons appear to form an exception to this general statement); (3) small quantities of copper do not alter the conclusions given above; (4) there is no difference in the result whether the bone ash is mixed with pure water or with water containing pearl ash or borax.

Determination of Antimony in Hard Lead.—F. W. Küster, Ph. Siedler and A. Thiel[35] investigated the method of estimating the percentage of antimony in hard lead by determining the specific gravity. (See page 45 of this volume.)

Lead Smelting in Southeast Missouri.—R. B. Brinsmade[36] gives a brief outline of the lead-smelting operations in southeast Missouri. The ore is a galena concentrate, from 0·3 in. in diameter down to slimes, assaying from 60 to 70% lead, the rest being dolomite and pyrite. It is treated in the reverberatory smelting furnace, the ore-hearth and the blast furnace. The Desloge Co., Desloge, Mo., has five Silesian reverberatory smelting furnaces. Two tons concentrates form a charge, three charges are worked per day in winter, two in summer; two men at $1.75 and $1.55 run a furnace in an 8-hour shift in winter and in a 12-hour shift in summer. The lead running from the furnace is collected and slightly purified in the external cast-iron crucible of the furnace and ladled into shipping bars; the gray slag is sold to smelting works in St. Louis.

The Federal Lead Co., St. Louis, Mo., smelts galena concentrates in hearth-furnaces of the American water-back type; the hearth is 30×32 in. and 15 in. deep, has four 1-in. tuyeres 1 in. above the crucible; the blast-pressure is from 6 to 8 oz.; the fuel a non-caking nut coal. Two men to a hearth smelt in an 8-hour shift from 4,000 to 5,000 lb. concentrates, and extract about 50% of the lead in the ore in the form of marketable lead; 32% goes into the brows (agglomerated raw and roasted ore) and gray slag, and 18% into the fume. The fume is collected in a bag-house of Lewis-Bartlett pattern; some of it is sold, the rest goes into the blast furnace charge with the brows, gray slag, and the drosses.

The St. Joe smelter at Bonne Terre, Mo., roasts the concentrates and then smelts in the blast furnace. The roaster is a long-hearth hand-reverberatory furnace with fusion box. The roasting-hearth is 40×11 ft.; the fusion box, 8 in. below the roasting-hearth, is 11×11 ft., its working-bottom a 1-ft. bed of fused pyrites concentrates; the fire-bridge is 20 in. above the grate and 16 in. above the fusing-hearth; the flue-bridge is 8 in. high; the roof 12 in. above the fire-bridge and 16 in. above the flue-bridge; the grate is 7×2·5 ft.; the stack 3×4 ft. inside and 40 ft. high; bituminous coal serves as fuel. The furnace treats 5 tons of concentrates in 24 hours with 2 men on a shift. Before dropping the charge onto the fusing-hearth, 15% sand is introduced in order to decompose lead sulphate and to prevent any metallic lead from being liberated. The ore is stirred every half hour on the roasting-hearth and every hour on the

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[35] *Chemiker Zeitung*, 1902, 26, 1107; *Oesterreichische Zeitung fuer Berg- und Huettenwesen*, 1903, 178; *Engineering and Mining Journal*, Dec. 27, 1902.

[36] *Mines and Minerals*, 1902, 22, 300.

fusing-hearth; it passes in 30 hours through the furnace; the sulphur is reduced from 15% to about 4%. The blast furnace plant at Herculaneum has three water-jacket furnaces 54 in. in diameter at the tuyeres and 12 ft. high (each furnace treating from 50 to 60 tons charge in 24 hours), and one oblong furnace, 54×180 in. at tuyeres and 12 ft. high, with a capacity of from 60 to 80 tons charge in 24 hours. A charge contains about 50% lead; the slag aimed for is SiO_2 30%, FeO 40%, CaO 12 to 14%. Matte and slag are tapped into conical pots, 2 ft. in diameter at the top, and separated on the dump when cold. The matte, with 10% lead, is roasted in a Pearce single-deck turret furnace, and the sulphur reduced to 4%. The roasted matte is smelted in the blast furnace. Concentration of copper, nickel and cobalt in the presence of lead cannot be carried beyond a certain limit without cobalt and nickel being slagged to a considerable extent. The lead is run through an Arent's siphon tap into a kettle and cast into 80-lb. bars, which are sent to the refinery. The refinery contains two liquating furnaces with trough-shaped hearths, consisting of two cast-iron plates 3×5 ft. and 2 in. thick, which discharge the liquated lead through holes bored 8 in. apart, into semi-circular troughs. These deliver the lead into two merchant kettles, where it is poled for 90 minutes with steam passing through a 1-in. pipe. A kettle 3 in. thick at the bottom and 2 in. at the sides holds 30 tons of lead. The contents of the two kettles are discharged by means of Steitz siphons into 50 double moulds supported by the horizontal frame of a circular revolving picking table. The wheel-shaped table has 50 spokes. One central stack furnishes the draught for the two liquating furnaces and the two poling kettles. The market lead assays 1·5 oz. silver per ton.

Lead at Freiberg, Saxony.—Kochinke[37] publishes a tree of the ore treatment of the Halsbrücken and Mulden smelting and refining works, Freiberg, Saxony, which gives full details of the modes of working these complex ores.

Lead at Laurion, Greece.—Ernst[38] discusses briefly the smelting of lead ore, cupellation of argentiferous lead, and the uses to which lead and litharge were put by the ancients. The smelting methods must have been very imperfect, as old slags contain from 7 to 14·5% Pb. The litharge found, however, contains less than 3 oz. silver per ton, showing that the ancients were very careful with cupellation. Older silver coins upon analysis give a fineness of from 983 to 986, while those of a later date gave 966 and even 919 fine, which was probably due to the ores having become more base or to less care in the cupellation.

Lead in Murcia, Spain.—According to Jannetaz[39] the ore treated at Murcia, Spain, is mainly a galena concentrate with from 50 to 55% lead. The mines contain also a ferrous-lead-silicate ore with 6% lead, which is used as flux. The galena ore is roasted in hand reverberatory furnaces with hearths from 40 to 46 ft. long and from 10 to 13 ft. wide. In 24 hours from 5·5 to 6 tons ore are roasted with a fuel consumption of from 16 to 18% of the weight of the ore. The former natural draught furnaces have been superseded by blast

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[37] *Freiberger Jahrbuch*, 1902, 96–98.

[38] *Oesterreichisches Jahrbuch*, 1902, 50, 475; Hofman, *Engineering and Mining Journal*, Oct. 21, 1898.

[39] *Memoires et Compte Rendus des Travaux de la Société des Ingenieurs Civils de France*, 1900, I., 705–711; *Transactions of the Institution of Mining Engineers*, 1900-1901, 20. 583.

furnaces, of which the following facts are given: total height, 13 .to 16 ft.; diameter at tuyeres, from 4·5 to 6·5 ft.; number of tuyeres from 4 to 6, blast pressure, from 4·3 to 5·9 in. water. The charge contains 30% lead, the coke consumption is from 12 to 15% of the weight of the charge; the daily product is from 5 to 12 tons lead. At Puerto de Mazzarron, there are seven water-jacket Pilz furnaces 25 ft. high, and one 33 ft. high with 16 tuyeres, the number of which is to be doubled. At the same works, there is an American water-jacket furnace, with 14 tuyeres, producing 22 tons lead in 24 hours.

SMELTING OF LEAD ORES.

Roasting Furnaces.—J. Gross[40] describes with illustrations the construction of an adobe reverberatory roasting furnace with two hearths, each 30×10 ft. The furnace is fired with wood, and serves for chlorodizing roasting.

The F. M. Davis Iron Works Co., Denver, Colo., has patented[41] a straight-line mechanical roasting furnace, in which the rake-arm with the stirring blades instead of being dragged over the hearth by a chain or rope device, is replaced by an arm, having at either end a long rack and a flat surface. The racks mesh with pinion wheels placed along the sides of the furnace, the shafts of the several pinions have plane wheels on which rest the flat surfaces, thus relieving the pinions from the weight of the arm. Rack and flat surface form the bottom of an iron box filled with water. A pair of opposite boxes filled with water is joined by three hollow shafts, the middle shaft carrying a double set of blades. On a forward trip in the furnace one set of blades is in action; before the return trip the middle shaft is automatically turned 90°, and before the second forward trip, it is again turned 90°, throwing the opposite set of blades into use. The loss of water due to evaporation is automatically replenished after every trip. The raw ore, instead of being dropped onto the hearth, is fed under it at one end and pushed up onto it by means of a screw conveyor. The roasted ore is removed by a similar conveyor and forced up on to a cooling hearth, which is located at the side of the furnace at the floor level. It is about 4 ft. wide and double-decked. The hearths are of corrugated iron, supported by angle iron frames. The ore is conveyed over the two hearths by several sets of rabbles attached to an endless chain on either side, the rabbles traveling in one direction on the upper hearth, in the opposite direction on the lower hearth. It is claimed that the furnace will roast in 24 hours 1 ton siliceous ore with from 2 to 4% S for every 14 to 16 sq. ft. of hearth area, reducing the sulphur to less than 0·5%. For sulphide ores with from 25 to 30% S, the hearth area required per ton in 24 hours is from 35 to 40 sq. ft. if the sulphur is reduced to 4%, and from 55 to 60 sq. ft. if reduced to 0·5%. For matte with from 30 to 35% S, the hearth area required per ton in 24 hours is from 40 to 45 sq. ft., supposing the sulphur to be reduced to 4%.

The silver-lead works of Ems[42] have patented a straight-line mechanical roast-

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[40] *Transactions of the American Institute of Mining Engineers*, 1902; *Engineering and Mining Journal*, June 14, 1902.

[41] United States Patent No. 700,185, May 13, 1902.

[42] *Fischer, Jahresberichte, Leistung der Chemischen Technologie, Anorganischer Theil.*, 1901, 247.

ing furnace in which travel a row of trucks, forming parts of the hearth. The trucks are coupled at the ends, the sides run in grooves sealed with sand. The furnace is heated in the usual way from external fire-places, the trucks receive their ore charges at one end of the furnace, pass slowly through and leave it at the other. The ore is rabbled by hand from the sides.

D. C. Jackling[43] has patented a mechanical roasting furnace and carriage. The furnace has an oblong stationary hearth; its roof is carried by skew-backs riveted to upright I-beams, the tops of which are joined by cross beams which carry the return track of the carriage as well as a corrugated floor forming the cooling hearth for the roasted ore. The carriage runs on rails placed inside the furnace walls.

W. A. Lorenz[44] patented a straight-line mechanical reverberatory roasting furnace assigned to the Lanyon Zinc Co., of St. Louis, Mo. The stirring mechanism is the opposite of that of Ropp, in so far as it is suspended by rods carried by trucks running on a track above the furnace instead of being supported by rods carried by trucks running in a vault underneath the hearth. In order to give the roof (which is divided into two parts by the longitudinal slot) the necessary strength, it has two arches, and as there is no abutment along the median line for the meeting arches, a heavy iron casting, firmly attached to steel cross beams, takes its place.

D. Sheedy and M. W. Iles[45] have patented an oblong mechanical roasting furnace, in which the abutments carrying the arch are built into cast-iron angles. These are suspended by iron rods from cross beams, and braced against the vertical beams of the upright frames extending over the furnace. The rabble carriages run outside of the furnace, and make their return trips on rails placed on the cross beams.

J. P. Cappeau[46] has patented a mechanical straight line reverberatory furnace similar in principle to the Ropp furnace. The improvement lies in the opening and closing of the central slot in the hearth by means of gates, which are controlled by the rake as it moves over the hearth.

The case of Horace F. Brown against the Lanyon Zinc Co.[47] for the infringement on the Brown patented roasting furnace was decided by the Circuit Court of Appeals in favor of Brown, thus upholding the decision rendered by the Circuit Court of Kansas.

A. D. Carmichael[48] has proposed to desulphurize ores by mixing them with calcium sulphate, and then heating to start the roast. The heat generated is to reduce the calcium sulphate to sulphide, and the latter is to be re-oxidized by the admission of air.

J. A. Ogden[49] has patented a gravimetric ore roaster by which term is to be understood a reverberatory furnace containing suspended shaking iron plates. The ore is to be subjected to dry concentration while it is being roasted.

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[43] United States Patent Nos. 706,755 and 706,756, Aug. 2, 1902.

[44] United States Patent No. 691,787, Jan. 28, 1902.

[45] United States Patent No. 711,852, Oct. 4, 1902.

[46] United States Patent No. 691,112, Jan. 14, 1902.

[47] *Mining and Scientific Press*, Sept. 13, 1902.

[48] United States Patent No. 705,904, July 29, 1902.

[49] United States Patent No. 691,868, Jan. 28, 1902; No. 708,728, Sept. 9, 1902.

J. L. Hopper[50] has patented a two-hearth oblong oil-burning roasting furnace, in which perforated oil supply pipes are placed in the side walls, near the floor, and in the roof of the lower hearth. The ore, fed at one end of the hearth, is discharged at the other.

A. W. Chase[51] has constructed a multiple-hearth roasting furnace for pyritic ores. A hearth is composed of three burnt fire clay troughs 2 ft. long, which are supported by arches. A water-cooled screw conveyor turns over and moves the ore along. The fire-place extends along the bottom of the furnace and supplies the necessary heat. A furnace with three hearths is 14 ft. long and 2 ft. high. A trial run with pyrites cinders gave a coal consumption of less than 1 ton in 24 hours. The results of three roasts are given in the subjoined table:—

Ore Fed in 24 Hours.	Sulphur in		Soluble Components in Roasted Ore.				Remarks.
	Raw Ore.	Roasted Ore.	Sulphur.	Copper.	Iron.	Lime.	
Tons,	%	%	%	%	%	%	
7·2	4·40	0·64	0·62	0·20	0	0·82	....
9·6	5·90	1·51	1·51	0·92	0	0·82	Heat low.
9·6	5·07	1·17	1·01	....	0	0·82	Heat high.

Th. D. Merton[52] has patented a multiple-hearth, oblong roasting furnace, in which the ore, fed onto the top hearth is moved through the furnace by a number of horizontal arms reaching out from vertical water-cooled, revolving shafts. The arms are arranged in such a way that the circles they describe overlap one another in part, and thus move the ore over the hearths.

Evans and Klepetko[53] have patented an improved form of MacDougall furnace, in which both the vertical driving shaft, and the horizontal stirring arms are water cooled. A detailed description of the furnace and of its work has been given by H. O. Hofman.[54]

L. T. Wright[55] patented some device (not clearly shown) for cooling the central shaft and the radial arms of a MacDougall roasting furnace.

F. L. Bartlett[56] has patented a furnace for refining lead and zinc fume. It is oblong, has a feed at one end, a discharge at the other, and a depressed fire-place on either side of the discharge opening.

W. D. C. Spike and J. T. Jones[57] have patented a reverberatory furnace for roasting and smelting. The ore is fed through a vertical chimney onto staggered rows of tilting grate-bars, which allow the products of combustion to zigzag over the ore, as they rise and pass off through the chimney. On the grates the ore is subjected to a preliminary oxidizing roast, and moved downward by tilting the bars. At the bottom of the roasting chimney is an inclined iron hearth on which the roast is supposed to be finished. The ore glides from this onto a brick hearth, where it is to be smelted. Air under pressure

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[50] United States Patent No. 702,004, June 10, 1902.

[51] *Engineering and Mining Journal*, June 7, 1902.

[52] United States Patent No. 697,868, April 15, 1902.

[53] United States Patent No. 700,399, May 20, 1902.

[54] Paper read before the American Institute of Mining Engineers, February, 1903.

[55] United States Patent No. 697,062, Apr. 8, 1902.

[56] United States Patent No. 692,972, Feb, 11, 1902, also No. 715,268, Dec. 9, 1902.

[57] United States Patent No. 698,076, Feb. 11, 1902.

circulates beneath the inclined iron roasting hearth, cools this and enters when superheated in part, under the grate of the deep fire-place of the furnace.

An editorial[58] gives brief descriptions of the newly patented roasting furnaces of P. Argall, [59] J. P. Cappeau,[60] H. Carmichael,[61] B. Hall,[62] W. A. Lorenz,[63] Th. D. Merton,[64] U. Wedge,[65] J. P. Wetherill,[66] L. T. Wright,[67] and F. W. Holtman.[68] The last-named furnace is a modification of the Spence furnace. The rakes are moved to and fro by means of threaded rotating shafts, the directions of which are reversed after each movement of the rakes. The shafts are mounted outside of the furnace, and are driven by bevel gearing. The rake arms protrude from the hearths through the sides of the furnace, the continuous slots being closed by long plates attached to the arms. Other patented roasting furnaces are those of A. M. Beam,[69] W. H. Mother,[70] P. Naeff,[71] Th. Edwards,[72] and A. C. Johnson.[73]

Blast-Furnace Table.—The blast-furnace table of Kochinke[74] contains several statements about the Przibram smelting works, which require a correction. According to Cap[75] the coke consumption during the last 28 years was 13·18%, and during the last 5 years 12·6%; it never reached 16% as stated by Kochinke; the coke often containing from 13 to 15% ash. Further, the diameter of the hearth is 4·92 ft., not 4·59 ft.; the diameter of tuyeres 2·27 in., not 2·36 in.; the blast pressure is 1 in. quicksilver, not 1·6 in.; the charge contains 16% lead, the ore 32% silica.

Blast-Furnace Construction.—C. Laughlin[76] has patented a slag-escape device for a blast-furnace tuyeres, and a means of cooling a wrought-iron water-jacket by making connection near top and bottom with a water tank. The idea of the second patent is that the hot water in the jacket will, while rising, draw in cool water near the bottom, and thus establish a circulation of the cooling water. The heated water is cooled in the open water tank.

E. H. Messiter[77] has patented a tuyere-elbow with a drop-valve, which prevents the back flow of gas into the bustle pipe, should the pressure in the tuyere-pipe be reduced below that prevailing in the furnace. Between the drop valve and the opening leading into the furnace is an escape passage leading in the open air, the passage being controlled by the pressure of the blast.

M. Barrett[78] has patented a sectional, water-cooled tapping-jacket for a matte settler.

Mechanical Feeding of Blast Furnaces.—A. S. Dwight discusses the mechanical feeding[79] of silver-lead blast furnaces, and gives much information in regard to the mechanical factors that govern the successful working of a lead blast fur-

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[58] *Engineering and Mining Journal*, Aug. 16, 1902.

[59] THE MINERAL INDUSTRY, IX., 445. [60] *Ibid.*, XI., 440. [61] *Ibid.*, X., 429. [62] *Ibid.*, X., 429. [63] *Ibid.*, XI., 440. [64] *Ibid.*, XI., 441. [65] *Ibid.*, IX., 445. [66] *Ibid.*, X., 430. [67] *Ibid.*, VIII., 401 and XI., 441.

[68] United States Patent No. 664,153, Dec. 8, 1900.

[69] United States Patent No. 708,615, Sept. 9, 1902.

[70] United States Patent No. 708,977, Sept. 9, 1902.

[71] United States Patent No. 711,338, Oct. 14, 1902.

[72] United States Patent No. 715,080, Dec. 2, 1902.

[73] United States Patent No. 714,464, Nov. 25, 1902.

[74] THE MINERAL INDUSTRY, X., 430.

[75] *Oesterreichische Zeitschrift fuer Berg- und Huettenwesen*, 1902, 147.

[76] United States Patent Nos. 707,601 and 707,602, Aug. 26, 1902.

[77] United States Patent No. 706,332, Aug. 5, 1902.

[78] United States Patent No. 701,670, June 3, 1902.

[79] Paper read before the American Institute of Mining Engineers, November, 1902.

nace. A modern lead blast furnace has a tuyere-section ranging from 42×120 in. to 48×160 in., and a throat-section from 54×132 in. to 84×200 in.; the height varies from 15 to 21 ft.

With hand feeding, the charge may be introduced from the top through a slot about 20 in. wide when the gases are drawn off from the side of the furnace, or from the side when the furnace shaft extends as a hood above the charging-floor from which a down-take carries the gases off into the dust-flue. Such a furnace will smelt in 24 hours from 80 to 200 tons charge (ore and flux), the quantity of foul slag added will be from 20 to 60%, and the coke consumption from 12 to 16% of the charge; the blast pressure will vary from 1·5 to 4 lb., averaging 2 lb. per sq. in. A furnace will be doing satisfactory work when the direct yield of lead in the form of base bullion is high, the slag fluid and clean, the matte low in lead, and the top of the furnace cool and quiet, making little fumes and dust. The charges should descend evenly, which means that the furnace should be free from accretions and crusts, the tuyeres be moderately bright and open, and the play of the lead in the well free. All these conditions are dependent upon a "good reduction," and this in turn is governed by the chemical composition of the charge, the proportion and character of the fuel, the volume and pressure (perhaps temperature) of the blast, the dimensions of the furnace and the mechanical character and arrangement of the smelting column. The last factor is the one that escapes absolute control in that it is dependent on the feeding of the charge. The proportions of ferric oxide reduced to ferrous oxide and metallic iron are governed in part by the manner of feeding. Reduction ought to be effected mainly by carbon monoxide, as reduction by carbon, besides being an endothermic reaction, presupposes a high column of incandescent charge, which leaves little room for the cooling and filtering of the ascending gases. The quantity of furnace gases produced depends upon the volume and pressure of the blast. An excessive volume will cool the furnace and require more fuel; the excess of fuel with the quickness of the gas current will have to be regulated by the density of the charge, and this, besides the mechanical condition, will be governed by the mechanical arrangement. By mixing the ingredients, the charge besides offering more resistance to the gases, will absorb more of their heat, and will be reduced more effectively than when coarse and fine are kept separate. Nevertheless, coarse particles will be fed rather toward the central portion than toward the walls, as the gases tend to follow the walls because there the resistance is least. This tendency has to be corrected by interposing fines. Large charges within certain limits give more favorable results than small charges, supposing, as is nearly always the case, that they are fed in alternate layers. The reason for this may be explained by the fact that the gases having forced their way through a dense ore charge pass evenly and easily through the porous coke charge which, forming a sort of equalizer, again gives them an opportunity to distribute themselves evenly over the whole furnace area for a renewed attack upon the overlying ore charge. Of course, the ore charge must not be too fine or too coarse, a mixture of one-third of pieces 5·5 in. in diameter, one-third 2·15 in. in diameter, and one-third smaller than 0·5 in., will give the right resistance. Slag ought to be in pieces about 6-in. diameter, coke ought to be somewhat broken, and a reasonable quantity of fines left with the larger pieces. Moistening of charge helps to pack the ore tightly, and to keep the heat down. While the evaporation of water consumes fuel, the loss in heat is smaller than that experienced from the smelting zone creeping up.

In the open-top furnace the fine particles when falling from the shovel, will drop near the center, the coarser particles acquiring a greater momentum will fall nearer the wall of the furnace. A similar arrangement will occur with the Pfort curtain. In the side-fed or hooded furnace the fines drop near the wall, while coarse ore is thrown more toward the center, as it ought to be. If a mechanical feeder can be constructed which will feed the fines toward the side and the coarse toward the center, there is no question of the mechanical feeding being preferable to hand feeding. Mechanical feeders are in use at the Pueblo, East Helena, Salt Lake City and El Paso works of the American Smelting & Refining Co., and are being adopted at the new plant at Torreon, Mexico. The author reviews with illustrations, the different mechanical devices that have been tried, discusses some details of the arrangement at Pueblo and East Helena. Fig. 4 is a sketch of the East Helena system adopted in 1900. It shows the charge car with curtains (now omitted) in the transfer carriage, and the roof-shaped spreader which deflects the charge toward the sides where the fine ore remains, while the coarse parts roll toward the center.

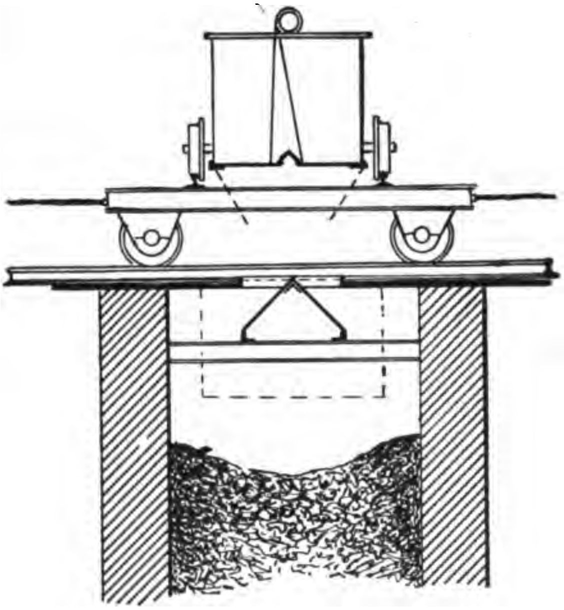

FIG. 4.—SYSTEM OF FURNACE-CHARGING AT EAST HELENA, MONT.

With this arrangement, as with most others, the contents of the car have to drop quite a distance before they reach the charge in the furnace. W. H. Howard[79a] avoids this disadvantage by his improved blast furnace charge feed,

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[79a] Private communication.

which consists of a feed-box with doors in the bottom that is raised from its trucks by a crane, lowered into furnace, emptied from any height that is desired, and returned to the furnace floor. The top of the furnace is closed by balanced doors which are opened by the carriage and swing into place again when the carriage is removed. While feeding, the top is automatically closed with a cover to prevent escape of smoke into the feed floor.

A paper similar to that of Dwight's, but relating to the iron blast-furnace, and referring mainly to the protection of the men on the feed floor, with 51 illustrations, has been published by Steger.[80]

Chemistry of the Blast Furnace.—K. Waldeck[81] has studied the gases from different parts of two lead blast furnaces at Altenau and St. Andreasberg, Harz Mountains. The blast furnace at Altenau was circular (diameter not given), 18 ft. high (floor to throat), and had two tuyeres 1·75 in. in diameter. At the time of the investigation the furnace was smelting silver-bearing matte with litharge in order to collect the silver in base bullion. The ore bed was made up of 5,000 kg. matte (Cu 41·36%, Fe 25·24%, S 21·76%, Zn 4·82%, Pb 3·87%, Ag 1·6%), 3,000 kg. litharge, 200 kg. limestone, 1,000 kg. iron ore, 1,000 kg. blast furnace slag (SiO_2 37·40%, Cu 0·10%, PbO 3·92%, FeO 33·39%, MnO 1·45%, Al_2O_3 9·52%, ZnO 4·80%, CaO 6·12%, MgO 0·88%, S 2·31%), and 10% coke (ash 14%, S 1·5%). The charge contained 7% sulphur. The blast pressure was 10 in. water, which gives 42 cu. ft. air entering the furnace per minute. Lead and matte were tapped every two hours.

In order to obtain samples of the furnace gases, three holes were drilled through the furnace wall, hole A 1·15 ft., hole B 3·93 ft., and hole C 7·22 ft., above the tuyere level. The gases were examined for the amount of dust they contained as well as for their chemical composition.

Hole.	Blast Pressure. cm. Water.	Fume, Grams per Liter from		Hydrogen Sulphide from		Sulphur Dioxide from	
		Center of Furnace.	Wall of Furnace.	Center of Furnace.	Wall of Furnace.	Center of Furnace.	Wall of Furnace.
A..........	24	0·0070	0·0410	....	....	....	....
	24	0·0065	0·0430	....	....	....	....
	24	0·0068	0·0417	....	....	....	....
B..........	24	n. d.	0·0169	n. d.	....	n. d.	....
	24	n. d.	0·0166	n. d.	....	n. d.	....
	24	n. d.	0·0168	n. d.	....	n. d.	....
C..........	24	n. d.	0·0088	n. d.	....	n. d.	....
	24	n. d.	0·0078	n. d.	....	n. d.	....
	24	n. d.	0·0080	n. d.	....	n. d.	....

The table shows that the percentage of fume in the gases decreases with the distance from the tuyeres, the gases growing cooler; (the charge was, however, still dark red at C), the charge acting as a filter, and that the percentage of fumes is greater near the furnace walls than at the center. This illustrates the well-known fact that the amount of fume carried off by the gases is in part due to the velocity with which these rise through the charge.

Chemical analyses of the gases gave the following values; each figure represents an average of six separate samples.

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[80] *Zeitschrift fuer Berg- Huetten-, und Salinenwesen im Preussischen Staate*, 1902, 50, 97.

[81] *Gasanalytische Untersuchungen an Bleischachtœfen*, Berlin, H. S. Herman, 1901. 85.

Hole.	CO_2.	CO.	$\frac{CO_2}{CO.}$
A.	5·1	20·4	0·25
B.	6·1	30·3	0·20
C.	7·8	21·8	0·36
Flue leading to stack.	1·5	1·1	1·36

The analyses show extraordinary high values for carbon monoxide. This is an indication that carbon at the tuyeres burnt mainly to carbon monoxide, and that up to the level C of the furnace, where the last gas samples were taken, indirect reduction was subordinate to direct reduction. The absence of oxygen, hydrogen sulphide and sulphur dioxide in the gases shows that no unconsumed air passed through the furnace, that neither the water vapor of the air nor the solid oxygen of the iron ore had any effect upon the sulphides in the charge, and that no carbon oxysulphide (sulphur acting upon carbon monoxide) was formed, which being decomposed by water would give carbon dioxide and hydrogen sulphide. The ratio of 1·36 of the gases in the flue leading to the stack shows that considerable carbon monoxide must have been oxidized to dioxide above the point C. This may have been caused by carbon monoxide acting as a reducing agent upon a readily reducible oxide (litharge *e.g.*), or by its burning at the surface of the charge when it came in contact with the air.

The furnace at St. Andreasberg, of the same general dimensions as the one at Altenau had four tuyeres 1·34 in. in diameter; it was running on foul blast furnace slag when the investigations were being made. The ore bed, containing 5·89% sulphur, was made up of 56,100 kg. lead matte (SiO_2 2·05%, Pb 13·72%, Cu 7·68%, Sb 0·31%, Zn 4·73%, Fe 44·73%, Mn_2O_3 1·01%, CaO 0·25%, S 24·32%); 1,400 kg. burnt pyrite (S 5%); 23,200 kg. drosses (Pb 30 to 40%, S 2%); 30,400 kg. speiss (S 3%); 4,300 kg. fume (S 9%); 34,800 furnace refuse (S 10%, *e.g.*, PbS 95·5%, FeS 3·2%, Sb_2S_3 2·5%), and 211,300 kg. foul slag (S 2%). It was smelted at the rate of 12·1 metric tons per day with 8·8% coke (S 1·5%); the blast pressure was 3·14 in. water corresponding to 282·3 cu. ft. air per minute. Five holes were drilled through the furnace walls to draw off gases: hole *a* was 0·49 ft., *b* 2·36 ft., *c* 3·71 ft., *d* 5.41 ft. and *e* 6·56 ft. above the level of the tuyeres. As the Altenau tests had shown that the sulphur of the charge was not oxidized during its descent in the furnace, it seemed of interest to find out here what effect water vapor might have upon coke. The first set of tests is brought together in the accompanying table.

Hole.	Blast Pressure. cm. Water.	Grams Water.		Difference.	Grams Fume in 1 Cu. M. Furnace Gas.	H_2S.	SO_2.	H.
		In 1 Cu. M Air.	In 1 Cu. M Furnace Gas.					
a.	8	9·2	8·8	—0·4	29·0	None.	None.	0·5
	8	9·2	8·9	—0·3	29·6	None.	None.	0·5
b.	8	10·0	9·3	—0·7	11·7	None.	None.	0·5
	8	10·0	9·5	—0·5	11·8	None.	None.	0·5
c.	10	12·0	12·0	0·0	7·0	None.	None.	0·1
	10	12·0	12·4	0·4	7·8	None.	None.	0·1
d.	10	13·6	16·5	2·9	6·6	None.	None.	Trace.
	14	18·6	47·3	33·7	7·2	None.	None.	Trace.
	14	13·6	47·8	34·2	7·3	None.	None.	Trace.
	24	13·6	n. d.	....	13·1	None.	None.	Trace.
	24	18·6	n. d.	....	13·3	None.	None.	Trace.
e.	8	11·8	82·9	71·6	6·2	None.	None.	....
	8	11·3	83·0	71·7	6·4	None.	None.	....

They show that the quantity of fume formed is one-third less than with the furnace at Altenau, although the charge contains more volatile matter, such as flue-dust, arsenic of the speiss, etc.

The explanation is to be found in the lower blast-pressure. The amount of fume collected is seen to diminish as at Altenau, with the distance from the tuyeres. The presence of hydrogen in the gases shows that in the lower parts of the furnace there is a slight decomposition of the water vapor entering with the blast by incandescent carbon. Its absence in the upper parts of the furnace may be due to two causes: the temperature is too low for decomposition of the vapor or the hydrogen has been acting as a reducing agent and has been converted back into water. The increase of water in the gases with the distance from the tuyeres is, of course, to be attributed to the moisture of the coke. The figures bring out the interesting point that it takes time to drive out all the water from the coke, and that coke, red hot on the outside may still retain some moisture in the interior.

Averages of the gas analyses made from the samples taken from the different bore-holes show:—

Hole.	CO_2.	CO.	$\frac{CO_2}{CO.}$
a..............	6·8	17·7	0 38
b..............	11·5	15·8	0·78
c..............	10·9	14·9	0·23
e..............	8·1	12·8	0·66

Here again the percentage of carbon monoxide in comparison with that of carbon dioxide is seen to be very high. The sudden increase in the percentage of carbon dioxide at bore holes *b* and *c* is not satisfactorily explained.

In summing up his work the author draws the following inferences: (1) The water vapor entering the furnace with the blast has no effect upon the sulphides of the charge and is only slightly decomposed by the coke; (2) there is no pyritic effect; (3) carbon oxysulphides are not formed; (4) the amount of fume formed depends upon the pressure of the blast; (5) the CO_2 : CO ratio is changed by the pressure of the blast, increasing as the pressure decreases and vice versa.

Blast-Furnace Slags.—H. E. Ashley[82] studied the constitution of slags by means of a tri-axial diagram with rectangular co-ordinates. He replotted R. Åkerman's data on silica-alumina-slags (represented by H. M. Howe[83] by the usual tri-axial diagram), and those of H. O. Hofman[84] on silica-iron-lime slags, drew "isocals" (10 calories apart) to connect the slags which gave up in solidifying and cooling to 0°C. per gram the same number of calories and "isotherms" to connect the slags which formed at the same temperatures. The curves show in certain regions maxima, in others, minima. Drawing an analogy between them and the freezing point curves of binary metallic alloys, in which maxima correspond to chemical compounds and minima to eutectics, the author concludes that in the field covered by Hofman there are but two chemical compounds, $(FeO)_2SiO_2$ forming at 1,270°C. and $CaO.(FeO)_2SiO_2$ forming at 1,250°C. He believes that these two compounds are perfectly miscible in all proportions

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[82] *Transactions of the American Institute of Mining Engineers*, 31, 855.
[83] *Ibid.*, 18, 345. [84] *Ibid.*, 29, 682.

when fluid, are not isomorphous, and are incapable of combining chemically with one another.

By means of the new system of plotting, it is easy to enlarge upon the facts found by Hofman regarding the changes in formation temperatures caused by replacing the different slag constituents, and to show what effects leaving out one or another constituent without replacement will have upon them.

H. von Jüptner[85] discusses mainly from the iron metallurgist's point of view, the relations that may obtain between the sulphur content of metal and slag. The general considerations he brings forth have an important bearing on the sulphur contained in matte and slag; he exemplifies this by examples of copper-matte and blast-furnace slag.

I. H. L. Vogt[86] discussed in a general way the behavior of melted silicates, and showed the application of the general laws of solution to silicates as well as to alloys. According to his view, melted silicates are igneous solutions of compounds in stoichiometrical proportions.

Waste Heat of Blast-Furnaces.—R. Brown[87] proposes to utilize the heat of the waste products of smelting furnaces by transferring it to the materials to be charged into the furnace. The charge is to be dropped into a closed chamber with perforated iron floors, beneath which pass the cars containing the furnace products.

Flue-Dust.—F. H. Long[88] has patented a metallurgical filter, which consists of a sheet-iron cylinder with conical bottom carrying a spreader, a spiral baffle and a filtering medium. Dust-laden gases are forced by means of a fan into the cylinder at the apex of the conical bottom, and through the filtering medium and drawn off, freed from dust, by means of an ejector. The apparatus thus works with pressure on one side of the filter and with a vacuum on the other. Details of arrangement of filter and of filtering medium are not given.

W. J. Jackson[89] patented a wet smoke condenser.

Briquetting of Ores.—R. Schorr[90] briefly reviewed the different bonds and methods employed in briquetting fines; he estimates the cost of briquetting to range from $0·65 to $1·25 a ton of briquettes.

Chisholm, Boyd & White[91] has published an illustrated description of their well-known briquetting machine, which consists of a lime slacker, an automatic feeding and measuring device, a conveyor mixer, and the press proper with belt-conveyor.

W. G. Irwin[92] has reviewed the briquetting of fuels and ores in general, and praises the White (Pittsburg) press. The paper is illustrated, and reproduces the well-known illustrations of the manufacturer.

H. Bumby[93] has discussed in detail the briquetting of finely divided iron ores.

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[85] *Stahl und Eisen*, 1902, 387 and 432.

[86] *Chemiker Zeitung*, 1902, No. 21, p. 280.

[87] United States Patent No. 708,018, Sept. 2, 1902.

[88] United States Patent No. 691,706, Jan. 21, 1902.

[89] United States Patent No. 700,934, May 27, 1902.

[90] *Engineering and Mining Journal*, Nov. 22, 1902.

[91] *Mining and Scientific Press*, July 12, 1902.

[92] *Engineering Magazine*, 1901-02, 22, 889.

[93] West of Scotland Iron and Steel Institute, Feb. 21, 1902, through *Stahl und Eisen*, 1902, p. 457.

R. M. Hale[94] has described the briquetting of flue-dust at an iron blast furnace.

R. Martin[95] has patented a horizontally revolving briquetting machine with radial mould and plunger-chambers. The fines are fed from above by an annular feed-chamber, and discharged below into an annular receiver.

Cost of Smelting.—Kirchhoff[96] reports the cost of ore smelting in Colorado in 1899 to have been $4·96 per ton of ore, made up of labor, $2·415; salaries, $0·255; supplies and materials, $2·165; taxes, rent, insurance and all other expenses, $0·125. The yield in lead of the 711,371 short tons of ore smelted was 10·3%; assuming an average yield of 90% of the lead charged, the average content of lead in the ore would have been 11·8%. The cost of smelting 68,719 short tons galena concentrates of Missouri, with 65% lead in the southeastern district, and 72% in the southwestern, is given as $9·72 per ton, *viz.*, labor, $3·72; salaries, $0·69; paid to contractors, $0·37; supplies and materials, $2·34; rent, taxes, insurance and all other expenditures, $0·60. The figures cannot be compared directly with those from Colorado, as beside the different methods of smelting (reverberatory furnace, ore-hearth, blast furnace), some works produce lead oxide. Thus, in 1899 Missouri produced 41,976 tons lead and 5,165 tons oxide.

Crude Oil in Smelting.—A. Von der Ropp[97] discussed the use of crude oil in smelting; taking his results mainly from the Selby Smelting & Lead Works, California. At this plant 47 oil burners are used in metallurgical furnaces and are effecting a saving in cost over coal of from 40 to 60%, the price of oil (26 to 27° gravity), is $1·71 per barrel, that of coal $6 per ton. The following furnaces are fired with oil: 4 roasting furnaces (11 burners), 1 matting furnace (35×16 ft.), (3 burners); 1 copper furnace (1 burner); 13 retorting furnaces (13 burners with 8-in. flames); 3 cupelling furnaces (3 burners); 1 antimony furnace (1 burner); 1 furnace for melting fine silver (1 burner). Besides the above-mentioned reduction in cost, there are many advantages in the use of oil over coal. In roasting, there can be maintained a steady oxidizing flame which permits putting through more ore and obtaining a better product than with coal. In matting, a higher- or a lower-grade matte can be obtained, according to the oxidizing or reducing character given to the flame. In either case the charge, on account of the steady heat, will smelt more quickly and evenly than when coal is used. The author prefers steam to compressed air as an atomizer, as the former keeps the oil more mobile, and thereby assists atomizing. If with air that cools upon expanding, the same result is to be obtained, the air will have to be preheated (other metallurgists[98] have recorded a greater saving in oil with air as atomizer than with steam). Von der Ropp also warns against the use of mixtures of heavy residues and light oils, as they will separate in the tanks and the residuum will clog the pipes.

New Method of Smelting Galena.—Catelin[99] proposes a new method of pro-

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[94] *Iron Age*, Dec. 11, 1902.

[95] United States Patent No. 712,696, Nov. 4, 1902.

[96] *Twelfth Census*, United States, through *Engineering and Mining Journal*, Aug. 16, 1902.

[97] *Mining and Scientific Press*, Nov. 29, 1902.

[98] Hofman's "Metallurgy of Lead," 1899, 442, 492.

[99] *Echo des Mines*, through *Oesterreische Zeitschrift fuer Berg- und Huettenwesen*, 1902, 525; *Engineering and Mining Journal*, Nov. 1, 1902.

ducing lead from galena without the use of carbonaceous fuel, which is based upon the following thermochemical considerations. Upon blowing a measured quantity of air through molten galena there are set free sulphur dioxide and metallic lead, at the same time some lead sulphide is sublimated in the form of a black fume. The reaction taking place may be expressed by

$$2PbS+2O=SO_2+Pb+PbS.$$

It is exothermic, and the heat set free by burning one-half of the sulphur of the charge is sufficiently large to melt and liquefy a new charge of galena of the same weight as the original charge. As any silver present in the galena remains with the liberated metallic lead, the sublimated lead sulphide, now free from silver, will furnish non-argentiferous lead when treated by the same process. If, instead of burning off only half of the sulphur, the oxidation is carried periodically further, the sublimated lead sulphide will be converted into lead oxide and sulphate. The dark and white fumes obtained in the two oxidation periods are collected in separate condensing chambers, then mixed and treated as would be galena, when lead and sulphur dioxide will be formed, the oxidation of part of the lead sulphide furnishing the necessary heat:—

$$PbS+O_2=Pb+SO_2 \text{ and}$$
$$PbSO_4+PbS=2Pb+2SO_2$$
$$2PbO+PbS=3Pb+SO_2.$$

The reactions require a galena with 75% lead or more. With ore of a lower grade, carbonaceous fuel has to be used to slag the gangue; the slag being rich in lead will have to be treated separately.

Electrolytic Reduction of Galena.—P. G. Salom[100] and J. W. Richards[101] describe the electrolytic reduction of galena carried on by the Electrical Lead Reduction Co., at Niagara Falls, N. Y. Finely crushed galena is spread to the thickness of 1 in. on the bottom of conical hard-lead reduction pans (from 15 to 18 in. in diameter and 18 in. deep, with sides protected by a rubber coating) and then some sulphuric is added. Eleven pans (cells) are stacked, one on top of the other, to form a pile; the bottom of the top pan forms the anode of the adjoining lower one, in which galena forms the cathode. A pile (or stack) of cells containing 33 lb. galena is electrolyzed in 5 days by means of a current of 33 amperes at 2·9 volts. In this process the ore is reduced to spongy lead which swells to a thickness of from 3 to 4 in.; the sulphur passing off as hydrogen sulphide, together with the hydrogen that is generated, is conducted away in pipes and burned. The spongy lead, when washed and dried is ready for use in a storage battery. At present, most of the lead sponge is burned in a furnace and converted into litharge. The plant has two Westinghouse 300-H.P. motors run by an alternating current of 2,250 volts. Each motor is directly connected with a Westinghouse direct-current 250-H.P. generator. The piles, each with 11 cells are grouped in sections of four run in parallel; thus the current of 125 volts runs through four

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[100] *Transactions of the American Electrochemical Society*, 1902, I., 87.

[101] *Electrochemical Industry*, 1902, I., 18.

stacks in series and through several sections in parallel. The plant, when running to its full capacity, will produce 10 tons of lead per day.

DESILVERIZATION OF BASE BULLION.

Pattinson Process.—Some details of Tredinnick's patented apparatus for carrying out the Luce-Rozan or Steam-Pattinson process[102] have recently been issued in pamphlet form.[103] While the Luce-Rozan[104] process has two melting pans and one crystallizer (holding 22 tons lead) from which the liquid lead is discharged into two large cast-iron molds, the solidified cakes being handled by means of a steam crane; Tredinnick has adopted a series of 12 crystallizers (each holding 45 tons lead) to be raised and lowered by hydraulic pistons.

Crystallizer No.	1	2	3	4	5	6	7	8	9	10	11	12
Silver in lead bullion. Oz. per ton.	300	180	100	60	35	20	12	7	4	2	1	0·5

Supposing the odd-numbered kettles to be filled with bullion assaying, respectively, 300, 100, 35, 12, 4 and 1 oz. silver per ton, and the even-numbered kettles to be empty; steam will be introduced into the filled kettles in the usual way until two-thirds of the contents has been crystallized; the liquid or enriched lead will be discharged into the kettles on the left, and, when drained off, the crystals will be reliquefied and discharged into the kettles on the right. Thus the even-numbered kettles will be filled with one-third liquid lead from the kettles on the left and with two-third crystals from the kettles on the right. The odd-numbered kettles, now empty, will be lowered and the even-numbered raised and treated as were the odd-numbered. The liquid lead from the 300-oz. kettle No. 1 will go to the cupel, the crystals in the 0·5-oz kettle (No. 12) will be market lead. The idea of doubling the capacity of the crystallizer originated at Eureka, Nev., in 1878, when it was found it took less time to run a 45-ton kettle than one holding 22 tons lead. In fact, 10 operations were carried out in 24 hours with the large kettle, as against six with the small one. At Eureka it was necessary to have in stock 210 tons lead and to re-melt 165 tons in order to produce 15 tons desilverized lead in 24 hours, the crew consisting of eight men.

Tredinnick states that with his improved apparatus he desilverized 120 tons lead in 24 hours with 18 men, and has to carry in stock only 275 tons of lead.

Parkes Process.—W. H. Howard has improved his alloy press for the separation of unalloyed lead from zinc-silver-lead crust. The improved form is shown in Fig. 5. The press consists of a cast-iron ring *F* closed at the bottom by a circular heavy plate *G*, having perforations *P*. The plate is attached to the shaft *K*. the ends of which rest in the sockets of the uprights *SS*. These pass through two sleeves *HH*, forming part of the cylinder. *B* represents an air-, steam-, or electric-motor turning the pinion *D*, which engages the gear *E*, and this in turn meshes with the screw-shaft *A*, carrying at its lower end the toothed or corru-

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[102] THE MINERAL INDUSTRY, 1900, IX., 457.

[103] S. A. Wetzstein, Butte, Mont.

[104] See Hofman's "Metallurgy of Lead," 1899, p. 418.

gated plunger *C*. The screw-shaft *A* with plunger *C* is firmly connected with the frame *RR*, which is suspended at *NN* from a traveling crane. The operation of the motor causes the cylinder *F* with bottom *G* to move up against the plunger. Thus the cylinder and bottom, the uprights moving along the guides *P*, and the motor with connecting gears, all move up and down together as a single piece. Supposing the cylinder to have been filled with a zinc-silver-lead crust and the motor started, the cylinder will rise, press the crust against the teeth *L* of the plunger. The teeth sink into the crust and facilitate the escape of the unalloyed lead through the perforations *P* of the bottom *G*. Reversing the motor causes the cylinder with the compressed cake to descend and leave the plunger which is connected with the base of screw-shaft (see *Q*) through collar and socket in such a manner that it can be turned. It is now given a slight turn, and the motor started for another compression, when the teeth will make a new series of holes, again aiding the escape of the unalloyed lead. By repeating these com-

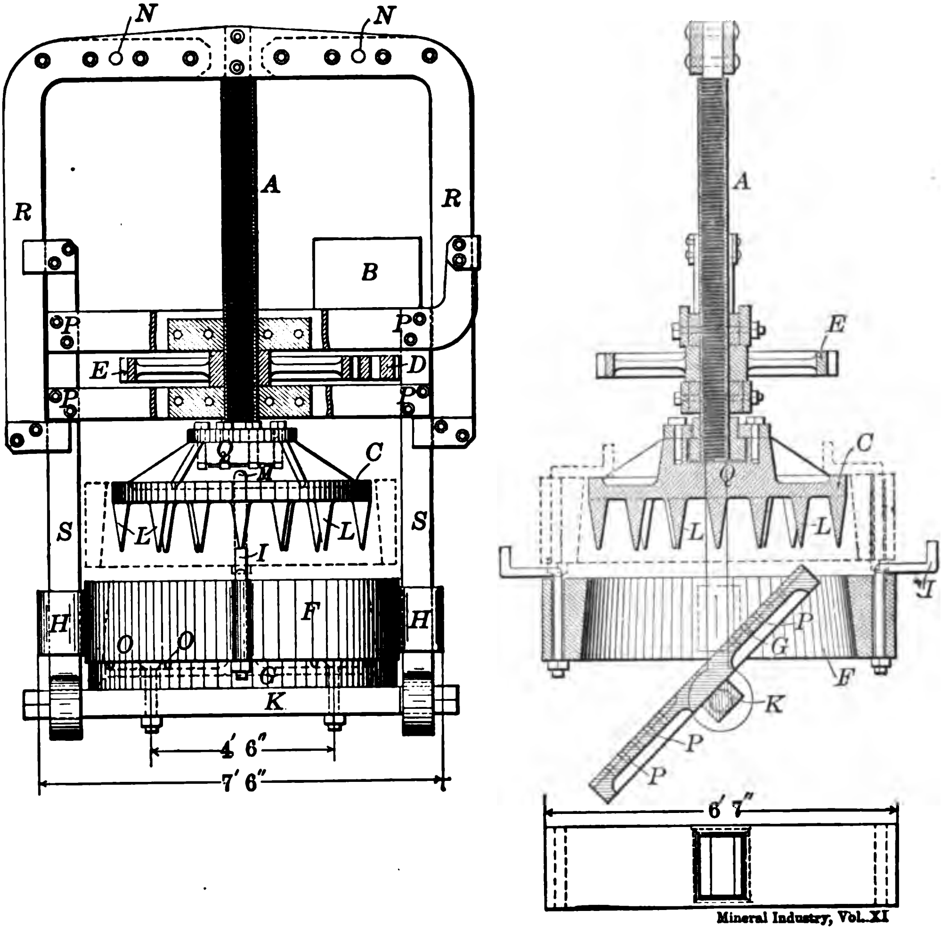

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FIG. 5.—IMPROVED HOWARD ALLOY PRESS.

pressions several times, a very dry zinc-silver-lead crust is obtained. When the pressing is over, the hooks *I*, passing through the iron ring *F* are turned as shown by the dotted lines, to engage with the plunger. When the motor is now reversed, the ring *F* remains suspended to the plunger while the cake of compressed crust follows the descending bottom. This is turned and the cake dumped directly into a buggy. In order to facilitate the passing-out of the cake of crust, the inside of the cylinder is flared downward. The advantages of the improved form over that in common use to-day are, the use of the toothed plunger, the changing of position after every single compression, which by repeated puncturing and compressing of the mass facilitates the escape of the lead, and thus gives a drier crust, the detached movable bottom which allows easy dumping of the crust, and the perforated condition of the crust which makes it easy to break into small pieces suited for the retort.

Danneel[105] discusses the electrolytic refining of zinc-silver alloy obtained at Friedrichütte in desilverizing argentiferous lead by the Roessler-Edelmann modification of the Parkes process.[106] The alloy anodes contain Ag 6·3 to 11·3%, Cu 6 to 8%; Pb 2 to 3%; NiCo 0·5 to 1%, Fe 0·25%, Al 0·5%, Zn 81·3 to 78·6%; zinc sulphate is the electrolyte; the current is from 80 to 90 amperes per sq. m. of cathode area at 1·25 to 1·45 volts; satisfactory cathode zinc is still obtained with a current density of 30 amperes per sq. m. cathode area. The anode mud (Ag 30 to 50%, Cu 50 to 30%, Pb 10 to 15%, difference Zn) is treated with sulphuric acid (to remove copper and zinc), washed, dried and then added to the cupelling furnace charges. The process has proved expensive, especially as the works treating very low grade base bullion furnish too little alloy to permit running the plant economically.

Electrolytic Refining of Base Bullion.—T. Ulke[107] has described the electrolytic refining process of base bullion of Betts-Labarth-Aldrich,[108] which is in operation at Trail, B. C.[109] The plant, which contains wooden electrolyzing vats painted with tar, has the general arrangement of an electrolytic copper refinery of the multiple system. The electrolyte is an acid aqueous solution of lead fluosilicide ($PbSiF_6$) with 8% lead and 11% free hydrofluoric acid. It is prepared by diluting hydrofluoric acid of 35% HF (3c. per lb. in New York) with an equal volume of water, and then saturating with pulverized quartz.

$$SiO_2+6HF=H_2SiF_6+2H_2O.$$

The electrolyte is stable in electrolysis and has a high conductivity. The base bullion forming the anode is cast into the form of two-lugged copper anodes, the cathodes are lead plates obtained by depositing lead on sheet steel, prepared by coating first with copper, then with lead, and painting the lead surface with a benzine solution of paraffine. The electrode distance is from 1·5 to 2 in. The anodes and cathodes of a tank are connected in multiple, the tanks in series.

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[105] *Zeitschrift fuer Electrochemie*, 1902, 8, March 6, p. 140.

[106] *Zeitschrift fuer Berg-, Huetten- und Salinenwesen in Preussen*, 1897, 45, 322; see THE MINERAL INDUSTRY, VI., 453.

[107] *Engineering and Mining Journal*, Oct. 11, 1902.

[108] THE MINERAL INDUSTRY, 1901. X., 485.

[109] United States Patent Nos. 713,277, 713,278. Nov. 11, 1902.

Contact with the bus bars is made by means of small wells of quicksilver, copper pins being clamped to the anodes and soldered to the cathodes. The fall in potential between vats is 0·20 volt. A current of 14 amperes per sq. ft. of cathode area has been found to give the best results. In the process, copper, antimony, bismuth, arsenic, silver and gold remain more or less adherent to the anode, while zinc, iron, nickel and cobalt go into solution. Allowing 175 cu. ft. electrolyte for a daily output of 1 ton of lead, there will be only a small concentration of impurity at the end of a year's work. The slimes at Trail assay about 8,000 oz. silver-gold per ton, and are treated at the Seattle Smelting & Refining Works by boiling with sulphuric acid in the presence of air to remove the copper, drying, melting down in a magnesia lined reverberatory furnace provided with tuyeres, and refining. After parting, the silver is 999 fine; the gold 992.

Treatment of 2 kg. base bullion assaying Pb 98·766%, Ag 0·50%, Cu 0·31%, Sb 0·43% in an experimental way, using a current of 25 amperes per sq. ft. of cathode area gave refined lead; Pb 99·997%, Ag 0·0003%, Cu 0·0007%, Sb 0·0019%; and anode mud: Pb 9·0%, Ag 36·4%, Cu 25·1%, Sb 29·5%. Another test on 450 lb. of base bullion of the Compañia Metalurgica Mexicana (Cu 0·75%, Bi 1·22%, As 0·94%, Sb 0·68%, Ag 358·9 oz., Au 1·171 oz.) with a current of 10 amperes per sq. ft. of cathode area gave refined lead; Pb 99·9861%, Cu 0·0027%, Bi 0·0037%, As 0·0025%, Sb none, Ag 0·0010%, Au none, Fe 0.0022%, Zn 0·0018%. As one ampere deposits per hour 3·88 g. lead, 2,240 lb. will require 260,000 ampere-hours. At 10 amperes per sq. ft. of cathode area, the entire anode or cathode area per ton of daily output would be 1,080 sq. ft. With an electrode distance of 1·5 in., 135 cu. ft. electrolyte will be enclosed by the electrodes, and 175 cu. ft. may be taken as the entire quantity of solution that is necessary. A total of 260,000 amperes at 0·25 volts equals 87 E.H.P. hours of 100-H.P. hours at the engine shaft. Estimating that 1-H.P. hour requires 1·5 lb. coal, and allowing 60 lb. for casting anodes and refined lead, a ton of refined lead will require 210 lb. of coal, which, at $6 per ton, will give a fuel cost of 60c. per ton of base bullion.

MAGNESITE AND EPSOM SALT.

BY JOSEPH STRUTHERS.

THE production of magnesite in the United States continues to be limited to California, and during 1902 the quantity reported was 3,466 short tons, valued at $21,362, as compared with 13,172 short tons, valued at $43,057, in 1901. The production during 1902 consisted of 1,230 short tons of crude product, valued at $5,582, and 1,050 short tons of calcined product, valued at $15,780, the latter being equivalent to 2,236 short tons of crude product, which are included in the total of 3,466 short tons of crude magnesite.

PRODUCTION OF MAGNESITE IN CALIFORNIA.

Year.	Crude.			Calcined.		Crude Equivalent of Calcined. Short Tons.	Total Crude.	
	Short Tons.	Value at Mine.	Per Ton.	Short Tons.	Value at Works.		Short Tons.	Value.
1898..........	200	$800	$4·00	1,018	$14,200	2,155	2,355	$9,420
1899..........	400	1,200	3·00	800	12,200	1,600	2,000	7,600
1900..........	469	1,876	4·00	1,018	15,900	2,239	2,708	11,832
1901..........	3,112	16,725	5·37	4,726	26,332	10,060	13,172	43,057
1902..........	1,230	5,582	4·05	1,050	15,780	2,236	3,466	21,362

The consumption of calcined magnesite has increased very largely since 1899, owing to its uses in the form of bricks or concrete as a refractory lining for open-hearth furnaces and converters in the steel industry, as a lining for rotary kilns used in the manufacture of Portland cement, as a non-conducting covering for boilers, steam pipes, etc., to prevent loss of heat, and more recently in electric furnace construction as a refractory material. It is used also in the manufacture of paper stock by the sulphite process, the wood pulp being digested under pressure with sulphurous acid or calcium and magnesium acid sulphite, whereby the lignin which forms the coloring matter of the wood, as well as other incrusting material of the fiber, is converted into soluble products, which are subsequently removed by washing. The general adoption of the basic process of steel making has largely increased the use of this refractory material for furnace linings, especially in the form of brick which are made by the Fayette Manufacturing Co., at Layton, Pa., and the Harbison-Walker Refractories Co. of Pittsburg, Pa.

The magnesite used east of the Rocky Mountains is imported, chiefly from Greece. The limited demand on the Western coast, and the cost of transportation have hitherto left the rapidly growing Eastern market in the hands of the Athens exporters. A feature of the development of the magnesite industry in California is to bring about the reduction of the cost of calcination to a point which will admit of the shipment of the calcined product to Pittsburg, to be used for the manufacture of magnesite bricks and other refractory products, an industry which at present uses magnesite imported from the Island of Eubœa, in Greece, and from Styria, in Austria.

The development of the iron and steel industry on the Pacific coast would give a strong impetus to the mining of magnesite and its manufacture into magnesia bricks and concrete for use as a basic lining to furnaces or converters, which treat phosphoric pig iron to make basic open-hearth or basic Bessemer steel.

The principal producing magnesite property during 1902 was near Porterville, Tulare County, where the mineral occurs in a series of vertical and flat veins up to 10 ft. in width, some of which outcrop boldly, having the wall rocks of serpentine and granite. A few veins have been traced on the surface for several thousand feet. A large quantity of mineral of exceptional purity has been disclosed by open cuts and a tunnel. A calcining plant of a capacity of 20 tons of finished product per day, has been completed at the mines, which are three miles from the railroad. The kiln is placed on the steep mountain side and the raw magnesite, broken to the required size at the mine above, is run down a long chute lined with sheet iron to the charging car without further handling. The calcined material after cooling is run directly into sacks, and is ready for shipment. Crude oil is used for fuel, and the mechanical equipment of the plant is modern in every respect. The calcining treatment, at a temperature of 2,500°F., occupies from three to three and one-half hours. The carbon dioxide gas which is expelled is allowed to escape into the air. Owing to the fact that during calcination magnesite loses from 48 to 52% of its weight, the cost of the calcined product at the kiln is stated to be from $12 to $14 per ton.

The production of crude magnesite is practically under the control of one firm, which ships the entire output to two manufacturers of carbon dioxide gas for the production of the gas by calcination; the calcined product, which is essentially magnesium oxide or magnesia, is returned to the shipper, and is subsequently utilized by paper mill concerns in California and Oregon. The demand for calcined magnesite for this purpose in the West is limited, and only a small portion of the available supply is utilized—a trade condition which is reflected by the different unit values of the calcined product in various years considered in connection with the quantities produced. Thus in 1900 the supply amounted to 1,013 short tons, and the average value per ton was $15·70; in 1901 the output of 4,726 short tons far exceeded the demand and the average value decreased to $5·58 per ton; in 1902, when the supply reached the normal consumption of 1,050 short tons, the average value per ton rose to $15.

Imports.—The imports of crude and calcined magnesite during 1902—chiefly from Greece and Austria—amounted to 49,786 short tons ($373,928), as compared with 33,461 short tons in 1901. There was also a large importation of magnesite bricks, but no statistics of their quantity and value are available. It is thus seen that the United States furnishes a small proportion only of the total consumption.

The total quantity of magnesite consumed in the United States is approximated by adding together the domestic production and the importation, although in the latter case there is no distinction made between the crude and calcined magnesite. On this basis the total consumption of magnesite during 1902 was 53,252 short tons, as compared with 46,633 short tons in 1901, and with 31,073 short tons in 1900.

Plans have been recently completed by the Asbestos Manufacturing Co. for the construction of a plant at Port Kennedy, Montgomery County, Pa., for the manufacture from dolomite of magnesium carbonate and allied products used in the making of steam pipe covering, magnesia cement, etc. The plant will have a daily capacity of 15 tons of magnesium carbonate.

Hungary.—Magnesite occurs at two localities in the Carpathian Mountains 20 km. distant from each other. The deposits are owned by the Magnesite Co., Ltd., which operates the mines at Burda and Ratko, the mining material being carried by means of a rope tramway to the works at Mynstya, near the Rima River and on the Hungarian State Railroad. The magnesite is calcined in four furnaces, and eight new ones are in course of construction; magnesite bricks also are manufactured at this plant. At Jolsva, the other deposit, the magnesite is calcined in four furnaces. The company owns a third magnesite calcining plant at Kobanya, near Budapest, and reports the following analyses of the dead-burnt product: Mynstya, MgO 91·1%, CaO 1·88%, Al_2O_3 0·1%, Fe_2O_3 5·7%, and SiO_2 0·98%. Jolsva, MgO 89·36%, CaO 2·66%, Al_2O_3 0·1%, Fe_2O_3 7·4%, and SiO_2 0·16%.

Epsom Salt.—Epsom salt ($MgSO_4$, $7H_2O$) is now manufactured from crude magnesite as a by-product in the production of carbon dioxide gas by treatment with sulphuric acid, magnesium sulphate being produced, which is dissolved in water, filtered and crystallized, yielding the pure salt. The chief use of the carbon dioxide gas derived from this source, both in the gaseous and liquefied forms, is to charge or carbonate, mineral waters. On account of its germicidal properties, the gas is used also in place of the ordinary pump or engine to raise beer and similar beverages. Its use in mechanical refrigeration in warm countries and on shipboard is being developed. During 1902 it is estimated that 17,500,000 lb. of Epsom salt were made in the United States. Early in 1903 a combination was effected of the various concerns engaged in the manufacture of Epsom salt. Until the beginning of 1902 the price of Epsom salt averaged 70c. per cwt. f. o. b. place of production; a trade condition resulting from the new source of supply as a by-product in the manufacture of liquefied carbon dioxide gas, a source which now yields the greater part of the output in the United States. A few manufacturers using kieserite continue to contribute a small quantity, but it is a matter of a short time only when this source of supply will cease. The principal factories for the manufacture of liquefied carbon dioxide gas are at Pittsburg, Pa., Cleveland, O., and Atlanta, Ga.[1] The monthly prices of Epsom salt at the New York market during 1902 were as follows: January, February, March and April, 85@90c. per cwt.; May and June, 90c.@$1; July, $1@$1·10; August, 95c.@$1·25; September, October and November, 95c.@$1·15, and December, 95c.@$1·25. At least 90% of the output is consumed in the manufacture of dyes, laundry soaps and paints, and in tanning leather, the balance being used in medicinal preparations.

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[1] The manufacture of liquefied carbon dioxide gas is fully described in THE MINERAL INDUSTRY, Vol. X., pp 763—774.

EPSOM SALT IN WYOMING.

BY WILBUR C. KNIGHT.

EPSOMITE occurs in Albany County, about 20 miles north of Rock River Station, on the Union Pacific Railroad. The deposits are situated upon a high plateau, about three miles north of Rock Creek, and lie in a huge, undrained depression that is deepest at its southern end, where it is about two miles wide, and lies 100 ft. or more below the level of the surrounding country. From this deepest portion a rather broad, shallow valley extends to the northwest for several miles and contains numerous deposits of sodium and magnesium salts, which have for a long time been tributary to the large epsomite deposit of about 90 acres in extent occupying the lowest portion of the basin. The prevailing formation is Red Beds (either Triassic or Permian), almost completely made up of red sandstones, which contain an abundance of gypsum near their base. The country is very arid, and the nearest palatable water is Rock Creek.

The deposits are often covered with water in early Spring or after a hard storm, which, however, soon evaporates. Near the northeastern quarter of the large deposit, which is the only portion that has been carefully examined, the epsomite occurs in a thick bed, containing in addition a good deal of foreign matter. Holes have been dug to a depth of 10 ft. in this salt, but the bottom has not been reached. While no accurate estimate has been made of the quantity of Epsom salt in this deposit, it is certainly very great and would furnish sufficient salts to supply the American trade for many years to come. From the surface of this deposit there have been taken some of the finest crystals of epsomite yet discovered.

The origin of the deposit, and those that are associated with it, has long been in doubt. In studying this problem I have ascertained that both epsomite and mirabilite (Glauber salt) have been derived from the decomposing sandstones, and have been transported by water to the natural depressions. Both the epsomite and mirabilite occur in the rocks, but on account of the greater solubility of the former, the soda salts are often precipitated in a depression, leaving the epsomite in solution. A sudden storm floods the deposit and carries the magnesium salts to a lower basin, if not to the lowest one. By this natural method of differentiation these salts have been separated, so that at the head of the valley the deposits are nearly pure mirabilite, while the main deposit is nearly pure epsomite. The composition of the various deposits is shown by the samples, which are averages taken from the various deposits and analyzed by Dr. Slosson, of the University of Wyoming. The large deposit, however, often has a thick covering of epsomite which is much purer than these samples.

Components.	Samples.					
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
$Na_2 SO_4$	95·46	94·54	50·90	47·74	39·18	25.61
Na Cl	0·28	0·28	0·50	1·86	1·00	5·28
$Mg SO_4$	4·26	5·29	48·60	50·16	59·82	70·11
$Ca SO_4$	....	1·89	....	....	....	....

No. 1 of this series was taken from near the head of the gulch and the other from the intermediate points, and the last from the large deposit. The series shows quite wide gaps in the succession, which would be filled by taking more samples from the intervening beds.

MANGANESE.

By D. H. Newland.

The manganese ore consumed in the United States in the manufacture of steel, chemicals, and for other purposes is derived from both domestic and foreign sources, the imported ores largely coming from Russia and Brazil. The output of ores of all grades in the United States during the period 1898-1902 is shown in the subjoined table, which, however, does not include the manganiferous iron ores of Colorado and other States consumed as a flux in silver-lead smelting, although account is taken of that portion utilized for the manufacture of ferromanganese and spiegeleisen. For further and detailed information concerning the occurrence and composition of ores mined in the various countries of the world, reference may be made to the previous volumes of The Mineral Industry.

STATISTICS OF MANGANESE ORE IN THE UNITED STATES. (IN TONS OF 2,240 LB.)

Year.	Production.											Imports.		Consumption.	
	Arkansas.	California.	Colorado	Georgia.	Michigan and Wisconsin.	New Jersey.	Tennessee.	Virginia.	Elsewh're	Totals.		Tons.	Value.	Tons.	Value.
										Tons.	Value.				
					(a)	(b)									
1898	2,775	398	17,792	2,477	112,318	47,470	1,250	3,307	......	187,782	$416,627	114,885	$931,967	302,667	$1,348,594
1899	855	268	29,161	1,628	53,702	58,921	80	3,626	75	143,256	306,476	188,349	1,584,528	331,605	1,891,004
1900	51	231	45,791	1,058	75,360	91.748	*Nil.*	3,988	......	218,222	461,994	256,252	2,042,361	474,474	2,504,355
1901	91	610	62,885	4,074	512,084	52,311	400	4,275	2,565	638,795	1,644,117	165,722	1,486,573	804,517	3,130,690
1902	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)

(a) Manganiferous iron ore. (b) Franklinite residuum. (c) Statistics not yet available.

In the following table the production of manganese ores in the different States is distributed according to the relative percentages of metallic manganese, and the total consumption of the United States is given in terms of ore containing 50% Mn.

MANGANESE PRODUCTION AND CONSUMPTION OF THE UNITED STATES ON A BASIS OF 50% MN CONTENT. (IN TONS OF 2,240 LB.)

Year.	50% Ores from Ark., Ga., Va., Cal.& Tenn.	30% Ore from Colorado.	12% Ore from New Jersey	7% Ore from Mich. and Wisconsin.	Equivalent Total Tonnage of 50% Ore.	Imported Ores of 50% Grade.	Total Consumpt'n of 50% Grade & Equivalent.	Per Cent. of Imp'd Ore.
1898..........	9,902	17,792	47,470	142,318	51,295	114,885	166,180	69·1
1899..........	6,397	29,161	58,921	53,702	44,353	188,349	232,702	80·1
1900..........	5,323	45,791	91,748	75,360	65,368	256,252	321,620	79·7
1901..........	9.450	62,885	52,311	512.084	a 131,127	165.722	296,849	55·8
1902..........	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)

(a) Not including 2,500 tons from Utah and small quantities aggregating 65 tons from Alabama, Missouri and North Carolina, of which the manganese content was not reported. (b) Statistics not yet available.

The price of manganese ore is determined by the Carnegie Steel Co., according to the following schedule, which is based on ores containing not more than 8% SiO_2 and 0·1% P. Deductions are made of 15c. per ton for each 1% of SiO_2 in excess of 8%, and of 1c. per unit of manganese for each 0·02% P in excess of 0·1%. Ores delivered at the works of the company, at Pittsburg or Bessemer, Pa. Settlements are based on analysis of samples dried at 212°F.; the percentage of moisture in the samples as taken being deducted from the weight. Ores containing less than 40% Mn, or more than 10% SiO_2 or 0·15% P, are subject to acceptance or refusal at buyer's option.

Tenor in Mn.	Price per Unit.		Tenor in Mn.	Price per Unit.	
%	Fe.	Mn.	%	Fe.	Mn.
Over 49........	5c.	25c.	43 to 46........	5c.	23c.
46 to 49........	5c.	24c.	40 to 43........	5c.	22c.

The imports of manganese ore during 1902 were 235,576 long tons, valued at $1,931,282, as compared with 165,722 long tons, valued at $1,486,573 in 1901.

The manufacture of ferromanganese by electrolysis has been proposed at works to be erected near Orlu in the French Pyrenees, where cheap water power is obtainable. It is planned to use the Simon process, by which the manganese oxide is dissolved in a bath of fluorspar and precipitated in the same manner as in the manufacture of aluminum. This method, it is stated, possesses the advantage over the usual smelting process in that the phosphorus present in the ore is partially volatilized, and hence lower-grade material can be used. Ferromanganese obtained in the experimental way by this process was found to possess the following composition: Mn, 83·50%; Fe, 8·74%; Si, 0·32%; C, 7·32%; P, 0·12%. It is thought that the cost of producing ferromanganese by this process would amount to about 204 fr. per metric ton, with an annual output of 20,000 tons.

Colorado.—The ores mined in this State consist of manganiferous iron ores which are used for the manufacture of ferromanganese and spiegeleisen and manganiferous silver ores utilized for flux by the silver-lead smelters. The output of ores of the former class in 1902 was valued at $8,400, containing on the average about 30% Mn and 23% Fe. The mines are situated around Leadville.

Georgia.—(By Thomas L. Watson.)—The mining of manganese ores in Georgia began in 1866, when 550 tons of ore are reported to have been mined in the Cartersville district. The manganese ores are distributed over the northern part, being limited to two geological areas—namely, the Paleozoic area, which includes the ten extreme northwest counties, and the crystalline area, which includes all the northern part except the ten northwest counties of the Paleozoic group. The Paleozoic area, constituting a part of the southern Appalachian valley province, is composed entirely of sedimentary rocks, which range in age from Cambrian to Carboniferous. The rocks include slates, shales, sandstones, quartzites and limestones. The topography of the region is the distinct ridge-valley type. The strata have been folded and faulted, and the resulting topographic features are largely dependent on the underlying structure. The crystalline area consists of crystalline rocks derived partly from original igneous masses and partly from original sediments. With few exceptions, the rocks are old geologically, but their definite relations have not yet been satisfactorily ascertained. The workable deposits of manganese ores are limited to the Paleozoic area, confined principally to Bartow, Floyd and Polk counties. The ores consist exclusively of the oxides of the metal, admixed usually in various proportions. Pyrolusite and psilomelane are the two most abundant occurring oxides. The two principal districts in the Paleozoic area from which the ore is mined are: (*a*) the Cartersville district in Bartow County, and (*b*) the Cave Spring district in the contiguous portions of Floyd and Polk counties. Smaller scattered deposits of the ores have been tested and in places worked to some extent in the following localities in the Paleozoic area: In the vicnity of Rome, Floyd County; in the extreme southeast portion of Bartow County, in the Seventeenth district; in the vicinity of Barnsley P. O., in both Floyd and Bartow counties; and to the north of Tunnell Hill, in Whitfield and Caloosa counties. Of these different areas, the Cartersville district has produced practically the entire output. During 1902 the following concerns were actively engaged in mining in the Cartersville district: R. P. Morgan, Knight & Barron, W. Keys, B. C. Sloan, Blue Ridge Mining Co., Satterfield (on the old Bartow property), and the Georgia Coal & Iron Co. (Chumley Hill). Of these, Mr. R. P. Morgan and Georgia Coal & Iron Co, made more than three-fourths of the total production. As to the shipments of ore from the Cartersville district in 1902, about 70 carloads were consigned to Lynchburg, Va., to be used for paint purposes; from 75 to 100 cars were shipped to Birmingham, Ala., to be used in the manufacture of steel; and the balance was shipped in small lots to various parties for paint purposes. The small amount of ore mined and shipped from Georgia during 1902 was entirely due to the low prices which ruled during the entire year. The only shipments of manganese ores outside of the Cartersville district were a few cars from the Lowe bank in the Floyd County portion of the Cave Spring district, formerly worked by Major James M. Couper, of Atlanta, Ga. Manganese ores have been worked sparingly at the following localities in the crystalline area of the State: In the vicinity of Draketown, in Carroll and Paulding counties; near Mt. Airy and Toccoa, in Hobersham County; in Hart County, one and a half miles east of Bowersville; at Blue Ridge and near Culbertson, in Fannin County; near Hiawassee, in Towns County; about six miles north from Cohutta Springs, in Murray County; and in the western part of Gilmer County. While the manganese exists to some extent in almost every county in the crystalline area, no valuable deposits have yet been found. A few tons of ore have been shipped from time to time from several of the localities mentioned in this area. The mode of occurrence and origin of the Georgia manganese ores were briefly described by me in THE MINERAL INDUSTRY, Vol. X.

North Carolina.—Manganese ore is known to occur near Brevard, Transylvania County; near Canton, Haywood County; and near Goldsboro, Wayne County. A few carloads of ore have been shipped, but mining is still in the initial stages of development. The deposit in Transylvania County is situated about seven miles northeast of Brevard and three miles from Blantyre, and has been prospected by seven shafts for a distance of 2,000 ft. along the strike, while the estimated width is 18 ft. It is capped by a mass of limonite, which carries only a trace of manganese. Assays of the ore showed from 22 to 57% Mn and from 3 to 32% Fe. By hand cobbing to remove the limonite the average ore may be enriched so as to assay from 45 to 50% Mn. At the locality in Haywood County the ore occurs as float and in the superficial rocks. Most of the material is soft and friable, with a considerable percentage of limonite; the small proportion of hand ore carries about 50% Mn. Only limited development work has been done, and the value of this deposit, as well as of that in Wayne County, is not yet established.

Virginia.—The mine at Crimora was operated during 1902, and for a time produced about 50 tons of ore per day. The system of underground mining formerly employed here has been superseded by hydraulic methods, as described in THE MINERAL INDUSTRY, Vol. X.

WORLD'S PRODUCTION OF MANGANESE ORE. (*a*) (IN METRIC TONS.)

Year.	Austria-Hungary.	Belgium.	Bosnia. (*b*)	Brazil. (*e*)	Canada.	Chile. (*d*)	Colombia.	Cuba	France.	Germany	Greece.	India.	Italy.
1897	10,043	23,372	5,344	16,054	14	23,528	8,382	......	37,212	46,427	11,868	74,862	1,634
1898	14,219	16,440	5,320	26,417	45	20,851	11,176	*Nil.*	31,935	43,354	14,097	61,469	3,002
1899	10,484	12,120	5,270	65,000	279	40,931	10,160	*Nil.*	39,897	61,329	17,600	88,520	4,356
1900	14,550	10,820	7,939	108,244	27	25,715	(*c*)	21,973	28,992	59,204	8,050	132,767	6,014
1901	12,077	....	6,346	100,414	399	18,480	....	......	22,304	56,691	14,166	135,307	2,181

Year.	Japan.	New Zealand.	Portugal.	Queensland.	Russia.	South Australia (*d*)	Spain.	Sweden.	Turkey	United Kingdom.	United States.
1897..	17,351	182	1,652	408	370,195	*Nil.*	100,566	2,749	....	609	161,138
1898..	11,517	220	907	68	329,546	5	102,228	2,358	....	235	190,787
1899..	11,340	187	2,043	747	659,301	102	104,974	2,622	49.468	422	145,548
1900..	15,228	166	1,971	77	(*c*)	*Nil.*	112,897	2,651	*d* 38,100	1,384	221.714
1901..	....	208	904	231	....	144	60,825	2,271	....	1,673	649.016

(*a*) From official statistics, except for the United States and Colombia, for which direct reports have been received from the producers. (*b*) Includes Herzegovina. (*c*) Statistics not yet published. (*d*) Export returns. (*e*) Shipments as stated in British Diplomatic and Consular Reports, except for 1899, which are estimated.

Brazil.—Deposits of manganese ore are widely distributed in this country, and in places they are enormously rich. The principal mines are situated near Miguel Burnier, Queluz, San Goncalo and Piquiry in the State of Minas Geraes. near Corumbá in the State of Matto Grosso, and near Nazareth in the State of Bahia. In Minas Geraes the largest producers are the Usina Wigg, Sociedade Geral de Minas de Manganez, and the Société Anonyme des Mines de Manganése de Ouro Preto. A new company, the Morro da Mina Co., was incorporated during 1902 to work the deposits at Queluz. The ores from the district of Miguel Burnier are high grade, carrying from 48 to 55% Mn and a very small percentage of phosphorus; those from Lafayette carry about 50% Mn and 0·12% P. The total exports of Brazil in 1902 were 143,320 metric tons.

Colombia.—The manganese industry of the Isthmus of Panama is described by E. G. Williams in a paper read before the American Institute of Mining Engineers, October, 1902. The ore-bearing region is situated on the Caribbean coast, extending from Puerto Bello easterly about 35 miles toward Point San Blas. Ore has been found in the interior at a maximum distance of about 10 miles from the coast. In general, the deposits occur within the drainage areas of the short streams that flow northward into the Caribbean Sea, although one large ore body is known to exist within the Chagres basin. The associated rocks are all of sedimentary origin, probably originally shales, but they are thoroughly decomposed, and in some cases metamorphosed into jasper. The ores include psilomelane, pyrolusite and braunite, the first-mentioned yielding the greater part of the commercial product. An analysis of high-grade ore indicates the presence of a new mineral with the formula Mn_3O_5.

The companies engaged in shipping ore from this region are the Caribbean Manganese Co., operating the Viento Frio, Carano, Concepcion and Soledad mines, and the firm of Brandon, Arias & Fillippi, who operate the Culebra and La Guaca mines. All the mines except the Culebra are situated along a narrow-gauge railway that enters the shipping port of Nombre de Dios. The most important mine, the Soledad, lying about six miles southeast of this port, has furnished over 40,000 tons of ore, or more than two-thirds of the total product mined in this region. At this mine the ore occurs in a series of lenticular or irregular masses varying from a few inches to 50 ft. in width. The accompanying rock is a decomposed shale highly impregnated with iron oxides and manganese and much contorted. At first the ore was extracted from open-cut workings, but after a depth of 120 ft. had been reached, a shaft was sunk 110 ft. and two levels were opened. The ore is usually stoped for the entire width of the deposit, and heavy timbering with supplementary filling is required to support the walls. Hoisting is done by a gasoline engine. After mining, the ore is hand-picked, and the large pieces are transported directly by tramway to the railroad, while the fine material is sent to a log-washer and screened after washing. The size above 0·5 in. is hand-picked and shipped, the fine portion being reserved for future treatment in a concentrating plant. Care in sorting the ore is made necessary by the presence of jasper, which, if not removed, would subject the ore to a fine for silica. Power drills, driven by a 35-H.P. gasoline air compressor, are used for breaking the ore in the mine. A cargo lot of ore from the Soledad mine assayed Mn, 57·50%; SiO_2, 4·18%; H_2O, 2·73%; and a total of 23,000 tons averaged Mn, 53·74%; SiO_2, 8·68%; P, less than 0·06%. The Concepcion mine lies about two miles north of the Soledad deposits. It is connected with the railway by a Bleichert tramway, 5,600 ft. long, operated by a 10-H.P. steam engine. The workings are less than 100 ft. in depth, and about 12,000 tons of ore have been mined, averaging about 50% Mn and 8% SiO_2. The Carano and Viento Frio mines have not been operated in recent years. At La Guaca mine, owned by Brandon, Arias & Fillippi, the ore occurs in large and small boulders, exposed originally in the beds of streams and upon the adjacent mountain stopes. It is probable that the boulders are float material from some large deposit as yet undiscovered. The mine has furnished about 2,000 tons of ore. The Culebra mine, also owned by this company, is situated in a small island about 14 miles east of Nombre de Dios and one-half mile from the mainland. The strata here are of the same general character as those outcropping on the mainland, and the ore is found in irregular or lenticular bodies, which conform in dip with the bedding planes. About 4,000 tons of ore have been mined from an open pit. The ore is chiefly psilomelane and pyrolusite, and is of high grade.

Cuba.—The deposits of manganese ore in Cuba are situated near the city of Santiago at the eastern end of the island. The first shipments in 1887 amounted to only 50 tons, but by 1890 they had increased to nearly 22,000 tons From 1898 to 1901 the Ponupo Mining & Transportation Co. was the only producer of manganese ore in this region. This mine, which in 1902 produced 33,000 tons of ore, lies in the center of an anticlinal fold and covers an area of about 80 acres. The ore varies from high-grade material to a hard jasper, locally called *bayate*, containing little manganese and occurring in irregular masses. Often the ore is intimately veined or impregnated with jasper, and in such cases it is valueless, but usually the rocks may be separated after mining. Three log-washers are used, and the tailings carry from 15 to 30% Mn. The mines give employment to 150 or more men at wages of $0·85 per day. The average output is 2,000 tons per month, costing $2·25 per ton at the mine. The freight rate to Santiago is $39 per car of 30 tons, and the rate from Santiago to New York varies from $1·80 to $2 per ton. The character of the deposits at the Boston and Ysabellita mines is similar to that of the Ponupo mine. A large quantity of ore has been extracted from the Boston mine, and operations have been started recently at the Ysabellita mine. The latter has an aërial tramway connecting with the mill where the ore is to be treated by a jig process. These are the only mines in operation at present, although it is possible that others will be developed with the completion of the Cuba Central Railway. From the mode of occurrence it seems probable that the deposits now operated are not of great extent.

France.—The ores mined include the carbonate, oxides and silicate of manganese. The deposits of Las Cabesses in the Department of Ariège supplied 3,500 metric tons of calcined carbonate in 1901, and the mines of Romanèche and Grand-Filon in Saône-et-Loire produced 9,600 tons of hydrous oxides. In addition there was a production of 6,200 tons of manganese hydroxides and silicate from the mines of Louderville, Aderville and Ville-Aure in the Department of Hautes Pyrénées.

India.—Manganese is extensively mined in the Vizagapatam district of Madras, about 500 miles north of the city of Madras and also near Kamptee, in the Nagpur district of the Central Provinces. In 1901 the former district produced 76,463 long tons of ore, and the latter 81,264 tons; while the districts of Balaghat and Bhandara, in which developments were only recently begun, produced 4,330 tons. The total exports from India during the same year were 133,170 tons.

Italy.—The production of manganese ore is limited to a few small mines in the districts of Carrara, Iglesias and Florence. The district of Florence produces also manganiferous iron ore, the output in 1901 being 24,290 tons, valued at about $3 per ton.

Queensland.—The production of manganese in 1902 was 4,674 metric tons, valued at £16,989, as compared with 221 metric tons, valued at £795, in 1901. In the Gladstone district, deposits at Mount Miller, Auckland Hill and Boat Creek have been worked at various times, but during 1902 operations were limited to the deposits at Mount Miller, which produced ore valued at £3,000.

The workings have reached a depth of 160 ft., the ore body varying from 3 to 20 ft. in width. The Auckland Hill deposit, owing to the influx of water, has only been developed to a small extent. The Boat Creek deposits are no longer worked. The Mount Morgan Co. uses all the ore mined in this colony.

Russia.—The chief source of manganese ore in this country, which furnishes more than one-half of the world's supply, is in the Province of Kutaïs in the Caucasus district. The largest mining center is Chiaturi, from which most of the ore is transported by railway to Poti and thence trans-shipped for export. In recent years the deposits in the Nicopol district of southern Russia have been extensively developed, the product being largely consumed at home. The geological features of this district, as well as the details relating to mining methods and production, have been fully set forth by Mr. Frank Drake in THE MINERAL INDUSTRY, Vol. X. The Russian mining industry in 1901 suffered severely from the overproduction in the previous year, and from competition in foreign markets with the Spanish, Brazilian and Cuban ores; consequently there was a marked decline in output. The exports from Poti and Batoum in 1901 were 263,963 and 16,000 long tons, respectively. During 1902 the conditions were somewhat more favorable as regards demand, although prices continued at a very low level. The exports in this year from Poti were 387,100 tons, and from Batoum 91,321 tons. The discovery of manganese deposits in the Province of Elisavetpol, district of Kasach, is reported. The deposits lie upon the surface, or are covered with a thin layer of soil, and apparently have the form of veins included in a siliceous schist. Analyses show about 60% Mn, with little phosphorus.

MICA.

By Henry Fisher.

The statistics of the production of sheet mica in 1902 are not yet available; the output during 1901, however, amounted to 360,060 lb., valued at $98,859. The mica imported into the United States during 1902, was 2,251,856 lb., valued at $466,332, 2,149,557 lb. ($419,362) being unmanufactured and 102,299 lb. ($46,970) being cut or trimmed.

The market for coarse and fine ground mica in New York, ruled at 3@4c. and 4@5c. per lb. respectively until the middle of September, when it dropped to 1·75@1·9c. and 0·87@2c., and remained there till the end of the year. The market for sheet mica did not vary throughout the year, and was as follows: 2×4 in., 30c.; 3×3 in., 80c.; 3×4 in., $1·50; 4×4 in., $2; 6×6 in., $3.

The General Electric Co., of Schenectady, N. Y., leased the plant of the Ottawa Porcelain Co., at Ottawa, and during 1902 employed 300 persons in trimming and cutting mica, most of it to be used in the manufacture of micanite. During 1902, only mica mined in Ontario was used, but the company has secured control of several important mines in Quebec, and will operate them in 1903.

A patent[1] has been granted to H. C. Mitchell for the manufacture of flake mica which consists in passing the sheet mica through bending rolls to loosen it, and then subjecting it to a blast of air, whereby the lighter flakes are blown into one chamber, and the plates not disintegrated are collected in a second chamber; the treatment being repeated a second time.

State.	1900.				1901.			
	Sheet.		Scrap.		Sheet.		Scrap.	
	Pounds	Value.	Short Tons.	Value.	Pounds	Value. (a)	Short Tons.	Value. (a)
New Hampshire	25,241	$11,358	2,405	$21,645	65,800	....	250	....
North Carolina and Virginia	34,500	24,150	2,790	19,530	266,160	....	1,775	....
South Dakota	65,000	45,000	222	1,554	25,000	....	....	....
Other States	2,500	2,000	20	160	3,100	....	146	....
Totals	127,241	$82,508	5,417	$42,889	360,060	$98,859	2,171	$19,719

(a) Not given.

California.—The Barton Mica mines on Piru and Lockwood creeks in Ventura County, which were discovered in 1901, had 10 men at work in 1902, and up to

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[1] English Patent No. 4,969, March 8, 1901.

July of that year had made two shipments of mica to San Francisco, where it was ground. A mill is being erected on the property. These deposits covering 2,080 acres, are 58 miles from Bakersfield. At the Gypsy deposit considerable "book mica" occurs, but most of the product is more suitable for grinding. A mill of 5 tons daily capacity is being erected.

Idaho.—The Idaho Mining Co. during 1902 developed four claims on Bear Creek, 13 miles from Troy, Latah County. The vein is reported to be 30 ft. wide, and samples of mica vary in size from 2×2 in. to 10×12 in. In the early part of 1903 the output of mica was 2 tons per week.

North Carolina.—The principal deposits of mica are in Mitchell, Yancey, Jackson, Haywood and Macon counties, over 100 mines occurring in these five counties. The mica is found in pegmatite dikes, and constitutes from 1 to 10% of the rock. Many other minerals are found with the mica, and some of them are obtained in sufficient quantity to be of commercial value.

South Dakota.—The Black Hills Porcelain Clay & Marble Co. operated its mica mine in Custer County throughout 1902. In the early part of 1903, the company shipped 30 tons of mica per month, obtaining $30 per ton, f. o. b. Custer. The Crown mica mine owned by the Chicago Mica Co. covers 40 acres in Custer Co. The mine is shipping regularly two carloads of mica to the company's plant in Indiana.

Brazil.—According to H. Kilburn Scott[2] mica occurs in workable quantities in the States of Goyaz, Bahia and Minas Geraes. In the State of Minas Geraes, the mica is found in pegmatite veins, lenses or dikes in metamorphic schists near the city of Santa Luzia de Carangola, the veins running parallel to the Cayama and Popgais Mountains. The veins are generally altered to kaolin, and vary in width from 20 in. to 10 ft. Although about six mines have supplied mica for export, only two, the Fonseca and Coronel Seraphino mines, have been worked regularly. About 30 tons of trimmed mica have been produced at the former mine, a large proportion of which has been used for lamp chimneys, and the rest has been shipped to the United States and London. The total output of the Coronel Seraphino mine is estimated to be 20 tons. The method used for trimming the mica is crude, and much of the material is wasted. About 50% of the mica from the latter mine, which is of the ruby variety, has been obtained in sheets over 6 in. in length. The mica is put up in packets of equal-sized sheets of about 2 lb. weight, and packed into boxes holding about 100 lb. These boxes are carried on pack mules to the Santa Luzia station of the Leopoldina Railway for transport to Rio, a distance of 10 to 15 miles. The approximate cost per ton of mica at ports in the United States or Europe is £63 12s., made up as follows: Cost of mining, trimming and transportation to Santa Luzia, £50; freight charges to Rio Janeiro, £1 12s.; State export tax, £6; expenses at Rio, £1; freight to Europe or the United States, £5.

Canada.—There was a large output of mica in 1902, the production being valued at $400,000, as compared with $160,000 in 1901. The exports of mica for the fiscal year ending June 30, 1902, amounted to 997,165 lb., valued at $242,310, classified as follows: Mica, cut to sizes, 540,228 lb. ($124,855);

Paper read before the Institution of Mining and Metallurgy, April 23, 1903.

edges trimmed, 111,385 lb., ($42,268); edges untrimmed, 345,323 lb. ($75,167); ground, 229 lb. ($20). The shipments to the United States during the fiscal year amounted to 868,645 lb., valued at $186,400; to the United Kingdom, 115,388 lb., valued at $53,001, the remainder going to France, Germany and Mexico. The phlogopite and biotite varieties are mined in the provinces of Ontario and Quebec, in the district about Ottawa, while transparent muscovite of excellent quality occurs at Tête Jaune Cache and Canoe River in Northern British Columbia. Although sheets of mica of over a foot in length are not uncommon, the deposits in British Columbia are too far distant from railroad communication to be worked at present. In Ontario there are mills at Sydenham, Ottawa, Kingston and Perth, which split the blocks of mica and "thumb-trim" it. A mill at Gananoque grinds the mica into scrap. In Quebec, as stated by J. Obalski, the mica market was very quiet in 1902, and while the demand was steady, the price for the larger sizes declined. Only a few of the more important mines, including those of Messrs. Blackburn Bros., Wallingford Bros., and Fortin & Gravel were operated in 1902. Messrs. Fortin & Gravel employ five men at their mine in Hull. The mica is sized, trimmed and packed at Hull, five women being employed at this work. Some of the smaller companies operating in 1902, were Allan Gold Reef, in Derry; Glen Almond, in Portland East; Vavassour, in Hull; and F. N. Webster at the Cascades in the Gatineau. The thumb-trimmed mica shipped from Quebec in 1902, amounting to about one-third of the total production, was in detail: 64,463 lb. of 1×3 in. mica, ($7,364); 27,861 lb. of 2×3 in. ($7,201); 27,296 lb. of 2×4 in. ($10,756); 11,772 lb. of 3×5 in. ($7,578); 890 lb. of 4×6 in. ($820), and 540 lb. of 5×7 in. ($585), aggregating 132,822 lb. of mica, valued at $34,304.

India.—Mica which is worked in a primitive manner in Bengal and Madras was produced to the extent of 996 tons in 1902, the exports amounting to 815 tons. In 1902, in the districts of Nellore, North Arcot, and Nilgris, in the Province of Madras, there were 69 mines in operation, employing 2,965 persons, and producing 228 long tons of mica, and in the district of Hazaribagh in the Province of Bengal, there were 61 mines employing 6,254 persons, and producing 768 long tons of mica, 628 tons being mined by one company. The Government annually leases the land to the highest bidder. The mica occurs in veins of coarse pegmatite and native methods are used to mine it. During the rains, the surface is prospected and shoots and patches of mica are marked when found, to be worked during the cold and hot weather. Machinery is not used, all the work being done by hand labor. Women are employed, who, seated on ladders, pass back and forth vessels filled with water and baskets with mica.

THE MICA INDUSTRY OF NEW HAMPSHIRE DURING 1902.

BY ALBERT J. HOSKINS.

THE mica industry of New Hampshire has not shown any advance during the past year. There were only two mines operated, one controlled by the Davis Mica Co. and the other by the Henri Picard Co.; the mines of both companies are situated in Alstead, Cheshire County. The Davis Mica Co. employ eight men, producing about 1 ton per day including scrap mica. The Henri Picard Co. employ 12 twelve men, the daily output averaging a little more than 1 ton. Several prospects have been opened up in Grafton and Sullivan counties, which, however, do not show enough mica to warrant the investment of capital for development.

The mica after being blasted out undergoes a hand dressing (rifting) in which operation the refuse or cracked and stained mica is split off. The remaining clean and free-splitting mica is trimmed and assorted to four grades or sizes. No. 1 grade measures either 4×6 in. or 6×8 in., and sometimes larger; No. 2 grade averages from 3×4 in. to 4×6 in.; No. 3 grade averages from 2×4 in. to 3×4 in.; and No. 4 grade averages from 1 in. to 2×4 in. Mica of No. 4 grade is known and sold as rough trimmed mica. The waste or trimmings are sold to the mills for grinding purposes.

The Henri Picard mills grind all the scrap mica taken from the mines in the vicinity. The scrap mica is ground into grades ranging from 10 to 200 mesh in size. The coarser grades, ranging from 10 to 66 mesh, are most in demand at present, due to the fact that they are used extensively in reproofing roofing, steampipe covering and insulating compounds. The finer grades are utilized by wall paper manufacturers for decorating purposes, also as an adulterant of rubber and in the manufacture of paint, lubricating oils and axle grease. The prices obtained for ground mica in carload lots at place of production are from $80 to $100 per ton, according to quality and fineness.

At the beginning of 1902 there was only a small quantity of scrap mica in the market, and the prices showed an upward tendency, ranging from $28 to $50 per ton. A considerable quantity of scrap mica is used in the manufacture of mica board, a business that is said to be very profitable. The only factory of this kind in New Hampshire has been in operation for the past three years at Groton. The process of manufacture is simple. The mica, after being split up into very thin plates, is built up in a form to the desired thickness, each piece being cemented with shellac. The block is then subjected to a pressure of 2,000 lb. to the sq. in. and pressed to a definite thickness. It is next steamed and pressed in a mold to secure the desired shape, and completed by hardening in a kiln. The manufacture of mica pulp, mica board and other mica compositions required by the trade is stated to yield very good profits on the capital invested.

THE MANUFACTURE OF MINERAL WOOL.

By Edwin C. Eckel.

Mineral wool is the product obtained by forcing a jet of steam or air against a stream of molten slag or molten rock. The effect of this proceeding is to scatter the molten material, small spherules being blown out from the main stream, each spherule, comet-like, carrying behind it a thread of the material. The fluidity and composition of the molten mass, and the pressure, size and direction of the jet of steam or air, are so manipulated as to give the greatest proportion of threads or fiber to spherules as the spherules are commercially unavailable and must be separated by mechanical means from the fibers if present in too great quantity. Usually, however, a satisfactory separation is obtained by changes in the direction or pressure of the steam, the spherules falling first while the lighter fibers are carried further into settling chambers.

The resulting product is a non-conductor of heat and sound, and is therefore largely used for pipe covering, safe linings, cold storage plants, partitions, etc. It is marketed under many names—mineral wool, slag wool, rock wool, silica fiber, silicate cotton, etc. The reasons for this great variation in nomenclature are given later in the article.

Growth of the Industry.—Blast-furnace slag was first manufactured into mineral wool about 30 years ago in Germany, and was shortly afterward taken up in England and in the United States. The first American plant was located at the Greenwood iron furnace, in Orange County, N. Y., the manufacture of mineral wool being taken up there on a small scale in 1875, under the management of Mr. Parrott. Later, an incorporated company acquired the slag wool plant, and under the management of Mr. A. D. Elbers the output was materially increased. In 1882 the product was 1,085 tons of "ordinary" grade, worth $27,125; and 92 tons of "extra," worth $5,520; a total of 1,177 tons, valued at $32,645. During the first six months of 1883, the product was 65 tons of "ordinary," worth $13,100; and 47 tons of "extra," worth $2,820, a total for the half-year of 702 tons, worth $15,920. From these figures it will be seen that the industry had established itself in this country within eight years, for the total annual production of slag wool and rock wool together up to the present year, usually varied between 5,000 and 7,000 tons. The number of slag wool plants in operation reached a maximum during the period 1885-1895. Since that time the relative number has decreased owing to the entrance into competition of plants using natural rocks in place of slag. The reasons for this relative decline in slag wool manufacture will be discussed on a later page. The total production of mineral wool (including both slag wool and rock wool) during 1902 is given[1] as 10,843 short tons, valued at $105,814 as compared with a production during 1901 of 6,272 short tons, valued at $68,992. Statistics collected by me indicated that in 1901 about 3,500 tons of the total quantity were produced from slag, the remaining 2,500 tons being made from natural rock. The year 1902 was marked by an increase in the total production; but the ratios of production between slag wool and rock wool were little changed. It is probable, therefore, that of the 10,843 tons of mineral wool produced in 1902, at least 6,000 tons were made from slag. The ratios as to value, however, are widely different from those of quantity, for rock wool is sold at a price per ton from 50 to 60% higher than that of slag wool.

The comparatively new material, mineral wool, found ready acceptance upon its introduction, and came into general use quite rapidly. Soon, however, objections were made to it, based partly on theoretical and partly on practical grounds. One at least of these objections seems to have been well founded, when the type of slag wool at first produced, is considered, but it is by no means certain that the argument holds good against the slag wool now made. Be all this as it may, the objection and the reasoning on which it was based have exerted a decided influence on the mineral wool industry in this country as well as in Europe.

The objection noted was made against the presence of sulphur in the mineral wools derived from slags. In the early days of the industry little attention was paid to this constituent, and in consequence, as much as from 3 to 5% of sulphur was often present in slag wools, while it rarely fell below 1%. Some years after the manufacture had become established, however, attention was called to the injurious influence exerted by sulphur under certain conditions. Prof. Wolpertz in Germany, and Prof. Egleston in the United States, took the most active part in this discussion, and references to it will be found in almost every one of the papers on slag wool cited in the bibliography at the close of this section.

The objection to the presence of sulphur is based upon the following facts. Blast-furnace slags of the type commonly used in slag wool manufacture are somewhat variable in composition, but commonly contain sulphur in combination with part of their lime as calcium sulphide. By blowing steam through a stream of molten slag it is possible that a small portion of the sulphur will be removed, but it is certain that the principal result of the process will be to make the finely divided and rapidly cooled slag wool more susceptible to chemical action than a normally cooled slag. If kept absolutely dry, however, no evil results will ensue, but when the material is used as a covering for water or steam pipes, water frequently gains access to the slag wool. This percolating moisture, either cold or aided by heat, acts on the unstable calcium sulphide, forming sulphuric acid, which at-

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[1] *Engineering and Mining Journal*, Jan. 3, 1903.

tacks the iron pipes. Slag wool coverings on pipes which are buried underground may also be attacked by organic acids.

The impression made on engineers by the discussion of these facts, and the consequent falling off in the utilization of mineral wool, led manufacturers to attempt the preparation of a material which would be free from the above-cited objections. These attempts took two very different lines, which will be separately discussed under the headings of (1) rock wool, and (2) desulphurized slag wool.

Rock Wool.—Obviously, one way out of the difficulty was to abandon the use of slags, which almost inevitably contain appreciable amounts of sulphur; and use in place of them other materials, of about the same bulk composition, but free from sulphur. A glance at the table of analyses of various mineral wools will show that the percentages of their principal constituents fall within the following limits: Silica, from 35·92 to 48·62%; aluminum and iron oxide, from 8·48 to 22·17%; lime, from 22·96 to 41·86%, and magnesia, from 2·98 to 19·82%.

It is possible to find natural rocks which will analyze after melting within these limits; but deposits of such favorable materials are not common, nor are they always well situated with regard to transporation facilities and market. In general, therefore, the rock-wool manufacturer is satisfied with a rock which can be cheaply extracted, and is well located, so long as it approximates the desired composition, which is subsequently obtained by adding to the rock a suitable quantity of sand, clay, or pure limestone, according as the main rock is deficient in silica only, in both silica and alumina, or in lime.

The methods of manufacture at the typical "rock wool" plant of the Crystal Chemical Works, Alexandria, Ind., is as follows: The material utilized in the manufacture of mineral wool is a highly siliceous limestone, analyzing: SiO_2, 26%; Al_2O_3, 12·02%; Fe_2O_3, 1·78%; $CaCO_3$, 37·92%; $MgCO_3$, 17·38%; H_2O, 4·90%. This rock forms a massive bed, 5 ft. thick, in the Niagara (Upper Silurian) formation which outcrops near Alexandria. The rock is blasted out in large fragments, drawn by team to the mill, which is near the quarry, and heated to a red heat, which disintegrates it. When sufficiently disintegrated it is dumped from the furnace, which has a drop bottom, and a new charge introduced. The disintegrated rock is then charged into the melting furnace or cupola.

When operations at the plant were started, a cheap and apparently permanent supply of natural gas was obtainable. The freedom of this fuel from sulphur made it an ideal source of heat for mineral wool manufacture. During this early period the disintegrated rock was melted in a large reverberatory furnace, with 150 sq. ft. melting surface which delivered 8 tons per 24 hours. Two men operated both furnaces and the boiler. The furnace bottom was formed of fire clay tile supported by six 1-in. pipes laid horizontally, having a space for air circulation below the pipes, which prevented the molten charge from escaping through the bottom. The furnace was fired at one end with natural gas, introduced through a specially constructed burner, and the waste gases passed up a stack at the other end. Attempts were made to utilize the waste heat either in the preliminary heating of the rock, or under the boiler, but with little success, owing to the choking of the flues with the fine dust carried from the charge by the draft. Under proper conditions, a furnace lasted from 10 to 12 months, when it became useless owing to the action of the molten charge on the brick work. The brick in the sides of the furnace immediately in contact with the charge, were destroyed much more rapidly, and it was found necessary to replace them every week. This renewal was provided for by having the furnace sides above this line, as well as the crown, independently supported.

The failure of the natural gas supply led to changes in the methods of melting the rock. Connellsville coke is now used for fuel, and the rock is melted in a drop-bottom, water-jacketed, cylindrical cupola, 40 in. inside diameter. The distance from tuyeres to charging floor is 7 ft., and its coke content is never more than 800 lb. at a time. After a day's run (24 hours) from 50 to 100 lb. of iron is found disseminated through the material in the bottom of the cupola, and the mineral wool contains a small percentage of iron oxide.

The molten material, as it issues from the cupola, is struck by a jet of steam, and blown into mineral wool. The spherules, being heavier, drop near the cupola, while the fibers are carried on to collecting chambers. The product analyzes about SiO_2, 37·5%; Al_2O_3 and Fe_2O_3, 20%; CaO, 30·6%; and MgO, 11·8%. The fiber weighs less than 3 lb. per cu. ft.; but is compressed when packed into bags for shipment, so as to weigh 8 or 9 lb. per cu. ft. It is usually packed in burlap bags, each holding 50 lb. A large quantity is also marketed in the form of slabs 1 to 1·5 in. thick, and 24×24 in. or 16×24 in. in area, for use in building partitions in cold storage construction. These slabs weigh from 12 to 14 oz. per cu. ft.

Desulphurized Slag Wool.—Elbers has described[2] the progress made in the attempt to produce a mineral wool, low in sulphur, from slag; and has also proposed a process for the manufacture of a product absolutely free from sulphur.

As above noted, slag wool was at first manufactured from slag direct from the furnace, without remelting. The shutting down of the furnace which supplied one of the early New Jersey slag wool plants, however, necessitated the use of slag from the cinder heaps, remelted in a cupola furnace. It was soon found that slag thus remelted gave a slag wool which contained materially less sulphur than when made from slags direct from the furnace; and the cupola remelting process is now in common use. Elbers states that by remelting slags in this way from one-third to one-half of the sulphur will become oxidized by the blast of the cupola, provided that good coke or anthracite coal is used as fuel. The proportion of sulphur can be reduced still further by melting about 15% of lime and sandstone with the slag, which will yield a product containing not over 0·3% of sulphur, a result fairly satisfactory, since the rock wool, made entirely from natural rock, usually carries at least 0·15% of sulphur, mainly derived from the ash of the coal or coke. Charcoal cannot be used as fuel, because it burns out too quickly to melt materials of so refractory a character.

Elbers'[2] patented process consists in the addition of gypsum, or other alkaline sulphates, to the slag before melting. The reaction being as follows:—

$3CaSO_4$, $2H_2O$(gypsum)$+Ca(Mg,Fe)S=3CaO+Ca(Mg,Fe)O+4SO_2+2H_2O$,

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[2] *Engineering and Mining Journal*, Vol. LXVIII., pp. 248-249, 1899.

the SO_2 and H_2O being carried off by the blast. In the experimental working of this process at a slag wool plant, the addition of 9% gypsum gave a slag wool carrying only 0·02% of sulphur. Elbers states in regard to manufacturing details, that "blast-furnace slag can be remelted with about the same amount of fuel, weight for weight, as foundry pig iron; but the yield is only 10% as large, *i.e.*, from 750 to 900 lb. per hour from a 42-in. cupola, with a blast pressure of from 2 to 4 oz. per sq. in. in the air pipe. A heat lasts from 12 to 20 hours, during this time the melt flows out continuously. The stream of the outflow should not exceed 0·75 to 1 in. in diameter, chiefly for the reason that equally good slag wool cannot be made from a stream of greater volume by proportionately increasing the size and force of the steam jet. The pressure of the steam should not exceed from 80 to 90 lb. per sq. in. On account of these various conditions a cupola 48 in. in diameter (inside of lining) is not likely to make more wool than a 42-in. one, while it will cost more for fuel; and it is likely that a 36- or 38-in. cupola will make as much wool (and of better quality) as either of the larger sizes. Cupolas smaller than 36-in. diameter are not so convenient for making inside repairs, which are needed after each melting, and do not give as long heats as are expedient. A well-conditioned plant of three cupolas should be able to turn out two carloads of mineral wool of 24,000 lb. each per day; but that is the maximum."

Physical Properties.—The appearance of mineral wool, under the microscope, is described[3] as follows:—

The sudden and violent explosive action by which the fibers and bulbs are formed would lead us to expect little regularity in their markings; but a considerable number exhibit a very beautiful and symmetrical ornamentation. The fibers vary in thickness from that of common spun glass to an extreme tenuity represented by fractions of a thousandth of an inch. The bulbs may generally be described as solid bodies containing more or less numerous vesicles or hollows. The more solid ones are transparent, or show iridescence. Many of the fibers are split, and occasionally several of them will be attached to the same bulb. When the fibers are crowded together they will form interstices of angular shape, so that free motion of the incased air is impossible, in consequence of which the material makes a poor conductor of heat. By calculation it is found that the "ordinary" and "extra" grades of slag wool contain respectively 88 and 93% of their volumes of air. This air circulates with such difficulty that the passage of heat is retarded, while the transmission of sound is prevented by the inelasticity or want of solidity of the material.

It is stated[4] that in ordinary practice a slag, weighing 192 lb. per cu. ft., will give 20% of "extra-grade" wool, weighing 14 lb. per cu. ft., and consisting of threads or fibers only, representing that portion of the material which has been blown entirely free from the "shot" or spherules. The remaining 80% will be of "ordinary" grade, weighing 24 lb. per cu. ft., and containing a considerable proportion of "shot" intermixed with the fibers.

Numerous experiments have been carried out to determine the relative con-

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[3] *Mineral Resources*, U. S. Geological Survey, 1882, p. 162.

[4] *Ibid.*, 1882, p. 161.

ducting power of various pipe covering materials. The papers describing these experiments are cited in the accompanying bibliography; and a few of the results are here summarized.

The data given in the following table have been selected from the results of Ordway,[5] Emery,[6] Coleman,[7] and from tests carried out by a firm manufacturing a rock wool. The results have been recalculated, when necessary, to permit the heat conducting power of mineral wool to be taken as unity.

HEAT CONDUCTING POWER OF VARIOUS MATERIALS.

Materials.	Authority.			
	Ordway.	Emery.	Coleman.	M'f'rs. Circular.
Sheep's wool	·62		1·36	
Cotton wool			1·22	
Loose lampblack	·75			
Hair felt	·69	·832	1·17	1·37
Compressed lampblack	·82			
Loose calcined magnesia	·95			
Mineral wool	1·00	1·000	1·00	1·00
Light magnesium carbonate	1·05			
Compressed magnesium carbonate	1·18			
Sawdust		1·223	1·08	1·79
Charcoal		1·316	1·40	1·56
Pine wood		1·504		1·28
Loam		1·518		
Infusorial earth			1·36	
Ground cork				1·17
Granulated cork				1·41
Sheet cork				1·67
Asbestos, air-cell block				1·22
Asbestos, molded block				1·51
Ground chalk	1·58			
Asbestos paper	1·67			
Asbestos cement				1·67
Gas coke		1·733	2·30	
Slaked lime		1.770		
Compressed calcined magnesia	3·28			
Asbestos	3·78	2·292		
Coal ashes		2·412		1·92
Fuel coke		3·004		
Sand	4·77			

Though discrepancies appear on comparing the different series of experiments, all of them seem to agree in bringing out the fact that mineral wool is the best non-inflammable coating of practical use. In addition to its low heat conducting power it has certain other advantages, in that it offers no attraction to animals, is not liable to char or burn, and is lower in first cost than most other coverings. The only defects to be guarded against by the manufacturer and user of mineral wool are the possible presence of sulphur and its liability to pack if wet.

Composition.—In chemical composition mineral wools vary considerably. The analyses given in the subjoining table, may be accepted, however, as being fairly representative, except in respect to the high sulphur content of Nos. 1, 2 and 3. These analyses were made about 1881 and 1894, and it is probable that no slag or other mineral wool now marketed has more than 1% S, while many commercial mineral wools are practically free from this element. Of the five analyses, No. 1 is that of a slag wool, and No. 5 that of a rock wool. The three remaining analyses are of wools whose origin cannot now be traced but it is probable, judging from their composition, that Nos. 2 and 3 were made from slag, and No. 4 from rock.

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[5] *Transactions of the American Institute of Mechanical Engineers*, Vols. V. and VI., 1884–1885.

[6] *School of Mines Quarterly*, Vol. 3, p. 145, 1882.

[7] *Engineering*, p. 237, Sept. 5, 1884.

ANALYSES OF MINERAL WOOLS.

Components.	Slag Wool. (1)	Slag Wool. (?) (2)	Slag Wool. (?) (3)	Rock Wool. (?) (4)	Rock Wool. (5)
SiO_2	38·97	43·48	48·62	35·92	37·5
Al_2O_3	7·84	11·95	9·20	22·17	20·0
Fe_2O_3, FeO	0·64				
CaO	26·56	22·96	24·10	41·86	30·6
MgO	19·82	18·24	17·26	2·98	11·8
K_2O	0·19	....	....	....	....
Na_2O	1·75	....	....	....	....
S	2·46	(a) 4·67	(a) 1·75	....	....
H_2O	1·08	....	....	0·07	....

(a) Given in original as SO_3, which is probably erroneous. (1) *Transactions of the American Society of Mechanical Engineers*, Vol. III., p. 250, 1882. (2) *Ibid.*, Vol XVI., p. 841, 1895. (3) *Ibid.*, Vol. XVI., p. 841, 1895. (4) *Ibid.*, Vol. XVI., p. 841, 1895. (5) *Manufacturers' Circular*, 1901.

Bibliography.—The following list of papers bearing on the manufacture or testing of mineral wool will be found serviceable:—

Barrus, G. H. Tests of steam pipe coverings. *Transactions of the American Society of Mechanical Engineers,* Vol. 23, p. 791-845. 1902.

Brill, G. M. Pipe-covering tests. *Transactions of the American Society of Mechanical Engineers,* Vol. 16, p. 827-855. 1895.

Egleston, T. An accident to steam pipes arising from the use of blast-furnace wool. *Transactions of the American Society of Mechanical Engineers,* Vol. 12, p. 253, *et seq.* 1883.

Elbers, A. D. The manufacture of sulphur-free mineral wool. *Engineering and Mining Journal,* Vol. 68, p. 248-249. 1899.

Emery, C. E. Experiments on non-conductors of heat. *Transactions of the American Society of Mechanical Engineers,* Vol. 2, p. 34, *et seq.*

Hutton, F. R. Note on the action of a sample of mineral wool used as a non-conductor around steam pipes. *Transactions of the American Society of Mechanical Engineers,* Vol. 3, p. 244-252. 1882.

Hutton, F. R. Tests of non-conducting materials. *School of Mines Quarterly,* Vol. 3, p. 145-146. 1882.

Hutton, F. R. On the use of mineral wool. *School of Mines Quarterly,* Vol. 3, p. 146. 1882.

Norton, C. L. The protection of steam-heated surfaces. *Transactions of the American Society of Mechanical Engineers,* Vol. 19, p. 729-753. 1898.

Ordway, J. M. Experiments upon non-conducting coverings for steam pipes (first paper). *Transactions of the American Society of Mechanical Engineers.* Vol. 5, p. 73-112. 1884.

Ordway, J. M. Non-conducting coverings for steam pipes; further experiments. *Transactions of the American Society of Mechanical Engineers,* Vol. 5, p. 212-215. 1884.

Ordway, J. M. Non-conducting coverings for steam pipes. Conclusion. *Transactions of the American Society of Mechanical Engineers,* Vol. 6, p. 168. 1885.

Redgrave, G. R. The utilization of slag. *Journal Society of Arts,* Vol. 38, p. 221-235.

Anon. Utilization of blast-furnace slag. *Mineral Resources of the United States* for 1882, p. 161-164. 1883.

MOLYBDENUM.

Owing to the reticence of the manufacturers of molybdenum and ferromolybdenum it has not been practicable to obtain exact figures of the production of these metals in the United States during 1902, although it is stated that the production was practically the same as in 1901, which amounted to 35,000 lb. of molybdenum metal and 16,000 lb. of ferromolybdenum. The price for molybdenum during 1902 remained within the limits quoted for the year 1901, *i.e.,* from \$1·55 to \$2 per lb. The production of molybdenum in the United States furnishes a very small portion only of the consumption, there being about 12 tons of ore produced during 1902. The price of molybdenum ore varies from 10c. to \$1·10 per lb., depending upon its richness and purity. To be marketable the ore must contain more than 45% Mo, and must be free from copper. The value of ore containing from 50 to 55% Mo is approximately \$300 per long ton.

Large deposits of molybdenite (MoS) are reported to have been found near Los Angeles, Cal., and ore containing 5% Mo and \$12 gold per ton is said to occur at the Dewey mine at Grapevine, near Warner's Hot Springs, San Diego County, Cal. Molybdenite and molybdite (MoO_3) occur in the Haliburton district in Ontario, Can., on property of the Land & Immigration Co., Ltd. The mass consists of pyroxenite with five narrow veins of pyrrhotite carrying molybdenite. Abroad a large deposit of molybdenite is reported to have been found at Rencontre, Fortune Bay, Newfoundland, and a recent discovery of this mineral has been made in the southern Vosges Mountains, near the border of Alsace, in France. In Queensland, Australia, molybdenite occurs at Wolfram Camp, on the Walsh River, in the Hodgkinson district. It occurs in vugs associated with tungsten and bismuth, and has to be separated by hand picking. In 1902 the production amounted to 41 long tons (£5,502), as compared with 26 long tons (£1,609) in 1901. In 1901 there were 15 to 20 tons of molybdenum glance produced at Tjötland, in the south of Norway.

Technology.

Mechanical Concentration.—According to information furnished by J. Walter Wells, molybdenite occurs at a number of localities in Canada, although there are but few deposits containing the mineral in commercial quantities. It is commonly associated with pyrite, pyrrhotite and chalcopyrite, and occurs in quartz veins. A sample of ore from the Giant mine, Rossland, B. C., upon analysis gave: Mo 24·2%, Co 1%, Fe 12·5%, Bi 0·19%, As 1·8%, traces of copper and lead, 4·14 oz. gold, and 1·2 oz. silver per ton. Experiments were carried out by Mr. Wells for the purpose of finding suitable methods for concentrating the Canadian ores. On a sample containing 50% pyrrhotite, 10% pyrite, and 6·5% molybdenite in a gangue of calcite, biotite, quartz and pyroxene, good results were obtained by crushing in a jaw crusher, hand picking of the large flakes of molybdenite, recrushing in rolls set to 0·2-in. space, and successive sizings in screens from 0·3-in. to 0·05-in. mesh. The oversize from the screens which consisted of molybdenite, mica and rock was treated on a Wilfley table and yielded a commercial product. The Hartz jig was not adapted for concentrating this ore, but good results were obtained with the Wetherill magnetic separator, although, owing to the high current and slow speed necessary, it is doubtful if this separation can be done on a practical basis. Treatment by a modified form of the Elmore process was only partially successful, as the large particles of molybdenite were not affected by the oil. Another sample consisting of quartz and feldspar with 2·5% molybdenite, was crushed and sized, but gave no clean ore on any of the screens. The whole sample was then ground to pass a 0·05-in. screen and concentrated on a Wilfley table, the final concentration being effected by the oil process. The experiments carried out by Mr. Wells showed that no standard method can be adopted for concentrating molybdenum ores. Separate mill tests are required to determine the proper treatment in each case.

Analytical Determination of Molybdenum.—G. Auchy[1] gives the following method for the rapid determination of molybdenum contained in steel: 0·8-g. of drillings are placed in a covered porcelain dish and treated with 15 c.c. dilute HNO_3, 10 c.c. concentrated HCl, and 3 c.c. concentrated H_2SO_4, and boiled to dense fumes of SO_3. The cover also must be thoroughly dried. The residue is then boiled with 50 c.c. H_2O, cooled and carefully poured into 100 c.c. NaOH solution (1 lb. NaOH in 2,100 c.c. H_2O) in an 8-oz. Erlenmeyer flask, provided with a file mark at 200 c.c. The liquid is diluted to the mark, shaken well and the precipitate allowed to settle, filtered through a dry filter into a 100 c.c. measuring flask. The filtered solution is placed in a beaker, and after adding 15 c.c. strong H_2SO_4 is reduced and titrated.

Another method for the rapid determination of molybdenum in ores, which has given satisfactory results, is to fuse the ore with Na_2O_2 in a nickel crucible, cool, dissolve the product in H_2SO_4, neutralize the solution with NH_4OH, which precipitates the iron present, filter, acidulate filtrate with H_2SO_4 and pass through a column of metallic zinc (Jones reductor) before the final titration with potassium permanganate.

E. Pozzi-Escot[2] states that molybdenum salts produce fast shades on leather, similar to the action of titanium salts. Molybdenum tannate, which has a great affinity for animal fiber, is naturally of a deep yellow color, but a large variety of shades may be obtained by using it in connection with logwood extracts.

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[1] *Iron Age*, Vol. LXX., No. 21, Nov. 20, 1902.

[2] *Comptes rendus*, CXXXV., 1902, 880; *Journal of the Society of Chemical Industry*, Dec. 31, 1902, 1588.

MONAZITE.

BY HENRY FISHER.

THE statistics of the production of monazite in the United States during 1902 are not yet available; the production during 1901, however, amounted to 748,736 lb., valued at $59,262. The output is mainly derived from North and South Carolina. The natives obtain the monazite sand throughout the Piedmont district, from the beds of small streams. The sand is covered with an alluvial deposit through which they dig till they strike sand and gravel. The sand is carefully removed and thrown into a wooden trough, 12 in. wide, 12 in. deep and from 12 to 18 ft. long. A stream of water flows through the trough and washes away the clay and accompanying light material, leaving the gravel and sand, which drop through a cast iron perforated plate set in the bottom at one end of the trough. The sand is washed a second time, and is then ready for market. It is brought in lots varying from a few to a hundred pounds to the agents of the Welsbach Light Co., several of whom are scattered through the monazite district. These men examine the sand, judge the amount of thorium oxide present, and pay for the material according to the oxide contents. This is necessary as many of the natives come from a distance, and require to be paid immediately, but the agents soon become so expert that they can judge the contents of thorium oxide within a few tenths of one per cent. The monazite sand is then shipped by the agents to the company's work at Gloucester City, N. J., where the thorium nitrate used in the incandescent mantle is manufactured.

PRODUCTION OF MONAZITE IN THE UNITED STATES.

Year.	Quantity.	Value.
	Pounds.	
1893	130,000	$7,600
1894	750,000	45,000
1895	1,900,000	114,000
1896	17,500	875
1897	40,000	2,000
1898	150,000	$7,500
1899	350,000	18,480
1900	908,000	48,805
1901	748,736	59,262

Technology.—E. Benz compares the ammonium oxalate, sodium thiosulphate and hydrogen peroxide methods[1] for determining thorium in monazite sand, and adds the following process: A mixture of 0·5 g. of the finely pulverized sand and 0·5 g. NaF is fused with 10 g. $KHSO_4$ in a platinum crucible till fumes cease

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[1] *Zeitschrift fuer angewandte Chemie*, 1902, 15 (13), pp. 297-309; also abstract in the *Journal of Society of Chemical Industry*, April 30, 1902, p. 563.

to be evolved. The crucible is then heated 15 min. longer, and the fused mass is dissolved in hot H_2O acidified with HCl, the insoluble portion filtered off, boiled with concentrated HCl, diluted and filtered. The filtrate is nearly neutralized with NH_4OH, boiled, from 3 to 5 g. of $(NH_4)_2C_2O_4$ are added, and the solution is vigorously stirred. It is allowed to stand over night, and the thorium precipitate is filtered off, washed and transferred to a porcelain dish, the filter paper being washed thoroughly with hot concentrated HNO_3. The solution in the dish is then evaporated to dryness on a water-bath, a few c.c. of concentrated HNO_3 are added, then 20 c.c. of fuming HNO_3, and the liquid evaporated again to dryness. H_2O is added and the solution is evaporated to remove free acid diluted, filtered, brought up to 100 c.c. in volume, NH_4NO_3 added, and the thorium precipitated by H_2O_2 at 60° to 80°C. The precipitate is filtered, ignited to ThO_2 and weighed.

A new method[2] for the separation of thorium from cerium, lanthanum and didymium and its application to the analysis of monazite has been proposed by F. L. Metzger, as follows: 1 g. of the finely powdered sand is repeatedly evaporated to dryness with concentrated H_2SO_4. The mass is added slowly to 700 c.c. of ice-cold H_2O, stirring constantly, digested for several hours, the residue filtered off and washed. The filtrate is nearly neutralized with dilute NH_4OH(1: 20) and 50 c.c. of a cold saturated solution of $(NH_4)_2C_2O_4$ added. The precipitate is filtered, washed and boiled with 25 c.c. strong KOH solution, the solution diluted, and the precipitate filtered, washed, and dissolved in dilute HNO_3(1: 1), evaporated to dryness, dissolved in 50 c.c. H_2O, and diluted with H_2O and alcohol, until the solution has a volume of 200 c.c. and contains 40% alcohol; 20 to 25 c.c. of a 1% solution of fumaric acid are then added, and the whole boiled. The precipitate is filtered off hot, washed with hot 40% alcohol, re-dissolved in 25 c.c. hot dilute HCl (1:1) and again evaporated to dryness. The residue is dissolved in 50 c.c. H_2O, alcohol and H_2O are added as before, and 10 c.c. fumaric acid, boiled, the precipitate filtered off, washed with hot 40% alcohol, ignited wet in a platinum crucible and weighed as ThO_2.

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[2] *Journal of American Chemical Society*, 1902, 24, pp. 901-917; and abstract in the *Journal of Society of Chemical Industry*, Nov. 29, 1902, p. 1415.

THE NATURAL GAS INDUSTRY OF THE UNITED STATES DURING 1902.

BY W. H. HAMMON.

DURING the year 1902 more natural gas was produced and sold in the United States than in any like period in the history of the industry. The quantity consumed was not less than 200,000,000,000 cu. ft., or nearly 1·5 cu. miles, an amount sufficient to provide an annual supply of 15,000 cu. ft. for every family in the United States. The value of this production, based on prices paid for coal in 1902, was approximately $40,000,000. In the matter of distribution, Pennsylvania still leads all other States, consuming nearly one-half the entire production. Indiana continues second, and Ohio and West Virginia third and fourth, although in production West Virginia leads Ohio. There has been a notable increase of output in all States except from the Trenton limestone formation of Indiana and western Ohio, which has been depleted until now but little is procured except by means of the gas compressor. The most marked increase has been from West Virginia, where are situated the most prolific fields thus far discovered. No extensive new reservoirs were found in 1902, the enlarged production resulting from the development of known territory.

Indiana.—The Indiana gas deposits, which are confined to the Trenton limestone, have steadily depleted during the year, although great efforts have been made to maintain the output by pumping. By the substitution of meters as far as possible for the former flat rate contract system of selling gas, a greater economy in its use has resulted. Many old contracts are still in force, however, and several gas companies that were unable to comply with their requirements have been forced out of business. Many large consumers have resorted to coal, and a large number of glass manufacturers have substituted producer gas for the natural product. Since it is not reasonable to expect natural gas in strata below the Trenton limestone (the oldest formation that contains large deposits of organic matter) it seems probable that the extensive use of natural gas in this region must be abandoned in a few years, or the supply transported unusual distances from reservoirs in other States.

Kansas and Indian Territory.—In the development of the oil field in southeast Kansas and northern Indian Territory, quite an extensive and productive gas field has been partially explored. Very productive wells of from 250 to 800 lb.

rock pressure have been found at various points, extending from the extreme northern portion of Allen County southward nearly 100 miles into Indian Territory. Probably the largest development thus far made is near Iola, Kan. As yet, no satisfactory market for the fuel has been obtained, as there are no large cities in that vicinity, although many manufacturing and smelting plants have located in the Territory, attracted by the prospects of cheap fuel.

Ohio.—The vast Trenton limestone reservoir covering nearly all of western Ohio is so exhausted that but little gas is obtained, except by reducing the line pressure at the mouth of the well by pumping. Large quantities are thus produced, however, and if the present rate of depletion is continued it will result in the practical abandonment of the field within two or three years. Already many towns and cities formerly supplied from this reservoir are arranging to draw their supply from the West Virginia fields. The output from the Clinton limestone, in central and eastern Ohio, has increased. The old Sugar Grove field is depleting quite rapidly; while pumps are not necessary to secure a production, the rock pressure being from 150 to 200 lb., still they are almost universally used to increase the output. Several of the largest pumping plants, containing the most modern types of machinery, are at work in this field. During the year the Licking County field, about 30 miles north of the Sugar Grove pool and in the same formation, has been rapidly developed, and gives fair promise of rivaling the latter reservoir in productiveness. Companies which formerly drew their supply from the Sugar Grove field are taking a larger and larger supply from the new territory, and at the same time are extending large pipe systems southward to connect with huge feeders from the West Virginia fields.

Pennsylvania.—In Pennsylvania, the most important development of 1902 was in the Speechly sand of Armstrong County. This sand was formerly productive of oil and gas in Warren and Forest counties, and as early as the winter of 1894-5 a well was drilled to this formation near Brady's Bend, Armstrong County. But it has been within the past two years, and for the most part in 1902, that the southern extension has been explored. The stratum lies from 600 to 700 ft. below the Butler-Venango group of sands, and is found quite generally where explorations have been made throughout Armstrong and the eastern half of Butler counties and even southwest in Beaver County. The sand is only occasionally productive, and most of the wells have been small, averaging, at the beginning, approximately 750,000 cu. ft. daily, open flow measure, but falling to one-half this amount after a few months' use. In September, 1902, a well was drilled, however, near Worthington, Armstrong County, by the Philips Gas Co., which was capable of producing about 30,000,000 cu. ft. per day, probably the largest well ever drilled north of Pittsburg. Since then several wells of 5,000,000 cu. ft. capacity have been drilled in the vicinity of Pine and Mahoning creeks, east of the Allegheny River, in the extreme northern portion of Armstrong County. The rock pressure of the Speechly gas wells is about 800 lb. per sq. in. In the Bradford gas and oil field of McKean, Elk and Forest counties, several pools have been discovered in a formation from 200 to 300 ft. below previous productive measures, which show rock pressures of 1,200 lb.

West Virginia.—In West Virginia, the promise of the most extensive deposits yet discovered has been fully realized by continued developments. Many Gordon sand wells in Lewis and Doddridge counties show rock pressures of from 1,000 to 1,200 lb., and several Fifth sand wells show approximately 1,400 lb. pressure. The volume of the wells is almost as remarkable as the pressure, several approximating 20,000,000 cu. ft. per day, open flow. Many good wells have been drilled in Braxton, Gilmer, Harrison and Tyler counties, but the territory does not appear to be as generally productive as Lewis and Doddridge counties to the east and Wetzel County to the north. While much larger quantities of natural gas were marketed from West Virginia than heretofore, it is a matter for congratulation that the reservoirs showed a slower rate of exhaustion than formerly. This is due to the greatly diminished waste of gas by oil wells drilled into or through the gas reservoirs and by unused gas wells which were opened in drilling for oil. Fully one-half of the entire deposit in the northern tier of counties was thus wasted, the waste being many times the quantity marketed, but during the last two or three years a large portion of the oil operators have taken quite successful means to stop this loss. There are, however, many producers who thus continue to waste a product frequently more valuable than the one they save, and it is to be deplored that there is no State law adequate to prevent such waste. The steps being taken at present for transporting the gas from West Virginia into distant points in Pennsylvania and Ohio exceed anything accomplished in the past. Gas is now being piped from Tyler County, W. Va., to Cleveland, O., and arrangements are almost completed to conduct gas from Lewis County in central West Virginia, to Toledo, O., a distance of about 200 miles. Four large corporations are laying lines of 16 in. or more in diameter, for the purpose of conducting gas more than 100 miles from the source of supply. About 500 miles of 16-, 18- and 20-in. pipe will be used in these lines. In addition, many other lines of 10- and 12-in. pipe are being laid. These arrangements will nearly double the output of the State during 1903.

Other Fields.—Quite extensive fields are being discovered in Wyoming, Colorado and Texas, but no extensive use of the fuel has been made.

Consolidation of Gas Companies.—One of the most marked changes of the past year has been the very apparent move on the part of smaller companies toward consolidation into a few great corporations. This result has been quite naturally brought about by the partial failure of the nearby pools from which the various small local companies formerly drew their supply, and the combination was necessary to provide for the expense of a common main to distant fields. Hundreds of smaller concerns have been thus merged into about seven concerns (considering the several Standard gas interests as one) which control probably 80% of the entire industry.

NICKEL AND COBALT.

By Joseph Struthers and D. H. Newland.

Prior to the year 1902, a portion of the total production of metallic nickel and cobalt oxide in the United States was obtained as by-products in the treatment of lead ores from Mine La Motte, Mo. In 1902, however, there was no production of these substances from domestic ores, as compared with 6,700 lb. of nickel and 13,360 lb. of cobalt oxide from this source in 1901. The cessation of the manufacture of these products from domestic ores may be attributed to the recent combination of the principal companies employed in this industry, whereby the final products are obtained from imported ores and matte at a lesser cost.

During 1902 the production in the United States of nickel as metal, oxide and sulphide from foreign ores and matte, aggregated 10,391,478 lb., as compared with 8,664,614 lb. in 1901, making the total production of nickel from all sources to be 10,391,478 lb. during 1902, as compared with 8,671,314 lb. in 1901. The production of cobalt oxide from foreign ores and matte during 1902, amounted to 17,140 lb. valued at $38,736, as compared with 13,360 lb. from both foreign and domestic ores and matte during 1901.

UNITED STATES PRODUCTION, IMPORTS AND EXPORTS OF NICKEL.

Year.	Production.						Imports. (b)		Exports. (c)	
	From Domestic Ore		From Foreign Ore.							
	Metallic.		Ni in Sulphide, Oxide, etc. (a)		Metallic.					
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Long Tons.	Value	Pounds.	Value.
1898......	11,145	$3,845	3,516,427	$1,213,167	3,611,857	$1,245,918	17,819	$1,090,932	5,637,618	$1,359,609
1899......	22,500	8,156	3,008,122	1,088,632	5,045,221	1,828,898	19,687	1,101,989	5,004,877	1,151,923
1900......	9,715	4,534	3,605,138	1,682,520	4,107,982	1,915,193	25,670	1,183,884	5,869,906	1,882,727
1901......	6,700	3,551	4,653,387	2,168,455	4,011,277	1,869,255	52,111	1,687,166	5,869,655	1,521,291
1902......	*Nil.*	*Nil.*	(*d*)	(*d*)	(*d*)	(*d*)	14,817	1,156,372	3,228,607	924,579

(*a*) The nickel reported as in oxide is now mostly converted into metal before consumption. (*b*) Ore and matte. (*c*) Comprises domestic nickel, nickel oxide, and matte. (*d*) Statistics not available.

UNITED STATES PRODUCTION FROM DOMESTIC AND FOREIGN ORES AND MATTE, AND IMPORTS OF COBALT OXIDE.

Year.	Production	Imports.		Year.	Production	Imports.	
	Pounds.	Pounds.	Value.		Pounds.	Pounds.	Value.
1897..................	19,300	24,771	$34,773	1900..................	12,270	54,073	$88,651
1898..................	9,640	33,731	49,245	1901..................	13,360	71,969	134,208
1899..................	10,200	46,791	68,847	1902..................	17,140	79,984	151,115

Prospecting for nickel ores and exploitation of known deposits of unproved value have continued during 1902, but very little information has been made public. Most of the deposits are of very low grade and the development work done on them has not been of sufficient magnitude to be of interest. The chief properties are in Arizona, Idaho, Nevada, North Carolina, Oregon and Wyoming, and early in 1903 the discovery of nickeliferous ore was reported near Wellington, Boulder County, Colo.

Market.—The market for nickel held steady throughout the year, being firmly controlled, so far as the United States is concerned, by the trust. The prices quoted for ton and larger lots at New York were 40@47c. per lb., according to size and terms of order. For smaller lots as high as 60c. per lb. was quoted. It is to be noted that the market prices do not reflect the actual terms obtaining in business transactions, as large sales are commonly made at much lower prices than those quoted.

The first annual report of the International Nickel Co., which was formed in April, 1902, to take over the properties owned by the Canadian Copper Co., the Orford Copper Co., the Anglo-American Iron Co., the Vermillion Mining Co., the American Nickel Works, the Nickel Corporation, Ltd., and the Société Minière Caledonienne was submitted on March 31, 1903, for all companies except the two last-named. In its report the company places a valuation on its properties, including the investments in stocks of the Nickel Corporation and the Société Minière Caledonienne of $28,566,612, and this sum, less $2,145,407, representing the surplus of the constituent concerns at date of transfer, is carried as an asset of the company. In addition the assets include £20,000 of debenture certificates of the Ray copper mine, valued at $40,000, advances to constituent companies of $188,490, and current assets including inventories, accounts and bills receivable, cash, etc., of $3,713,332, making a total of $30,363,027. Among the liabilities of the company are a capital stock of $17,483,012, divided equally into common and preferred, bonded debt of $9,903,441, current liabilities of $1,321,658, and surplus account of $559,149. The year's earnings amounted to $1,119,417, which, less administrative and office expenses of $110,025, gave a net income of $1,009,392. The company further states that the various manufacturing plants have been found to be in a very poor condition, much of the machinery being old and expensive to operate. During the year the sum of $225,435 was expended for repairs at the works of the Canadian Copper Co., the Orford Copper Co., and the American Nickel Works. It is intended to reconstruct the plants and to bring them up to the highest standard of metallurgical and economic efficiency. At the Ontario works of the Canadian Copper Co. a third Brown calcining furnace has been installed, and the older furnaces have been increased, each 40 ft. in length; while at the Orford plant a new nickel refinery has been erected and new boilers and engines installed. The construction of a new smelting plant at the works of the Canadian Copper Co. in Canada is now under way. It is estimated that this plant, which will cost $500,000, will effect a saving of from $200,000 to $250,000 per year.

THE WORLD'S PRODUCTION OF NICKEL. (METRIC TONS.)

Year.	From New Caledonian Ores.					Canada. (b)	Norway.	United States.		World's Total.
	Prussia.	France.	England	United States.	Total.			Domestic	Imported	
1898.....	1,108	1,540	960	....	3,608	2,503	*Nil.*	5	3,234	6,116
1899.....	1,105	1,740	1,000	....	3,845	2,605	(*a*)	10	3,651	6,460
1900.....	1,376	1,700	1,600	(*d*)	4,676	3,212	(*a*)	4	3,499	7,892
1901.....	1,660	1,800	(*a*)	1,796	6,202	4,168	(*c*) 27	3	3,643	10,373
1902.....	(*a*)	(*a*)	(*d*)	(*d*)	(*d*)	4,850	(*d*)	*Nil.*	4,714	....

(*a*) Individual statistics not yet reported. (*b*) Nickel in ore and matte, nearly all the Canadian nickel is refined in the United States. (*c*) Nickel in Norwegian ore, included in U. S. production from imported ores. *d*) Statistics not available.

NOTE.—The figures for France and Prussia are from official reports; the amount credited to England has been obtained by deducting the output in France from the combined output of the French and English works as given by the *Metallurgischegesellschaft*, *A. G.*, except in 1899, when the English production was reported separately. The actual output of all English works is somewhat greater than the above amounts as a little Canadian ore is smelted there. The Prussian figures include a small amount of nickel of domestic origin. The Canadian figures are those of the Geological Survey of the Dominion. The world's total has been arrived at by adding the production from New Caledonian ores, the output of Canada and Norway, and the domestic production of the United States. In 1899, however, the total represents the total output in the United States and the production from New Caledonia ores, since the imports into this country were not derived from Canada alone.

Austria.—The nickel mines of Austrian Silesia were described by Illner in the *Zeitschrift fuer das Berg-, Huetten-und Salinenwesen,* No. IV., p. 816, 1902. The mines are situated at Kosemitz, Züsendorf and Gläsendorf, a short distance north of Frankenstein. Geologically the ore, which contains from 0·5 to 3% Ni, is usually associated with a very siliceous rock called "red" rock, filling fissures in serpentine. Occasionally the veins are of talcose nature and then carry from 4 to 18% Ni. The only mines operated at the present time are the Martha and Benno, of which the former has two shaft furnaces capable of treating 50 tons of ore daily. The composition of the ore ranges about as follows: SiO_2 60 to 65·4%, MgO 8·5 to 12%, $Fe_2O_3+Al_2O_3$ 6 to 8%, Ni 2·3 to 3·5%, and ignition loss 8 to 15%. Before smelting the ore it is first mixed with gypsum or with calcium sulphite and limestone, crushed to 12 mm. size and pressed into bricks. The shaft furnace is 5 m. high and 1·75 cm. in cross-section, and is charged with the bricks and coke in the proportion of 180 kg. of the former to 50 kg. of the latter. A very fluid slag is produced containing 0·3% Ni, which is used in making slag bricks. The matte, composed of about 31·4% Ni, 49·7% Fe and 14·5% S, is crushed and subjected to an oxidizing roast in a two-stage reverberatory furnace, which is 6·13 m. wide and has a capacity of 300 kg. in eight hours. There are four furnaces of this type at the works. The roasted matte containing approximately Ni 65%, Fe 15% and S 20% is run into a Bessemer converter with sufficient sand to slag the iron oxide, and is blown for 45 minutes, thus raising the tenor in nickel to 77·8%. This fine matte is pulverized and treated to a dead roast in the reverberatory, which converts it into a grayish-green nickel oxide containing 77·6% Ni. The oxide is pulverized, moistened, cut into small cubes, dried and charged with charcoal into fire brick muffles that are heated in a regenerative gas furnace. After three hours' treatment in the furnace, the metal contains 99% Ni and 0·3% Fe. The sulphur dioxide from the roasting is caught in water and the solution neutralized with lime, the resulting calcium sulphite being used as flux in the shaft furnace. During the half year ending June 30, 1902, when there were 1,036 laborers employed in the mines and works, the quantity of ore treated was 5,689 tons, which yielded 108 tons of nickel.

Canada.—According to the report of the Dominion Geological Survey, the production of nickel in 1902 was 10,693,410 lb. valued at $5,025,903, as compared with 9,189,047 lb., valued at $4,594,523 in 1901. The detailed statistics of Ontario, compiled by Thomas W. Gibson, Esq., Director of the Ontario Bureau of Mines, are as follows:

Schedule.	1897.	1898.	1899.	1900.	1901.	1902.
Ore raised..................Short tons.	98,155	123,920	203,118	216,695	326,945	269,538
Ore smelted................Short tons.	96,093	121,924	171,230	211.969	270,380	233,388
Per cent. nickel........................	2·08	2·23	....	1·67	....	2·55
Per cent. copper........................	2·86	3·43	....	1·59	....	1·78
Ordinary matte............Short tons.	13,706	21,101	19,109	23,336	29,588	24,691
Bessemerized matte.......Short tons.	328	....	106	112	15,546	13,332
Nickel content.............Short tons.	1,999	2,284	2,872	3,540	4,441	5,945
Copper content ....Short tons.	2,750	4,187	2,834	3,364	4,197	4,066
Value of nickel (*a*)......................	$359,651	$514,220	$526,104	$756,626	$1,859,970	$2,210,961
Value of copper........................	200,067	268,080	176,236	319,681	589,080	616,763
Wages paid	253,225	315,501	443,879	728,946	1,045,889	835,050
Men employed...	535	637	83[illegible]	1,444	2,284	1,445

NOTE.—The quantities reported in 1901 and 1902 under "Bessemerized matte" include both Bessemerized matte and high-grade matte, the former being the product of the Mond Nickel Co.'s works and the latter of the Ontario Smelting Works, which retreat the low-grade matte produced by the Canadian Copper Co. (*a*) Value based on nickel in matte and not on refined nickel.

The report of the Mond Nickel Co., Ltd., for the year ending April 30, 1902, states that satisfactory progress was made in both the Canadian and English works. The capital stock of the company at this date consisted of £475,000, divided into £125,000 in preference shares, £300,000 in ordinary shares and £50,000 in deferred shares. A valuation of £295,828 was placed on the company's property, £100,000 on patents, £28,693 on materials, £82,726 on ore and products, and £9,687 on miscellanies; a total of £516,934. The following is a summary of the operations during 1902: Ore raised, 38,545 short tons; ore smelted, 37,107 tons; Bessemerized matte produced, 2,403 tons; estimated content of matte, 996 tons copper and 1,020 tons nickel. At the Clydach works some trouble was experienced in 1902 owing to the fact that the process proved to be injurious to the health of the men employed. After a breakdown in the plant there were over 20 cases of poisoning which resulted in several fatalities.

(By A. McCharles.)—The transfer of the properties and business of the Canada Copper Co. to the International Nickel Co. was the chief and almost the only important event in connection with the Sudbury nickel mines during 1902. The new company, or "Nickel Trust" as it is commonly called, has not absorbed any additional companies or mines during the year, nor has it made any extensive changes in its plant or in the process of treating the ores. On taking charge last spring, the new management closed down most of the mines and works, and operations were discontinued until the latter part of the year when they were resumed. The nickel companies in this district have heretofore been capitalized at from $1,000,000 to $3,000,000, while the capitalization of the old Canadian Copper Co. was only $2,500,000. The trust, however, has started with a capital stock, including outstanding bonds, of $36,000,000, and this feature of the scheme is regarded locally as a mistake. It is doubtful if all the mines in the district can pay a fair dividend on so large a sum, as less than one-half of them belong at present to this company. Besides the six mines owned by the Mond Nickel Co. and the Lake Superior Power Co., there are also quite a number of valuable nickel properties on the main or southern range, notably the Murray, Worthington, Mt. Nickel and Sultana, all well developed, which are outside the holdings of the trust. It is seen, therefore, that either the capitalization of the company is too high, or there are very large profits in the nickel industry. The latter conclusion apparently is accepted by the public by reason of the fact that the chief parties in the trust were the main producers and refiners of nickel in America, and that they should, therefore, know what profit is to be derived from the business.

During the summer only two of the ten smelters of the Canada Copper Co. were in blast, but in the fall four more furnaces were blown in and work was resumed at three of the mines. The Orford concentrating works at Copper Cliff were operated throughout the year, making into high-grade matte the entire output of the smelters of the Canadian Copper Co.

The Mond Nickel Co. made steady progress during the year. The Victoria mine at Denison, owned and worked by this company, has proved to contain a large and valuable body of ore, which is now being exploited below the 500-ft. level. At the company's works near the mine, the matte from the smelting furnace is Bessemerized before being exported. The company has also bonded the North Star mine which was operated on a smaller scale during the summer. The smelting plant was closed down in the fall for the purpose of making an alteration in the furnaces, but it is intended to start operations again early in 1903.

The Lake Superior Power Co. erected a smelting plant at its chief mine in Creighton, which was in operation during the latter part of the year. Owing to financial troubles, the company closed down the Elsie mine from which the largest part of the ore was produced during 1901, and it is said that the proposed Bessemerizing plant will not be built for some time.

Summarizing the year's progress in the Sudbury district, the output of ore was considerably less than in 1901, but the prospects for the coming year give every assurance of the busiest and most progressive season in the history of the mines. It is probable that there will be six companies operating in the district before the close of 1903.

Chile.—The San Juan group of mines, lying north of the Port of Peña Blanca, are located on well formed lodes varying from 1 to 6 ft. in width. The ore consists of oxide, arsenate and sulpharsenide of cobalt with an average tenor of about 4% Co. The workings have reached a depth of from 40 to 70 m.

Germany.—The firm of Basse & Selve produces nickel from Norwegian and New Caledonian ores and occasionally from copper matte. In addition to this firm there are one or two nickel refineries of lesser importance.

A new discovery of nickel ore, apparently of considerable importance, has been made at Sohland, in Lausitz, Saxony. The deposit consisting of chalcopyrite, pyrrhotite and copper oxides is associated with a black decomposed diabase. The ore is said to average from 4 to 5% Ni and 2% Cu.

New Caledonia.—(By F. Danvers Power.)—Though nickel has fallen somewhat in price, still so far the miners in New Caledonia have not felt the effects, as a reduction in home freights permits the buyers to pay the old prices; in fact, recent contracts have been made on advanced rates. The principal producer of nickel is still the Société le Nickel, a French company, with a capital of $2,000,000, divided into 40,000 shares of $50 each. Last year the company distributed a dividend of 9%. The great event of the year was the advent of the International Nickel Co., which has secured large interests in New Caledonia. This corporation, outside its Canadian mines, has purchased the business and properties of La Société Minière Caledonienne, and has a controlling interest in the Nickel Corporation of London. The idea of the International Nickel Co. is to erect works for the treatment of the New Caledonian ores, either in Australia or New Caledonia, so as to deal with ores of a grade that would otherwise be too low to ship to Europe or to America. In New Caledonia the inhabitants are very keen on having the works erected there, but this is hardly to be done, for in spite of certain concessions there are many objections. Suitable labor would have to be imported, likewise the fuel and machinery; the local fluxes are scattered and limited, and there is no central place for the works which would suit mines that are so spread over various parts of the colony, whereas to erect two or more smaller plants would prove an expensive mistake. Everything points to New South Wales as being the most suitable locality in which to erect the works. The shipping facilities are good; fuel, fluxes and labor are abundant, and there are large foundries in that State. The most likely sites are at Port Kembla on the south coast, and Newcastle on the north coast. Both places can be reached by rail from various parts of the country, but the former has deeper water, and the additional advantage of a supply of coal in the district which is better for coking purposes.

New South Wales.—The cobalt mines at Port Macquarie, which are operated by an English corporation, reduced their output in 1902. The ore is raised, washed in sluices, screened, rewashed and sorted, the concentrates obtained by this treatment consisting essentially of cobaltiferous wad. Cobalt associated with gold in arsenical ores has been found at Burnt Yards near Mandurama. Attempts are being made in the Lyndhurst district to smelt the cobalt ore with the addition of gold and copper ores to form a cobaltiferous matte or speiss. The exports of cobalt ores in 1902 were 34 long tons valued at £304, as compared with 111 tons valued at £1,051 in 1901.

Switzerland.—Nickel and cobalt ores occur in Canton Wallis, at Annivierstal, and in Turtmanntal. At Kaltenberg in Turtmanntal, the ore averages Co 7 to 8%, Ni 3 to 4% and Bi 2 to 3%. Rich nickel and cobalt ores also occur in the Gollyre and Grand Praz mines near Ayer in the Val d'Anniviers.

COBALT IN NEW CALEDONIA.

By F. Danvers Power.

At the end of 1901 and the beginning of 1902 the price of cobalt ore containing 4% Co, in New Caledonia, was forced up higher than circumstances warranted. For a long time the price in Europe did not justify more than 90 fr. per ton being paid for this quality of ore at the mines, but the price steadily rose to 330 fr., until recently, since which it has receded. This unsteadiness cannot be accounted for either by the falling off of the production, or by an increased demand for cobalt, but was due to an insane competition between the various buyers in New Caledonia, which showed a lack of the sense of responsibility on behalf of some of those who had the handling of other people's money, for all the operators must have had heavy losses in connection with their transactions, the prices paid in Europe not being sufficient to recoup them. Underlying all this was apparently an attempt to drive some of the buyers out of the market, but as the principal competitors were too well matched, they have agreed to cease this cut-throat practice, so the price at the mines has accordingly fallen. The inflated prices naturally caused unusual activity in cobalt mining.

PROGRESS IN THE METALLURGY OF NICKEL DURING 1902.

BY TITUS ULKE.

Developments at Sault Ste. Marie, Ontario.—During 1902 was demonstrated the commercial impracticability of cheaply roasting Sudbury pyrrhotite nickel ores, which do not average over 25% S, in Herreshoff furnaces in order to utilize the sulphurous acid gas thus obtained to make sulphite pulp or liquid acid. The use of the dead roasted residue in the making of ferronickel was also found to be commercially unsuccessful. It is recognized that unless this roasting in the Herreshoff furnace can be done mainly without the aid of extraneous heat, the cost, compared with heap-roasting, is prohibitive, and that in any case the average percentage of sulphurous acid in the gas produced is too low to be economical for use in the manufacture of calcium bisulphite for making sulphite pulp.*

The roasted nickel ore produced at Sault Ste. Marie was briquetted during 1902, but was not used in the way originally planned by Messrs. Clergue and Sjöstedt; that is, for making ferronickel in electrical furnaces, probably because its copper and residual sulphur contents were too high to yield a satisfactory product. It is evident that ferronickel made in this way would be too costly and too cupriferous for use in making nickel steel commercially.

Later the Lake Superior Co. proposed the treatment of pure nickel ore, that is, ore containing nickel without copper, although it appears that no such ores, in paying quantities, have yet been discovered in the Sudbury district. Furthermore, any hand-picking process of freeing the nickel ore from copper and phosphorus-bearing material which is chiefly contained in the gangue, in order to get these elements low enough to make good pig iron and steel, is impracticable.

Plans and estimates have been prepared, and, it is reported, requests for tenders have recently been made for a large custom nickel and copper smelting and refining works to be erected at Sault Ste. Marie. The site for the plant, whether on the American or on the Canadian side, has not yet been decided upon, although its location in Ontario seems probable, owing to a provision of the Canadian tariff relating to the refining of nickel. The plant, as designed, is

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* The statement by Mr. Ulke that the process of roasting pyrrhotite nickel ores, as developed at Sault Ste. Marie, proved unsuccessful has been controverted by Mr. E. A. Sjöstedt in the *Engineering and Mining Journal*, April 25, 1903. According to the latter, the process has been worked out in a most satisfactory manner, the pyrrhotite being roasted without extraneous heat and yielding sulphurous acid in quantities that more than repay the cost of converting the raw ore into briquettes. The results of operations for two weeks in 1903 showed an average recovery of 86·4% S, and a total working cost of $1·86 per ton of ore.—[EDITOR.]

of a daily capacity of 75 tons of electrolytic copper, 7·5 tons of electrolytic nickel, and from 2,000 to 5,000 oz. (in fine bars) of precious metals. The proposed process of treatment is as follows: Crude nickeliferous copper anodes, averaging from 80 to 90% Cu, from 8 to 9% Ni and a few ounces of silver, gold, platinum and palladium per ton, are to be obtained by treatment of Sudbury matte, together with ordinary copper matte, or with silver-bearing copper concentrates, such as the argentiferous mineral recovered in the Quincy, Isle Royal, Osceola and other stamp mills of the Upper Peninsula, purchased outright by the smelter or refined on toll. These anodes are to be electrolyzed just as in modern copper refining, and the process of depositing fine copper will be carried on in exactly the same way, except for the continuous withdrawal of a small amount of the electrolyte, and its replacement by solution free from nickel, in order to prevent the enrichment of the electrolyte in nickel sulphate beyond the standard adopted. The withdrawn acid solution is sent to the separating works, where simple and well-known chemical means are used to remove the copper and iron, and a neutral solution of nickel sulphate, now free from copper and iron, is obtained. After evaporating this solution to dryness the double salt obtained is calcined, so as to recover the ammonium sulphate from which ammonia (for neutralizing the acid solution) can be obtained by distillation with lime and steam. The nickel sulphate is reduced until semi-metallic nickel, or at least semi-coherent black nickel oxide, is secured. This is then to be placed in a frame, similar to the one patented in 1898, by Mr. F. A. Thum, and used as an anode. Each nickel depositing tank contains a sufficiently large number of such anodes and a hot neutral solution of nickel sulphate, from which compact deposits of pure nickel of any required thickness can be secured. By the use of a soluble anode of this character instead of an insoluble anode of lead or graphite, the cost of refining is considerably reduced, as polarization is diminished and a lesser voltage is needed. The power required for the refining plant (between 3,400 and 4,000 H.P.) is to be furnished in the shape of a three-phase alternating current of 10,300 volts, delivered to the high tension switchboard of the refinery power house at a total estimated yearly cost of $12·50 per metered electrical horse power at the generating station. The works are to be located on a site having facilities for shipping both by rail and water. They are designed to allow the erection of a limited or unit-section of the works, and so arranged that future extensions in at least two directions may be made by a simple duplication of the first section.

Developments in the Sudbury District.—The Mond smelting and converting plant at Victoria Station, Ont., closed down recently, in order to make changes in the method of smelting, with a view to the use of hot blast and possibly pyritic smelting.

The experimental plant erected at Worthington Station for the Nickel-Copper Co., of Hamilton, Ont., to treat the ores of its mines by a new self-roasting process, has proved a failure, due chiefly to the low rate of concentration effected and insufficient heat generated by the process itself.

During the early part of 1902, the Canadian Copper Co. operated 11 or 12 smelting furnaces in its two works at Copper Cliff, which have a capacity for smelting of at least 1,400 tons of Sudbury ore daily. At present only four or five of these furnaces are kept running by the company. Its electrolytic refinery, near Cleveland, shut down late in 1902.

The Orford Copper Co. is now enlarging its two Brown straight-line roasting furnaces near Copper Cliff, and is also putting in a new one.

The Lake Superior Power Co.'s two smelting furnaces at the Gertrude mine, 12 miles from Sudbury, were started during the summer and fall of 1902, and have already produced matte of the estimated value of over $200,000.

Mond's Refinery at Clydach, Wales.—Mond's process of nickel refining, as applied at the Clydach works, Swansea Valley, Wales, is carried out[1] as follows: The Bessemerized Sudbury matte is dead roasted and treated with dilute sulphuric acid, whereby about 66% of the copper and not over 2% of the nickel are extracted. The residue, after drying, assays from 45 to 60% Ni. It is treated in charges of 500 kg. with water gas in a reduction tower at a temperature of not to exceed 300°C. The tower is 7·5 m. high, and contains 14 hollow shelves, which are heated with water gas to 250°C. The ore is moved from shelf to shelf by means of rakes operated by a vertical axle. The lowest shelves are cooled. The reduced charge is transferred to a similar tower called the volatilizer, in which the metal is treated with carbon monoxide at a temperature not exceeding 100°C. The residue from the volatilizing tower is returned to the reducing tower, and the charge goes back and forth between the two towers for from 8 to 15 days. When 60% of the nickel has been volatilized as nickel carbonyl, the residue is returned to the roasting furnace. The nickel carbonyl is treated in the decomposing apparatus, wherein the nickel is recovered as granules assaying from 99·4 to 99·8% Ni. Reports indicate that Mond's volatilization process, although ingenuously worked out in its practical application, developed several weak features, notably; incomplete extraction at several stages of the operation, which make it necessary to hold back considerable nickeliferous material in process for retreatment; danger of explosion; losses in nickel, and poisoning from leakage of CO gas. All of these features seem to militate against the commercial success of Mond's process.

Developments in Germany.—The electrolytic works of the Allgemeine Elektro-Metallurgische Gesellschaft, at Papenburg-a.-d.-Ems., are reported as producing a small output of copper and nickel, according to a modified Hoepfner process, using a chloride solution. The capacity of the works is one ton of refined copper and nickel daily, although the actual output is only a small fraction of a ton. The following process is said to be in use: The ores and matte received at the works are leached with a cupric chloride solution to dissolve the copper, nickel and silver contents, and simultaneously reduce the cupric salt to the cuprous state. After purification and freeing from silver, the solution is passed into electrolytic cells provided with carbon anodes and copper cathodes. Chlorine is liberated at the anodes and utilized; about half of the copper in the electrolyte is recovered by electro-deposition, and the cupric solution remaining after electrolysis is withdrawn and re-used in leaching a fresh charge of ore or matte, until it is found desirable to recover the nickel in the solution. This is done electrolytically, after

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[1] *Stahl und Eisen*, Vol. XXII., p. 1082.

first removing the copper in the acid solution, probably by electro-deposition with lead anodes in so-called "finishing" tanks. Very recent reports indicate that the Papenburg concern has not been eminently successful, and that the entire plant is to be remodeled.

Prof. W. Borchers finds that sulphide ores of nickel can be leached by an improved process, analogous to the Siemens & Halske ferric sulphate method, both cheaply and with a high percentage of extraction. He is now engaged in testing the practicability of this new method, which embraces the electro-deposition of the nickel in the treatment of low-grade ores containing nickeliferous sulphides.

Borchers and Gunther propose[2] to smelt nickel-copper sulphide ore to a matte in the ordinary manner and then to reduce the matte to a nickel-copper alloy. The latter is to be electrolyzed in an acid solution of copper sulphate, according to Andre's method, yielding electrolytic copper, an anode slime consisting of Cu_2S, Cu_2O and the precious metals, and a solution of nickel sulphate. The latter is to be freed from cobalt and small quantities of iron by known methods and then electrolyzed hot, with lead anodes, in solutions of alkali salts, of which the anion will form soluble salts with the anode metal, whereby products which can be worked up into white lead, chrome yellow, etc., will be obtained at the anode and pure nickel at the cathode. This is conceived to offer advantages over the American method of tops and bottoms smelting.

The blast furnace erected near Frankenstein, Silesia, for treating the nickel ores of the neighboring Martha and Benno mines has a capacity of 25 tons of ore daily, but is soon to be enlarged. The crushing mill and blowing engine for the smelter are supplied with power from two steam engines, one of 120 H.P., and the other 75 H.P. Productive operations started in 1899 when 80 tons of nickel ore were treated, and the output was increased in 1900 to nearly 4,000 tons crude ore valued at $20,000.

Magnetic Behavior of Nickel Alloys.—Prof. Barret and Dr. Brown find that 2·5% Ni in iron hardly affects the magnetic quality, and 5% Mn in steel leaves a strongly magnetic material, but 2·5% Ni plus 5% Mn in steel makes the latter non-magnetic.

Perron's Process of Treating Copper-Nickel Ores.—C. Perron,[3] of Rome, Italy, patented a lixiviation process for poor copper-nickel ores, consisting in the treatment of the said ores in crude or natural condition with ammonium sulphide.

Haas' Process of Melting Nickel.—H. L. Haas,[4] of New York, has patented a continuous process of melting and refining nickel containing carbon, consisting in subjecting a column of a mixture of nickel in granular form directly with fuel, to heat generated from said fuel; passing large quantities of air under excessive pressure upwardly through the entire column of nickel and fuel, to insure a temperature above the melting point of nickel and to oxidize the carbon in the nickel; allowing the melting nickel to flow downwardly through the mass, and in contact with the air; drawing off the melted nickel with more or less continuity below the column; and supplying fuel and granular nickel as necessary to the top of the column to maintain the temperature and to continue the process.

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[2] *Zeitschrift fuer Elektrochemie*, 1902, Vol. VIII., p. 747.

[3] United States Patent No. 709,277, Sept. 16, 1902.

[4] United States Patent No. 709,218, Sept. 16, 1902.

Browne's Process for Separation of Copper and Nickel.[5]—This process consists in first treating copper-nickel matte to form copper-nickel alloy substantially free from sulphur, and then treating said alloy with chloride and a solvent for cuprous chloride.

Present Development of Electrolytic Nickel Refining.—The Vivian, Balbach, Cleveland, Hamilton and the Papenburg electrolytic nickel refineries were described by Ulke,[6] who gave many new facts concerning the Vivian and the Balbach plants and the conditions governing profitable refining. The Vivian electrolytic nickel-copper separating works were erected at Swansea, Wales, in 1892, and were designed to treat about 10 tons per week of a nickel-copper alloy produced from Sudbury matte. The Balbach electrolytic nickel refinery was built in 1894, and operated until 1900, during which time about 1,000 tons of electrolytic nickel were produced. With every horse-power of current, averaging between 1·7 and 1·8 volts and 15 amperes per sq. ft. of cathode surface, there were deposited between 2 and 4 tons of nickel per annum out of a hot neutral solution of nickel sulphite. From crude nickel anodes, assaying between 94 and 97% Ni, a remarkably pure and strong metal, containing not more than 0·25% Fe, and practically free from carbon, silicon and sulphur, was obtained. The main drawback of the process adopted was the large amount of scrap produced from the imperfectly smelted and very brittle anodes. It was subsequently found that this difficulty could be obviated, or at least considerably diminished, either by using an anode frame, in which metallic or semi-metallic granules, scrap or powder (easily secured by reducing nickel oxide) is used instead of the more expensive cast anodes, or by connecting slabs of crude nickel, serving as electrodes, in series circuit, as suggested by Mr. William Thum, so that the nickel deposited on the cathode side would make a staunch backing for the crumbling crude nickel of the anode side, besides obviating the need of anode suspension and contact lugs. It is claimed that electrolytic nickel cathodes can be produced from Orford anodes in this way at a cost of less than 1c. per lb.

Besides metallic nickel, the metallurgists of the Balbach Smelting & Refining Co., who were the pioneers in the commercial electrolytic refining of nickel as well as of copper in America, have for many years been producing nickel-plater's salts. The Balbach method of recovering nickel sulphate consists chiefly in repeated fractional crystallizations and a final removal of the remaining copper by electrolysis.

Nickel-Steel Rails.—The results of tests made by the Pennsylvania Railroad with nickel-steel rails at points where the wear is unusually heavy appear to have been favorable, for orders were recently placed for 9,000 tons, the steel to carry 3·5% Ni. Although the price for such rails is very nearly double that of ordinary steel rails, it is believed that their extraordinary toughness and hardness will repay the extra cost. The nickel used in making the rails is metallic nickel, and according to reports, is added in the converter.

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[5] United States Patent No. 714,861, Dec. 2, 1902.

[6] *Electrochemical Industry*, 1903, Vol. I., p. 208.

OCHER AND IRON OXIDE PIGMENTS.

BY JOSEPH STRUTHERS.

THE production of mineral paints, including ocher, umber, sienna and iron oxide in the United States during 1902 amounted to 55,320 short tons, valued at $705,026, as compared with 43,036 short tons, valued at $516,308 in 1901. The aggregate quantities of these products imported in 1902 and 1901 were respectively 13,447,408 and 11,149,274 lb. The production of Venetian and Indian reds in 1902 was 11,758 short tons, valued at $196,905, as compared with 9,201 short tons, valued at $153,467 in 1901. The leading States in the production of ocher are Pennsylvania, Georgia, California and Vermont, while iron oxide comes largely from New York, Pennsylvania and Tennessee. Umber and sienna are produced chiefly in Illinois and Pennsylvania. Under Venetian and Indian red is included only the pigment made by calcination of copperas. The chief producers are the American Steel & Wire Co., at Waukegan, Ill., and Worcester, Mass.; C. K. Williams & Co., Easton, Pa.; S. P. Wetherill & Co., Philadelphia, Pa.; George S. Mepham & Co., St. Louis, Mo.; Henry Erwin & Sons, Bethlehem, Pa., and Hanna & Andrus Co., Chicago, Ill.

IMPORTS OF OCHER, UMBER AND SIENNA INTO THE UNITED STATES.

Year.	Ocher of All Kinds.						Umber. (a)		Sienna.			
	Dry.		Ground in Oil.		Total.				Dry.		Ground in Oil.	
	Pounds.	Value.	Pounds	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds	Value.
1898	a 5,898,720	$46,571	81,460	$1,546	5,980,180	$48,117	1,123,079	$9,051	544,713	$11,451	4,008	$280
1899	9,765.616	72,825	14,881	756	9,780,497	73,581	1,739,036	13,386	758,691	14,242	6,484	492
1900	8,449,252	57,842	19,167	1,019	8,468,419	58,861	1,703,256	11,862	796,584	14,912	6,835	495
1901	8,546,691	83,196	16,738	918	8,563,429	84,114	1,465,431	12,510	1,106,553	18,294	13,861	1,004
1902	9,988,518	107,285	19,668	1,013	10,008,186	108,298	1,894,425	16,133	1,535,877	27,310	5,921	494

(a) In 1898, 4,608 lb. ($823) ground in oil and 1,118,471 lb. ($8,728) crude, powdered, washed or pulverized; in 1899, 4,849 lb. ($300) ground in oil and 1,734,187 lb. ($13,086) dry, crude, powdered, washed or pulverized; in 1900, 11,658 lb. ($723) ground in oil, and 1,691,608 lb. ($11,139) dry, crude, powdered, washed or pulverized; in 1901, 3,184 lb. ($173) ground in oil and 1,562, 248 lb. ($12,337) dry, crude, powdered, washed or pulverized: in 1902, 11,999 lb. ($689) ground in oil and 1,882,426 lb ($15,444) dry, crude, powdered, washed or pulverized.

Iron oxide and Venetian red are made from both natural and artificial materials, chiefly the latter in connection with the manufacture of copperas, which is obtained as a by-product from the spent sulphuric acid used in the cleansing of wire, wire rods and tin plate. The copperas which is crystallized in the bottom of the tank is too impure to be of commercial value, and, owing to its limited use, the greater part of it is converted by different processes into iron oxides. There are two principal methods of manufacture, the "dry" and the "wet," details of which are given in THE MINERAL INDUSTRY, Vol. X. In the dry process, which is considered the cheapest for the production of low grades of oxides, the copperas is roasted in a furnace with lime or similar material to neutralize the acid in the sulphate until the desired strength and color of the product are obtained. In some cases copperas alone is roasted until the pure iron oxide remains, which is then mixed with a filler, as whiting or gypsum, to form the different grades of Venetian red, some having as little as 10% of iron oxide or coloring power. The wet process, which is the cheaper for general use, yields a less uniform product. In principle, the waste liquor from the cleansing or pickling process is treated direct for its iron oxide content by the addition of milk of lime, sodium carbonate, or similar reagent, which precipitates the iron as a hydrate or carbonate to the bottom of the tank; subsequently the iron salt is separated from the liquor by filtration through a press, the dried cakes are roasted in furnaces, cooled and packed for the market without grinding. Iron oxides made in this manner are not uniform in quality and have only a limited use. Various colors and strengths of oxides are obtained by the admixture of natural ore and ochers, and iron ores are sometimes ground and sold direct as Venetian reds. The natural products, however, are inferior to the manufactured and do not command as high a price. Great improvements in the processes of manufacture of iron oxides have recently been made, particularly in the dry process. Formerly, the domestic product averaged but 50% Fe_2O_3, but by the construction of crucible furnaces of special design whereby better control of heat and oxidation is obtained, the grade of the product has been raised to chemically pure iron oxide, the supply of which until now had been obtained entirely from foreign manufacturers. The improvements in the wet process are not so marked, although much has been accomplished in the direction of lessened cost of labor by the use of mechanical appliances which in addition has also yielded a more uniform product. It is probable that nearly the entire domestic demand for high- and low-grade iron oxides will be filled in the United States in the near future.

The principal manufacturers of iron oxides and Venetian red are: The American Steel & Wire Co., at Worcester, Mass., and Waukegan, Ill.; C. K. Williams & Co., Easton, Pa.; S. P. Wetherill & Co., Philadelphia, Pa.; Henry Erwin & Sons, Bethlehem, Pa.; George S. Mepham & Co., St. Louis, Mo., and Hanna & Andrus Co., Chicago, Ill. There are also smaller producers in the country who devote their attention to the mined and natural reds only.

Market.—Prices in New York during 1902 averaged about $14 per ton in barrels for mined reds, some of the product mined in Maryland and the South being offered at $10@$11 per bbl. For the manufactured or copperas reds prices averaged about $23 per ton, while for the iron oxide considerably higher prices were obtained, depending entirely upon the strength of iron and color. During 1902 domestic iron oxide red of high grade in carload lots has been sold as high as 6c. per lb.

PETROLEUM.

BY D. H. NEWLAND.

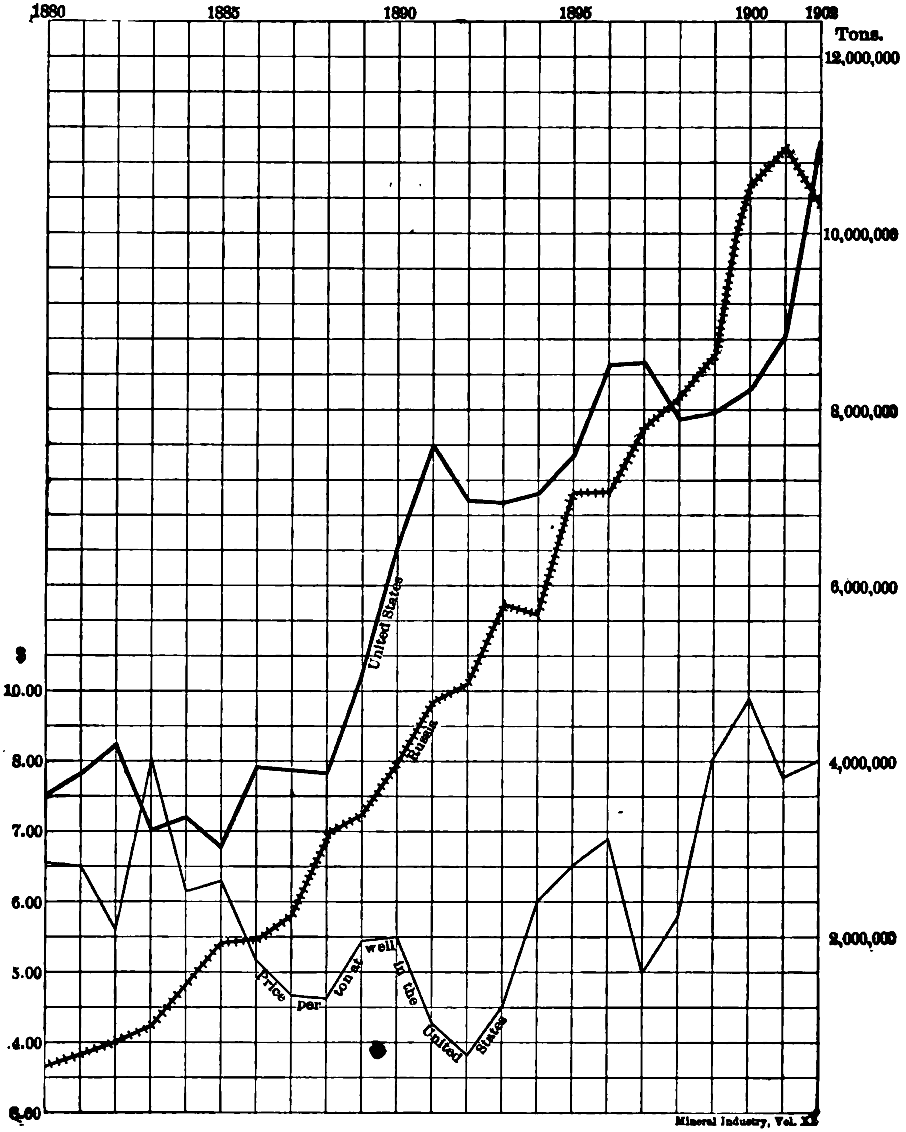
THE production of petroleum in the United States in 1902 was the largest recorded in the history of the industry, exceeding the total of the previous year by over 20%. This increase may be credited to the phenomenal development of the Beaumont field, which contributed more than one-fifth of the entire output, and in a lesser degree to the progress made in the California fields. The returns from the Appalachian district again showed a falling off, due to the exhaustion of territory without commensurate new discoveries, while the Lima field of Ohio and Indiana gave a slightly increased output. The year was thus characterized by a very large increment in the supplies of the lower grades of petroleum, and by nearly stable conditions in the Eastern fields from which the high-grade illuminating products are obtained. The demand for oils of all grades was unprecedented. Almost the entire production of the Beaumont and California wells was absorbed by refiners, consumers of liquid fuel, and gas manufacturers, at prices that rose steadily in the latter part of the year. The enlarged market for illuminating oils caused a heavy drain upon stocks in the Appalachian field, reducing them to the lowest figure known since 1895.

PRODUCTION OF CRUDE PETROLEUM IN THE UNITED STATES. (BARRELS OF 42 GAL.)

Year.	Appalachian Field. (*a*)	California. (*b*)	Colorado.	Indiana. (Lima Field.) (*c*)	Kansas.	Ohio. (Lima Field.)	Texas. (*f*)	Wyoming.	Other States.	Total.
1898......	31,695,360	2,249,088	650,000	3,751,307	88,000	16,578,000	544,690	3,500	(*e*) 10,000	55,499,875
1899......	32,870,689	2,677,875	600,000	3,818,718	(*c*) 69,556	16,565,092	601,308	6,071	(*e*) 25,000	57,234,304
1900......	35,540,965	4,250,000	525,000	4,329,950	(*e*) 65,000	16,407,704	800,000	7,200	(*e*) 30,000	62,538,544
1901 (*g*) ..	33,618,180	8,786,330	460,520	5,757,086	179,150	16,176,293	4,393,660	5,400	12,623	69,389,194
1902......	*e*30,500,000	*e*12,500,000	*e*500,000	7,585,561	322,028	*e*16,000,000	16,838,154	(*e*)10,000	(*e*) 50,000	84,250,788

(*a*) Includes New York, Pennsylvania, West Virginia, and part of Ohio. (*b*) Statistics of California State Mining Bureau. (*c*) Statistics of State Geological Survey. (*e*) Esimated. (*f*) The statistics for 1899 and 1900 were furnished by Mr. C. F. Z. Caracristi. (*g*) Statistics of the United States Geological Survey.

One of the most noteworthy features of the year was the large consumption of oil as fuel. In California, especially, an extensive market has been developed, and crude oil has largely supplanted coal as a source of heat and power. The erection of several refineries in Texas raises some doubt, however, whether the Beaumont petroleum will be utilized for fuel to the extent that has been anticipated; a small rise in prices would seriously limit its possibilities for competing with coal, and such an increase may be expected if the refining industry proves to be a commercial success.



PRODUCTION OF PETROLEUM IN THE UNITED STATES AND RUSSIA.

The table on the following page gives an estimate of the quantity of petroleum produced in the important countries of the world during the period 1897-1901. There are a number of countries that make a small production from which it has been impossible, so far, to secure any reports, owing to the fact that the industry is conducted in a most primitive manner. China, Persia, Turkey, and several of the South American republics are among the producers not included in this table.

PRODUCTION OF CRUDE PETROLEUM IN THE COUNTRIES OF THE WORLD. (*a*) (IN METRIC TONS.)

Year.	Austria.	Hungary.	Canada.	Germany	India.	Italy.	Japan.	Russia.	United States.
1897..........	275,204	2,299	99,310	23,303	76,834	1,982	42,184	7,831,254	8,513,140
1898..........	323,142	2,471	98,044	25,789	71,627	2,015	(*c*)59,980	7,841,671	7,764,713
1899..........	309,590	2,125	113,718	27,027	106,000	2,242	(*c*)100,882	8,470,925	7,926,400
1900..........	347,213	2,199	91,139	50,375	140,084	1,683	64,508	10,524,919	8,262,406
1901..........	404,663	3,296	79,537	44,095	185,877	2,246	(*e*)	*f*10,879,736	8,839,263

(*a*) From the official reports of the respective countries. This table is only partially complete since it does not include the production of Roumania, Sumatra, Borneo, Java, South Africa, Peru, and some other countries. (*c*) Crude oil. (*e*) Statistics not yet available. (*f*) Output of Baku fields.

The stocks of oil on hand at the end of the year in the Appalachian and Lima districts are given in the following table, in which the quantities are expressed in barrels of 42 gal.:—

Appalachian.				Lima.			
1899.	1900.	1901.	1902.	1899.	1900.	1901.	1902.
13,451,191	13,147,717	9,635,492	5,699,127	10,345,927	14,988,928	17,760,306	17,463,518

The average prices of petroleum in the Appalachian and Lima fields are shown below:—

MONTHLY AND YEARLY AVERAGE PRICE OF PIPE-LINE CERTIFICATES PER BARREL OF CRUDE PETROLEUM AT THE WELLS IN THE APPALACHIAN FIELD.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Aver'ge
1898...	$0·65	$0·67½	$0·78⅛	$0·73½	$0·82½	$0·87⅛	$0·93½	$0·97⅛	$1·01⅜	$1·13¼	$1·16⅝	$1·17¼	$0·91⅛
1899...	1·17	1·15	1·18	1·18	1·18	1·13½	1·22⅛	1·27⅛	1·44⅛	1·50⅞	1·57⅛	1·65⅛	1·29⅛
1900...	1·66⅛	1·68	1·68	1·55	1·39⅛	1·25⅛	1·25⅛	1·25⅛	1·23	1·10⅛	1·06½	1·08½	1·35½
1901...	1·69⅛	1·25	1·29	1·20⅛	1·07⅛	1·05	1·18⅛	1·25	1·25⅛	1·30	1·30	1·21	1·21
1902...	1·15	1·15	1·15	1·17⅛	1·20	1·20	1·22	1·22	1·22	1·28	1·38	1·49	1·24

AVERAGE MONTHLY PRICES OF CRUDE OIL IN THE LIMA FIELDS.

Month.	1899.			1900.			1901.			1902.		
	North Lima.	South Lima.	Indiana	North Lima.	South Lima.	Indiana	North Lima.	South Lima.	Indiana	North Lima.	South Lima.	Indiana
January..	$0·80	$0·75	$0·75	$1·19¾	$1·14¾	$1·14¾	$0·87¼	$0·82¼	$0·82¼	$0·85	$0·80	$0·80
February.	0·80	0·75	0·75	1·24⅛	1·19⅛	1·19⅛	0·91	0·86	0·86	0·85	0·80	0·80
March	0·79	0·74	0·74	1·26	1·21	1·21	0·93⅛	0·88⅛	0·88⅛	0·85	0·80	0·80
April	0·79	0·74	0·74	1·19	1·14	1·14	0·88¼	0·83¼	0·83¼	0·86⅛	0·81⅛	0·81⅛
May	0·81⅝	0·76⅝	0·76⅝	1·08	1·03	1·03	0·80⅛	0·75⅛	0·75⅛	0·88	0·83	0·83
June......	0·85⅛	0·80⅛	0·80⅛	0·95⅛	0·90⅛	0·90⅛	0·79	0·74	0·74	0·88	0·83	0·83
July.......	0·90⅛	0·85⅛	0·85⅛	0·95	0·90	0·90	0·84	0·79	0·79	0·89	0·84	0·84
August....	0·93⅛	0·88⅛	0·88⅛	0·93⅛	0·88⅛	0·88⅛	0·91	0·86	0·86	0.89	0·84	0·84
September	1·03¾	0·98¾	0·98¾	0·91⅛	0·86⅛	0·86⅛	0·91¼	0·86¼	0·86¼	0·89	0·84	0·84
October...	1·07⅝	1·02⅝	1·02⅝	0·82⅛	0·77⅛	0·77⅛	0·94	0·89	0·89	0·93	0·88	0·88
November	1·11¾	1·06¾	1·06¾	0·80	0·75	0·75	0·94	0·89	0·89	1·00⅜	0·95⅜	0·95⅜
December.	1·16⅝	1·11⅝	1·11⅝	0·87	0·82	0·82	0·88⅝	0·83⅝	0·83⅝	1·10	1·05	1·05
Average...	$0·92⅛	$0·87⅛	$0·87⅛	$1·01¾	$0·96¾	$0·96¾	$0·88⅛	$0·83⅛	$0·83⅛	$0·90⅜	$0·85⅜	$0·85⅜

The exports of mineral oils from the United States during the past five years are given in the subjoined table. It will be observed that the exports of illuminating oils in 1902 were considerably less than in the previous year, while there was a large increase in the shipments of the crude, lubricating and residual products. The total foreign shipments from Galveston amounted to 26,666,875 gal., valued at $241,649, of which 18,430,353 gal., valued at $109,326, consisted of crude petroleum.

EXPORTS OF MINERAL OILS FROM THE UNITED STATES. (IN GALLONS.)
(1=1,000 IN QUANTITIES AND VALUES.) (*a*)

Year.	Crude Petroleum.		Naphthas.		Illuminating.		Lubricating and Paraffine.		Residuum.		Totals.	
1898.....	120,436	$5,016	17,257	$1,071	764,823	$38,895	65,596	$7,626	30,436	$815	998,478	$53,423
1899.....	118,690	5,958	18,210	1,597	733,393	49,173	71,105	8,656	21,609	658	963,007	66,042
1900.....	138,161	7,341	18,570	1,681	739,163	54,693	71,211	9,933	19,750	845	986,855	74,493
1901.....	127,008	6,088	21,685	1,743	827,479	58,491	75,306	10,260	27,596	1,255	1,079,059	78,786
1902.....	145,234	6,331	19,683	1,393	778,797	49,079	82,200	10,872	38,316	922	1,064,230	68,597

(*a*) In addition to the above, the following quantities of paraffine and paraffine wax were exported: 1898, 166,317 lb. ($6,368); 1899, 181,861 lb. ($7,650); 1900, 157,108 lb. ($8,186); 1901, 151,695 lb. ($7,960); 1902, 175,269 lb. ($8,898).

The following statistics showing the exports of naphtha, illuminating, lubricating and paraffine oils from the United States and Russia during 1902, are of interest. The quantities are expressed in gallons.

Countries.	Naphtha.	Illuminating.	Lubricating and Paraffine.	Total.
United States....................	19,682,627	778,796,758	82,200,133	880,679,518
Russia	....	319,651,670	44,645,400	364,297,070
Totals........................	19,682,627	1,098,458,428	126,845,533	1,244,976,588

The quantities of crude, residuum and distillate are omitted from both countries. Of the products named in the above table, the United States exported 70·7% and Russia 29·3%, showing a slight decrease for the former country, and a corresponding increase for the latter, as compared with 1901. The average value of the illuminating oil exported from the port of New York was 6·6c. per gal., while the average prices of Russian refined f. o. b. vessels at Baku was 0·77c. per gal.

The chief markets of the manufactured products exported from the United States, Russia and other countries are the United Kingdom and Germany.

The following is an official statement of the importation of petroleum and its products—illuminating and lubricating oils—into the United Kingdom for 1900, 1901 and 1902, in Imperial gallons, which are one-sixth greater than the United States gallon:—

IMPORTS OF PETROLEUM INTO THE UNITED KINGDOM. (IN ENGLISH GALLONS.)

Countries.	1900.	1901.	1902.
United States....................................	153,776,766	162,791,889	184,436,176
Russia....................................	87.765,897	78.206.984	88,202,588
All other countries....................................	13,435,380	12,785,873	12,161,722
Total	254,978,043	253,784,746	284,800,486

The exports to Germany for the years 1899, 1900, 1901, have been made up from the countries exporting the manufactured petroleum, and embrace the naphtha, illuminating and lubricating products in gallons exported from the United States and Russia.

While the importations into the United Kingdom from the United States increased from 60% in 1900 to 64% in 1901, those from Russia decreased in the same years from 34% to 31%. In 1902 Russia maintained its relative position with nearly 31% of the imports, and the United States showed a slight gain furnishing about 65% of the total. Of the imports into Germany from the two

REFINED PETROLEUM EXPORTED TO GERMANY BY THE UNITED STATES AND RUSSIA.
(UNITED STATES GALLONS.)

Countries.	1900.	1901.	1902.
United States	145,993,313	150,018,779	132,724,004
Russia	29,994,478	21,914,240	34,231,655
Total	175,987,791	171,933,019	166,955,659

countries, the United States furnished 83% in 1900, 87% in 1901, and 79% in 1902.

Liquid Fuel.—During 1902 a series of tests was carried out by the Bureau of Steam Engineering, United States Navy, with the view of determining the value of liquid fuel for naval purposes. The oil used for the official tests was Beaumont petroleum of the following composition: C, 83·26%; H, 12·41%; S, 0·50%; O, 3·83%; sp. gr., 0·926; flash point, 216°F. The calorific value of the combustible calculated by Dulong's formula was 19,481 British thermal units. The results obtained are summarized as follows: (*a*) Oil can be burned in a very uniform manner. (*b*) The evaporative efficiency of nearly every kind of oil per pound of combustible is probably the same. (*c*) Marine steam generators can be forced to even as high a degree with oil as with coal. (*d*) No ill effects were exhibited by the boiler. (*e*) The air requisite for combustion should be heated if possible before entering the furnace, as such heating assists the gasification of the oil. (*f*) The oil should be heated so that it can be readily atomized. (*g*) If steam is used for atomizing, high pressures are more advantageous than low pressures. (*h*) The consumption of liquid fuel probably cannot be forced to as great an extent with steam as an atomizing agent as when compressed air is used for this purpose.

Naphtha residues (mazut) are used in melting and re-heating furnaces in the steel works near St. Petersburg. After heating the oil to 40° or 50°C. by steam coils, it is gasified in gas regenerators and pumped into an accumulator which affords a pressure of from 5 to 7 atmospheres. The feed is effected by a Körting atomizing injector, with nozzles of varying aperture from 1·5 to 3 mm. blowing into the side of the regenerator near the bottom. A small accessory air supply is introduced at the same time to burn the first portion of the oil-gas which would otherwise choke the brickwork by a deposit of coke. The arrangements of the regenerator are similar to those for producer gas, except that the arch of the chamber must be raised about 6 in., as the specifically lighter oil-gas attacks the brickwork very readily. A newer and better method, which, however, has not been generally applied as yet, is to feed the furnace through concentric nozzles, the inner one carrying the oil and the outer one air at high pressure, when absolutely perfect combustion is obtained and the gas regenerators are dispensed with. In this system five water-cooled injectors are required, two for each end of the furnace, and a central one in the crown of the arch. Under ordinary working conditions, with 10 to 15-ton open-hearth steel-melting furnaces, the consumption of oil is about 20%, or in some cases 18% of the weight of the materials charged, the endurance of the furnace and the speed of working being about the same as with producer gas-firing.

Alaska.—Discoveries of petroleum have been made recently in the vicinity of Controller Bay, near the mouth of Copper River, where early explorers found some indications of oil from springs. A well sunk 265 ft. yielded high-grade petroleum, containing a large proportion of refinery products and little residue, while another well gave a good lubricating oil. This district is to be actively explored during the summer of 1903.

Appalachian Field.—There was little change in the status of the Pennsylvania and West Virginia fields. The failure of the strong advance in prices during the year to stimulate an increase of output, together with the large number of dry holes put down, created apprehension as to the future, and there is little doubt that the productive areas in these States have been quite closely defined. The unfavorable condition of the producing industry necessitated a heavy drain upon stocks to meet the demand. In West Virginia new oil territory was found in the Salem district of Harrison County, and two pools were opened near Big Knob Run, Ritchie County, which gave a large output. Wetzel and Greene counties also made a favorable showing. An experiment in the pumping of wells by electricity from a central station is to be tried in the Folsom district of Wetzel County. A plant is under course of erection which will be equipped to pump 200 wells, and it is hoped that a considerable economy will be effected over present methods. The Sartwell field in McKean County, Pa., attracted considerable attention during the year with the result that about 1,000 acres of productive territory was proved. The oil is found in the Kane sands at a depth of from 1,000 to 2,000 ft., and is of high quality. In southwestern Ohio a new discovery was reported near Jerusalem, Monroe County.

California.—While the petroleum industry continued in its course of rapid expansion during 1902, the conditions were less satisfactory than in the previous year. In 1901, when an increase of about 100% was registered, the production far exceeded the consuming capacity of the market as then developed, and as a necessary result the prices declined rapidly toward the close of the year. The same relation between production and consumption prevailed throughout 1902, although there was a steadily enlarging demand for the heavy oils for fuel purposes. The crude product of the Kern River field brought as low as 50@60c. per bbl. in San Francisco, which is equivalent to 10@20c. at the wells, while the price of Los Angeles oil fell to 35c. at the wells. Owing to this depression in the market many wells were closed down, and the drilling of new wells was carried on less vigorously than hitherto. The most important developments were made in the search for light oils for which there has been a sustained demand on the part of the existing refineries. Two new fields yielding petroleum of low specific gravity have been opened—the Santa Maria field in Santa Barbara County and the Halfmoon Bay field near San Francisco. In the former the Western Union Oil Co. has brought in 10 deep wells, giving a valuable refining product which can easily be transported to the coast. The Halfmoon Bay field, which is situated close to the sea, yields an oil of from 45° to 52° gravity; several productive wells have been opened, and a small refinery is in operation. The search for light oils continues elsewhere in the State. The important coaling field in Fresno County has maintained an even status, but its development has been hampered by the lack of transportation facilities. The production of petroleum by counties in 1901 was as follows:—

County.	1901.
Kern	4,493,455
Los Angeles	2,188,633
Fresno	780,650
Ventura	463,127
Orange	724,565
Santa Barbara	135,900
Santa Clara	....
Unapportioned	....
Total	8,786,330

The value of the output in 1901 was $4,974,540, or 57c. per bbl.; (statistics for 1902 not yet available). The total number of producing wells was about 2,500. As in the previous year the transportation facilities proved inadequate for handling the output of the interior fields. It is expected, however, that the situation will be relieved to a great extent with the completion of the pipe-line from the Kern field to San Francisco Bay, 278 miles distant, which will have a capacity of from 8,000 to 10,000 bbl. per diem. The pipe-line is being laid by the Standard Oil Co., which has also under construction a large refinery with storage tanks of an aggregate capacity of 750,000 bbl. at Port Richmond on San Pablo Bay.

Among the notable features of the year was the activity of the Associated Oil Co., a combination comprising about 30 producing companies in Kern County. In its first annual report for the year 1902 this company states that it produced and sold 2,648,456 bbl. of oil for which the gross sum of $1,572,426 was received, while the income after paying transportation charges amounted to $817,440.

It is estimated that the consumption of California petroleum during 1902 amounted to 12,000,000 bbl., or about 500,000 bbl. less than the production. The situation as regards maintaining a closer balance between supply and demand in the future is encouraging. The consumption of fuel oil by railroad and steamship companies will continue to expand at a rapid rate, as petroleum at present prices is much more economical than coal. At the beginning of 1903 there were about 1,000 locomotives burning California petroleum, and the consumption by railways alone approximated the rate of 6,500,000 bbl. per annum. So far the utilization of petroleum by steamships is limited largely to river and coasting craft, but several ocean-going steamers have recently installed oil burners, and the number will be increased during 1903. Liquid fuel has been successfully applied to smelting operations at the Selby works, near San Francisco, as described on page 449 of this volume.

Colorado.—(By Harry A. Lee.)—The oil fields of Fremont County have been productive since 1887, and during the past year this section has shown increased activity, many new wells having been drilled. The oil is encountered at depths varying from 1,200 to 3,000 ft., and is pumped to the surface. The extent of the oil field is not yet determined, or the source of supply fully understood. The oil appears to be found at different geological horizons, the Fox Hill shales underlying the coal measures being the most productive. The oils from the various wells do not differ greatly in character. A number of tests published and made by competent chemists show the naphtha and benzine to range from 4 to 6%; illuminating oils, 25 to 28%; paraffine and heavy oils, 55 to 60%; and a residuum (mainly coal tar), 6 to 7%. The refined products are consumed by the Western trade, and the residuum is utilized for fuel purposes. At the close of 1902 there were 57 wells producing and several new holes nearing the oil horizon. There are two local refineries with a combined capacity of about 2,000 bbl. per day. The following is a list of producing companies: Florence Oil Refining Co., Triumph Oil Co., Griffith, Rocky Mt., Fraser Oil & Gas Co., Fremont Oil & Gas Co., Keystone, Columbia Crude Oil Co., and the United Oil Co.

Prospecting in the southwestern and western portions of Colorado is still persistent, numerous surface indications having stimulated activity. In Mesa County, near De Beque, oil was encountered by one company at a depth of 600 ft.; but the flow being deemed insufficient, boring was continued to a depth of 1,300 ft., when a strong flow of salt water was encountered and the hole was abandoned.

Indiana.—During 1902 a new discovery of oil was made near Birdseye, Dubois County, in the southwestern part of the State. The oil-bearing stratum is believed to be the Trenton limestone, the same as in the Lima district, and is encountered at a depth of about 1,000 ft. The first well yielded about 5 bbl. per day. Two additional wells were drilled during the year, and early in 1903 a flowing well was reported to have been brought in by the Standard Oil Co. The Lima district of Indiana was the scene of great activity, the output for 1902 showing a gain of over 30% from the previous year's total.

Kentucky.—Following the discovery of the Sunnybrook field in May, 1901, there has been much activity in the various fields of this State. Many new wells have been put down in the Sunnybrook, Slickford, and Cooper districts, Wayne County; in the Ragland district, Butte County; in the Whitehouse district, Floyd County; and in the Richland district, Knox County. While the output of the individual wells is usually small, the cost of drilling is light owing to the shallowness of the oil horizon. The construction of the pipe line from Somerset to Chambersburg, W. Va., now under way, will give cheap transportation facilities to the fields of eastern Kentucky.

Louisiana.—The discovery of a new oil field in this State in 1902 has given further proof of the wide occurrence of petroleum within the Gulf coastal plain. The productive territory is situated in Acadia Parish about six miles northeast of Jennings and 93 miles east of Beaumont. Development work was started in the summer of 1901 by the Jennings Oil Co. and the Southern Oil Co., both of which found oil but were compelled to abandon the wells owing to clogging by loose sands. In May, 1902, the Southern Oil Co. drilled a third well, utilizing a lining to prevent the creeping in of sand, and oil was encountered at a depth of 1,850 ft. The well proved to be a powerful gusher with a yield of from 20,000 to 25,000 bbl. per day from a 6-in. boring. Other productive wells were opened during the year. The strata penetrated by the drillings consist of clay, sand and "gumbo" with only 8 ft. of firm rock above the cap rock overlying the oil sand, which is said to be more than 45 ft. in thickness. Storage tanks were erected near the wells, and a 4-in. pipe-line laid to the Mermenteau River and to Jennings, whence the oil was shipped by boat and railway. The local markets absorbed most of the year's production. The oil resembles that of Beaumont in having an asphaltic base, but it is said to contain little sulphur, and its gravity is 26°B. No definite estimate can be made as yet of the extent of the oil-bearing stratum; the area proved by the first wells was not more than 300 ft. square.

Montana.—Oil was found in the well of the Butte Oil Co. at Kintla Lake, near the Canadian boundary, but the yield was small. The Dillon properties have so far proved unproductive.

New Mexico.—The Salado district in Guadalupe County was actively prospected during 1902. Indications of oil are found in Silurian limestone. A large number of companies have been formed to operate in the Santa Rosa district, which is considered especially promising. Prospecting wells were drilled near Raton and near Farmington.

Texas.—The development of the Beaumont field made rapid strides in 1902, and the maximum productive capacity apparently has now been reached. In addition to the enormous increase in output, which amounted to over 175% compared with the previous year, the most noteworthy features of the industry were the steady decline of output from flowing wells, and the appreciation in prices of the crude product. The influx of salt water into many of the wells was another event which may be of serious portent. Despite the unusual flowage shown in the borings first put down on Spindle Top, the pressure began to decrease in the early part of 1902, and before the end of June many companies were unable to obtain sufficient supplies to fill their contracts. Pumping apparatus was hastily installed, and some 60 wells were thus equipped during the summer. The sudden decline in production reacted favorably upon prices, which for some time had ruled at from 15@20c. per bbl.; before the close of the year oil in lots of 100,000 bbl. for shipment was quoted as high as 50c. per bbl., with the demand still in excess of the supply. Several concerns which had engaged to furnish oil under low price contracts, later on repudiated their obligations. With the commencement of pumping operations trouble was experienced from salt water, which first appeared in the deepest wells, and later spread to all parts of the field, rising to a level of about 925 ft. below the surface. The source of the trouble was ascribed by some authorities to the influx of water from dry wells. The output of the Beaumont field in 1901 and 1902 was approximately as follows:—

PRODUCTION OF PETROLEUM IN BEAUMONT FIELD, TEXAS.

	1901.	1902.
	Barrels.	Barrels.
Shipments	3,593,118	9,128,154
Production held as stocks	1,592,770	6,105,000
Local consumption and waste	775,000	900,000
Total production	5,960,868	16,133,154

Transportation facilities, especially by railway, proved inadequate and consumers at distant points found difficulty in getting crude oil to meet their requirements. A considerable proportion of the product also was absorbed by the refineries, and there was a strong demand from the manufacturers of illuminating gas. The growing importance of the refining industry doubtless had its effect upon prices, as tests upon a commercial scale have shown that Beaumont oil is worth more for this purpose than upon a fuel basis. The products of refining include illuminating oil, gasoline, spindle and other commercial oils, and asphalt. The Gulf Refinery at Beaumont, when completed, will have an estimated capacity of 24,000 bbl. per day. A part of the plant was operated during 1902. The Burt refinery, southwest of Beaumont, is planned to handle an equally large quantity of crude oil, and two other refineries—one at Port Arthur and the second at Orange—are to be built. These extensive undertakings would seem to indicate that the utilization of Beaumont oil for fuel will not attain the importance that has generally been expected.

The outlay for new equipment in this field during 1902 is itemized below, the estimates being prepared from most reliable sources. Combining the total here given with the total outlay for 1901, it appears that the capital invested up to the end of 1902 was $10,572,085, or 48c. for each barrel of oil produced. These figures, however, do not include the expenditures for drilling outfits and tank cars, or the investments in land which represent a very large outlay, as in many instances small parcels on Spindle Top were sold at the rate of $120,000 an acre.

248 wells at an average of $1,500 each	$372,000	Earthen tankage	$625,000
Pipe lines to seaboard	1,100,000	Power plants	800,000
Loading racks	28,000		
Refineries in course of erection	2,250,000	Total investment during 1902	$7,175,000
Steel and wooden tankage	2,000,000		

The Sour Lake field, 20 miles northwest of Beaumont, reached the producing stage during 1902. Several flowing wells were put down in the early part of the year, and the region was soon the center of great activity, in which many of the prominent Beaumont companies participated. The results so far obtained indicate that the field has a promising future. Storage tanks of large capacity have been erected and a pipe line laid to Beaumont. The shipments during 1902 were limited by the lack of transportation facilities, the region being isolated from railway lines. It is stated that a tract of 850 acres in this field was sold for $1,000,000. The crude oil resembles that of Beaumont, but is superior to the latter for refining purposes.

New developments were reported in the Saratoga field in Hardin County, 14 miles west of Kountze. In 1895, a well was drilled here which produced oil in small quantities, and recently a flowing well yielding about 500 bbl. per day has been put down. Further exploration is now under way. The oil is very heavy, and nearly free from sulphur.

Utah.—The Green River district attracted considerable attention during 1902, and it is reported that eight wells were drilled which yielded oil by pumping.

Wyoming.—(By Wilbur C. Knight.)—The production of petroleum for 1902 did not show any marked increased over that of 1901, due to the lack of transportation. Wells have been commenced at Hilliard, Spring Valley, Twin Creek, Popo Agie, Powder River, Bonanza, Belle Fourche, Newcastle, Salt Creek, Douglas and near Ft. Steele, and oil has been found at Twin Creek, Ft. Steele and Douglas. Producing wells were completed at Spring Valley, Popo Agie and Salt Creek. The Popo Agie field has eight producing wells, each of which will yield, from the best available data, 200 bbl. per day. These are all spouting wells, and are now packed awaiting transportation. This field could within a very short time supply 1,000,000 bbl. of oil annually. At Salt Creek the Pennsylvania Co.

have nearly doubled its output by drilling new wells, and is arranging for extensive development during 1903. Three other companies are arranging to commence work at Salt Creek. In other fields where companies have commenced developments, the wells have not reached a sufficient depth to penetrate the oil horizons. Three of the 22 oil fields in the State have been proven producers, and none of the fields has as yet been abandoned as worthless. There are companies organized at the present time to enter every oil district in the State during the coming year, and without question there will be sufficient drilling done during 1903 to prove at least one-half of the fields where there are oil springs or outcroppings of oil sandstone.

THE PRODUCTION OF PETROLEUM IN FOREIGN COUNTRIES DURING 1902.

BY PAUL DVORKOVITZ.

THE year 1902 was characterized by a gradual development of existing sources of oil supply, as well as of facilities for the distribution of the product. There were no great strikes such as made the year 1902 notable; the chief work being done in a readjustment of economic conditions, which in the previous year were sadly out of harmony. The year was also marked by a greater practical interest in petroleum as a substitute for coal for power purposes, the Texas oil strike bringing the question nearer to the region of possibility for fuel users in Great Britain. The first and foremost factor in the latter country has been the Shell Transport & Trading Co., Ltd., whose large tank steamers have been engaged in taking consignments of the Texas heavy oil into the United Kingdom for use as fuel and for gas enrichment purposes. Several railway companies have taken first steps toward the utilization of Texas oil on their locomotives, and some advance has been made in its adoption in the marine service. It is probable that great strides will be made in this direction during the coming year. A loading-depot has already been established at Thames Haven, eight miles from London, where the Hamburg-American liner *Ferdinand Laiesz* took aboard the first supply of petroleum for fuel purposes. This storage installation is the first of a number of similar installations being erected in different parts of the United Kingdom.

The general condition of the Russian industry does not call for much comment. The most marked feature, as will be seen later, has been a reduction in output in every district with the exception of Romany. At the same time industrial and economic forces have been at work which are not representable by figures, but which undoubtedly have had a considerable influence on the Russian oil industry. This was especially instanced in the export trade as a result of the combination of certain interests and of the disastrous condition in which the refiners found themselves. Prices during the year showed a tendency toward firmness, and the year 1903 opened with much better prospects than the past year. During 1902 Russian oil came into much closer competition with the American product than in the previous year, especially in Far Eastern markets. In England, however, American oil has been sold in greatly increased quantities, showing an increment of something like 20,000,000 gal., while Russian oil has advanced only by about 5,000,000 gallons.

As to other Continental fields, those in Roumania have shown an increased output, but conditions there have not been favorable to an extension of trade; Galicia has fared even worse, though its output has advanced. Lack of good management and local friction have contributed to the unsatisfactory year's results in both countries.

In the oil industry of the Far East there is nothing special to chronicle beyond the fact that the Standard Oil Co. endeavored unsuccessfully to obtain a foothold in the oil fields of British India.

The Canadian fields have attracted renewed attention during the year, due to the development of a large well which flowed regularly 50 bbl. an hour—the largest yet opened in this country.

In reviewing the occurrences of the year the official visit of Mr. Gulishambaroff, representing the Russian Government, to the Texas oil fields should be noted, and the exhaustive report[1] which he subsequently published in regard to this region.

The working of the English companies in the Russian fields has been attended with unfavorable results during 1902; the consumption of oil for fuel fell off, and prices having been low, the majority of the companies showed either losses or a greatly depleted surplus. The Russian Petroleum & Liquid Fuel Co. has been the only concern to pay a dividend, which was much lower than in previous years.

Austria.—The total quantity of crude oil produced by the Galician wells during 1902 was 576,000 metric tons, exclusive of oil used as fuel. This quantity exceeds that of the previous year by 123,800 tons, or 21·35%, the advance being due chiefly to the great progress made at Boryslaw, where 261,220 tons were produced, which is 46% of the total output. Eastern Galicia contributed 467,300 tons, and Western Galicia 108,760 tons. The number of borings at the close of 1902 was 1,824, showing the average output per well to have been 316 tons. In Boryslaw, however, where the oil was obtained from spouters, the average production per well was 3,000 tons. In this district no less than 125 wells were in course of boring at the close of the year. About 490,230 tons of crude oil were passed through the refineries, but nearly 85,000 tons of this total could not find a market, and consequently there was a considerable fall in prices. During the year 30,930 tons of burning oil were exported to foreign countries, the Galician oil having made good progress in various foreign markets.

Canada.—During 1902 the new oil field discovered at Chatham, Ontario, was the cause of considerable excitement in America and England. The well first brought in at a depth of 357 ft. was a gusher, and produced as much as 50 bbl. an hour. The oil is of good quality and has a gravity of about 34°B., which is about two degrees lighter than the Petrolia oil. The Standard Oil Co. holds land in the vicinity of this well to the extent of 1,900 acres, and among other companies working in the neighborhood is the Canadian Oil Fields, Ltd., an English company already owning a large tract of land with 350 oil wells.

Dutch East Indies.—Considerable attention was devoted to the petroleum industry in this part of the world during the year, but the record of the different

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[1] *Petroleum Review*, July 26, 1902.

fields has been a very variable one. Mr. A. V. Ragosine, of Baku, paid an extended visit to these eastern fields, writing a very comprehensive and valuable report thereon for a Russian journal. These articles were translated and appeared in English in the *Petroleum Review*,[2] and are full of interesting data, including the geological conditions, qualities of the different crude products obtained, as well as of the refined products, general conditions of marketing, etc. From a geological point of view, the formation of the Palembang oil fields belongs to the Miocene, and that of Langkat to the Eocene period. The deposits in eastern Java also belong to the Miocene period. The crude oils produced are of a varied character. Some are rich in benzine and others contain none whatever, and not infrequently little kerosene. Some contain a large quantity of solid asphalt, while others not only do not contain asphalt, but little, if any, mazout. Some oils contain paraffine; others yield residuals suitable for the manufacture of fairly viscous lubricating oils; while others are entirely free from high-boiling hydrocarbons. The specific gravity of the crude oil varies within the following limits: Sumatra, 0·780 to 0·964; Java, 0·780 to 0·964; Borneo, 0·853 to 0·975.

The length of pipe lines laid in the Dutch East Indies is considerable. The Royal Dutch Co. has in north Sumatra a pipe line from its fields to the refinery, a distance of more than 130 miles. The Moesi Ilir Co. is now building at Palembang a 4-in. pipe line 106 miles long from its fields to the refinery. The Royal Dutch Co. produced 3,950,700 cases kerosene in 1902, compared with 3,295,000 cases in 1901, and 1,350,000 cases in 1900; the Sumatra Palembang Co., 654,000 cases in 1902, 770,000 cases in 1901, and 797,000 cases in 1900.

Germany.—The petroleum industry of Alsace made good progress during the year, though there are no figures available to show the total output of all companies. As to new work in Germany, recent explorations were made for petroleum in the alluvial flats of the Rhine valley at some distance from Pechelbronn. A geological survey revealed that in the vicinity of Kandel a Tertiary anticlinal existed, which crossed the Rhine near the confluence of the Lauter and consists in part of the same Oligocene strata which have been so productive at Pechelbronn. So far, two borings have been sunk in the new district yielding petroleum vapor and traces of the liquid product. The constitution of this gas is similar to that at Pechelbronn.

India.—In 1901, the production of petroleum, which in India is confined to Burma and Assam, amounted to 50,000,000 gal. Of this quantity, 49,000,000 gal. were produced in Burma. Notwithstanding the fact that the production has largely increased it is insufficient to meet the demand and kerosene and lubricating oils are imported from Russia and America. According to a special report by M. Miraboff, delegate of the Baku Naphtha Association, the imports of Russian petroleum into Bombay during the fiscal year 1901-2 amounted to 28,398,987 gal., while those of American petroleum were only 185,264 gal. In 1887-8 the imports of Russian oil were 2,193,877 gal., and of American 2,315,287 gal. The imports into Calcutta in 1902 were 15,889,000 gal. from Russia and 1,560,000 gal. from America.

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[2] *Petroleum Review*, Vol. VII., No. 198, *et seq.*

Mexico.—The Mexican Petroleum Co. expended over $500,000 during 1902 in sinking wells and construction work on its property near Ebano, State of Vera Cruz. It is reported that oil was found on the line of the Vera Cruz & Pacific Railroad in Vera Cruz, and encouraging results were obtained in the Masuspama fields of Tabasco.

Persia.—Researches on the Perso-Turkish frontier have proved the existence of an extensive petroleum deposit, and a concession was obtained from the Persian Government for the exploitation of petroleum in that country for a period of 60 years. The oil field is in the Kermanshah province, about 10 miles from the village of Kassershirin, and contains a group of five petroleum hand wells, of which three yield a good quality of oil, and two contain oil mixed with water and slime. For the purpose of delivering the oil on board tank steamers for distribution to the ports of the Persian Gulf, India, and the Red Sea, it is proposed to construct a pipe line to Muhammer, a distance of about 400 miles.

Peru.—The principal companies engaged in the production of petroleum in 1901 were the Establecimiento Industrial de Zorritos operating in the district of Tumbas, and the London Pacific Petroleum Co., in the district of Payta. The total output for the year was 11,272,400 gal. crude petroleum, of which 3,258,000 gal. was refined and yielded 516,920 gal. kerosene, 667,412 gal. benzine, and 1,983,500 gal. residuum, while about 6,400,000 gal. were sold in the crude state.

Roumania.—The oil industry of Roumania during 1902 has been the victim of adverse circumstances resulting chiefly from the unsatisfactory condition of the Russian industry. While the production of oil showed an advance in all other aspects the year was a poor one. Prices for crude oil, which stood at 4 fr. per 100 kg. in October, 1901, were as low as 3 fr. in April, 1902, declining toward the end of the year to 1·90 fr. The natural result of this fall in price was that a number of producers had to reduce their output, while much boring work in progress was brought to a standstill.

The output from the Roumanian wells from 1893 to date is given in the following table:—

Year.	Metric Tons.	Year.	Metric Tons.	Year.	Metric Tons.
1893	56,600	1897	110,000	1900	250,000
1894	64,550	1898	180,000	1901	270,000
1895	75,000	1899	250,000	1902	310,000
1896	80,000				

The districts from which the output in 1902 was obtained, with the contribution from each, were as follows: Prahova, 259,000 tons; Dambovitza, 33,000 tons; Baicoi, 13,000 tons; Buzeu, 5,000 tons.

The chief producing company in the country is still the Steaua Romana Co., although much important work has been done by the International Petroleum Co. and the Telega Oil Co.

During the year the districts of Griusor and Baicoi in Prahova and Gura Ocnita in Dambovitza have been prominent. In the Baicoi district prospecting work led to the discovery of a large deposit of ozokerite.

One of the chief disadvantages from which Roumania has suffered during the past year was the want of unanimity among refiners and exporters of the oil. Toward the close of the year this was somewhat alleviated by the formation of a syndicate of the principal refineries who combined to maintain the price of refined products.

A branch of the industry in which Roumania has a great interest is that of liquid fuel, the consumption of which by industrial establishments as well as by railways, made rapid progress during the year. About 40,000 tons of petroleum were consumed by the Roumanian railways as compared with 30,000 tons in 1901. Its use for marine purposes has also obtained great favor, and it is to be introduced in vessels belonging to the Government.

The exports of petroleum products from Roumania during the last eight years were as follows:—

Year.	Tons.	Year.	Tons.	Year.	Tons.
1895	16,015	1898	84,511	1901	60,554
1896	19,871	1899	68.635	1902	70,000
1897	24,270	1900	87,962		

Of the exports in 1902, Germany received 22,764 tons, England, 17,600 tons, and Austria-Hungary, 15,467 tons.

In the *Petroleum Review,* Oct. 18, 1902, an illustrated account is given of the electric installation at Sinaia, Roumania, for supplying electricity to the borings at Campina and Bustenari.

The central power station is at Sinaia, where the water works also are situated, which drive the turbines employed for generating the electric current. Each turbine is coupled to a 250-kw. dynamo, and the power generated is transmitted to Doftana, a distance of 34 km. The total available power is 1,500 H.P., the current being generated at 3,000 volts, which is raised in four transformers to 11,000 volts, and so transmitted. At Campina and Bustenari this is retransformed into 500 volts, the voltage used for the motors. At the wells great precautions have been taken to prevent sparking; the motors are carefully enclosed, and the cables enclosed in insulated tubing, are not brought nearer to the derrick than 20 m. By a special device the men at the derrick are able to start, stop or reverse the motor at a moment's notice. The company claims that by the introduction of electric power for the purpose of boring, a saving of 40% in expenses is obtained. Every motor has an independent switch and resistance, and the power generated is transmitted by a belt attached to countershafting on the derrick. The speed can be kept under control. The Steaua Romana Co. has 30 motors working at Campina, and 27 at Bustenari. The usual depth of the wells at Campina is between 350 and 450 m., and the diameter at the bottom varies between 5 and 14 in.; the water-flush system of boring is used, being a combination of the Canadian and the Vogt systems.

Of the 60 electrical borings in Campina, only 30 are in operation. At Bustenari 27 of the 40 are producing. The cost of electric installation for boring, including the motor and necessary accessories, amounts to between 12,000 and 15,000 fr. per well.

Russia.—Baku.—The production in 1902 has shown a considerable shrinkage from that of the previous year, the statistics being respectively, 10,274,200 and

10,879,736 metric tons, equivalent to 76,383,463 and 80,553,152 bbl., respectively. The proportionate contributions from the various fields and the average depths of the wells during the last five years were as follows:—

Field.	Percentage of Total Production.					Depth of Wells.				
	1898.	1899.	1900.	1901.	1902.	1898.	1899.	1900.	1901.	1902.
						Feet.	Feet.	Feet.	Feet.	Feet.
Balakhany	22·4	21·8	20·6	17·8	16·3	720	795	749	749	714
Bebe-Aibat	19·9	15·2	18·2	19·7	20·2	1,601	1,309	1,211	1,289	1,568
Romany	20·7	17·6	18·9	18·0	21·2	1.439	1,339	1,428	1,456	1,456
Saboontchi	37·0	43·8	41·4	41·9	42·4	966	994	847	980	994

Saboontchi has thus practically held its place as a producer among the Baku districts, while each of the other fields has registered a marked decline. It is to be noted also that the average depth of the wells has increased.

In order to show in more detail the condition of the Russian fields relative to the descriptions of wells the following table is presented, giving the production by "spouters" and pumping wells.

	1902.		1901.	
	Spouters.	Pumping.	Spouters.	Pumping.
	Tons.	Tons.	Tons.	Tons.
Balakhany	....	1,637,165	....	1,899,739
Saboontchi	163,650	4,145,866	612,163	4,150,008
Romany	621,720	1,535,410	407,506	1,647,728
Bebe-Aibat	743,310	1,312,059	613,977	1,541,078

It will thus be seen that Bebe-Aibat has again broken the record in the way of increased output by spouters. Romany has also made a great advance in this respect, while Saboontchi has experienced a very great decline.

The stocks of crude oil at Baku at the close of the year compared with the previous year were:—

	Jan. 1, 1902.	Jan. 1, 1903.
At the wells	2,058,983 barrels.	1,015,056 barrels.
At the refineries	6,850,733 barrels.	3,378,335 barrels.

The course of Russian prices during 1902 has been a gradual progression, opening the year with crude at 5@5·25 kopecks per pood, refined at 6·5@6·75 kopecks, and residuals at 6@6·25 kopecks. As a contrast to this, the year 1901 opened with prices of crude at 11·725@11·75 kopecks, refined at 15 kopecks, and residuals at 13·5 kopecks. At the close of the latter year, the figures had fallen to 6@6.25, 6·75@7, and 6·75@7 kopecks respectively, a remarkable agreement in price for the different products. This anomalous condition of things continued into 1902, the price for crude still rising, refined falling, and residuals rising. At the middle of the year the market took a turn for the better, although crude still continued to rise. This was the first point of improvement, and at the end of July, refiners saw the first favorable balance between the price of the crude and their products. With one or two fluctuations, this amelioration was carried through the remainder of the year when prices were: Crude, 8 kopecks; refined, 15 kopecks; and residuals, 7·125 kopecks.

The export of refined Russian oil showed a falling off, a result that was unexpected in view of the low prices prevailing at Baku. The principal part of the decrease was in bulk and case shipments to points beyond the Suez Canal. The total exports from Black Sea ports in 1901 and 1902 were as follows:—

EXPORTS OF PETROLEUM FROM BLACK SEA PORTS (BARRELS OF 42 GALLONS).

	Crude and Residuum.	Lubricating Oil.	Solar and Distillate	Refined.
1901	815,950	915,710	1,147,500	7,826,963
1902	305,192	1,062,986	1,080,327	7,610,754

The number of wells sunk during 1902 was 244 compared with 355 in the previous year, and the borings in progress numbered 171 against 271 in 1901.

A few years ago an electric power station was erected by Messrs. Nobel Bros., the electric motors being driven by five gas engines of from 112 to 125 H.P. each, for which special gas works were erected. This station continues to work to the present time, although it has proved too small for the Nobel fields. It supplies only 10 motors; power for the other borings is obtained from the Electric Power Co., which supplies power for all the motors in case of stoppage of the Nobel station. The Electric Power Co. has already spent 7,500,000 rubles on the equipment of its electric stations. Electric energy is generated by means of four steam engines. The White City station supplies at present 46 motors. The replacing of steam by electricity is developing very slowly at Baku, notwithstanding the fact that the danger of the fire from the boilers is admitted to be great.

Grosny.—The petroleum industry of Grosny, affected largely as it is at present by the conditions of the Baku industry, has not shown many signs of prosperity during the past year. The chief direction in which these fields could improve their position is by an increased output, and this has not been obtained, in spite of the many statements made in different quarters in regard to the productive character of the field. The production of crude petroleum in 1901 amounted to 4,190,918 bbl., while for the year 1902 the quantity was 4,125,999 bbl.

The number of wells drilled on January 1, 1900, was 106; 1901, 147; 1902, 177.

Other Districts.—Rich petroleum deposits occur near the village of Tchongelek, on the Black Sea, within 16 miles of the town of Kertch. In 1884, Col. Gowen, an American, put down several boreholes near Kertch, and although of slight depth and small diameter, they yielded a large quantity of combustible gas and petroleum. This venture, however, was discontinued for want of capital. In 1883, the Société Anonyme des Pétroles de Crimeé, was formed for the exploitation of petroleum deposits in the Crimea. Borings were to have been put down over an area of about 60,000 dessatines (162,000 acres), which was leased for the exploitation of petroleum. This company also failed.

It would appear that the oil deposits of the Caucasus, Grosny, and the Crimea form one belt along the Caucasian mountain range, the northern wing of the belt beginning on the Kertch Peninsula. In generalizing the occurrence of petroleum, some geologists declare that the rich Roumanian oil fields (200 km. west of the Black Sea) are a continuation of the Kertch, Taman, and Grosny oil deposits.

The Tchongelek crude petroleum is of superior quality. According to analyses made at the laboratory of the Kharkoff Technological Institute, its specific gravity is not more than 0·8641 or 31°B. The products obtainable by distillation are: kerosene, 36%, and heavy oils, 30%.

During the last two years work in the oil fields of Tcheleken has been proceeding actively. Apart from several spouting wells there are more than 50 wells on the island now producing, the oil being pumped. Nobel Bros. has started a 26-in. borehole on its Alia-Tepe plot. Altogether the number of borings on Tcheleken amounts to about 100.

The district of Berikei has also been exploited during the year. The property is situated about five miles from Berikei, 25 miles from Derbent and about 230 miles from Baku. On Dec. 12, 1902, a trial boring having a depth of 1,365 ft. and a diameter of 12 in. began to spout, but was soon stopped by a cork being formed. The well was subsequently opened again, but the yield did not exceed 6,000 poods per 24 hours. Prospecting work on the adjoining plots is attended with little success, although indications of oil are found there.

South Africa.—A deposit of petroleum exists in the Wakkerstroom district, but it is not certain that oil is present in paying quantities. According to the latest report by Mr. E. Cave, the indications of petroleum are most pronounced. One locality known as the "oily" spring, is situated upon an anticlinal in the Pongola mountain chain.

Spain.—Up to the present time little has been done in connection with the production of petroleum in Spain, although deposits are known to exist. The Sociédad Española á de Sodeos has sunk borings at Salvatierra to a depth of 325 ft., under the direction of Federico Luzuriaga. Salvatierra is situated in the narrowest part of the Alva plain in a valley enclosed on one side by the mountains of Elgea and San Andrian and on the other side by those of Eucia and Urbasa. The surface of the ground is very broken, and the sedimentary strata running from east to west, have a varying dip toward the south. Veins of calcite with a strong odor of petroleum cross each other in all directions, forming a network. The more important of these strike northeast and southwest. About 16 km. southwest of Salvatierra are situated the celebrated asphalt mines of Maetsu, which according to Mr. Adan de Yarza, are situated 2,670 ft. above sea level, while Salvatierra is at an altitude of only 1,940 ft. The north of Spain falls within the petroliferous region of Europe, and petroleum is known to exist in large subterranean pools, especially in regions close to mountain ranges and sea coasts; while the asphalts are at a higher level than the naphtha bitumens and liquid hydrocarbons.

Turkey.—Mr. J. E. Spurr describes the oil resources of the Turkish Empire in the *Engineering and Mining Journal,* Oct. 4, 1902. Fields of considerable extent and of possible future importance are known to occur in the southeastern part of the Empire in the vicinity of Bagdad. The oil-bearing strata are apparently of Tertiary age, from which the petroleum exudes and collects in little lakes at the surface, these occurrences having been known to the inhabitants for a long time. The conditions are apparently similar to those obtaining in the oil districts of Persia near the Turkish frontier, and in the Russian oil fields of Baku. Oil is said to exist also on the south shore of the Black Sea, being here a continuation of the Baku field. On the southwestern coast of Asia Minor north of Cape

Chelidonia is the famous Chimæra of the ancient Greeks. Here gases are continually disengaged from fissures, and are known to have been burning for at least 2,800 years, as the phenomenon was described by Hesiod before the time of Homer. According to the Russian geologist Tchiatcheff the gas is emitted from fissures in an altered igneous rock (serpentine) which is intrusive in limestone. In this connection it is interesting to note that burning wells were known in the Baku field before oil was discovered. It is an open question whether the escaping gas of the Chimæra (modern Turkish, *Yanartash*—"stone that burns") is of organic origin and indicative of oil below, or is due to volcanic action. The conditions, however, seem to favor the former alternative, as the igneous rocks of the locality do not indicate recent volcanic activity. As is often the case, there seems to be a general connection between petroleum and natural asphalt in the Turkish Empire. Asphalt deposits are known in a number of localities of which those in Albania near the Adriatic and in Palestine deserve particular mention. From a general consideration of the facts noted it seems quite possible that important oil fields may be developed in this country.

PHOSPHATE ROCK.

By Joseph Struthers.

The production of all varieties of phosphate rock in the United States during 1902 amounted to 1,464,668 long tons, valued at $4,636,516, as compared with 1,483,723 long tons, valued at $5,316,403, which shows a decrease of 38,955 long tons in quantity and $679,887 in value from the statistics of the earlier year.

PRODUCTION OF PHOSPHATE ROCK IN THE UNITED STATES. (*a*) (IN TONS OF 2,240 LB.)

Year.	South Carolina.	Florida.	North Carolina.	Tennessee.	Other States.	Total		
						Quantity.	Value.	Per Ton.
1897	333,626	543,490	7,000	121,251	2,000	1,007,867	$3,022,101	$3·00
1898	434,278	546,881	2,200	272,191	2,100	1,257,645	4,355,026	3·46
1899	476,238	706,677	15,000	462,561	3,000	1,663,476	6,350,144	3·82
1900	414,084	642,321	17,500	450,856	3,000	1,527,711	5,375,956	3·52
1901 (*c*)	321,181	751,996	*b* 20,000	409,653	893	1,483,723	5,316,403	3·55
1902 (*c*)	313,365	759,784	*b* 25,000	390,799	720	1,464,668	4,636,516	3·17

(*a*) The figures for 1899 are based on railway and export shipments, except those for Tennessee, which were furnished by the Commissioner of Labor and Inspector of Mines. In 1898 and 1897 the statistics were compiled partly from shipments and partly from direct reports of the producers. (*b*) Low-grade rock not used for fertilizing purposes and not included in the total production. (*c*) Through the United States Geological Survey, statistics based on marketed output.

PRODUCTION OF PHOSPHATE ROCK IN THE UNITED STATES DURING 1901 AND 1902, CLASSIFIED AS TO VARIETY. (IN TONS OF 2,240 LB.)

Year.	Marketed Output.									
	Florida.						South Carolina.			
	Hard Rock.		Land Pebble.		River Pebble.		Land Rock.		River Rock.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1901	457,568	$2,393,000	247,454	$660,702	46,974	$105,691	225,189	$716,101	95,992	$245,789
1902	429,384	1,743,694	325,345	754,588	5,055	8,987	245,243	753,220	68,122	166,505
	Quantity Mined.									
1902	447,445	1,862,704	305,751	721,975	5,456	9,711	254,556	778,005	75,808	184,207

Year.	Marketed Output.					
	Tennessee.		Other States.		Total.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
1901	409,653	$1,192,090	893	$3,000	1,483,723	$5,316,403
1902	390,799	1,206,647	720	2,875	1,464,668	4,636,516
	Quantity Mined.					
1902	396,015	1,210,673	2,445	8,500	1,487,471	$4,770,775

In considering the two tables given above, it should be remembered that the statistics pertaining to the years 1901 and 1902 have been based on the marketed output and not on the actual quantities mined, an arrangement which, in the absence of exact figures of stocks on hand at the beginning of each year, presents more clearly the relation between the consumption and supply.

In general, the phosphate rock industry in Florida, South Carolina and Tennessee is generally assuming a more satisfactory business basis, due to the centralization of interests whereby the cost of production is diminished and profitable returns secured even at a lower price for the marketed output. The larger companies have extended their property holdings and are applying modern business methods in order to secure, if possible, a uniform price for the product, an advantage which will materially aid the future development of the industry. A noteworthy feature during 1902 has been the purchase of phosphate lands by the larger fertilizer companies, so that the control of the supply of raw material for their works may be secured. The speculative features which characterized the phosphate industry in the early stages of development in the different fields, has become practically eliminated, and the removal of active competition among the many small companies formerly in the field, which forced sales at prices admitting of little or no profit, and at times even entailed loss, has served to place the industry on a more satisfactory and permanent basis. A detailed review of progress in the various States is given later in this section.

Prices.—The prices for Florida high grade rock continued low throughout the year, being influenced by the decline in the European markets. January opened at $7·50 per long ton, f. o. b. Fernandina, and from May to early in December the average was $6·75, falling later to $6·25. The average price for the year was $6·95, as compared with $6·83 in 1901. Abroad, the market quotations suffered from the competition with Algerian and other phosphates. The c. i. f. prices at United Kingdom and European ports averaged $11·12 from January to March; in September they declined to $9·87, and closed in December at $9·77. The year's average was $10·36, against $11·45 in 1901. Ocean freight rates were demoralized by the competition among the shipping interests. The rates from Florida and Savannah, Ga., were: Continental ports, $3·46 in March, $3·72 in September, and $3 in October. The range in rates for foreign shipments were: Baltic ports, $3·42@$3·96; Mediterranean ports, $3·34@$3·60; United Kingdom, $2·55@$3·12. Florida land pebble brought $3@$3·25 f. o. b., averaging $3·13, while the c. i. f. prices abroad fluctuated from $6·65 to $8·40; averaging $6·96 for the year.

Tennessee phosphate in the domestic market was favored by the general understanding as to prices existing among the larger companies operating in the Mt. Pleasant field. Export quotations, however, were influenced by the keen competition that prevailed in the European markets. Export rock containing from 78 to 82% bone phosphate sold f. o. b. Mt. Pleasant at $3·50 per ton from January to April; $3·75 in May; $3·25@$3·75 in June; and at $3·25@$3·50 during the following months. The average for the year was $3·47, as compared with $3·33 in 1901. Abroad the selling prices were $10·53@$10·92 from January to March; $9·48@$10·27 in April; and $8·58@$9·36 during the remaining months of the year. The average was $9·48, against $10·76 in 1901. The domestic prices for high grade rock f. o. b. Mt. Pleasant fluctuated from $3·00 to $3·25; averaging $3·13, against $2·97 in 1901. Rock carrying from 70 to 74% bone phosphate sold at from $2·10 to $2·40, as compared with $2 to $2·75 in 1901.

South Carolina land rock sold at an average of $3·25 per ton f. o. b. Ashley River, while river rock sold at $1·75@$3. These prices are lower than those for

1901, and the weakness was apparent also in the European markets. The c. i. f. prices abroad fluctuated from $5·67 to $6·30, averaging $5·98 for the year, against $6·88 in 1901. Ocean freight rates ruled at $2·64@$2·94 to France, and $2@$3·12 to Great Britain, these countries absorbing most of the exports.

SHIPMENTS OF PHOSPHATE ROCK. (IN TONS OF 2,240 LB.)

States.	1900.			1901.			1902.		
	Foreign.	Domestic.	Total.	Foreign.	Domestic.	Total.	Foreign.	Domestic.	Total.
South Carolina.....	63,500	389,500	453,000	45,709	275,472	321.181	55,000	247,125	302,625
Florida............	410,000	120,000	530,000	548,315	191,361	739,676	627,015	237,330	864,345
Tennessee..........	135,000	280,000	415,000	164,389	245,264	409,653	139,500	298,000	437,500
North Carolina....	....	17,500	17,500	....	20,000	20,000	*Nil.*	*Nil.*	*Nil.*
Pennsylvania......	*Nil.*	1,000	1,000	....	953	953	*Nil.*	*Nil.*	*Nil.*

YEARLY SHIPMENTS OF HIGH-GRADE FLORIDA PHOSPHATE ROCK. (*c*) (IN TONS OF 2,240 LB.)

Countries.	1899.	1900.	1901.	1902.	Countries.	1899.	1900.	1901.	1902.
	Tons.	Tons.	Tons.	Tons.		Tons.	Tons.	Tons.	Tons.
Austria	....	5,922	8,114	14,310	Italy.............	4,546	....	5,842	16,868
Belgium....	37,108	31,639	58,181	41,245	Norw'y & Sweden	11,938	8,000	6,750	10,250
Denmark ..	5,475	2,930	6,064	2,750	Russia	1,700	2,702	....	2,600
England....	31,789	20,542	28,790	30,068	Scotland.........	9,545	1,790	6,185	12,430
France.....	3,165	....	6,498	3,950	All other (*b*)......	8,360	6,408	6,093	8,068
Germany...	243,887	208,422	214,280	264,550					
Holland (*a*).	87,167	54,349	72,158	77,176	Total............	444,675	348,556	424,130	492,610
Ireland	....	5,852	5,175	8,850					

(*a*) A large proportion of the shipments to Rotterdam is forwarded to the interior of Germany. (*b*) Included in these shipments are those made to the United States, Australasia, Japan, Spain, and the West Indies. (*c*) From the annual report of Anchincloss Bros.

Imports and Exports.—The total imports of phosphate rock in 1902 (not restricted to the quantity entered for immediate consumption) amounted to 137,386 long tons, valued at $646,264, as compared with 175,765 long tons, valued at $872,503 in 1901. The total exports of phosphate rock in 1902 amounted to 802,086 long tons, valued at $6,193,372, as compared with 729,539 long tons, valued at $5,839,245 in 1901. The exports of Florida high-grade hard rock were 492,610 long tons in 1902, as compared with 424,130 long tons in the preceding year.

THE WORLD'S PRODUCTION OF PHOSPHATE ROCK. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Algeria.		Belgium. Cubic Meters.		Canada.		France.		Norway.	
1897..........	222,141	$912,564	350,056	$436,762	824	$3,984	535,390	$2,852,887	*c* 872	$12,960
1898..........	269,500	1,078,000	156,920	303,230	665	3,665	568,558	3,115,958	3,598	53,852
1899..........	324,983	1,299,932	190,090	342,180	2,722	18,000	645,868	3,334,145	1,500	22,275
1900..........	319,422	1,277,688	215,670	367,164	1,284	7,105	587,919	2,827,291	300	4,445
1901..........	265,000	1,060,000	(*f*) 222,520	361,398	937	6,280	535,676	2,614,548	(*e*)	(*e*)

Year.	Redonda. Br. W. Indies. (*d*)		Russia. (*b*)		Spain. (*b*)		United Kingdom.		United States.	
1897..........	812	$5,525	5,917	$22,132	2,084	$16,672	2,032	$17,500	1,023,485	$8,022,101
1898..........	750	4,725	1,870	4,784	4,500	46,008	1,575	13,565	1,257,645	4,855,025
1899..........	1,507	9,250	16,863	58,640	3,510	35,100	1,469	12,645	1,663.476	6,350,144
1900..........	2,230	13,720	(*e*)	(*e*)	4,170	18,590	630	5,425	1,552,154	5,875,956
1901..........	*Nil*	....	(*e*)	(*e*)	4,220	16,880	71	680	1,527,681	5,336,408

(*a*) From the official reports of the respective countries and *Annual General Reports on the Mineral Industry of the United Kingdom*, by C. Le Neve Foster. (*b*) Phosphorites exported. (*c*) Apatite exported. (*d*) Aluminum phosphate exported. (*e*) Statistics not yet published. (*f*) Metric tons.

PHOSPHATE MINING INDUSTRY OF THE UNITED STATES DURING 1902.

BY C. G. MEMMINGER.

Alabama.—There was no reported production of phosphate rock in the State during 1902 or 1901. In 1900, however, an output of 334 long tons, valued at $534, was recorded.

Arkansas.—The marketed output of phosphate rock during 1902 amounted to 550 long tons, valued at $1,650, although the quantity reported as mined was 2,200 long tons, valued at $6,600. The deposits in this State have been well described in the report of John C. Branner and John F. Newsom, entitled, "The Phosphate Rocks of Arkansas," which constitutes Bulletin No. 74 of the Arkansas Agricultural Experimental Station, Fayetteville, Ark., 1902. The phosphate deposits occur in the counties of Independence, Stone, Izard, Searcy, Marion, Baxter and Newton. But little attention has been attracted to them until recently, when two railroads began constructing lines through different parts of the region; one on the north, up the White River to Batesville, and the other on the south, to Harrison. The Arkansas Phosphate Co., near Batesville, has started the manufacture of acid phosphate from the crude ore, which occurs in beds of from 3 in. to several feet in thickness, and contains calcium phosphate varying in content from 50 to 80%. The deposits promise to be of considerable extent and richness, and with the extension of the railroads, the early development of the industry in this field will doubtless result.

Florida.—Since 1894 Florida has been the chief producer of phosphate rock in the United States, and although the marketed output during 1902 was slightly less than that of 1901, the industry, as a whole, may be considered as very healthy. The production of hard rock phosphate during 1902 was greater than that of the preceding year, due to the exceptionally favorable weather conditions which prevailed throughout the year and allowed mining operations to be carried on practically without interruption. The shipments of high grade rock were heavy and the stocks on hand at end of 1902 were below the normal, in spite of increased production. There was a marked increase in the production of land pebble phosphate during 1902. Shipments were heavy and demand was so brisk that there were practically no stocks on hand at the end of the year. Despite the large increase in the production of pebble during the past few years, the increase in consumption of fertilizers has kept full pace with the supply of crude phosphate; overproduction has thus been avoided, and the mines have been taxed to their utmost capacity to meet the demand.

The decrease in the production of river pebble resulted from the destruction by fire of the calcining plant of the sole operating company early in January, 1902. A new plant is being erected, however, and as soon as completed the product will be taken by the American Agricultural Chemical Co., which has obtained control of the Peace River Phosphate Co. Making an allowance for this circumstance by assuming an output equal to that of the preceding year, the total production of phosphate rock in Florida during 1902 would have been considerably greater than the record year of 1901.

There are no changes of special interest to be noted in the methods of mining hard rock, except that a number of operators are installing dredges of the dipper type to mine deposits that have been worked down to the so-called "water-level," particularly in those cases where it has been found impracticable to handle the water with pumps. Mining with dipper dredges presents many economical features. With deposits which can be handled by this method, it has given very excellent results and has made it possible to treat profitably many deposits otherwise of no commercial value. A dredge should not be installed, however, until it has been ascertained that the deposits are of a character suitable for dredging; the conditions must be filled exactly in order that the work shall be successful. The expense of the installation of a dredge is considerable, and in event of failure the loss would be heavy. It is interesting to note the innovation that has appeared in the works of the Prairie Pebble Phosphate Co., where a central plant has been installed for the generation of electric and hydraulic power for the mining operations. The results have proven very successful and economical, and under proper conditions this method promises eventually to supersede the older methods. The fuel question is the most serious one to be considered, and the producers are securing large tracts of wood lands for fuel supply. It is merely a question of a comparatively short time when coal will be substituted for wood, a change which will be speedily adopted when the mines control the transportation to the port of shipment.

The tendency in the pebble rock district, as in the hard rock district, is toward centralization and combination, and negotiations are already under way that will bring the various mines under the control of two or three companies. No new mining plants have been constructed during 1902, nor has there been any extension made of the known phosphate territory. Such deposits as have been opened up have been promptly purchased by the present operators.

The usual amount of prospecting has been carried on during the year, but no extension of known territory has been made, nor have any extensive finds been reported. Some of the so-called exhausted deposits have been extended, a matter which has caused no surprise, as prospecting is now carried on with exceptional care, and through a greater depth of overburden than was formerly the case. As a result of this more thorough exploration, deposits are now being developed in land which was formerly passed over. The mining of deposits having a heavy overburden is a sure indication that the operators realize that the deposits of hard rock phosphate are by no means inexhaustible.

The excessively high transportation and terminal charges prevailing in recent years have forced the miners to seek relief. The Dunnellon Phosphate Co., which was the first to take this matter in hand, has constructed a railroad 18 miles in length from its central plant at Rockwell to the mouth of the Withlacoochee River, where a port has been opened, known as Port Inglis. A large sum of money was expended in this work, which was completed during the year, and has so far proven eminently successful. The entire output of the company's mines is now handled through this port.

In general, there appears to be a tendency toward a combination of the larger producers and the gradual absorption of the smaller mines by the larger operators. The indications are that in the near future the entire business will be combined on a basis which will put an end to the useless competition that has existed in the past, and will enable the producers to maintain prices at a level which will admit of mining at a fair profit.

The total quantity of phosphate rock produced in Florida since the inception of the industry in 1888 is stated to aggregate more than 6,500,000 tons of a marketed value of nearly $25,000,000.

North Carolina.—In recent years there has been an output of shell rock at Castle Haynes. The material was of too low a grade to be of value in the manufacture of fertilizers, and the quantity produced has not been included in the tables of production. The entire output has been utilized to macadamize the streets of Wilmington. The quantities produced have been estimated at 25,000 long tons in 1902, as compared with 20,000 long tons in 1901, and 15,000 long tons in 1900.

Pennsylvania.—There was a small quantity of phosphate rock produced in this State during 1902, amounting to 100 long tons, valued at $400, as compared with 893 long tons, valued at $2,600 in 1901. The deposit is at Rossfarm, Juniata County.

South Carolina.—There is nothing of special note to be recorded in the phosphate industry of South Carolina during 1902. The Virginia-Carolina Chemical Co. practically controls the land deposits, and mines the land rock for its own consumption. Contrasted with the production of 1901, the output reported showed an increase in quantity of 20,054 long tons, and in value of $37,119. In the river mines there has been a marked decrease in production owing to the withdrawal of the Coosaw Co. from the business. As compared with the statistics for 1901, the decrease amounted to 27,870 long tons in quantity, and of $79,234 in value. The total quantity of phosphate rock reported to have been mined in Tennessee from the beginning of operations in 1867 to 1902, inclusive, aggregates more than 10,500,000 long tons. The Central Phosphate Co. is now the largest producer of this class of rock.

Tennessee.—During 1902 the demand for all classes of phosphate rock, especially for domestic consumption, has been good, and, while the production was very nearly equal to that of the preceding year, there has been a very marked decrease in the export. In fact, in view of the increasing domestic consumption and the absorption of some of the best deposits in this field by the Virginia-Carolina Chemical Co., it is a foregone conclusion that in a short time the exports of Tennessee phosphate rock will cease.

In the Mt. Pleasant district the Virginia-Carolina Chemical Co. had purchased valuable mines, and the field is now under control of a limited number of operators. No new finds of importance are to be noted, and there has been no change in the general method of mining and preparation of the crude ore.

In the brown rock and blue rock districts the increased demand for domestic consumption has caused greater activity in mining. The situation, however, is well in hand, and there is no danger of an overproduction.

The total quantity of phosphate rock produced in Tennessee since 1894, the year in which the industry began, exceeds 2,000,000 long tons, valued at nearly $6,000,000.

In general, while new finds have been noted from time to time, in various parts of the State, no developments of commercial importance have been made.

An interesting and valuable report on the white phosphate rocks of Tennessee has been prepared for the United States Geological Survey by Dr. C. W. Hayes and Mr. E. C. Eckel. The report, which is now in press, embraces the deposits in Perry and Decatur counties.

General.—Taken as a whole, the phosphate industry of the United States is in a healthy condition. The producers in the various sections are combining for mutual advantages, and there has been a marked increase in the domestic demand; the business, as a whole, has passed through the various stages of development, and may now be considered as established on a firm basis.

According to the bulletin issued by the U. S. Census Bureau, there are 422 fertilizer works in the United States, exclusive of 18 small establishments, each of which reported a value for all products of less than $500 during 1900. The 422 establishments produced 923,198 tons of superphosphate, valued at $8,471,943, 142,898 tons of ammoniated superphosphate, also 1,436,682 tons of "complete fertilizers," by which is meant a mixture of superphosphate with both potash and ammoniates, valued at $25,446,046, and 291,917 tons of other fertilizers, including bone meal and similar substances, valued at $4,178,284.

Porto Rico.—Deposits of calcareous phosphate are reported to occur at San Germán, Cabo Rojo, Lajas, Isabela, Manati, Ponce and Pueblo Viejo, and many concessions have been granted for exploitation. The largest deposits, however, are on the islands of Caja de Muertos and Mona. The former is situated south of Porto Rico, 8 miles from Ponce, and contains an immense deposit of phosphate and guano of satisfactory composition. The right of exploitation on this island was awarded to Miguel de Porrata Doria in 1899. The Island of Mona is situated west of Porto Rico, 34 miles from the city of Mayaguez, and contains a phosphate deposit of very high grade character, the right to exploit which was granted by the Spanish Government, in March, 1877, to Porrata Doria and Contreras & Co., the concession to hold good until 1907.

PHOSPHATE MINING IN FOREIGN COUNTRIES.

Algeria.—The production of phosphate rock in 1902 amounted to 270,252 metric tons, a decrease of 4,249 tons as compared with that of the previous year. Of the total output in 1902, 84,685 tons were exported to Great Britain, 79,817 tons to France, 40,455 tons to Germany, 32,276 tons to Italy, 12,600 tons to the Netherlands, 6,349 tons to Spain, 4,500 tons to Russia, 3,015 tons to Belgium, 2,805 tons to Portugal, 2,570 tons to Austro-Hungary and 1,000 tons to Roumania. The phosphate rock industry has been developed rapidly until it has become the most important mineral product of Algeria. The first shipments of commercial importance were made in 1893 amounting to about 5,000 metric tons, and while the output during 1902 was less than that of 1901, the decrease is comparatively small. The rock is quarried in the vicinity of Tébessa and at Toqueville in the Province of Constantine.

The deposits of the Tébessa group are in a chain of mountains extending in a direction S.W.—N.E. from Djebel-Djerrar on the south to Dyrel-Kef on the north, and show the presence of considerable quantities of ore over a distance of nearly 176 km. The three principal centers of exploitation are: (1) Djebel-Kouif, exploited by the Constantine Phosphate Co.; (2) Ain-Kissa, exploited by La Société des Phosphates de Tébessa; (3) Dyr, exploited by Crookstons Brothers, of Glasgow.

The deposits of Djebel-Kouif are on the frontier separating Algeria from Tunis, 27 km. N.E. of Tébessa. The region consists principally of two large plateaus—that of Ain-el-Bey, at the altitude of 1,160 m. in Algeria, and that of Aie-el-Kebir at an altitude of 1,180 m. in Tunis. A single layer of phosphate has been discovered, reaching at times 6 m. in thickness, which seems to extend over the two plateaus. The rock is obtained by quarrying. The Constantine Phosphate Co. has connected its workings by a branch track to the Tébessa station of the Bone-Guelma line, which permits the direct transportation of the phosphate to the coast without trans-shipment. The branch road is 30 kilo. in length.

At Ain-Kissa, 7 km. north of Tébessa, the quarries of the French Phosphate Co. are connected with the station of Youks-les-Bains by a small narrow gauge branch road, 9 km. in length.

Under the name of Dyr is designated a large rectangular plateau 50 km. in circumference. The rock is mined, the overlying stratum being nummulitic limestone. The mined material is conveyed to the railroad partly by aërial cable.

The importance of these beds of phosphate to the French possessions in northern Africa is increasing.

Australia.—A discovery of phosphate rock, 30 miles S.W. of Dunedin, New Zealand, has been reported. The deposit is of large area and overlies the country limestone, which has been extensively quarried for many years. The calcium phosphate content of the higher grade rock varies from 52 to 80%, the average being 65%, while that of the lower grade, a sandy variety which exists in a layer of from 40 to 50 ft. in thickness, averages 30%. A deposit of phosphate rock has been found on the Murray flats near Robertstown, South Australia.

Canada.—There was no direct production of phosphate rock in Quebec during 1902, although shipments obtained as a by-product in the mining of mica amounted to 535 short tons of high-grade rock, valued at $4,280, and 326 short tons of low-grade material, valued at $1,121, as compared with a total shipment of 1,033 short tons, valued at $6,450 in 1901.

Dutch West Indies.—The exports of phosphate rock from the Island of Aruba in 1901 amounted to 10,413 tons, as compared with 12,075 tons in 1900 and 12,476 tons in 1899. About one-half of the output was shipped to Great Britain.

Egypt.—Large deposits of phosphate rock have been found on the property of the Egyptian Mines Exploration Co., Ltd., 10 miles inland from Wady Safaga; the formation in which the beds of phosphate occur are parallel to the coast of the Red Sea, and extend a distance of 40 miles. The phosphate is soft and friable and has the following composition:—

P_2O_5 33·12%=72·3%, $Ca_3(PO_4)_2$, CaO 51·85%, Fe_2O_3 and Al_2O_3 0·65%, MgO 8·55%, CO_2 3·41%, H_2O, and insoluble 2·42%.

France.—The output of phosphate rock in 1901 amounted to 535,676 metric tons, valued at \$2,614,543, as compared with 587,919 metric tons valued at \$2,827,291 in 1900. The rock was produced in 23 departments, the greatest production being in the departments of Pas-de-Calais, Somme, Aisne, Meuse, Oise, Ardennes, Lot, Indre, Nord and Manche. The Department of Somme produced 265,000 metric tons in 1901, the principal quarries being at Vaux-Éclusier and other villages of the districts of Péronne, Marcheville and Beauval. The Department of Aisne produced 133,000 metric tons, the quarries being at Étaves-Bocquiaux and Hargicourt. In the Department of Pas-de-Calais, the mines of Orville et Auxi-le-Château produced 64,000 metric tons. The output from the Department of Meuse amounted to 23,000 metric tons, and for the Department of Oise, 20,000 metric tons.

Polynesian Islands.—The phosphate deposits of Ocean Island, in the Gilbert group and Nauru or Pleasant Island in the Marshall group, have been described in detail by F. Danvers Power in THE MINERAL INDUSTRY, Vol. X., pp. 533-535. The deposits on Ocean Island are exploited by the Pacific Islands Co., operating under a 99-year lease from the British Government. Two stations have been established, one at Home Bay and the other at Tapiwa. A track has been laid extending to the end of the long jetties, when the rock is conveyed by large surf boats to steamers made fast to moorings a few hundred yards distant. The company employs 25 white laborers and 300 natives. The total shipment of phosphate which is consumed chiefly in the Australasian markets has amounted to approximately 50,000 tons. The following analysis of a 3,000-ton shipment has been reported: CaO 52·83%, P_2O_5 39·78%, (=$Ca_3(PO_4)_2$ 86·85%). CO_2 1·47% (=$CaCO_3$ 3·35%), Fe_2O_3 and Al_2O_3 0·44%, SiO_2, MgO, SO_3, K_2O and Na_2O 2·46%, H_2O (combined) and organic matter 3·02%.

On Christmas Island, the deposits of phosphate rock were actively mined during 1902, the exports amounting to 57,544 tons as compared with 46,898 tons in 1901. The formation of the phosphate has resulted from the alteration of limestone by the percolation of meteoric waters from the overlying deposits of guano.

Norway.—The annual production of phosphate rock (apatite) in recent years has averaged less than 2,000 metric tons. Several companies operating the mines at Bamle near Kragerö have formed a combination with a capital of \$200,000. The entire production is exported, and in 1902 the quantity shipped amounted to 3,600 metric tons.

Russia.—Extensive phosphate deposits occur in the provinces of Podolia, Bessarabia, Kostroma and Smolensk. The output during 1900 was obtained from Podolia and Bessarabia, and amounted to 25,663 metric tons, as compared with 1,868 metric tons in 1899. The area of the deposits in Podolia extends over 1,775 sq. miles, while in Bessarabia, 270 sq. miles are covered. Analyses of the rock show a phosphoric acid content as high as 30%, which is equivalent to 75% of tribasic calcium phosphate. The output of rock is consumed in part by the fertilizing factories, which have increased their output of superphosphates due to the development of the beet sugar industry. The quantity of superphosphate fertilizer produced from domestic rock is not sufficient to supply the demand, and is supplemented by imports of phosphate rock from the United States.

Tunis.—The output of phosphate rock is limited to the mines of the Compagnie des Phosphates et du Chemin de Fer de Gafsa, which operates the deposits at Metlaoui. During 1901, the mine gave employment to nearly 1,000 laborers composed mainly of Sicilians, Moors, Kabyles, and Tunis Arabs. During the summer months, the material is dried in the air, while in the winter, various types of kilns are used for this purpose.

The phosphate deposits in Kalaâ-Djerda, which have been the object of litigation for several years, consist of strata varying from 12 to 25 ft. in thickness. The quantity of phosphate rock contained in the deposits has been estimated as high as 10,000,000 tons, but the grade is less than 65% tribasic phosphate.

The exports of phosphate rock during 1902 amounted to 263,493 metric tons, as compared with 172,375 metric tons in 1901. Of the former quantity the five leading countries to which the production was shipped were: France, 109,567 tons; Germany, 30,280 tons; Italy, 51,809 tons; Great Britain, 48,356 tons; and Holland, 12,339 tons.

PLATINUM AND IRIDIUM.

BY JOSEPH STRUTHERS.

THE production of platinum from domestic ores in the United States during 1902 amounted to 94 oz., valued at $1,814, as compared with 1,408 oz., valued at $27,526 in 1901, which was the largest quantity reported for any one year since the statistics of the production of the metal from domestic ores have been collected. The large decrease in the production of this important metal during 1902 places the industry very nearly on the basis of 1894, in which year the production of platinum from domestic ores was 100 oz. of crude platinum grains. A reference to the quantity of platinum annually imported into the United States, shows the comparative insignificance of the domestic production to the total consumption in the United States. In connection with the production of platinum from domestic ores during 1902 there were obtained also 20 oz. of iridium, as compared with 253 oz. in 1901. Iridium is so closely allied to platinum in its properties, that doubtless it has formed at least 15% of the platinum production reported in early years.

The domestic supply of platinum in recent years has been obtained as a secondary product chiefly from gold placer deposits in Trinity and Shasta counties, Cal. The occurrence of the metal has been reported in many other gold placers of California, as well as in Washington, Oregon, Idaho, Montana, Colorado and Alaska; the deposits, however, have not been sufficiently rich to place the extraction of the metal on a profitable basis. There have been very few new reports of discoveries of platinum during the year. The Rambler district, near Encampment, Albany County, Wyo., continues to attract attention, and one or two other mines in that region claim to have covellite (CuS, copper sulphide) carrying sperrylite ($PtAs_2$, platinum arsenide) in the ore. According to S. F. Emmons[1] the gangue rock of the Rambler mine consists of quartzite with some limestones and conglomerates, penetrated by sheets and dikes of eruptive rocks, mainly diorite. In one zone the diorite is decomposed, and forms a white kaolinized mass of the consistency of soft clay. Covellite is irregularly distributed throughout the mass, but sometimes occurs in massive lenses in thickness varying

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[1] United States Geological Survey, Bulletin No. 213.

up to 2 ft. With this covellite the sperrylite is found. The New Rambler Co. has purchased the Rambler mine and is extensively developing the property. Formerly no allowance was made by the refining companies for the platinum metals present in the matte, as these metals were not collected. In order to determine the value that should be allowed, a refining test of five carloads of matte was made and duplicate analyses of the matte by Baker & Co., of Newark, N. J., were: Au 0·45 to 0·40 oz., Ag 7·4 to 7·46 oz., Pt 1·05 to 0·99 oz., and Pd 3·15 to 3·25 oz. per ton. A carload lot of ore also was sampled, the analyses showing Au 0·16 to 0·19 oz., Ag 3·8 to 4·72 oz., Pt 0·74 to 0·69 oz., and Pd 1·8 to 1·9 oz. per ton.

It has not yet been determined whether the other rare metals reported to be associated with the platinum and palladium are present in commercial quantities. Osmium and iridium have been noted, and chemists are investigating the slimes from the copper refineries treating the copper mattes from the Rambler district. Tests on the Rambler ores are also being made at the Preston mill, Boulder, Colo., which may result in the addition of a refining plant for the extraction of the platinum metals.

A second district of interest is at Kerby, near Grant's Pass, Josephine County, Ore., where the Waratah Minerals Co. operated a concentrator for the treatment of platinum ores, and, while a considerable quantity of the metal was collected, it was not put on the market during 1902. Samples of earth from the region of the Grand Cañon of the Colorado, supposed to contain platinum, were examined by Dr. D. T. Day; the material contained white pyrite, which has the appearance of platinum, but no platinum whatever was found on analysis. The gold sands of the Corozal River, 40 miles west of San Juan, Porto Rico, contain an appreciable quantity of platinum, which has heretofore been rejected by the natives in washing the material for the gold contained; it is quite possible that platinum is present in sufficient quantity to render its extraction profitable on a commercial scale. The reported occurrence of platinum in commercial quantities on an island in the Lake of the Woods, 12 miles from Rat Portage, has not been verified. An interesting occurrence of platinum is noted by Prof. J. F. Kemp in the ash of Australian coal of the following analysis: C 65·2%, H 4·6%, O 21·8%, N 1·9%, S 3·8%, H_2O 0·7%, ash 1·7%; total 99·7%, the ash containing 25·1% vanadium and 3·6% platinum metals, which makes the coal the richest platinum ore yet discovered.

Prof. James F. Kemp has prepared a very interesting and valuable report on The Geological Relations and Distribution of Platinum and Associated Metals.[2] The platinum deposits are classified into three types: (1) Placers, as exemplified by those in the Urals, Colombia, Brazil and British Colombia. (2) Veins, as at Tilkerode, in the Hartz; Minas Geraes, Brazil; Santa Rosa, California; Beresovsk, Russia; Gualdalcanal, Spain (with tetrahedrite and bournonite); Rambler mine, Wyoming (sperrylite with covellite); and (3) Disseminated in eruptive rocks, in two ways—(a) sperrylite with the copper-nickel ores in uralitized norite, Sudbury, Canada, and (b) the native metal in basic eruptive rocks, especially peridotites, frequently intimately associated with chromite.

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[2] United States Geological Survey, Bulletin No. 193.

The conclusions of practical value arrived at by Prof. Kemp are: (1) That platinum is very sparsely distributed in the mother rock so that the chances of finding it in quantity sufficient to mine are small; also, if found, the recovery of the platinum other than by stamping and washing is yet to be solved, as the metal may be in a very finely disseminated state and its extraction will necessarily be difficult. (2) Large and permanent placers may be sought only on very old land areas which have been subjected to protracted degradation and concentration. (3) In the assay of antimonial, arsenical and other copper ores (especially tetrahedrite) it is advisable to search for small percentages of platinum. (4) Deposits of chromite should be tested for the presence of the metal.

Imports.—The imports of platinum into the United States during 1902 are reported as follows: Unmanufactured, 632 lb. ($172,967); ingots, bars, sheets and wire, 6,713 lb. ($1,778,395); vases, retorts and other apparatus, vessels and parts thereof for chemical uses, $34,913, and manufactures not specially provided for, $2,705. Practically the entire supply of platinum in the United States during 1902 was derived from foreign sources.

Market.—Despite the attempts that have been made to replace platinum by other metals or alloys, the demand for it has continued to increase, and as a natural result the price steadily rose during 1901 until May 15 in New York it was $18·20 per oz. for ingot platinum, rising to $20@$21 later in the year. In January, 1902, the price continued at $20@$21, but fell in February to $19·50, and in June to $19, a price which prevailed to the close of the year. Best hammered was quoted as follows: January, 82c. per gram; June, 76c.; July, 74c.; August, 73·5c., and December, 72·5c.

Osmiridium is quoted at from $6 to $10 per oz. Practically the price of the metal is determined by the English concern, Johnson, Matthey & Co., which refines a large proportion of the Russian output.

THE PRODUCTION OF PLATINUM IN FOREIGN COUNTRIES.

The production of platinum in the world ranges annually between 160,000 and 170,000 Troy ounces, supplied chiefly from Russia, the balance coming mainly from Colombia, South America. Unfortunately, in the latter country the revolutions which have been prevalent in recent years have seriously hindered the development of this important industry. The uses of the metal would be largely increased if it could be obtained in sufficiently large quantity to lower the price. Unfortunately, for many purposes there is no metal to take its place, and the limited supply maintains the price almost equal to that of gold. Russia supplies about 90% of the entire output of platinum in the world.

Australia.—The production of platinum in New South Wales during 1902 amounted to 375 oz., valued at £750, as compared with 389 oz., valued at £779 in 1901, and 530 oz., valued at £1,007 in 1900. The entire output in 1901 and 1902 was derived from the Fifield district, about 322 miles west of Sydney, where it is found associated with gold. The principal workings are at Platina, two miles from Fifield, a deep alluvial lead, containing platinum and gold, extending from near the former place for over a mile in length, and varying from

60 to 150 ft. in width. The sinking is from 60 to 70 ft., through loam, with some bands of barren quartz drift. The platinum and gold occur in fairly coarse waterworn grains, which, as a rule, are confined to the cavities in the bedrock and to the washdirt for a few inches above it. Occasional nuggets of platinum have been obtained; the largest hitherto found weighs 27 dwt. The washdirt contains from 5 to 12 dwt. of platinum, and from 1 to 3 dwt. of gold per ton.

Canada.—Samples of copper sulphide ore reported to have been obtained from the Yale and other districts of British Columbia, show by analysis both platinum and palladium, although not in sufficient quantity to admit of profitable extraction except in connection with copper smelting whereby the metals of the platinum group would be collected in the residual slimes from the electrolytic refining of the copper product. The form in which the platinum and palladium occurs has not been definitely determined. It is quite probable, however, that it is similar to the occurrence at the Rambler mine, Wyoming, where the metals exist as arsenides.

Through the courtesy of William F. Robertson, of the Department of Mines, British Columbia, the following analyses of black sands have been reported:—

ANALYSES OF BLACK SANDS AND CONCENTRATES FROM BRITISH COLUMBIA.

Locality.	Assay Values in Ounces per Ton.			
	Gold.	Silver.	Platinum.	Iridosmine.
Sands.	Ounces.	Ounces.	Ounces.	Ounces.
Quesnel River.				
At Quesnel (mouth of Quesnel River)..........	3·8	Not determined.	1·0	....
3 miles from mouth..........................	0·85	Not determined.	0·25	3·2
13 miles from mouth..........................	4·7	Not determined.	7·8	....
15 miles from mouth..........................	121·8	Not determined.	3·9	....
26 miles from mouth..........................	0·2	Not determined.	0·4	....
25 miles from mouth..........................	1·0	Trace.	0·5	Nil.
30 miles from mouth..........................	Not determined.	Not determined.	6·4	Not determined.
30 miles from mouth (Quesnel Forks)..........	2·5	Trace.	2·5	Nil.
40 miles from mouth..........................	1·0	Not determined.	2·8	....
40 miles from mouth..........................	0·06	Not determined.	0·14	....
Fraser River.				
2 miles above Quesnel..........................	Not determined	Not determined.	2·4	Not determined.
Concentrates.				
Thibert Creek..................................	Not determined.	Not determined.	12,864·5	3,475·5
Mouth of Quesnel River........................	(*a*) 2,068·4	Not determined.	(*a*) 20,684·4	(*a*) 908·2
Cobeldick Dredge..............................	913·0	Not determined.	165·7	Nil.

(*a*) 0·7 oz. of concentrates yielded 0·05 oz. gold, 0·5 oz. platinum, and 0·022 oz. osmiridium.

The Salt Creek Hydraulic Co. was formed in 1902 to work a tract of 320 acres on Salt Creek, which is on the Washington side of the Similkameen River. Operations, however, will extend into Canadian territory. The reported proportion of precious metals in the sands in this district is 66% gold and 33% platinum, and the gravel contains values of 25c. per cu. yd.

According to Charles W. Dickson, it is very probable that the platinum found in the Sudbury district, Ontario, occurs in the form of sperrylite, which is almost, if not exclusively, contained in the chalcopyrite of the nickel-copper ores, a condition analogous to the results obtained by Prof. Vogt from his examination of various ores from the Norwegian nickeliferous deposits which showed that a small but appreciable quantity of metals of the platinum group is always present, the accompanying copper minerals containing the greater proportion.

Russia.—The production of platinum in the Urals from 1891 to 1902 is given in the subjoined table:—

Year.	Poods.	Oz. Troy.	Year.	Poods.	Oz. Troy.	Year.	Poods.	Oz. Troy.
1891........	258	135,874	1895.......	269	141,668	1899.......	363	191,172
1892........	279	146,934	1896.......	301	158,520	1900.......	332	174,846
1893........	311	163,787	1897.......	345	181,698	1901.......	380	200,260
1894........	318	167,473	1898.......	365	192,225	1902.......	446	234,878

The production during 1902 was as follows: Société du Platine, of Paris, 159 poods; Count P. P. Schouwaloff, 99 poods; Prince Demidoff, of San Donato, 53 poods; Kolli, 40 poods; small exploitations, 15 poods; others unknown (placed on the market surreptitiously) 80 poods; total, 446 poods. The entire output was obtained from the Ural, and, with the exception of a few ounces used in St. Petersburg, was exported to London and Hanau.

The Russian sources of platinum supply, which furnish at least 90% of the total consumption of the world, are comparatively limited. The platinum bearing areas extend along the eastern watershed of the Ural Mountains, on Eastern Perm and on the western watershed farther south. Until within a few years the greater part of the Russian output was derived from the district of Nijni-Tagilsk; at present it is obtained in the Goroblagodat and Bisersk districts, 130 miles to the north. The platinum occurs chiefly in the sands of Tura, Tagil, Salda, Lala and Loswa rivers on the boundaries of the district of Goroblagodat, as well as the property of Count Schouwaloff and that controlled by the manufacturing works of Bogoslow and Demidoff. The richness of the ore varies from a few milligrams to from 10 to 13 grams per ton. The depth of the platinum sands is about 1 m., while the depth of the overlying turf is usually from 2 to 3 m., although in some cases it is from 10 to 14 m. Generally the platinum grains are small, but occasionally lumps also are found. Apart from the occurrence of the metal in sands, it is found in slight quantities in native gold. Recently a discovery of platinum *in situ* was made on the Martian River in the Nijni-Tagilsk circle, where the metal is found in peridotite, diallage and in serpentine. It has also been found in the gold sands of Birussia. A recent discovery of platinum has been reported on the Gusseva River, a tributary to the Issa River in Western Siberia.

There are two platinum refineries at St. Petersburg which treat a part of the domestic product, the greater bulk of which is exported in the crude state. The crude platinum is sold at from $3,090 to $3,605 per pood (1 pood equals 16·38 kg.); 1·25 pood of concentrates yields 1 pood of refined metal, valued at from $8,240 to $9,270; the cost of refining is $154·50 per pood. The accompanying metals, iridium, palladium and osmium also are recovered. Between 1884 and 1897, 1,833 poods of platinum, costing 29,748,953 fr., were exported to North America and sold for 42,472,276 fr., the net profit being 42·7%. The Franco-Russian Platinum Industry Company, which was organized to free the Russian industry from the control of foreign smelters, did not accomplish its aim, although its efforts resulted in raising the price to be paid by the refiner for the concentrates to $8,240 per pood.

A description of the washing of platinum sands in the Urals will be found in the review of the "Progress in Gold Milling during 1902," under the section "Gold and Silver," elsewhere in this volume.

Technology.—Leidié and Quinnessen have devised a scheme for separating the metals of the platinum group from one another, a detailed description of which will be found elsewhere in this volume under the section devoted to "Rare Elements."

F. Glaser,[3] in his investigation of the action of potassium cyanide on platinum when used for electrolysis, found that platinum is soluble to a slight extent in the cold, the solvent action being greatly augmented with an increase of temperature. Potassium and sodium amalgam have a notable effect, increasing the rate of solution. Platinum is dissolved in potassium cyanide (in the absence of oxygen) by hydrogen being set free, whereas gold and silver are not appreciably attacked by potassium cyanide unless oxygen is present.

The markings on the surface of platinum, after it has been exposed to a high temperature, have been studied microscopically by W. Rosenhain[4] who found that they showed a pattern characteristic of an etched crystalline metal. On treating the surface with aqua regia, the pattern showed more distinctly. He obtained the same markings when a new platinum surface was exposed to a high temperature in an oxidizing atmosphere, proving that they are not due to the action of the carbon from the flame, as had been believed, but solely to the recrystallization of the metal.

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[3] *Zeitschrift fuer Electrochemie*, Jan. 1, 1903.

[4] *Chemical News*, Aug. 1, 1902.

POTASSIUM SALTS.

BY JOSEPH STRUTHERS AND HENRY FISHER.

THE United States Potash Co. has examined immense beds of sodium nitrate in Death Valley, Cal., and in other parts of the desert lands of the West. In most cases the deposits contained small quantities only of potassium salts, except where formed by the leaching of bat deposits. As much as 87·5% KNO_3 was obtained in a few small deposits which in time may be consumed locally. Large deposits of ancient volcanic salts were found consisting mainly of potassium sulphate which may be utilized within the next few years to supply the Western demand for this salt. A thorough test of the economic value of these deposits is to be made during 1903. Strong indications exist of the occurrence of beds of salts similar to those at Stassfurt. The proximity to the market and the quantity of salts present are the predominant factors for the future success of the exploitation. It is proposed to continue the exploration work by drilling, as during 1902 the surface deposits only were examined.

Imports and Exports.—The imports of potassium salts into the United States in 1902 were as follows: Potassium chloride, 140,980,460 lb. ($2,141,553); crude potassium nitrate, 10,505,474 lb. ($299,416); potassium chlorate, 1,209,148 lb. ($60,429); all other potassium salts, 92,857,009 lb. ($1,820,585); a total of 245,552,091, valued at $4,321,983, as compared with a total of 231,146,770 lb., valued at $4,268,067 in 1901. The exports of domestic potash and pearl ash in 1902 were 1,408,342 lb., valued at $66,027, as compared with 1,077,605 lb., valued at $52,802 in 1901. The exports of foreign potassium salts in 1902, consisting of potassium chloride, chlorate, nitrate, and other salts aggregated 1,266,125 lb., valued at $59,789, as compared with 633,100 lb., valued at $43,446 in 1901.

The world's supply of potassium salts, with the exception of saltpeter, continues to be derived from Germany, where the production is controlled by the Kali-Syndicate which was organized by all the active mines for the protection of common interests and especially to avoid overproduction. The agreement first entered into in 1879 has been renewed and revised from time to time. The last renewal dates from June 30, 1901, and is to run until December 31, 1904. According to this agreement the marketable products are divided into three classes: (1) Crude salt, that is, potassium and magnesium products direct from the mines, not including boracite; (2) manufactured products, so far as they are prepared in the chemical works connected with the mines; (3) mixed salts, mixtures of crude and prepared salts, for fertilizers.

In 1902, an agreement was made by the Kali-Syndicate with the Virginia-Carolina Chemical Co. and the American Agricultural Chemical Co. to supply them with potassium salts at more favorable terms than those prevailing in recent years in order to stimulate consumption. The importance of the consumption of potassium salts in the United States is reflected by the large quantity imported annually from Germany. In 1902 the aggregate imports of potassium salts exceeded 100,000 metric tons.

The Kali-Syndicate by its agreement, determines not only the sale and the prices of the different products, but it has also decided the exact quantity which each mine may contribute to the total output. In this connection the products of the mines are divided into four classes, according to their percentage of potassium, as follows: (1) Products with more than 48% K_2O, an equivalent of 76·1% KCl or 88·9% K_2SO_4. (2) Products with not more than 48% K_2O nor less than 18%, equivalents of 76·1 to 28·5% KCl or 88·9 to 33·3% K_2SO_4. (3) Crude salts (not carnallite) with 12·4 to 18% K_2O, equivalents of 19·7 to 28·5% KCl or 23·0 to 33·3% K_2SO_4. (4) Carnallite salts with less than 12·4% K_2O.

A change has been made in the classification of potash salts as follows: Class 1 has been changed to include products containing 42% K_2O. The 38% potash manure salts, as well as potassium magnesium sulphate, have been added to this class, while class 3 now includes salts with as high as 19·9% K_2O. Through the latter change, works which had formerly to mix crude salts containing nearly 20% K_2O with 20% manure salt in order to sell their product, can now sell them directly as crude salts, while the former change places in class 2 only the potash manure salts, those manufactured salts not essentially for German agricultural purposes, being placed together in class 1. Although permission to exchange in the same class was retained, an exchange of manure salts for potassium magnesium sulphate and low grade potassium chloride is not permitted, an exchange between the manufactured sulphate and chloride in class 1, on the other hand being allowed. It was also agreed that a further exchange is possible when the consent of the general assembly by a two-thirds vote has been obtained. When the settlement of the part apportioned to each member took place, there were more difficulties encountered, the Prussian Fiscus, on account of the establishment of new works at Bleicherode, demanding a larger portion as its share. The quota assigned to the different members of the syndicate to take effect Jan. 1, 1902, was as follows:—

	In Parts per 1,000 K_2O.			
	Class I.	Class II.	Class III.	Class IV.
Koenigl. Preussicher Bergfiscus	108	108	100	106
Herzogl. Anhaltischer Bergfiscus	94	93	92	82
Consolid. Alkaliwerke Westeregeln	79	79	78	75
Neustassfurt	79	79	78	75
Actiengesellschaft Kaliwerke Aschersleben	79	79	78	75
Ludwig II	57	57	25	60
Hercynia	80	80	78	74
Deutsche Solvaywerke	80	80	78	74
Thiederhall	37	36	....	40
Wilhelmshall	57	59	68	59
Glückauf	42	42	56	40
Hedwigsburg	36	36	52	40
Burbach	34	34	45	40
Carlsfund	34	34	48	40
Beienrode	35	35	27	40
Asse	34	34	47	40
Kaliwerk Salzdetfurth	40	40	50	40
Total	1.000	1,000	1.000	1.000

The statistics of the Stassfurt salt industry for the past five years are given in the following tables, which were kindly furnished by the Verkaufssyndikat der Kaliwerke, Leopoldshall-Stassfurt, commonly referred to in the trade as the "Kali-Syndicate." Statistics from the beginning of the industry in 1857 to 1895, inclusive, are given in detail in THE MINERAL INDUSTRY, Vol. VIII., pp. 480 and 481.

KALI-SYNDICATE OUTPUT OF CRUDE SALTS OF ALL KINDS. (IN METRIC TONS.)

Year.	Rock Salt. NaCl.	Carnallite. $KCl, MgCl_2+6H_2O$.	Kieserite. $MgSO_4+H_2O$.	Sylvinite. KCl.	(a) Hartsalz, Schoenite and Kainite.	Boracite. $Mg_7B_{16}O_{30}Cl_2$.	Total.
1898...	291,591	990,998	2,444	94,270	1,120,616	252	2,500,171
1899...	310,378	1,317,948	2,066	100,658	1,063,195	155	2,794,395
1900...	(b)	1,697,808	2,047	147,791	1,189,394	228	3,037,258
1901...	(b)	1,860,189	2.335	190,084	1,432,186	(c)	3,484,694
1902...	(b)	1,727,672	1,821	188,821	1,332,521	(c)	3,250,835

(a) Hartsalz, $NaCl, KCl, MgSO_4+H_2O$; Schoenite, $K_2SO_4, MgSO_4+6H_2O$, Kainite, $KCl, MgSO_4+3H_2O$
(b) No longer compiled. (c) Not stated.

UTILIZATION OF THE CRUDE POTASSIUM SALTS. (IN METRIC TONS.)

Year.	Carnallite and Rock Kieserite.				Kainite and Sylvinite (a) (including Hartsalz and Schoenite).			
	For Agricultural Purposes.		For Manufacturing Concentrated Salts	Total.	For Agricultural Purposes.		For Manufacturing Concentrated Salts	Total.
	Germany.	Elsewhere.			Germany.	Elsewhere.		
1898..........	60,793	7,189	925.461	993,443	722,115	334,111	158,660	1,214,886
1899..........	58,677	4,611	1,256,730	1,320,018	717,637	314,869	131,342	1,163,848
1900..........	55,489	2,869	1,641,493	1,699,851	724,624	375,007	237,554	1,337,185
1901..........	77.862	7,382	1,777.280	1,862,524	859,115	494,220	268,835	1,622,170
1902..........	68,706	5.227	1,655,559	1,729,492	825,170	401,599	244,213	1,470,982

(a) Quantities of sylvinite containing more than 18% potash.

PRODUCTION OF CONCENTRATED SALTS. (IN METRIC TONS.)

Year.	Potassium Chloride. 80%	Potassium Sulphate. 90%	Sulphate. Potassium—Magnesium		Kieserite; Ground and Calcined.	Kieserite in Blocks.	Potash Manure Salt. (a)
			Crystalliz'd 40%	Calcined. 48%			
1898......................	174,380	17,781	914	10,535	728	19,934	24,234
1899......................	180,672	24,656	579	8,459	260	28,216	70,916
1900......................	206.471	31,255	982	12,150	358	28,508	129,863
1901......................	211,421	28,159	751	11.750	361	26,727	140,683
1902......................	181,341	30,202	600	16,834	767	26,809	181,598

(a) Quantities containing 38% potash.

The output of potassium chloride in 1902 was less than during the previous year, due to a smaller domestic consumption, and a decrease in the exports to France, Belgium and Holland. There was, however, an increase in the shipments to the United States. The increase in the production of potassium sulphate was due to the increased exports to the United States and France, the increase more than offsetting the decreased home consumption of this salt. The increase in the production of calcined potassium magnesium sulphate was due to the increased consumption by the United States, Belgium and Holland. Of the output of crystallized potassium magnesium sulphate, none is exported. There was an increase in the production of potash manure salts of 20, 30 and 40% potash contents, caused by Germany and Austria-Hungary consuming more of the 40% product than in 1901, and Norway, Sweden, Denmark, Belgium, Holland, Scotland and Russia importing more of the 20 and 30% product; the United States, on the other hand, importing less potash manure salts.

A history of the potash industry at Stassfurt by J. Westphal appeared in the *Zeitschrift fuer das Berg-Huetten-und Salinen-Wesen,* Vol. L., Nov. 1, 1902, pp. 61-91, and Dr. L. A. Groth has written a book, The Potash Salts, Their Production and Application to Agriculture, Industry and Horticulture, Lombard Press, London, 1902.

The production of potassium salts in metric tons in Germany in 1902 was as follows: Potassium chloride, 267,512 ($7,886,250); kainite, 1,322,633 ($4,802,500); potassium sulphate, 28,279 ($1,133,500); and potassium and magnesium sulphate, 18,147 ($351,250); the corresponding figures for 1901 being potassium chloride, 294,666 ($8,782,250); kainite, 1,498,569 ($4,327,250); potassium sulphate, 37,394 ($1,460,000), and potassium and magnesium sulphate, 15,612 ($286,500).

Markets in 1903.—The prices established by the Kali-Syndicate for the year 1903, for New York, Boston, Philadelphia and Baltimore per 100 lb. are as follows: Potassium chloride, 80 to 85%, basis 80%, $1·80; potassium chloride, minimum, 95%, basis 80%, $1·83; potassium sulphate, 90%, basis 90%, $2·08; potassium sulphate, minimum, 96%, basis 90%, $2·11; double manure salt, 48 to 53%, basis 48%, $1·09; manure salt, minimum, 20% potash, 62c. For Norfolk, Va., Charleston, Savannah, Wilmington, N. C., and New Orleans, add 3·5c. to the New York prices for potassium chloride salts, 3c. for potassium sulphate salts and 2·5c. for double manure salt. For bulk salts on basis of foreign analysis, kainite testing 12·4% potash is quoted for New York at $8·80 per ton of 2,240 lb., invoice weight at shipping port, or $9·05 actual weight at receiving port; sylvinite, 38c. per unit of potassium sulphate, invoice weight at shipping port, or 39c. per unit, actual weight at receiving port. Kainite prices for Norfolk, Charleston and other Southern ports are 50c. higher, while sylvinite is 2c. per unit higher for Norfolk, Charleston, and other Southern ports. These prices are for not less than 500 tons of bulk salts or 50 tons of concentrated salts, and are based on river shipment from the mines to the seaport. For rail shipments an additional amount of 40 pfennigs per 100 kg. or 5c. per 100 lb. is required.

For the first nine months of 1902, domestic potassium chlorate crystals for spot delivery were quoted at $8@$8·125 per 100 lb. f. o. b. works, and $7·50@$7·75 per 100 lb. for future delivery, powdered potassium chlorate bringing $8·50@ $8·75 per 100 lb. f. o. b. works. In October, there was a decline in the price of crystallized salt to $7@$7·25 for prompt delivery and $7 for future delivery, but toward the end of the year a slight recovery in price took place, the salt being quoted at $7·375@$7·625. Contracts for 1903 were made at $6·875@$7·125 per 100 lb. f. o. b. works, or about 50c. less than for 1902. In New York, foreign potassium chlorate in crystals brought $10@$10·50, and in powder $10·50@$10·75 per 100 lb., but toward the end of 1902 the foreign brands also declined, being quoted at $7·50@$7·75 per 100 lb. for immediate delivery and $7@$7·25 for future delivery. Contracts for 1903 for foreign brands were made at the same price as for domestic brands, $7@$7·25 per 100 lb. in New York.

Alkaline Hypochlorites and Chlorates.—F. Foerster and E. Müller[1] determined under what conditions the highest efficiency was obtained, when sodium chloride was electrolyzed in the manufacture of sodium hypochlorite and chlorate.

Temperature.	Anodic Current Density.	E. M. F.	The Electrolyzed Solution contained		Current Efficiency.	Watt-Hours consumed per Grams of Hypochlorite Oxygen.
			Hypochlorite Oxygen per Liter.	Bleaching Chlorine per Liter.		
°C.	Amp.sq. cm.	Volts.	Grams.	Grams.	Per cent.	
13	0·017	2·40	4·20	18·6	96	8·40
13	0·017	2·40	5·24	23·2	90	8·95
10	0·070	3·10	6·80	30·1	96	10·84
13	0·170	3·60	5·28	23·4	99	12·20
13	0·170	3·60	8·70	38·5	87	13·50
14	0·170	4·70	5·20	23·0	95	16·60

This table gives the result obtained when a solution containing 280 g. NaCl and 2 g. K_2CrO_4 per liter was electrolyzed at a low temperature. In the last experiment with the solution which contained 100 g. NaCl per liter, it was found that an E. M. F. of 2·2 volts was sufficient to decompose a strong salt solution, and that 7·2 watt-hours was the minimum quantity of electrical energy theoretically required to produced 1 g. of hypochlorite oxygen. In commercial practice, however, about three times this energy is required. In making alkaline chlorate, it was found that the yield was increased when K_2CrO_4 was added to the solution, and in order to keep the salt in the chromate state, HCl was added from time to time.

E. Walker describes G. J. Aitkins' process[2] for the manufacture of hypochlorite. The cell consists of a semi-cylindrical wooden vat, with axis horizontal, 10 ft. long and 2 ft. wide. The inside is lined with sheet lead, and on the sheet lead are placed carbon bricks about 2 in. thick, whose inner surfaces form a semi-cylinder, concentric with the lead and wood. These carbon bricks are cemented together and to the lead by a waterproof carbon cement. A wooden cylinder covered with lead revolves in the vat within an inch of the surface of the carbons, and the space between is filled with the salt solution. The carbon forms the anodes and the current is distributed to them through the lead. The current is led away from the end of the revolving leaden cathode. The total area of the anode surface is about 20 sq. ft. The current used varies from 1,000 to 1,500 amperes at from 3 to 4 volts, and the quantity of 10% salt solution acted on, varies from 500 to 1,000 gal. per hour, the figures depending on the strength of resulting hypochlorite solution required. Preferably the apparatus is worked at the plant where the solution is at once used, as it is not practicable to store and ship the hypochlorite.

No other chemical is required in the vat as the hypochlorite rapidly gives up its oxygen and passes back to common salt again. The salt can therefore be used repeatedly. One of the great advantages of the sodium salt over chloride of lime is that there is no insoluble precipitate, as is the case when chlorine is released from bleaching powder.

The process may be used as a source of chlorine. The addition of sulphuric acid to the hypochlorite solution releases chlorine and oxygen, and forms sodium

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[1] *Zeitschrift fuer Elektrochemie*, Jan. 1, 1902, pp. 8–17.

[2] *Engineering and Mining Journal*, Nov. 22, 1902, p. 679.

sulphate. It is probable that it would be a better source of chlorine for chlorination than bleaching powder, and at any mine where fuel, water and salt are obtainable, the cell might be erected for the direct production and use of chlorine both in treating gold ores and in leaching low grade copper ores. The metallurgist of the Mount Morgan Mine, Queensland, is at present investigating the applicability of the process to the ores of that mine, and intends to install an experimental plant.

The McDonald electrolytic cell for the production of chlorine has been described[3] by Titus Ulke. The advantages claimed for this cell are simplicity of design, relative cheapness of construction, and the small amount of attention it requires. The plant at the Clarion paper mill, at Johnsonburg, Pa., consists of 50 McDonald cells arranged in two parallel rows, occupying a floor space of 60×15 ft.

The cell is a very simple and compact electrolyzer, without revolving or reciprocating parts. It has 10 carbon anodes extending into the closed central compartment of a three-chambered rectangular cast iron tank, the outside or cathode compartments of which are separated from the anodes, by asbestos diaphragms lining the inner surface of the perforated iron partition walls.

The electrolytic tank, which is 1 ft. wide, 1 ft. high, and 5 ft. 2 in. long, is cast in one piece with two longitudinal partition walls, thus dividing it into three compartments, (Fig. 2). Against each perforated side wall of the central or anode compartment of the tank is stretched a diaphragm, consisting of a layer of asbestos paper fastened to asbestos cloth by a small quantity of sodium silicate. This diaphragm is held in position by cement placed over both the end walls and the bottom of the anode compartment. The latter is closed by a cover *B*, of cast iron, 5 in. deep, 6 in. wide and nearly 5 ft. long, into which the anodes are cemented. It is painted inside with asphalt varnish and lined with cement.

The anodes *C* consist of blocks of graphitized carbon, 4 in. square and 10 in. long, into each of which a round copper conductor, 9 in. long, is fastened by means of hot lead poured in and about the socket and over the copper so as to encase it completely in a protecting film of lead. The conductors are slit at their ends and connected in multiple by means of a flat copper bar, about 0·1667 ($\frac{1}{6}$) in. thick, resting in the slits. As all the cells of a group are placed in series circuit, the copper bar of the first cell only is attached to the positive line conductor, and the iron tank of the last cell to the negative line conductor. The negative poles, therefore, are formed by the tanks themselves, or rather by their partition walls. These, as stated, are perforated, there being 4 or 5 perforations to the sq. in., and each perforation measuring about 0·03125 ($\frac{1}{32}$) in. in diameter.

The partition walls *D* are flanged, as shown in Fig. 4, so as to form a seat for the reception of the cover and for a layer of cement, which extends completely around the cover and hermetically seals the joints between the same and the end and partition walls of the tank, and thus prevents the escape, except through the lead pipe *E*, of the gases from the anode compartment.

The lead pipes *E* from all the cells lead through a flexible connection into the

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[3] *Engineering and Mining Journal*, June 6, 1908, p. 857.

gas main of vitrified pipe, which carries the chlorine gas to the absorbing towers, where it is brought into contact with lime water and lime to form bleaching solution ready for use.

Each cathode compartment of the cell may be closed by a cover into which a pipe extends and through which the evolved hydrogen gas may be drawn off and

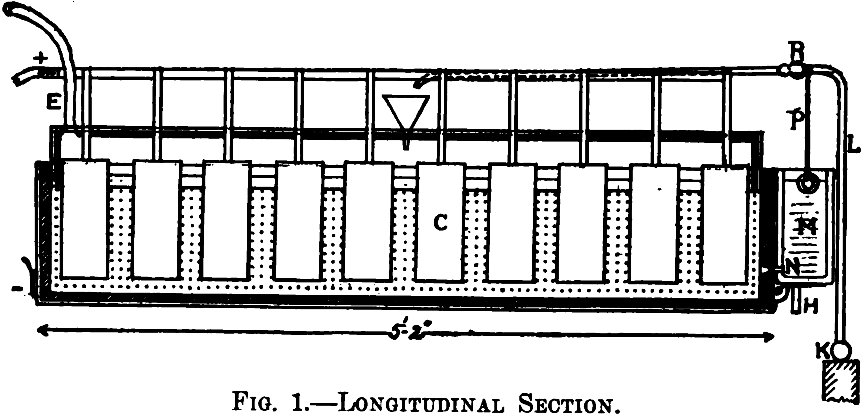

FIG. 1.—LONGITUDINAL SECTION.

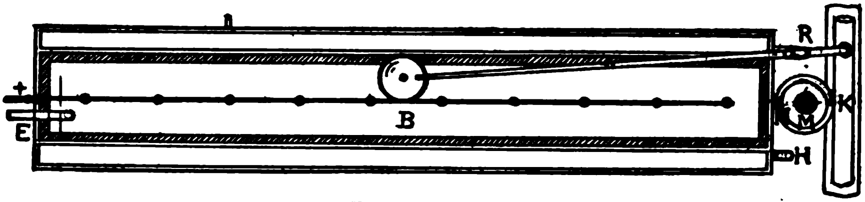

FIG. 2.—PLAN.

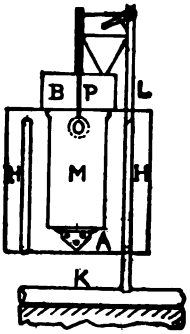

FIG. 3.—END ELEVATION.

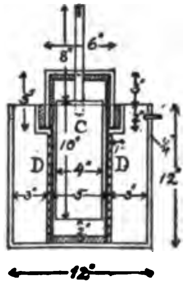

FIG. 4.—CROSS SECTION.

THE MCDONALD CELL.

utilized, although allowed to escape, at present, as is the general practice with electrolytic chlorine plants.

In Figs. 1 to 3, *H* represents overflow pipes communicating with the cathode compartments and used for carrying off the caustic liquor. These pipes are of elbow form, and so arranged as to cause the withdrawal of the caustic liquid from the bottom of the cathode compartments, thus preventing escape of the hydrogen.

The brine is supplied to the anode compartment from the brine main *K* through pipe *L*, and its feed may be controlled by an automatic feeder consisting of a vessel *M*, in communication by a tube *N* with the anode compartment, so that the level of the liquid in said compartment and vessel will always remain the same. A float *O* is contained in the vessel *M*, and is connected by a rod *P* with a pivot valve *R* in the pipe *L*, whereby the rise and fall of the liquid in the anode compartment controls the supply of fresh liquid through the pipe *L*.

In operation, the compartments are filled with brine, and the electric current is then turned on. The chlorine gas accumulates in the anode compartment and passes into the gas main, while caustic soda (NaOH) appears in the cathode compartments, as a result of the action of the separated sodium on the water according to the equation: $Na+H_2O=NaOH+H$. In this way the practical separation of the chlorine gas from the hydrogen gas and caustic liquor is effected.

With a current of 420 amperes and 225 volts (4·5 volts per cell), about 1,400 lb. of chlorine are produced daily. With 500 amperes at 250 volts, under the most favorable conditions, it is claimed that 5,000 lb. of bleaching powder containing 35% available chlorine could be produced daily. This is equivalent to 167·5 electrical H.P. for 2·5 tons of bleaching powder, or 67 H.P. per ton per day, or nearly 10·5 lb. of chlorine per H.P. day. It is reported that a ton of bleaching powder does not cost more than $12 to $15 to produce, without including the value of the caustic liquor and the hydrogen obtained as by-products.

For the manufacture of chlorates and perchlorates, P. L. E. Lederlin[4] uses chromic acid in the alkaline chloride solution, and passes the electric current. In order to keep the chromic acid in the state of bichromate, hydrochloric acid or any suitable mineral acid is added to the electrolyte, and on cooling the electrolyzed liquor, the chlorate or perchlorate crystallizes out of the solution.

In cells for electrolyzing fused salts, J. Raschen has patented[5] a method for keeping the liquid cathode at the bottom at a constant level.

Hans A. Frasch has patented[6] a method for producing alkali by the reaction of a metal (especially nickel) on salt in the presence of ammonia.

Potassium Cyanide.—A description of the manufacture of potassium cyanide appeared in THE MINERAL INDUSTRY, Vol. X., pp. 550-554. A. Adair[7] describes a method for determining the amount of cyanide in commercial potassium cyanide.

A process of producing pure alkaline cyanide has been patented[8] by J. D. Darling, which consists in subjecting alkaline oxide to the action of carbon and nitrogen under the influence of heat, whereby cyanized charcoal is produced; and subjecting this cyanized charcoal to the action of ammonia gas and alkali metal under the influence of heat, whereby the carbon remaining in the cyanized charcoal is converted into cyanide.

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[4] United States Patent No. 698,085, Feb. 11, 1902.

[5] English Patent No. 13,662, of 1901.

[6] English Patent No. 19,096, of 1901.

[7] *Journal of the Chemical and Metallurgical Society of South Africa*, January, 1903, *Engineering and Mining Journal*, April 11, 1903.

[8] United States Patents Nos. 698,262, 698,263, 698,264, April 29, 1902.

QUICKSILVER.

By Joseph Struthers.

The production of quicksilver in the United States during 1902 amounted to 34,451 flasks of 76·5 pounds, valued at $1,500,142, as compared with 29,727 flasks, valued at $1,382,305 in 1901, an increase in quantity of 4,704 flasks and in value of $117,207. Of the total production during 1902, California contributed 29,199 flasks and Texas 5,252 flasks. Oregon, which reported a production of 75 flasks during 1901 from properties undergoing development, made no production during 1902.

PRODUCTION AND EXPORTS OF QUICKSILVER IN THE UNITED STATES.

Year.	Production.			Exports.			Year.	Production.			Exports.		
	Flasks.	Met. Tons.	Value.	Flasks.	Met. Tons.	Value.		Flasks.	Met. Tons.	Value.	Flasks.	Met. Tons.	Value.
1897..	26,079	965	$910,418	13,173	475	$394,549	1900....	27,855	967	$1,288,851	10,172	353	$425,812
1898..	30,493	1,058	1,109,945	12,830	445	440,567	1901....	(a)29,727	1,031	1,382,305	11,219	389	475,609
1899..	28,879	993	1,155,160	16,518	573	609,586	1902....	34,451	1,195	1,500,412	13,247	459	575,099

(a) The total production is divided as follows: California, 26,720 flasks; Texas, 2,932 flasks; Oregon, 75 flasks.

The imports of quicksilver during the past six years were as follows: 1897, 45,589 lb. ($20,147); 1898, 81 lb. ($51); 1899, 131 lb. ($83); 1900, 2,616 lb. ($1,051); 1901, 1,441 lb. ($789).

Prices.—The average monthly prices of quicksilver at New York and San Francisco during 1902 are given in the subjoined table:—

Month.	New York.	San Francisco.	Month.	New York.	San Francisco.
January	$48·37	$46·44	August	$48·00	$46·00
February	48·00	47·75	September	48·00	46·00
March	48·00	47·75	October	48·00	46·00
April	48·00	47·75	November	48·00	46·00
May	48·00	46·40	December	48·00	46·00
June	48·00	46·00			
July	48·00	46·00	Average	$48·03	$46·51

California.—During 1902 the mines at San Benito, Napa and Santa Clara counties contributed nearly 20,000 flasks of the total of 29,199 flasks for the entire State. The chief producing companies in the order of their outputs during 1902 were: New Idria Quicksilver Mining Co., San Benito County; The Quicksilver Mining Co., Santa Clara County; Napa Consolidated Mine, Napa County; Karl Quicksilver Mining Co., San Luis Obispo County; Boston Quicksilver Mining Co., Napa County; Great Western Mine, Lake County; Empire Consolidated

Quicksilver Mining Co., Colusa County; Great Eastern Quicksilver Mining Co., Sonoma County.

The Ætna Consolidated Quicksilver Mining Co. made no production in 1902, the work being confined to opening old tunnels a distance of 706 ft. and running new drifts and tunnels 690 ft. at a cost of $15,211. The deficit reported for the year was $20,146, reducing the balance brought forward from the previous year from $60,712 to $40,566. The Boston Quicksilver Mining Co. during 1902 treated 23,774 tons, as compared with 19,045 tons in 1901, and obtained 1,950 flasks of quicksilver, as compared with 1,545 flasks in the earlier year. From the sales of quicksilver during 1902 there was received $70,898, while the quicksilver on hand Jan. 1, 1903, was valued at $11,550, a total of $82,448. The total expenditure amounted to $84,218, against a total income of $84,398, leaving a net profit of $180, reducing the debit balance brought forward from the previous year from $9,034 to $8,854. During the year the drifts and tunnels were excavated 2,037 ft., as compared with 2,507 ft. in 1901. The Napa Consolidated Quicksilver Mining Co. treated 31,737 tons of ore and obtained 3,900 flasks of quicksilver, of which a quantity valued at $139,249 was sold, and the balance, valued at $24,780, remained on hand at the end of the year. The income of the company was $168,346, and the total expenditure amounted to $172,374, the net loss for the year being $4,028. Dividends of $30,000 were paid, and the balance brought forward from the previous year was reduced from $70,748 to $36,719. The amount of drifts excavated was 8,376 ft. During a part of the year the ore was from medium to low grade and one furnace was closed three months for repairs. The New Idria Quicksilver Mining Co. treated 49,160 tons of ore and produced 7,225 flasks of quicksilver, from the sales of which it realized $261,249, the quicksilver unsold being valued at $42,000, a total of $303,249, which, with interest and increase of supplies, increased the income of the company to $309,989. The expenditures amounted to $149,642, the net earnings were $160,347, out of which dividends of $100,000 were paid, increasing the balance brought forward from the previous year from $40,929 to $101,276. The drifts were excavated during the year to a distance of 1,253 ft.

A few new mines were added to the list of producers during 1902, notably the Helen mine in Lake County, the Mercury mine in Sonoma County, and the Silver Creek mine in Santa Clara County. New companies reported to have begun operations in 1902 are:—the Monterey Quicksilver Mining Co., near New Idria; the Modoc Chief mine, 18 miles east of Reading, Shasta County; the Mariposa, Elizabeth, Uncle Sam and Eureka mines, near Cambria, San Luis Obispo County, and the Summit, Adobe Valley and Orestimba properties, in Stanislaus County. Deposits of good grade cinnabar ore are reported 25 miles southeast of Cedarville, in Modoc County, which is in the extreme northwest part of the State, an entirely new section for cinnabar. The claims here have not been sufficiently developed to prove the commercial value of the property.

Under ordinary circumstances, quicksilver may be produced in California at a cost of $3 per ton of ore mined and smelted, which makes it possible to work profitably ores averaging from 0·3 to 0·6% Hg, and occasionally of lower grade. According to B. M. Newcomb, the cost of producing quicksilver from the average mine in California, exclusive of interest and development work, exceeds $35 per flask. Although the greater well-known quicksilver mines are in a measure exhausted, it is practically assured that the future production of quicksilver in the State will occupy a prominent position of economic importance for many years to come. It is not probable that other mines equal in extent to the New Almaden or New Idria will be discovered, but on the other hand there are numerous smaller mines throughout the State which can contribute an output of from 20 to 300 flasks per month. Furthermore, it was the general belief ten years ago that the New Idria, Ætna, Oat Hill, New Almaden, and other prominent mines were practically exhausted, yet the production from these properties still continues to be of much importance.

Classified by counties, the output of quicksilver in California during 1901 and 1902 was as follows:—

County.	1901.		1902.	
	Flasks. (*a*)	Value.	Flasks. (*a*)	Value.
Coluss	235	$10,575	1,883	$88,610
Lake	4,395	211,824	2,833	204,058
Napa	7,738	388,176	6,792	289,474
San Benito	4,800	242,300	7,290	306,080
San Luis Obispo	840	41,513	3,312	147,214
Santa Clara	5,220	236,608	5,869	254,260
Salina	......	......	42	1,890
Sonoma	2,130	95,850	1,440	74,685
Trinity	1,302	58,668	238	10,251
Total	26,720	1,283,014	29,199	$1,271,522

(*a*) Flasks of 76.5 lb. net.

Oregon.—There was no production of quicksilver in Oregon during 1902, as compared with 75 flasks in the preceding year. Prospecting has been quite active, and considerable development work has been accomplished at several properties. The smelting furnace of the Blackbutte Quicksilver Mining Co., at Blackbutte, which furnished the output during 1901, was not operated during 1902 owing to the delay in rebuilding the condensing plant.

Texas.—The production of quicksilver in Texas during 1902 was 5,252 flasks, valued at $228,620, as compared with 2,935 flasks, valued at $132,438 in 1901, which shows a very active development of the industry in this State; the entire output for both years was made by the Marfa & Mariposa Mining Co., operating at Terlingua, in Brewster County. According to Mr. B. F. Hill, in Bulletin No. 4 of the University of Texas Mineral Survey, cinnabar occurs in the Terlingua mines, either in hard and durable limestone, or in soft and friable argillaceous beds. In the Excelsior claims, the quicksilver occurs mainly as cinnabar, but small quantities of native mercury, calomel and terlinguaite (a new mineral species consisting of mercury oxychloride) are also found. A 10-ton Scott furnace to treat these ores was erected in August, 1900, by Messrs. Norman, Sharpe & Golby, who formed the Marfa & Mariposa Mining Co. in February, 1901, and a second 10-ton furnace was installed early in 1902. The Terlingula Mining Co. built a 40-ton Scott furnace in 1902, which, however, was closed down shortly after it was completed. The Colquit Mining Co. is building a 10-ton Scott furnace to treat the ore from the Excelsior mines, which occurs in veins of from 8 in. to 3 ft. in width and in occasional pockets. The operations by this company have been limited mainly to the surface. The ore is hand sorted, crushed to lumps of from one to two inches in size, and conveyed by belts to the ore bins above the level of the top of the furnace into which the ore is subsequently charged by hoppers; the greater part of the ore is oxidized or treated with lime in a Scott continuous furnace, a small quantity only being distilled direct in retorts.

The Scott continuous furnace, which is used by this company, is fully described with illustrations in THE MINERAL INDUSTRY, Vol. VII. At Terlingua both wood and water are scarce. At present most of the water used is hauled by wagons from the Rio Grande, a distance of 12 miles.

Utah.—A battery of retorts for the treatment of the mercurial gold ores of the Sacramento mines of Mercur, is reported to have been started early in 1903.

QUICKSILVER PRODUCTION OF THE WORLD. (*a*) (IN METRIC TONS.)

Year.	(*b*) Austria.	Canada.	Hungary	(*b*) Italy.	Japan.	Mexico.	(*b*) Russia.	(*b*) Spain.	United States.	Total.
1897.....	532	0·3	0·7	192	2·7	294	616	1,728	965	4,327
1898.....	491	*Nil.*	6·8	178	1·4	358	362	1,691	1,058	4,128
1899.....	536	*Nil.*	27·0	205	*Nil.*	324	360	1,357	993	3,775
1900.....	510	*Nil.*	31·8	260	2·7	124	304	1,095	983	3,276
1901.....	525	*Nil.*	33·3	278	*c* 2·8	128	368	754	1,081	3,120
1902.....	*d*510	*Nil.*	(*e*)	*d*265	(*e*)	(*e*)	416·5	1,500	1,196	....

(*a*) From official reports of the respective governments and direct reports of the producers to THE MINERAL INDUSTRY. (*b*) The figures for Austria and Italy are due to V. Spirek, that for Russia to the sole producer and that for Spain to the *Revista Minera*. (*c*) Estimated. (*d*) Idria only. (*e*) Statistics not yet available.

LONDON QUICKSILVER STATISTICS. (*a*)

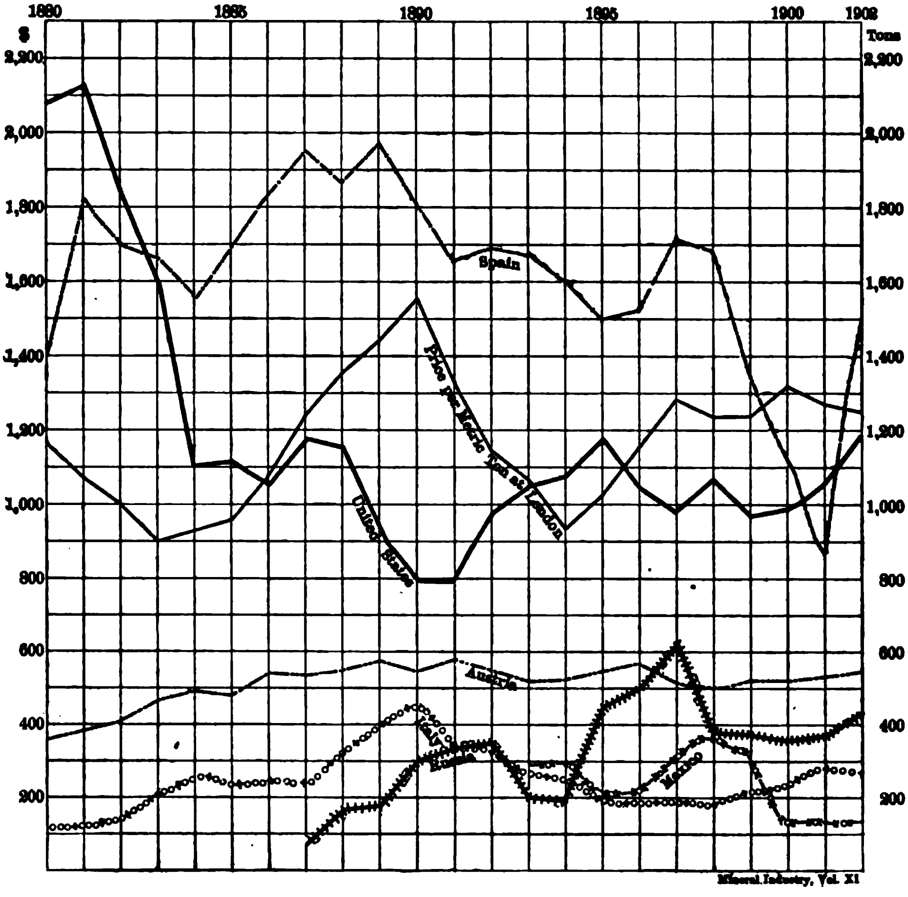
	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.
	Flasks. (*b*)	Flasks. (*b*)	Flasks. (*b*)	Flasks. (*b*)	Flasks. (*b*)	Flasks. *b*)	Flasks. (*b*)	Flasks. (*b*)
Shipments from Spain to London...........	40,409	40,949	46,577	46,367	45,729	10,963	29,050	28,997
Shipments from Italy to London..................	5,775	3,800	4,450	5,650	6,206	6,045	5,254	3,187
Total....................	46,184	44,799	51,027	52,017	55,935	17,008	34,304	32,184
Shipments from London....	37,937	31,273	31,784	31,026	31,903	24,958	*c* 26,830	20,000
Maximum price of Spanish.	£7 7s. 6d.	£7 5s.	£7 7s. 6d	£7 15s.	£9 12s. 6d	£9 12s. 6d	£9 2s. 6d	£8 17s. 6d
Minimum price of Spanish..	6 7s. 6d.	6 8s. 6d	6 12s. 6d	7 0s.	7 15s.	£9 2s. 6d	8 17s. 6d	8 15s.

(*a*) From W. Sargant & Co.'s Annual Metal Circular, excepting for the years 1901 and 1902 which was taken from official reports. (*b*) American, Russian and Italian flask, 76·5 lb. (34·7 kg.); Mexican flask, 75 lb. (34·08 kg.); Spanish flask, 76 lb. (34·5 kg.). (*c*) For the year ending Nov. 30, 1901.

Algeria.—Deposits of cinnabar accompanied by zinc blende, calamine, siderite and galena have been found at Taghit. The ore is said to carry from 1·25 to 1·5% Hg and from 5 to 15% Pb and Zn. Sufficient exploratory work has been done to expose a large ore reserve, and three calcining furnaces have been erected at the mines. The furnaces are supplied with Cermak-Spirek condensers for the recovery of the quicksilver, details of which are given elsewhere in this section.

Austria.—In Spizza, in southern Dalmatia, quicksilver occurs in dolomite, and in some places is found with barytes. The quicksilver in the high-grade ore assays from 3·5 to 16·09% Hg, and in the low-grade ore from 0·18 to 1·3% Hg. The commercial development of the new property is in contemplation. The mines at Idria, in the Province of Carniola, have been operated by the Government for more than three centuries, about 80,000 tons of ore are produced annually, which is smelted in three furnaces, giving employment to 1,200 men. During 1902 the output from these mines amounted to 510 metric tons.

Australia.—A 50-ton shaft furnace is being erected to treat the cinnabar ore from the mines of the Great Australian Quicksilver Co., at Yulgebar, on the Clarence River, New South Wales. It is estimated that the ore can be mined and smelted at a cost of £2 per ton, which will permit the profitable treatment of material containing as low as 2% Hg. The company had 400 tons of 4% ore mined at the end of 1902 and large bodies of ore containing from 2 to 3% of mercury are being developed. On account of the high cost of labor the ore will not be hand picked, but will be charged to the furnace as mined. Charcoal is used for fuel. The cinnabar occurs in granite which is irregularly dispersed throughout the country rock; it is found also in a concentrated form in channels fairly well defined. The extensive body of quicksilver ore in Ewengar,



PRODUCTION OF QUICKSILVER IN THE PRINCIPAL COUNTRIES OF THE WORLD AND THE PRICE PER METRIC TON AT LONDON.

Drake Division, New South Wales, has been exploited during 1901 and a proposal made to erect a plant to treat the ore at the mine. Prospecting was carried on at Carwell, Rylston district, but no payable ore was found. It is reported that prospecting for cinnabar in the district between Waitahuna and Waipori (Otago), New Zealand, has resulted in the discovery of an ore body of considerable extent.

Brazil.—The cinnabar deposits at Tripuhy, near Ouro Preto, have been purchased by a Belgian company, which will shortly begin mining operations. Samples of ore have assayed from 0·88 to 4·73% Hg. The cinnabar is found in a vein having a dip of 30°, which will facilitate the mining of the ore.

China.—The Anglo-French Quicksilver & Mining Concession (Kweichow Province) of China, Ltd., has been operating in the Province of Kweichow since the latter half of 1899. Owing to the Boxer uprising in the following year, the company's operations were considerably hampered, but since 1901 work has progressed in a very satisfactory manner. The operations are confined principally to the development of the Wen Shan Chiang quicksilver mines, near the western border of Hunan, embracing an area of 4 sq. miles. The mines are 12 miles north of the Yuen River, a tributary of the Yangtze Kiang River, and the transport of material and passengers, although slow, is easily effected. The country is mountainous and deeply fissured by enormous cañons and ravines, which form a serious obstacle to the transport of materials from the river to the mines. The country rock is magnesium limestone, several hundred feet in thickness, which covers a very extensive tract of this and the neighboring province. The ore bodies occur in a distinct zone of the limestone, and are isolated and irregular in shape and size; as yet, no connection has been found to exist between the deposits. The principal mines, the Dah Siao Tung and Gian Gia Wahn, are being worked, and several smaller ones which have been operated for several generations are worked in a primitive manner by natives.

The ore consists of cinnabar in two varieties, one is bright red in color and transparent, and the other is dark red and almost opaque; the former, when perfectly clear, finds a ready sale in the local market at prices equal and often considerably higher than quicksilver, depending on the size and transparency of the crystals. The ore mined is hand sorted roughly, the richer pieces being crushed and washed for cinnabar, while the poorer ore is broken down to pass a 1·5-in. screen, and subsequently treated in a 12-ton Granzita furnace, which has been in operation since April, 1902. Another Granzita furnace of the same capacity is in course of construction, and will be completed in May. The company owns an extensive compound which covers an area of 5 acres, wherein are built the furnaces and ore bins, and the offices, stores and dwellings for the European and Chinese staffs. The production of quicksilver since the commencement of operations to the end of 1902 has amounted to 32,500 lb., and 5,000 lb. of cinnabar also have been produced.

India.—The discovery of a large deposit of cinnabar has been reported at Devil's Hill, between Tellicherri and Cannamore, in the Madras Presidency.

Italy.—According to Vincente Spirek, the five quicksilver works at Monte Amiata, Tuscany, are equipped as follows: 1. Siele, three Cermak-Spirek furnaces, of 24, 12 and 2 metric tons capacity per day, and three shaft furnaces of 4 to 6 tons capacity per day. 2. Cornacchino, two Cermak-Spirek furnaces (24 tons and 2 tons) and one shaft furnace (4 to 6 tons). 3. Abbadia San Salvadore, two Cermak-Spirek furnaces of 24 tons, two of 2 tons, and two shaft furnaces of 6 tons each. 4. Montebuono, one Cermak-Spirek furnace of 12 tons. 5. Cortivecchie, two Cermak-Spirek furnaces building, one of 24 tons, one of 12 tons. The record of all the works from 1893 to 1901, both years inclusive, is as follows:—

Year	Ore Treated.	Average Yield.	Quantity of Quicksilver Produced.	Year	Ore Treated.	Average Yield.	Quantity of Quicksilver Produced.
	Tons.	%	Tons.		Tons.	%	Tons
1893	14,950	1·9	273	1898	19,201	0·80	193
1894	15,022	1·7	258	1899	29,822	0·70	205
1895	10,504	1·9	199	1900	33,930	0·75	260
1896	18,701	1·8	188	1901	35,000	0·77	271
1897	20,659	0·99	192				

The average value of the quicksilver produced was 4·85 lire per kg. in 1893, and 4·40 lire per kg. in 1894. Since then it has risen gradually but steadily, to 6·50 lire per kg.—$43·50 per flask—the price reported in 1902. Cinnabar is found in the provinces of Tuscany, Florence, Pisa, Lucca, Genoa, Parma, Como, Belluno and Calabria. The ores contain, on an average, 1·2% Hg at Siele, 0·6% at Cornacchino, and 0·4% at Montebuono, as compared with 8% at Almaden, Spain; 0·8% at Idria, Austria; 1% at Nikitowka, Russia, and from 1 to 3% in California. The large Cermak-Spirek continuous furnace has a capacity of 45 tons of ore, but the quantity worked through in 24 hours varies according to the character of the ore. At Siele, it amounts to from 12 to 16 tons, and at Cornacchino, from 20 to 26 tons; while at Montebuono, from 8 to 12 tons of ore are passed through the medium-sized furnace in 24 hours. The temperatures that are obtained in the furnace are as follows: In the combustion chamber, 800° to 900°C.; in the first tier of the roasting-zone, 700° to 800°C.; in the second, 500° to 600°C.; in the third, 500°C.; in the fourth, 360° to 400°C.; in the discharging and collecting passages, 260° to 360°C., and in the drying chamber, which is merely heated from below by the furnace gases, 100° to 200°C. The ore from the mines is sorted into coarse ore over 35 mm. in size, and mixed ore below that size to dust, and then passes direct to the furnace, except that when the proportion of moisture exceeds 7% the ore is dried in summer by the sun's heat, and in winter in specially constructed kilns. The coarse ore, over 35 mm. in size, is treated in stack furnaces, of which the more recent ones are double-stack furnaces. At Siele, in the three-stack furnaces, 18 tons of ore are treated in 24 hours, with an expenditure of 360 kg. of hard charcoal. The results of working with the Cermak-Spirek furnaces, since they have been in proper order, show that with an ore charge containing 529·91 tons of quicksilver, 505·46 tons are recovered, representing a loss of 4·6%. When new condensers are installed, the loss increases to 6%. The mercury absorbed by the plant is, however, recoverable when reconstruction is being carried out.

The cost of the furnaces at the Siele works was as follows: Large Cermak-Spirek furnace, 25,000 fr.; condenser with 6 cast-iron pipes and 300 clay pipes, 13,000 fr.; medium-sized furnace, 22,000 fr.; small furnace, 5,000 fr.; double-stack furnace, 8,000 fr.; single-stack furnace, 4,000 fr.; central condensation chamber, etc., 10,000 fr.; engines, 8,000 fr.; muffle-furnace, 9,000 fr.; buildings, 40,000 fr.; drying kiln, 6,000 fr.; total, 150,000 fr.

Mexico.—The principal producing quicksilver mines are near Huitzecuco, Guerrero, where cinnabar occurs in pockets and is distributed in metamorphosed limestones and slates. The ore which carries silver and antimony also, is found at or near the tops of small hills and occurs as a soft, sandy clay, filling in crevices that often radiate from a common center. The average content of the ore in quicksilver is about 1·7%, but the extraction is very low, about 50%, although ore of 0·62% Hg has been worked. The plant at the Cruz and Anexas mine represents an outlay of $250,000, and from 250 to 300 flasks of quicksilver are produced monthly. The process of treating the ore is quite primitive, consisting in coarse crushing, roasting in brick furnaces whereby the quicksilver is expelled from the ore as a black soot which is subsequently condensed and the quicksilver obtained therefrom by rabbling on a heated iron plate placed at an angle to allow of the outflow of the reduced metal. The Nueva Potosi deposits, San Luis Potosi, were worked 25 years ago, and have been re-opened. The ore carries less than 1% Hg, but is said to exist in large bodies easily mined. The Montezuma district in San Luis Potosi, may also be mentioned, especially the Dulces Nombres mines, where ore of 30 to 70% Hg has been found in a ferruginous gangue. According to B. F. Hill, cinnabar occurs in porphyry near Archuivo, Chihuahua, and in gypsum and limestone, with calcite and fluorite near Guadalcazar, San Luis Potosi. At the latter locality the metal content of the ore varies from 2 to 3·5%.

Peru.—The production of quicksilver during 1900 was 11 metric tons, valued at $7,473.

Russia.—The report of the sole quicksilver producing concern, Messrs. A. Auerbach & Co., an English company operating mines in the Ekaterinoslav district in southern Russia, states that during 1902 it mined 99,970 metric tons of ore averaging 0·45% Hg at a cost of $1·36 per ton. Of this quantity, 91,370 tons were sorted, and 91,370 tons roasted, which yielded 416,441 kg. (=11,974 flasks) quicksilver at a treatment cost of 70c. per kg. The average selling price was $1,246·84 per metric ton, and the 12,000 iron flasks required cost 78·13c. per flask.

Spain.—The output of quicksilver in Spain continues to be obtained from the historic Almaden mine in the Province of Ciudad Real, and while other quicksilver mines are worked in the Province of Oviedo, the output therefrom is comparatively insignificant. The contract for the supply of quicksilver flasks required by the Almaden mines during the next eight years has been awarded to a Spanish concern at the price of 6·1 pesetas per flask. The exports of quicksilver from the Port of Seville during 1902 amounted to 1,132 metric tons, as compared with 830 tons in 1901 and 1,025 tons in 1900.

TECHNOLOGY.

Review of Analytical Chemistry.—The gravimetric determination of mercury and its separation from antimony, arsenic and copper, according to C. J. Pretzfeld[1] may be accomplished as follows:—To the solution of the four metals, 30 c.c. of a saturated solution of tartaric acid is added, and the whole thoroughly stirred; KCN in solution is then added gradually until the precipitate which forms at first is completely dissolved, the addition of KCN being continued until from 2 to 3 g. are in excess. The cold solution is then saturated with H_2S, and the precipitate settled, filtered, washed with water containing H_2S, and finally dissolved in a mixed solution of KOH and K_2S. The resultant solution is diluted to 125 or 130 c.c., heated to 70°C. and electrolyzed with a current of $ND_{100}=0{\cdot}12$ amperes and 2·5 volts, or a cyanide solution may be used for the electrolyte with a current of $ND_{100}=0{\cdot}07$ amperes and 3·5 volts at a temperature of 65°C. The electrolytic method, however, is not applicable to ores or alloys containing tin.

Spirek Furnaces.—The details of the new Spirek reverberatory furnace are shown in Figs. 1 and 2. Fig. 1 gives the general arrangement in plan of the reverberatory and shaft furnaces and condensers, while Fig. 2 shows a longitudinal vertical section of the reverberatory furnace and condensers. This furnace is supplied with the same charging device as the shaft furnace described in THE MINERAL INDUSTRY, Vol. X., p. 559. The ore falls through the channel *b* to the roasting chamber *a*, where its progress during the treatment is regulated by means of the opening *c*. The fireplace *d* occupies the whole width of the furnace and the flame passing to the roasting chamber, is carried with the quicksilver vapors through the chambers *e* to the condenser. From the chamber *a* the spent ore is collected in the funnels *k*, where it may be withdrawn by means of the levers *l*. The air before entering the roasting chamber is preheated by passing through channels *m* and *n*. The furnace stands upon iron posts and is strengthened with iron plates. For the roasting of quicksilver-lead ores a temperature of from 300° to 400°C. should be maintained.

The Cermak-Spirek furnace which has been described in THE MINERAL INDUSTRY, Vols. VI. and X., is now used at Siele, Comacchino, Montebuone and Abbadia San Salvadore, in the Monte Amiata district, Italy; at Nikitowka, Russia, and at Taghit, Algeria. There are in course of construction also four furnaces at Almaden, Spain, and one at Cortivecchia, Italy; while one furnace has been built at Ponte di Nossa, Italy, for the calcination of zinc ores.

At the Taghit mine in Algeria, owned by Laguchee Co., of Paris, two furnaces have been erected. Of these one is a Cermak-Spirek roasting and calcining furnace of 6 tons daily capacity (ores finer than 35 mm. in size) and the other a Spirek shaft furnace to treat 6 tons of ore per day, of a size greater than 35 mm. These furnaces treat the zinc ore for quicksilver in the winter when there is enough water to cool the condensers, treatment of the calcined ore free from quicksilver being reserved for the summer months, when the condensers are disconnected. After the extraction of the quicksilver the calcined ore is sold. For the extraction of the quicksilver a temperature of from 400° to 600°C. is required, while that for calcining is 1,100°C.; both processes, however, are worked in the

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[1] Dissertation for the degree of Doctor of Philosophy, Columbia University, 1902.

same furnace and very satisfactory results are obtained. For smelting the galena, the Spirek reverberatory furnace has been used. It is small, can be operated from both sides but great care is requisite during the removal of the quicksilver; the temperature should be between 300° and 400°C., so that the galena is not melted. This process also has been successful, the furnace being in operation since December, 1901.

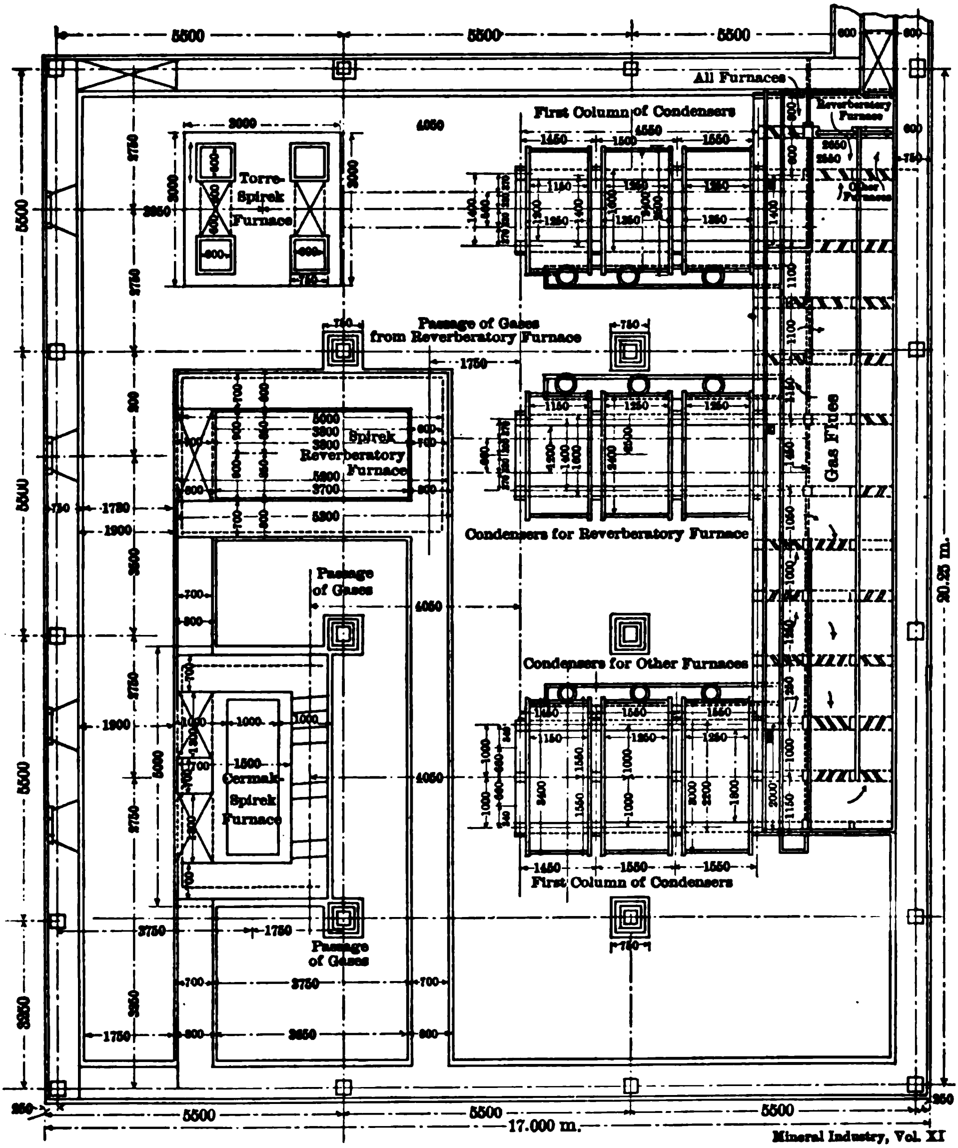

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FIG. 1.—GENERAL ARRANGEMENT IN PLAN OF THE SPIREK REVERBERATORY AND SHAFT FURNACES AND CONDENSERS.

The itemized costs of a plant consisting of two continuous furnaces, each with a capacity of 12 tons ore per day; one continuous furnace of 6 tons ore per day, and one duplex shaft furnace of 12 tons per day, together with channel, chimney and engines, were as follows: Fireproof material and terra cotta for furnace and condensers, 21,703 fr.; ironwork, 27,586 fr.; woodwork for condensers and channels, 6,636 fr.; materials for foundations, channel and chimney, 11,620 fr.; engines, including blower, 8,000 fr.; total, 78,539 fr. (sic).

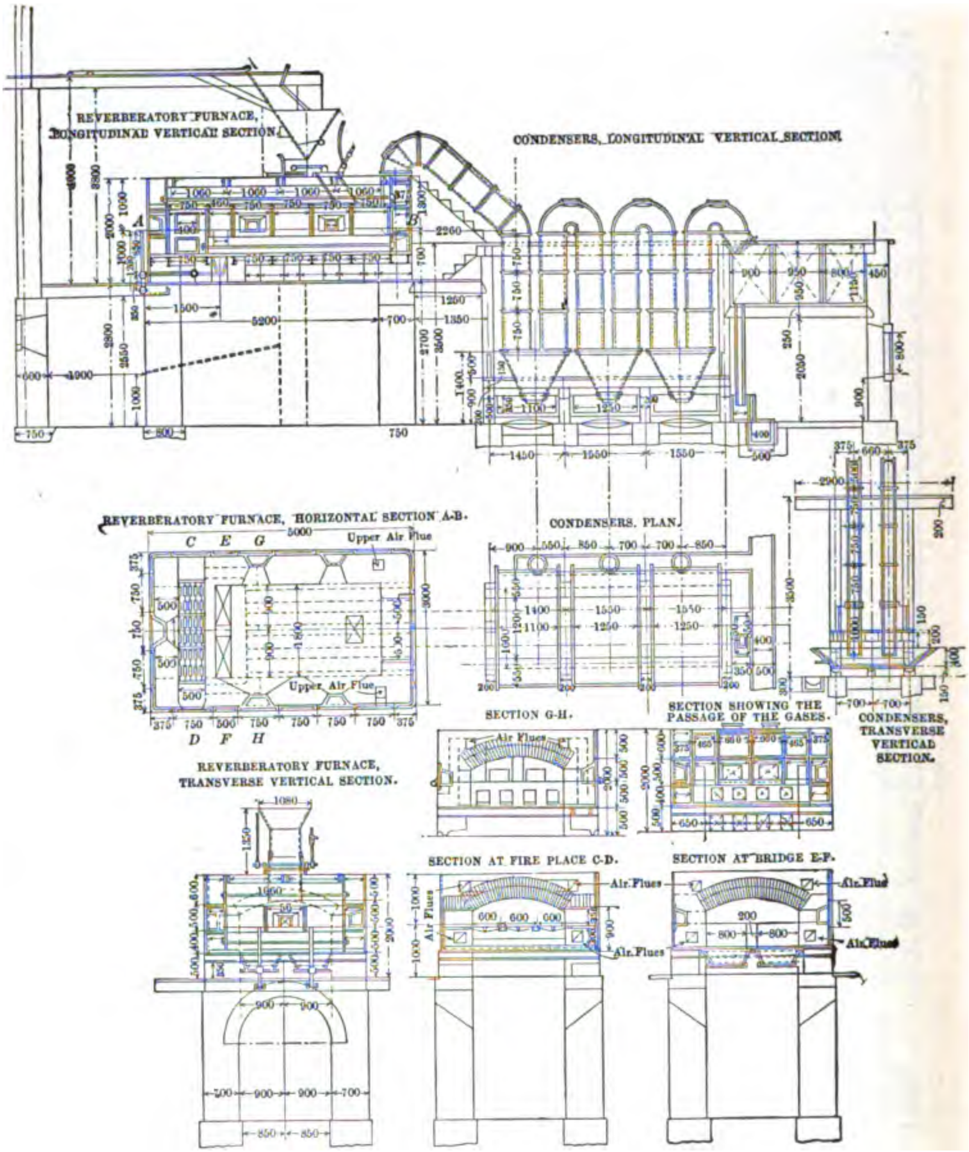

FIG. 2.—LONGITUDINAL VERTICAL SECTION OF THE SPIREK REVERBERATORY FURNACE AND CONDENSERS, WITH OTHER SECTIONS.

The Spirek furnace is being introduced into the United States by the concern of Thomas J. Ryan and Horejse-Spirek, of New York.

THE RARE ELEMENTS.

BY W. J. HUDDLE.

THE interest of the year centers largely around the so-called radioactive substances, and much has been added to our knowledge of them. The subject is still in a very unsettled condition and affords an interesting field of investigation.

Madame Curie gives the atomic weight of radium as 225, and the experiments of Markwald point strongly to the actual existence of polonium. The evidence now at hand seems to show that radium, thorium, uranium, polonium, and possibly other elements, possess inherently the property of radioactivity. This property seems to be due to the discharge at high velocity of minute particles charged with negative electricity. The Curies have found that radium radiation carries a negative charge. J. J. Thompson calculates from their work that it would be thousands of years before the loss of weight would be noticeable. Not only can different substances be rendered active by exposure to the influence of radioactive bodies, but the action of a strong negative charge has the same effect. Since the earth is negatively electrified, we might expect objects on its surface to be radioactive. Elster and Geitel state that this is true and that the points of leaves, lightning rods and similar objects possess this property strongly.

Certain chemical transformations take place under the influence of Roentgen and Becquerel radiation. Berthelot suggests that a study be made of the comparative effect of Becquerel rays, light and the silent electrical discharge.

Bohuslav Brauner[1] states as his belief that between cerium 140 and tantalium 182 no elements except the rare earths exist. He expects, however, the discovery of several more of these. The atomic weight determinations of tellurium still give it a value above iodine. In this connection it is important to note that the recently determined physical constants of H_2Te do not fall into a series with H_2S and H_2Se.

The use of alloys of titanium, vanadium and uranium in steel manufacture is still in the experimental stage, but much is promised for the future.

Following up his work of last year on metallic neobium, Moissan has prepared the analogous element tantalum, and described its properties. The valuable properties of fused silica indicate that it will be widely used for chemical apparatus. Small vessels are now being made by a German firm.

E. Stanfield[2] states that pure barium cannot be prepared by the Goldschmidt process, but that in all cases an alloy of barium and aluminum results containing as high as 60% Ba.

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[1] *Zeitschrift fuer Anorganische Chemie*, 32, 1–30.

[2] *Proceedings of the Manchester Literary and Philosophical Society*, 46, (4), 1901–1902.

The cheap production of metallic calcium is very important to the industrial world. It would find wide application as a reducing agent and to remove impurities from iron. Heretofore, however, the cost has prohibited its use even for experimental work. Recent improvements in the electrolysis of the fused salt seem to have overcome the earlier difficulties and it is stated that the metal can now be produced at a cost of 45 cents a pound.

The methods of the different investigators, Borchers and Stockem,[3] K. Arndt,[4] and Ruff & Plato[5] are much the same. All use internal heating and employ a large carbon anode and small iron cathode. The electrolyte is $CaCl_2$, containing a small amount of CaF_2. The metal must be removed as formed, otherwise it gradually recombines with the chlorine liberated at the anode. Both Ruff and Borchers describe a subchloride having the probable formula CaCl, which is formed in the process. This salt is red in color.

The use of electrodes of calcium carbide in arc lamps has been patented by Robert Hopfelt. They are covered with waterproof compound or sheathed with aluminum. He claims that metallic carbides give a more powerful light than carbon.

Cerium.—By passing a current of from 30 to 40 amperes at a pressure of from 12 to 15 volts for two hours through fused anhydrous cerium chloride, Muthmann[6] obtained from 23 to 29 g. cerium 99·92% pure. He describes the metal as harder than lead but soft enough to cut with a knife. It is slightly attacked in dry air, easily in moist, slowly by cold water, more rapidly by hot water; and easily dissolves in acids with evolution of hydrogen.

Sterba[7] has prepared the oxycarbide of cerium $2CeO_2.CeC_2$, sp. gr. 4·8, by heating CeO_2 with insufficient carbon in the electric furnace. He has also prepared[8] the silicide, $CeSi_2$, from silicon and CeO_2 in the electric furnace. The crystals are small and of steely luster. The silicide is acted on slowly by water. Fluorine attacks it in the cold; Cl, Br, I and HCl gas when heated. The alkalies are without action in the cold. It burns at red heat in oxygen, also on boiling with sulphur or selenium.

E. Baur[9] finds that cerous sulphate solution containing potassium carbonate when shaken in the air, gives cerium peroxide and also some ceric salt. R. Meyer and Koss[10] separate cerium from mixtures of the rare earth by repeated boiling with magnesium acetate.

C. R. B. Bohm[11] has studied the separation of the cerite metals by use of fractional precipitation with chromic acid. For successful separations it is necessary that the solution of the earths and chromate should be very dilute; that the solution must be kept boiling and that the precipitate be finely divided and thoroughly stirred to secure intimate contact with the solution.

Germanium.—This element, which was predicted by Mendelejeff and occupies the place below silicon in the periodic system, was discovered in the silver ore argyrodite by Winckler in 1886.

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[3] *Zeitschrift fuer Elektrochemie*, 8, 40, 757, 1902.

[4] *Ibid.*, 8, 861.

[5] *Berichte*, 35, 17, 3612.

[6] *Annalen*, 320, 231, 1902.

[7] *Comptes rendus*, 134, 1056, 1902.

[8] *Ibid.*, 135, 170, 1902.

[9] *Zeitschrift fuer Anorganische Chemie*, 30, 251, 1902.

[10] *Berichte*, 35, 672, 1902.

[11] *Zeitschrift fuer angewandte Chemie*, 15, Dec. 16, 1902.

Vogelen[12] has found that germanium compounds in presence of nascent hydrogen yield germanium hydride. The hydride burns with a bluish-red flame and deposits on cold porcelain, a bright, metallic mirror, which is red in transmitted and green in reflected light. The mirror is more difficultly volatile in a current of hydrogen than is arsenic. It is easily identified, as a solution of the chloride yields with H_2S a white precipitate of germanium sulphide. Germanium hydride when passed into $AgNO_3$ gives silver germanium, which corresponds most nearly to Ag_4Ge. The decomposition of the hydride also indicates that its formula is GeH_4, which corresponds with the hydrides of carbon and silicon. The gas is not liquefied by the solid carbon dioxide and ether. Efforts to prepare the hydride of tin were unsuccessful, so the author places germanium among the non-metals.

Hydrides.—Moissan has prepared the hydrides of sodium[13] and potassium.[14] On heating the metals at a temperature of 370°C. in a current of hydrogen, white crystalline substances result having formulas NaH and KH respectively. These compounds burn in the halogens and in oxygen, and are decomposed by moisture. The hydrides[15] afford new syntheses of methane and formic acid according to the following reactions:—

$$CH_3I+KH=CH_4+KI \text{ and } CO_2+KH=HCOOK.$$

Guntz has prepared the hydride of strontium and finds for it properties similar to the hydrides of sodium and potassium, but it unites less violently with oxygen and the halogens. Gutier[16] has investigated the conditions of stability of the hydrides and nitrides of the alkaline earths. He finds that the hydrides dissociate above 675°C. The nitrides form at 600°C. and are stable at 1,000°C. At a temperature of 600°C., BaH_2 and SrH_2 are broken down by nitrogen with the formation of the nitride. Calcium hydride breaks down similarly at 700°C.

Iridium.—Meitzschke[17] separates iridium from gold by fusing the metals in a clay crucible at a high temperature in a muffle. The iridium forms the silicide and adheres to the crucible while the gold is poured off. The iridium silicide is fused with litharge reducing agents and flux and the button of lead and iridium refined with silver.

Recent investigations show that platinum-iridium anodes may be used in solutions of sodium chloride without serious loss. Foerster states that the brittleness and low conductivity of the alloy is due to the presence of ruthenium, which can be removed.

Leidié and Quinnessen[18] have worked out a scheme for the detection of the metals of the platinum group by the action of sodium peroxide. Osmium is converted into sodium osmate, which forms a yellow solution. On warming and treating with chlorine, osmic peroxide volatilizes. This can be collected in iced water and recognized by the formation of potassium osmate when alcohol and potassium chloride are added. Ruthenium forms perruthenate which gives with water the

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[12] *Zeitschrift fuer Anorganische Chemie*, 30, 325.

[13] *Comptes rendus*, 134, 18, 1902.

[14] *Ibid.*, 134, 71, 1902.

[15] *Bulletin de la Société Chimique*, (3), 27, 1148, 1152.

[16] *Comptes rendus*, 134, 1108, 1902.

[17] *Journal de Pharmacie et de Chimie*, 15, (2), 68.

[18] *Bulletin de la Société Chimique*, 27 (6), 179.

orange colored solution of ruthenate. This, treated with chlorine as above, distils over but is reduced to ruthenium when heated with alcohol and potassium chloride. Palladium forms sodium palladate. This does not distil with chlorine but when neutralized with HCl, and KCl added, ruby red crystals of potassium chloropalladate separate. Iridium gives a blue solution of the basic iridate $IrO_3.2Na_2O$, which, when treated like the palladium solution, yields black crystals of chloriridate. Sodium platinate is not soluble in water, but on treatment with HCl, the platinum is identified as the chloroplatinate. Rhodium remains insoluble as the dioxide and sesquioxide, of which the former is soluble in HCl and on further treatment with NaCl gives a rose-colored solution of $6NaCl.Rh_2Cl_6$.

Neodymium.—Muthman[19] has prepared metallic neodymium by electrolysis of fused neodymium chloride containing barium chloride, using carbon electrodes and a current of 35 amperes at a pressure of 25 volts. The metal is silver white, harder than cerium (see under the section "*Cerium*"), more easily oxidized and has a higher melting point. At its melting point it attacks porcelain with the formation of the silicide. It dissolves readily in acids, and unites with bromine to form the tribromide and with iodine when heated. When electrolyzed with metallic salts it gives alloys. C. Malignon[20] has prepared the anhydrous chlorides of neodymium, praseodymium and samarium by heating to 180°C. in a current of HCl. These anhydrous salts dissolve in water with the evolution of heat and in alcohol.

Nitrides.—Guntz[21] suggests the preparation of metallic nitrides by heating the metallic chloride with the nitride of lithium.

$$Li_3N + 3MCl = M_3N + LiCl.$$

According to Moeser and Eidmann[22] boron nitride can best be prepared by passing NH_3 over strongly heated B_2O_3 and Ca_3PO_4. Upon washing the product with HCl, BN 80 to 90% pure may be obtained. Boron nitride is a strong reducing agent.

Osmium.—Tests on osmium lamps show that the osmium filament is in many respects superior to carbon. A high efficiency is maintained throughout the life of the lamp. In Berlin, 300 lamps were used on street lighting circuit with entirely satisfactory results. The efficiency is about 1·5 watts per candle power. As yet they have been used only on circuits of 50 volts or less which necessitates burning in series.

Palladium.—The recent discovery of platinum and palladium in the copper ores of the Rambler mine near Laramie, Wyo., seems to promise a larger supply of palladium than has heretofore been known. The palladium occurs as the diarsenide $PdAs_2$, and corresponds to the mineral sperrylite. At present the use of palladium is confined almost entirely to the manufacture of scientific instruments, but in general, the alloys have not been carefully studied.

Polonium.—The radioactive bismuth found in pitch blende, has been considered by many investigators to contain no new element, polonium being re-

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[19] *Annalen*, 320 (2), 231, 1902.

[20] *Comptes rendus*, 134, 1808.

[21] *Comptes rendus*, 135, 738, 1902.

[22] *Berichte*, 35, 535, 1902

garded by them as only bismuth in an excited condition. Markwald[23] was able to precipitate a strongly active metal from a solution of active bismuth chloride with a bismuth rod. Since a metal cannot thus throw itself out of solution, it seems that after all polonium must be an element. Since it occurs in such exceedingly small quantities, one ton containing less than a gram, Markwald has not been able to calculate its atomic weight.

Radium.—From radium chloride which contained no other impurity than a spectroscopic trace of barium chloride, Madame Curie[24] has made a new atomic weight determination, estimating the chlorine as chloride of silver. A value of 225 was obtained, which she believes to be within one unit of the truth. This value places radium in the second group below barium, in line with thorium and uranium. Geitel[25] concentrates radium material by fractional crystallization of the bromides. The first crystallization frees it from most of the calcium and strontium. Eight subsequent crystallizations separate the radium almost entirely from the more easily soluble barium bromide. The progress of the concentration is determined by the coloration of the Bunsen flame. Fractional precipitation with ammonium carbonate may also be used, the radium coming down last.

In his work on radioactive lead, Geitel gets a body from uranium mineral as active as radium preparations which showed strong activity after a year. The examination of the spectrum by Demarçay showed it to be almost entirely lead salt but to contain also two unknown lines. Hoffmann and Wölfl[26] found the active constituent of lead can be most conveniently obtained by dissolving $PbCl_2$ in sodium thiosulphate solution. On being kept some days an extremely active black sulphide separates. This substance differs from polonium in that it acts rapidly on photographic plate through gutta percha.

The Curies show that liquid as well as gaseous dielectrics become conductors under the action of Roentgen and Becquerel rays. The highest conductive obtained was 20×10^{-14} in the case of CS_2. Liquids ordinarily almost perfect insulators, exhibit the same effect.

Radioactivity can be imparted to substances by subjecting them to cathode rays. J. C. McLennan[27] states that the sulphates and sulphides become strongly active on exposure to such radiation at temperatures 100°C. Becquerel rays have been found to consist of a mixture of cathode and Roentgen rays, so that this behavior is not surprising. It is worthy of note that all the permanently radioactive elements have high atomic weights, radium, thorium and uranium belonging to the last period in the system of Mendelejeff. Rutherford shows that the activity of thorium is mostly due to the presence of a very active substance which he calls Th_x, and which is being constantly formed and constantly reverting to ordinary thorium. He was able to separate fractions of thorium compounds which were much richer in this Th_x than the original material. The activity of the greater portion was lost in the process but was subsequently regained while the very active fraction soon lost its increased activity.

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[23] *Berichte*, 35, 865.

[24] *Comptes rendus*, 135, 161.

[25] *Berichte*, 35, 173, 608.

[26] *Ibid.*, 35, 14, 58.

[27] *Philosophical Magazine*, (16), 3195, 1902.

Silicon.—Moissan and others have prepared a number of new silicides. Lithium and silicon[28] heated in a vacuum give Si_2Li_6. The silicide consists of small indigo crystals having a sp. gr. of 1·12. It unites violently with the acids and water forming with the latter H and Si_2H_6. Liquid Si_2H_6[29] has been prepared by Moissan by cooling down with liquid air the gaseous products of the decomposition of magnesium silicide with HCl. It has a melting point of 52°C. and a freezing point of 138°C. It burns spontaneously in the air and is a strong reducing agent. When Si_2H_6[30] is decomposed by an electric spark H and Si result. The silicon appears in long filaments and shows remarkable reducing properties, reducing copper sulphate in the cold. Vanadium silicide[31] made by heating V_2O_5 and silicon in the electric furnace, has a formula VSi_2. It is not attacked by acids, except HF, nor by alkalies. Lebeau[32] describes three crystallizable silicides of cobalt; $SiCo_2$, SiCo and Si_2Co, which he has prepared in the electric furnace. The last-named of these is new. It has a hardness of from 4 to 5, and is not easily acted upon by acids except HF. Calcium silicide[33] has a formula $CaSi_2$ and consists of grayish crystals, sp. gr. 2·5, which are decomposed by water and acids giving H but no silicon hydride.

Strontium.—Guntz, using a mercury cathode, electrolyzed a solution of strontium chloride, and obtained metallic strontium from the amalgam by heating in vacuum to full redness. The metal is white, very like barium, but fuses higher and does not so readily form the metal ammonium. By electrolysis of fused $SrCl_2$ in a vessel composed of a carbon cylinder forming the anode and arranged with an insulated bottom pierced by a cathode of iron, Borchers and Stockem[34] obtained globules of pure metallic strontium, which sank to the bottom of the bath.

Tantalum.—Metallic tantalum has been prepared by Moissan[35] by heating Ta_2O_5 and sugar carbon in the electric furnace. The metal had a crystalline fracture and contained only 0·5% C. It scratches glass, has a sp. gr. of 12·79 and fuses in a powerful arc. Chlorine begins to attack it at 150°C., and at 250°C. the reaction takes place with incandescence. The chloride sublimes as orange yellow needles. Bromine acts on tantalum only at red heat and iodine not at all at 600°C. At 600°C. the metal burns in oxygen. HCl gas attacks it with the evolution of hydrogen but the simple acids do not attack it except H_2SO_4, which does so slowly. It dissolves, however, in a hot mixture of HF and HNO_3. With KOH it gives off hydrogen and forms the alkaline salt. Tantalum will reduce PbO, PbO_2, MnO_2 and $HgCl_2$, being more strongly reducing than neobium, which it greatly resembles.

Terbium.—The existence of this element has often been disputed. Marc[36] after exhaustive researches reaches the following conclusion: Terbium oxide is deep brown, ocher color. There is also a lower oxide which is colorless. The earths previously described as terbia earth were mixtures of yttria and a heavier earth, colored by terbium oxide. Terbium has probably an absorption spectrum

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[28] *Comptes rendus*, 134, 1083.

[29] *Ibid.*, 134, 569.

[30] *Ibid.*, 134, 1552.

[31] *Ibid.*, 135, 78.

[32] *Comptes rendus*, 135, 475.

[33] *Ibid.*, 134, 503.

[34] *Zeitschrift fuer Elektrochemie*, 8, 40, 759.

[35] *Comptes rendus*, 134, 211.

[36] *Berichte*, 35, 2382, 1902.

consisting of the band λ 464-461. He regards thulium as a mixture of yttrium and ytterbium with varying amounts of holmium and terbium.

Tellurium.—The brittleness and bad quality of certain ingots of American silver is ascribed by C. Vincent[37] to the presence of a minute quantity of tellurium. G. Frerichs[38] estimates tellurium by the reduction of the oxide with hydriodic acid. Hall and Lenher[39] find that tellurium and tellurium minerals precipitate gold quantitatively from either warm or cold solutions, according to the reaction:—

$$3Te+4AuCl_3=TeCl_4+4Au.$$

Silver salts are reduced by tellurium with the formation of silver telluride. Tellurides of gold do the same but on the other hand the telluride of silver is without action. Lenher[40] has already questioned the chemical composition of telluride of gold and these later results strengthen the position he has taken. The action of selenium on gold and silver salts is similar to that of tellurium but is less energetic. Selenium reduces silver solutions in the cold but is without action on gold solutions unless heated to near boiling.

Thorium.—The methods in use for the separation of thorium from the cerite metals has been reviewed by E. Bentz.[41] F. J. Metzger[42] states that thorium may be completely separated from cerium and lanthanum by the addition of 40% alcoholic solution of fumaric acid. Kolb[43] finds that thorium is completely precipitated by water saturated with aniline, while cerium, lanthanum, didymium, yttrium and erbium are not so precipitated. Miss Jefferson[44] has studied the action of the different aromatic bases on thorium, zirconium, cerium and lanthanum, and finds a number of separations possible by their use.

O. A. Derby[45] found monazite and zircon grains in a magnetic iron ore from Brazil. They were also present in two Brazilian graphites. Rutherford has shown conclusively that thorium compounds possess permanent radioactivity. White and Trever[46] have made some extended investigations of the theory in the incandescent mantle. The usual temperature of the commercial mantle is from 1,500°C. to 1,600°C. For single mantles the illumination varies with temperature but for different mantles depends on the proportion of ceria and thoria. The illumination therefore does not seem to be a matter of temperature but is rather due to a solid solution of ceria in the thoria, the temperature being below that which the latter alone would attain in the flame.

Titanium.—The Crawford-Voelker "glow lamp" uses a filament of titanium or uranium carbide. In a recent article J. R. Crawford[47] states that they have placed the manufacture of their lamps on a commercial basis. He claims that

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[37] *Bulletin de la Société Chimique*, (3), 27, 23, 1902.
[38] *Journal fuer Praktische Chemie*, 66, 261, 1902.
[39] *Journal of the American Chemical Society*, 24, 918, 1902.
[40] THE MINERAL INDUSTRY, Vol. X., 571.
[41] *Zeitschrift fuer angewandte Chemie*, 15, (13), 297, 1902.
[42] *Journal of the American Chemical Society*, 24, 901.
[43] *Journal fuer Praktische Chemie*, 66, 59, 1902.
[44] *Journal of the American Chemical Society*, 24, 562.
[45] *American Journal of Science*, (4), 13, 211, 1902.
[46] *Journal of the Society of Chemical Industry*, Aug. 15, 1902.
[47] *Electrochemist and Metallurgist*, 35, March, 1902.

these filaments are superior to carbon, both in the quality of the light and in that they may be used on circuits up to 500 volts. Carbon filaments have never been used successfully at this voltage. The titanium light is much whiter than carbon and is very soft to the eye. Uranium carbide gives a yellow light. Its use is suggested for outside lights of high candle power.

Auguste J. Rossi has been studying the metallurgy of titanium. Although it is usually considered that ores containing titanium are very difficult to work in a blast furnace, he states[48] that he has been able to treat ores of this character easily. The pig iron produced from them, while containing little titanium, is of superior quality. The addition of titanium in minute quantities to iron and steel increases tensile strength enormously. Titanium has a great affinity for nitrogen and Rossi suggests that the presence of titanium in iron and steel acts not only as a dioxygenizer, but also takes out nitrogen which is present in minute quantities. The making of titanium alloys is described in THE MINERAL INDUSTRY, Vol. IX. In this connection mention should be made of the large deposits of rutile which occur in Virginia.[49]

Uranium and Vanadium.—The use of uranium and vanadium in the manufacture of steel is still in the experimental stage and small quantities only are produced. The total production of uranium ores in the United States during 1901 was 375 tons, obtained chiefly from Colorado. The presence of vanadium in steel is said to render it so hard that by its use armor plates may be reduced to one-half the ordinary thickness. One peculiarity of vanadium steel is that it does not acquire its maximum hardness through tempering but by reheating from 700°C. to 800°C. In consequence of this property, the cutting tool of a planer made of vanadium steel continued to cut without being injured by heat, even when heated to redness. This property would be of great importance in the making of armaments and heavy projectiles. When the projectile strikes armor plate, the temperature is raised even to fusion so that if the presence of vanadium prevents the loss of hardness, and consequently of sharpness, the penetrative power would be greatly increased. The influence of vanadium in steel is due to its strong affinity for oxygen, its presence insuring the removal of the last trace of iron oxide. The tendency of steel to crack and rupture is attributed to traces of iron oxide which can be removed in no other way.

Yttrium and Ytterbium.—Dennis and Dales[50] after trying many methods for separation of the metals of the yttrium group, find that unusually rapid separations of these earths may be effected with ammonium carbonate and acetic acid. Fractional solution of the hydrates with saturated ammonium carbonate gives rapid separation and this, combined with fractional precipitation of the carbonate solution with acetic acid, gives striking results; erbium and terbium concentrate in the first fraction and ytterbium comes down last.

Cleve has studied the chemistry of ytterbium. He finds it to be a purely trivalent element forming characteristic compounds, as the gold double chloride, the periodate $YbIO_5$, and the basic carbonate $Yb(OH)CO_3$. Even in acid solution it forms the neutral orthophosphate $YbPO_4$. He suggests that ytterbium

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[48] *Journal of the Franklin Institute*, 64, 241.

[49] *Engineering and Mining Journal*, March 8, 1902.

[50] *Journal of the American Chemical Society*, 24, 40.

can be classed with yttrium, erbium and gadolinium on a basis of the similarity of the platinum cyanides all of which crystalize alike, apparently with 18 molecules of water. A new mineral, Hussakite, is reported from Minas Geraes, Brazil, which contains 60% of the yttria earths, *i.e.*, Y_2O_3 43·43%, Er_2O_3 14·82%, and Gd_2O_3 1·99%. It seems to be the parent mineral of xenotime.

Zirconium.—Gutbier and Hüller[51] separate iron and zirconium quantitatively by heating in a current of hydrogen. The method is as follows: The metals are precipitated as hydrates with NH_4OH, a second precipitation being necessary to bring down all the zirconium, and weighed as oxides; the iron is reduced to metal in a current of hydrogen at red heat. Since none of the zirconium oxide is reduced, a second weighing enables the amount of iron to be calculated.

In quantity, the Nernst lamp furnishes the best electric light yet produced. The efficiency is stated to be on a parity with the enclosed arc and double that of the incandescent lamp. Hulse[52] publishes a number of tests on these lamps. The life of the glower he finds to be about 400 hours, and the average candle power 0·48 c.p. per watt. The chief cost, then, is in the renewal of the glower, which brings maintenance to a much higher figure than with arc or filament lamps. These lamps will find a wide use where large candle power is required and power is not cheap.

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[51] *Zeitschrift fuer Anorganische Chemie*, 32, 98, 1902.

[52] *London Electrician*, 48, 947.

fornia, and as a development of this change in business methods it is interesting to note that the combination of salt producers in California, which maintained the price of coarse salt at $18 per ton, was formally indicted by the Federal Grand Jury, and enjoined by the United States Circuit Court from forcing prices above a reasonable compensation for the cost of manufacture. Also, that the National Salt Co. of New York, the largest individual producer of common salt, was declared insolvent on Sept. 30, 1902, and was placed in the hands of a receiver.

Imports and Exports.—The imports of salt entered for consumption during 1902 were 369,528,186 lb. ($647,554), as compared with 403,465,946 lb. ($676,324), in 1901; the exports of domestic salt amounted to 10,188,771 lb., ($55,432), in 1902, as compared with 18,865,247 lb. ($86,414), in 1901.

SALT PRODUCTION OF THE CHIEF COUNTRIES OF THE WORLD. (*a*) (*g*) (IN METRIC TONS AND DOLLARS.)

Year.	Algeria.		Austria. (*d*)		Canada.		France.		Germany.	
1897........	23,222	$78,058	331,084	$10,224,576	46,584	$225,730	948,000	$2,239,828	1,306,684	$3,838,426
1898........	21,300	86,000	341,959	10,607,799	51,796	234,520	999,283	2,115,120	1,370,341	3,954,748
1899........	17,878	67,300	342,059	10,124,760	51,796	234,520	1,193,582	2,506,832	1,432,181	3,978,750
1900........	18,325	76,288	330,277	9,957,173	56,296	279,458	1,088,634	2,415,973	1,514,027	4,627,500
1901........	18,518	79,976	333,238	9,888,231	53,927	262,328	910,000	2,012,800	1,563,811	5,064,750

Year.	Greece.		Hungary. (*d*)		India.		Italy. (*e*)	
1897........	20,421	$308,357	171,711	$5,375,788	937,888	$975,260	31,526	$117,504
1898........	25,250	363,600	178,551	5,679,534	1,049,828	1,485,702	29,745	120,715
1899........	37,125	579,150	182,593	5,479,782	977,240	1,324,748	28,842	64,418
1900........	22,411	336,165	180,363	5,456,600	1,021,426	1,146,363	29,221	128,617
1901........	23,079	351,700	184,083	5,668,200	1,120,187	1,405,682	33,744	131,786

Year.	Japan. (*f*)	Russia.		Spain.		United Kingdom.		United States.	
1897........	621,731	1,551,894	$2,711,077	508,606	$1,159,294	1,983,949	$3,104,490	2,009,625	$3,898,556
1898........	646,719	1,505,600	2,566,906	479,358	1,025,682	1,908,723	3,100,575	2,382,197	4,753,664
1899........	590,433	1,681,362	2,767,168	598,108	1,091,133	1,945,531	3,220,870	2,522,610	5,437,941
1900........	669,694	1,968,005	3,124,000	450,041	834,535	1,873,601	3,059,600	2,651,278	6,944,603
1901........	(*c*)	(*c*)	(*c*)	345,063	599,934	1,812,180	2,864,950	2,612,204	6,617,449

(*a*) From the official reports of the respective countries. For Austria, Hungary, Russia, Spain, and the United States, the production of all kinds of salt is given; Germany, rock salt and common salt; Greece, sea salt; France, rock and sea salt; Algeria, sea and rock salt; Italy, rock and salt from brine; United Kingdom, rock and brine salt; India, salt which is liable to British salt tax only, and does not include salt made in certain native States. (*b*) Not reported in the official statistics. (*c*) Statistics not yet published. (*d*) The high valuation of salt in Austria and Hungary is due to the government monopoly of production and high taxation. (*e*) Rock and brine salt only. About 400,000 tons of sea salt is made annually. (*f*) No value given. (*g*) In addition in 1900, Australasia produced 34,095 metric tons ($188,145); Cape Colony, 11,833 metric tons ($158,300); Ceylon, 11,079 metric tons ($15,900); Cyprus, 3,175 metric tons ($21,515); Peru, 15,000 metric tons ($275,000); Switzerland, 49,284 metric tons; Tunis, 9,160 metric tons ($64,120); Turks and Caicos Islands, 55,615 metric tons ($117,460).

SILICA.

UNDER this caption are grouped the various forms of silica that have a commercial or industrial value, including diatomaceous earth, tripoli, sand, silica brick, flint, pumice, sandstone and novalculite used in the manufacture of grindstones and whetstones. Sandstone for building purposes will be found under the caption "Stone" elsewhere in this volume.

Diatomaceous Earth.—Deposits of diatomaceous earth have been found in the southeastern corner of Pinal County, Ariz. According to Prof. W. P. Blake, the region of greatest development is in the San Pedro valley, a few miles south of Mammoth and near Redington. The beds of earth are horizontal and form the almost vertical walls of the chief lateral cañons, contrasting strongly with the red clays lying above and below them. The greatest thickness from the floor of the cañon to the top of the beds is estimated at 100 ft. The material is snow white, porous, and can be readily cut into blocks with saw or knife. Examinations under the microscope show it to be composed of volcanic ash and siliceous skeletons of diatoms. The particles of volcanic glass range in size from 0·1 to 0·005 mm. An analysis of the earth gave the following results: Insoluble matter (SiO_2) 82·81%; Fe_2O_3 1·10%; Al_2O_3 4·84%; NaCl 0·45%; CaO 2·10%; MgO, trace; loss by ignition (chiefly water) 5·07%.

The production of diatomaceous earth and tripoli in 1902 amounted to 4,855 short tons, valued at $49,974, as compared with 4,020 short tons, valued at $52,950 in 1901.

Grindstones.—The value of the production of grindstones in the United States in 1902 was $656,832, as compared with a value of $580,703 in 1901. The value of the millstones produced in 1902 was $57,451.

Pumice.—About 100 tons of pumice were obtained from the deposits in Utah during 1902. The mines were closed down during the previous year, owing to the severe competition with foreign material.

Silica.—The manufacture of apparatus for use in the chemical and electrical industries from fused quartz is carried on at Hanau, Germany. The material has a smaller coefficient of expansion than ordinary glass, so that it is little effected by changes of temperature, and besides is resistant to the action of acids, and is said to possess other advantages which make it valuable for technical purposes. Ordinarily, when quartz is subjected to high heat in the electric furnace, it is reduced and volatilized, but by blowing a current of air into the crucible volatilization ceases and the mass fuses. The same result may be obtained in a Moissan furnace of the reverberatory type, by placing the material below the arc and allowing the heat to be radiated upon the charge. In this way it is possible to fuse quartz around a core of carbon without reduction, and thus a rough tube may be formed which can be drawn and blown. Quartz glass is well adapted for vessels in which acids are concentrated, for accumulator cells, electrolytic tanks, and for pumps handling corrosive liquids.

The output of crystallized quartz in the United States during 1902 amounted to 13,904 short tons, valued at $117,423, as compared with 14,050 short tons, valued at $41,500 in 1901.

Siloxicon.—A new refractory substance, to which the trade name siloxicon has been given, was first made in 1902. The material possesses refractory properties that may make it valuable for crucible manufacture, furnace linings, etc. It is composed of silicon, carbon and oxygen in proportions varying between the limits represented by Si_2C_2O and Si_7C_7O. For typical material the formula may be given as Si_2C_2O, which is formed according to the following equation: $2SiO_2+5C=Si_2C_2O+3CO$. It is of grayish green color and has a density of 2·74. Tests show that it is neutral, insoluble in molten metals and unaffected by any acids except hydrofluoric acid which seems to attack it slowly. When heated above 2,674°F. in presence of free oxygen, siloxicon decomposes according to the following equation $Si_2C_2O+7O=2SiO_2+2CO_2$. If the material is in the form of a brick or other molded mass the reaction takes place on the surface producing a vitreous glaze which in most cases is tinged light green from the presence of iron. In the absence of free oxygen no decomposition occurs, and the temperature may be raised to the point of the formation of carborundum or approximately 5,000°F. before any change takes place, when it breaks up in carborundum and other substances probably as follows: $Si_2C_2O=SiC+Si+Co$.

Siloxicon is made in a furnace somewhat similar to that used in the manufacture of carborundum, although of larger proportions, and worked at a lower temperature. The furnace is about 30 ft. long, 9 ft. wide and 5 ft. high, and has multiple cores, whereas the carborundum furnace has a single core. The furnace is filled with a mixture of sand and coke, to which a certain amount of sawdust is added in order to secure the necessary porosity to allow of free escape of the carbon monoxide gas. Through the center of the mixture pass two or more large flat cores of granular carbon, the cores being so proportioned that they give a very great radiating surface. The temperature of the cores is adjusted so as not to go to such a high temperature as to reach the point of decomposition.

SODIUM SALTS.

BY JOSEPH STRUTHERS AND HENRY FISHER.

THE production of soda and sodium salts in the United States for the year 1902 is estimated at 562,000 metric tons, as compared with 480,000 metric tons for the year 1901. These figures include the production of soda ash, caustic soda, bicarbonate and crystals, all reduced to the basis of 58% alkali, the output of soda ash being about 427,000 tons, of caustic soda 75,000 tons, and of sodium bicarbonate, 52,500 tons.

The large increase in the production of sodium salts in the United States during 1902 has not been fully met by increased consumption, and it is believed that of the production for the year, a considerable tonnage is held as stock. The imports have remained at about the same figure as in 1901, namely 15,000 tons, while the exports for the year 1902 show a slight decrease from those of the previous year.

The changes during the year 1902 in a majority of the works producing sodium salts have been unimportant. The Michigan Alkali Co. continued the reconstruction of its No. 1 soda ash plant, which was destroyed by fire in December, 1901. The company was not able to get this plant in operation, as had been expected, before the close of 1902, but it is thought that it will be completed in the early part of 1903. The Columbia Chemical Co. at Barberton, O., continued producing soda ash and caustic soda during the year, making no radical changes in its plant. The Frasch Process Soda Co. of Cleveland, O., has continued in irregular operation during the year 1902. It is said that under favorable conditions its output is at times as much as 30 tons of soda ash per day, but the rate of production is very uncertain. The Mathieson Alkali Co. of Saltville, Va., produced throughout the year soda ash, caustic soda and sodium bicarbonate. This plant has had additions and improvements in progress for some time, and the production during 1902 is said to have been somewhat larger than heretofore. The Solvay Process Co. of Syracuse, N. Y., and Detroit, Mich., produced soda ash, caustic soda, bicarbonate and crystals throughout 1902. The Acker Process Co. of Niagara Falls, N. Y., continued the production of caustic soda and bleaching powder by the electrolytic process on a somewhat increased scale over the previous year, the capacity of the plant being about 11·8 tons of 76% caustic soda and 26 tons of bleaching powder per day. The Castner Electrolytic Alkali Co. of Niagara Falls, N. Y., put in operation during the first half of the year, its enlarged plant, which has increased the capacity for producing caustic soda and bleaching powder to three times what it was at the beginning of 1902. The American Alkali Co. appears to be so deeply involved in financial difficulties that its future is problematical. The property is now in the hands of a receiver. An agreement has been made with the Consolidated Lake Superior Co., whereby a half interest in the Canadian Electro-Chemical Co., whose stock is owned by the American Alkali Co., is transferred to the former company in settlement of its claims. The Pennsylvania Salt Manufacturing Co. during the year 1902 has continued work on its electrolytic plant at Wyandotte, Mich. It was expected that this plant would be completed and in operation by the fall of 1902. This expectation has not been realized, however, and the plant is not yet producing caustic soda or bleaching powder. The Dow Chemical Co. is enlarging its plant at Midland, Mich., to double its present capacity, and in order to pay for these improvements, $115,000 new treasury stock has been issued.

The annual report of the Electrolytic Alkali Co., Ltd., operating the Hargreaves-Bird process, for the year ending Aug. 31, 1902, states that the net profit for the year was £6,420, to which must be added £1,242 brought forward from the previous fiscal year, making an available balance of £7,662, out of which a cumulative dividend of £7,331 is to be paid, leaving £331 to be carried forward. The United Alkali Co., Ltd., for the calendar year 1902 reports assets of £9,031,249, consisting of property, plant, etc., valued at £7,226,661; stocks of manufactured products, raw material, stores, etc., on hand, £738,488; debts owing to the Company, £261,611; outstanding consignments, £36,649; investments, £478,213; cash on hand and bills receivable, £289,627. The gross profits for the year were £434,028, and net profits, £242,796. The balance brought forward from the previous year was £38,107, making a total of £280,902 available for distribution, out of which a 7% dividend on the preferred stock amounting to £185,612 was paid, £15,000 transferred to debenture redemption account, and the balance, £80,290, brought forward.

IMPORTS OF SODA PRODUCTS INTO THE UNITED STATES.

	1898.		1899.		1900.		1901.		1902.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
		$		$		$		$		$
Soda, nitrate..	330,386,560	2,298,240	328,142,080	3,486,313	407,921,920	4,936,520	467,884,960	5,997,595	661,348,800	5,996,205
Soda, bicarb...	280,988	5,794	162,398	5,219	133,137	4,509	(b)	(b)	176,480	6,482
Soda, caustic..	24,981,873	354,270	13,363,529	186,008	8,403,749	150,530	3,812,847	94,303	3,334,697	77,482
Soda ash (a)...	73,064,707	447,119	57,053,837	425,205	73,815,425	613,379	31,415,788	276,261	31,869,092	284,634
Oth'r soda salts	23,354,295	256,958	26,840,840	355,502	20,351,801	255,293	14,491,559	189,543	16,973,702	277,263
Lime, chloride.	106,462,828	1,229,978	123,582,061	1,208,364	132,510,478	1,524,205	120,611,346	1,678,190	112,374,478	1,456,435

(a) Including sal soda. (b) Included in other soda salts.

Market Conditions.—The average monthly price of domestic 58% ash per 100 lb. in lots of 50 tons or more f. o. b. works, is given in the following table:—

Year.	Jan.	Feb.	Mch.	April.	May.	June.	July.	Aug.	Sept	Oct.	Nov.	Dec.	Average.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1898....................	53·75	51·25	53·75	50·50	57·50	57·50	51·50	52·50	50·00	59·00	57·50	57·50	54·35
1899....................	57·50	59·20	62·50	66·50	67·50	63·75	68·75	70·00	71·75	80·00	82·50	83·50	69·45
1900....................	86·66	87·50	87·50	82·50	82·50	82·50	82·50	82·50	77·50	77·50	72·50	75·50	81·43
1901.......	80·00	80·00	74·00	80·00	78·75	77·50	80·00	76·50	75·50	77·50	78·50	85·00	78·60
1902....................	84·08	80·75	80·50	82·50	82·50	82·50	82·50	83·50	85·00	85·00	84·50	88·12	83·04

Domestic sodium bicarbonate for the first six months of 1902 sold at 95c.@$1 per 100 lb., f. o. b. works, but toward the end of the year prices rose, till in November and December it sold for $1·25. Extra grades remained unchanged throughout the year at $3 and up per 100 lb., according to grade. Foreign ordinary grades sold in New York at $1·50@$1·60 per 100 lb.

Domestic caustic soda in 1902 sold at $1·90@$2 per 100 lb., f. o. b. works for prompt delivery, future deliveries being 5c. per 100 lb. less. Yearly contracts were made at $1·90@$1·95 per 100 lb., f. o. b. works. In November and December, contracts were made for 1903 to 1904 at $1·65@$1·875 per 100 lb., f. o. b. works. Foreign caustic soda brought $2·25@$2·75 per 100 lb. in New York.

The prices for domestic soda ash, 58%, varied from 75@80c. to 87·5@90c. per 100 lb., f. o. b. works for spot delivery, future deliveries being 5c. per 100 lb. cheaper. Foreign high test soda ash sold in New York at 90@95c. per 100 lb.

Domestic sal soda was quoted at 55@60c. per 100 lb., f. o. b. works, and foreign brought 65@70c. per 100 lb. at New York.

Sodium sulphate was sold at 80@82·5c. per 100 lb. f. o. b. works.

Bleaching powder of domestic manufacture during the first nine months of 1902 was quoted at $1·375@$1·625 per 100 lb. f. o. b. works, but toward the end of the year quotations dropped to $1@$1·25. Contracts for 1903 delivery were made at $1@1·25 per 100 lb. For the foreign bleaching powder, prices for the Liverpool brand were $1·625@$2 per 100 lb. in New York, lower prices ruling toward the end of the year, and contracts were made for 1903 as low as $1·25 per 100 lb. Prices of the Continental brands were lower, $1·625@$1·75 per 100 lb. in New York at the beginning of 1902, and $1·25@$1·375 at the end of the year, while contracts for deliveries during 1903 were made at $1·20 per 100 lb. The fall in price of the foreign bleaching powder was due to the active competition of the American product, on account of increased production in the West.

Natural Sodium Carbonate.—The Inyo Development Co. at Owens Lake, Cal., produced 25,000 short tons of natural sodium carbonate (97% carbonate) during 1902, which is equivalent to 16,000 short tons of 58% soda ash, as compared with the equivalent of 15,000 short tons of 58% soda ash in 1901. The crude material was obtained from Nevada and California.

Sodium and Potassium Chlorates and Hypochlorites.—A review of these industries during 1901 by Mr. J. B. C. Kershaw will be found in THE MINERAL INDUSTRY, Vol. X., pp. 547-550, and other references will be found elsewhere in this volume.

Sodium Nitrate.—Chile saltpeter.—The nitrate beds in California were examined by Prof. G. E. Bailey in 1902, who reported that nearly all are situated in the northern part of San Bernardino County, and extend through the southern part of Inyo County, the deposit being about 25 miles long and 15 miles wide. He estimates that there are 35,000 acres of sodium nitrate in the Owl, Upper Canyon, Lower Canyon, Round Mountain, Confidence, Salt Springs, Tecopah, Pilot, Danby, Needles and Volcano districts. The crude nitrate occurs in beds from 6 to 12 ft. thick, assaying from 15 to 40% of the mineral, the minimum thickness of the surface nitrate being 6 in. Shafts have been sunk in the beds to a depth of from 5 to 45 ft., but no water has been found, the nearest point at which water can be obtained is Furnace Creek, 35 miles distant. The deposit is also a considerable distance from railroad communication, the nearest line being at Johannesburg, 125 miles from the beds. The deposit is to be worked by the American Nitre Co. which was organized in 1901, and which has established a laboratory at Camp Inyo, Inyo County, Cal.

Chile.—The report of the Asociación Salitrera de Propaganda (Nitrate Propaganda Association) states that the production of sodium nitrate in 1902 amounted to 29,829,679 quintals (1 quintal=101·61 lb.), an increase of 1,461,319 quintals over the production in 1901. The exports were 30,089,440 quintals as compared with 27,385,228 quintals in the preceding year. The total deliveries in 1902 amounted to 28,400,840 quintals, being 2,937,032 quintals less than in the previous year. The decrease was due to a decreased consumption in Europe and other countries of 3,339,998 quintals, offset by an increase in the consumption by the United States and Chile of 402,966 quintals. The visible supplies on Dec. 31, 1902, amounted to 21,966,244 quintals, distributed as follows: For Europe, on shore, 5,599,440 quintals; afloat, 9,427,470 quintals; total, 15,026,910 quintals; for the United States, on shore, 166,634 quintals; afloat, 1,288,700 quintals; total, 1,455,334 quintals; the stock on the coast of Chile amounted to 5,484,000 quintals. In December, 1902, there were 78 nitrate works in operation. Of the companies engaged in this industry the Alvanza Co. showed the greatest net profits in 1902, £174,907, and paid a dividend of 10%; the Rosario Co. showed a net profit of £140,104, and paid an 8% dividend. The greatest dividend payers were the Santiago and Liverpool Co.'s, the former paid 18% and the latter 17·5%. In order to keep within the limits of the output fixed by the combination for 1903, and to allow for new producers coming into the combination, which now consists of 16 companies, the individual quotas of present producers will have to be reduced about 25%. The Salar del Carmen Nitrate Syndicate reports for the year 1902 gross profits of £54,754, and net profits of £44,289, out of which a dividend of £10,950 (10%) was paid, leaving a balance of £1,135 to be carried forward.

On March 16, 1903, the President of the Republic was authorized to sell at public auction for the term of one year, 24 nitrate properties, 16 being in Tarapacá and 8 being at Toco.

The following table was obtained from the report of W. Montgomery & Co., London, the figures being for the 12 months ending June 30:—

	1899.	1900.	1901.	1902.	1903.
	Tons.	Tons.	Tons.	Tons.	Tons.
Shipments from South American ports to all parts	1,373,000	1,351,000	1,452,000	1,278,000	1,329,000
Consumption in United Kingdom	121,000	126,000	126,000	111,000	112,000
Consumption on the Continent	981,000	1,026,000	1,042,000	897,000	1,003,000
Consumption in the United States	133,000	170,000	200,000	190,000	240,000
Consumption in other Countries	25,000	28,000	14,000	16,000	19,000
Consumption in the world	1,260,000	1,350,000	1,382,000	1,214,000	1,374,000
Visible supply on June 30	326,000	298,000	332,000	358,000	270,000

It has been declared by the committee of the producers that not more than 31,750,000 quintals shall be shipped during 1903, but as the committee has the right to increase its figures, it is probable that the quantity finally declared will be 33,000,000 quintals.

Market Conditions.—At the opening of the year 1902, sodium nitrate was quoted in New York at $1·95@$1·975 per 100 lb. Prices began to rise and in February it was quoted at $2·10@$2·35, and in March at $2·30@$2·40. This high price was reported to be due to delayed shipments and a strike at Iquique and Caleta Buena, Chile. At the beginning of April, sodium nitrate was still quoted at $2·35@$2·40, but from the end of April to July, prices declined $2·25@2 per 100 lb. Between July and October, prices fell from $2·05 to $1·85, in November rose to $1·95@$2·025, and in December to $2·10@$2·25, but closed at $1·975. The quotations for future deliveries were more steady, the year opening with futures quoted at $1·95@$1·975 per 100 lb., in February and March at $2·025@$2·10, but fell to $1·925@$1·975 in May, to $1·825@$1·85 in July, and remained at these figures till the end of the year.

Metallic Sodium.—Although there are several works in the United States manufacturing metallic sodium, statistics of their production are not available. An article entitled the Manufacture and Uses of Metallic Sodium, appeared in the *Journal of the Franklin Institute,* January, 1902, pp. 65-74, in which Mr. J. D. Darling described his process and the sodium plant of Harrison Bros. & Co., at Philadelphia, Pa.

STONE.

THE leading varieties of stone produced in the United States in the order of their importance are limestone, granite, sandstone, marble and slate. Detailed information as to the important quarrying centers, character of their output, and the relative value of stones for different uses, will be found in THE MINERAL INDUSTRY, Vol. VIII.

The total value of the stone produced in the United States during 1901 amounted to $55,488,137, against $45,066,708 in 1900; neither of which totals includes the sandstone used in the manufacture of grindstones and whetstones, which is included under silica, and are also exclusive of the value of the production of slate. The statistics covering the year 1902 are not yet available.

Limestone.—The value of the total production during 1901 was $26,406,897, the value of that used for building being $5,219,310, including $404,163 for railroad bridges; for railroad ballast, $1,758,541; for macadam, $2,298,286; for concrete, $1,214,815; for riprap and rubble, $1,024,109; for the production of lime, $8,204,054; for blast furnace flux, $4,659,836, and for the limestone used in the manufacture of Portland cement, $570,882. The principal producers rank in the order of maximum production as: Pennsylvania, with a production valued at $5,081,387 for 1901; Illinois, $2,793,837; Indiana, $2,993,186; Ohio, $2,606,502; New York, $1,738,716; Missouri, $1,362,272; Wisconsin, $1,225,448.

Granite.—The total value of the granite produced during 1901 amounted to $15,976,971, which includes that used for concrete, $477,709; for road making, $2,008,966; and for railroad ballast, $516,768; for curbing and flagging, $670,703; riprap and rubble, $1,755,959; sold in the rough, $3,486,574; for paving blocks, $1,821,431; and for dressed building stone sold by the producers, $3,781,294. The principal States rank in the order of their maximum production as: Maine, $2,703,116; Massachusetts, $2,216,258; Vermont, $1,245,828; California, $1,134,675; South Carolina, $996,084 and New Hampshire, $935,494.

Sandstone.—The total value of the production during 1901 was $8,844,978, of which was used for building purposes, $4,875,973; for railroad ballast, $30,887; for road making, $130,503; for concrete, $123,957; for paving, $358,910; for riprap and rubble, $447,520; for curbing, $636,722; for flagstones, $1,026,499; for other purposes, including grind and whetstones, $1,214,007. The principal producing States rank in the order of production as: Ohio, with a total production valued at $2,576,723; Pennsylvania, $2,063,082; and New York, $1,331,327.

Marble.—The total value of the marble produced during 1901 was $4,965,699, of which that used for building purposes was $1,236,023; for ornamental work, $126,576; sold in the rough, $591,667; for interior work, $1,008,482, and for cemetery work, $1,948, 892.

THE TESTING OF BUILDING STONE.[1]

BY EDWIN C. ECKEL.

ALTHOUGH there were earlier contributors on the subject, the work of Gen. Q. A. Gillmore, about 25 years ago, may be regarded as the foundation on which the modern study of building stone testing has been based. The accuracy of some of Gillmore's conclusions may be questioned, but the real value of his work cannot be minimized. Physical methods of testing building stone have advanced but slightly since his day.

Crushing Strength.—In the matter of size of test piece, Gillmore's earlier experiments seemed to prove that a large cube gave higher compressive resistance per sq. in. than a small cube, and he constructed a formula showing the variation in compressive strength in relation to size of cube. This formula will frequently be found quoted in engineering and geological treatises, though within a year of its announcement Gillmore had determined, from the results of a longer series of experiments, that the so-called law did not hold true. Regarding the shape of test piece, it has been determined that a prism whose height is 1·5 times the width of its base will give far more accurate results than the cube. This determination has had little effect on testing practice, however, the cube being employed as heretofore.

Transverse Strength.—Little attention is usually paid to testing the transverse strength of building stones, except in the case of stones intended for use as flagging, lintels, etc. This neglect is the more curious because building stone, in actual construction, often fails under transverse strain, as may be seen in the walls of many buildings. In theory, of course, a building should be so constructed as never to subject its wall material to anything but a direct compressive strain. In practice, however, the case is very different. Owing to bad masonry work, or more generally to the unequal settlement of foundations, transverse strains do frequently occur, and their effect is shown by vertical cracks in the poorer or weaker stones of the walls.

Hardness.—The resistance of stone to mechanical wear is rarely of sufficient importance to justify testing, when the stone is used strictly as a building material. Flagging, steps and sills are, however, subjected to considerable wear, and it is possible that some simple abrasion test might be of service. The only structural stone, however, that really fails, owing to mechanical wear, is serpentine, which is entirely too soft to be used in any unprotected situations.

Expansion.—It has long been recognized that much of the lack of durability of building stone is due to the effects of changes of temperature. Except in the case of an entirely homogeneous material, these operate to disintegrate the stone because the various component minerals will have different ratios of expansion on heating, as in a granite, while in sandstones the cementing material and the enclosed grains or fragments may expand unequally. The tendency of a stone to extoliate or disintegrate under changes of temperature can obviously be tested directly, and uniformity in the method of applying the test may be obtained without difficulty.

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[1] From the *Engineering and Mining Journal*, June 20, 1908.

Absorption.—Changes of temperature, as already indicated may of themselves cause serious injury to a stone; but when taken in connection with the action of water contained in the pores of the stone, the effect is greatly augmented. The tests applied for expansion are mainly to determine the effect of alternate heating and cooling, and particularly of high heating and rapid cooling. The tests for porosity or absorption, on the other hand, are carried out with a view to determining the probable resistance of the stone to the action of frost. Other things being equal, it is obvious that the stone which absorbs the greatest quantity of water per cu. in. in a given time, will be the stone that is subject to the greatest injury at low temperature owing to the freezing of the water contained in it.

The action of frost is frequently simulated by using in the absorption test, instead of pure water, a saturated solution of some salt, which expanding on solidifying, tends to crack or disintegrate the stone. Tests of this type have, however, fallen largely into disuse.

Chemical Tests.—In regard to uniformity in analytical methods marked progress has been made during the past few years. Dr. Hillebrand has described[2] in great detail the methods of rock analysis followed in the laboratory of the United States Geological Survey, and it seems probable that future progress in the standardization of such methods will follow closely along the lines of his paper. The practical value of a chemical analysis depends largely on the type of rock in question. In the case of a granite, trap, or other crystalline igneous rock, an analysis is of itself of little service, though it may do some good if taken in connection with a careful microscopical investigation. With sandstones, analyses are somewhat more useful, in determining the character of the cementing material, though even here a microscopical investigation will probably be more serviceable. The value of a chemical analysis is greater in the case of limestones and slates, particularly the latter.

Microscopic Examination.—The examination, under the microscope, of thin sections of a stone serves to determine the characters and condition of the component minerals, the shape and method of aggregation of the individual grains; and, in the case of non-igneous rocks, the character of the cementing material. Microscopic examination, therefore, is perhaps the most valuable single test; but it is the one which can least readily be applied by the quarryman or engineer, as instruments and training are rarely obtainable.

Field Examination.—The examination of old buildings, and of natural exposures of the stone under test are valuable aids to a determination of its probable durability. Field examination requires, however, a good knowledge of the geological history of the area in which the quarry occurs, as the degree to which a natural exposure of the stone has disintegrated will depend not only on the character of the stone, but on the length of time it has been exposed to the weather. Rock areas in New York and New England are rarely weathered deeply, as this district was swept clean during the Glacial period, while rocks of similar type in the Southern States may be covered by from 50 to 150 ft. of material resulting from their own disintegration.

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[2] W. F. Hillebrand Bulletin, 176, United States Geological Survey.

SULPHUR AND PYRITE.

BY JOSEPH STRUTHERS.

THE production of sulphur in the United States during 1902 was 8,336 short tons valued at $220,560, as compared with 7,690 tons valued at $223,430 in 1901 and 5,186 tons valued at $102,091 in 1900. The production during 1902 was derived from Louisiana, Nevada and Utah in order of importance of their output; Oregon and Idaho which contributed to the output during 1901 reported no production for 1902.

The quantities of sulphur produced in the United States during 1901 and 1902 are the largest annual outputs that have ever been recorded, which indicates that the development of this important branch of the mineral industry is worthy of considerable attention. In recent years the production of domestic sulphur has amounted to less than 1% of the total consumption, which is insignificant when compared with the imports from foreign countries; during 1902 the quantity of sulphur consumed in the United States from domestic and foreign sources, including the sulphur content of iron pyrite which is used in the manufacture of sulphuric acid, amounted to 483,297 short tons.

SULPHUR PRODUCTION, IMPORTS, AND CONSUMPTION IN THE UNITED STATES.

Year.	Production.			Imports.								Consumption. (a)	
	Sulphur.			Crude.		Flowers of Sulphur.		Refined.		Totals.			
	Long Tons.	Value.	Value per Ton	Long Tons.	Value.	Long Tons.	Value.	Long Tons.	Value	Long Tons.	Value.	Long Tons.	Value.
1898	2,726	$59,754	$21·92	159,790	$3,081,974	507	$14,548	163	$4,391	160.460	$3,100,913	161,772	$3,128,845
1899	1,565	33,585	21·46	140,841	2,494,387	336	9,917	184	4,519	141,361	2,508,823	142,449	2,531,604
1900	4,630	102,091	22·05	166,457	2,918,610	628	17,437	243	6,279	167,328	2,942,326	171,418	3,030,922
1901	6,976	223,430	32·04	174,194	3,261,397	748	20,901	268	6,308	175,210	3,287,906	182,076	3,511,336
1902	7,443	220,560	29·64	170,637	3,337.327	788	19,954	14	369	171,389	3,357,650	177,579	3,550,186

(a) In calculating the consumption of sulphur the exports were taken into consideration, although they do not appear in the above table, viz.: 1898, 1,414 long tons ($31,822); 1899, 477 long tons ($10,804); 1900, 540 long tons ($13,495); 1901, *Nil*, and 1902, 1,253 long tons ($28,024).

Market.—The average monthly price of seconds and thirds during 1901 and 1902 is given in the subjoined table:—

AVERAGE PRICE OF BRIMSTONE PER LONG TON IN NEW YORK.

Month.	1901.		1902.		Month.	1901.		1902.		Month.	1901.		1902.	
	Seconds.	Thirds.	Seconds.	Thirds.		Seconds.	Thirds.	Seconds.	Thirds.		Seconds.	Thirds.	Seconds.	Thirds.
January..	$22·67	$20·67	$23·38	$20·75	May.......	$26·69	$24·69	$22·47	$20·02	September	$22.75	$19·75	$22·50	$21·00
February	22·44	20·33	23·19	20·69	June.......	22·40	20·35	22·34	20·09	October...	24·69	21·31	22·88	21·13
March ...	25·30	23·30	23·04	20·49	July.	22·50	19·92	22·16	20·16	November.	26·25	22·50	23·15	21·44
April.....	22·06	20·06	22·54	20·04	August....	22·50	20·50	22·20	20·40	December.	24·25	21·25	22·81	21·06

Average for 1901: Seconds, $23·71; thirds, $21·22. Average for 1902: Seconds, $22·72; thirds, $20·61.

WORLD'S PRODUCTION OF SULPHUR. (*a*) (IN METRIC TONS.)

Year.	Austria (*d*)	France. (*c*)	Hungary	Germany	Greece.	Italy. (*b*)	Japan.	Russia.	Spain. (*f*)	Sweden	United States.
1897........	530	10,723	112	2,317	358	496,658	12,018	574	*b* 3,500	*Nil.*	1,717
1898........	496	9,818	93	1,954	135	502,351	10,389	1,018	3,100	50	2,770
1899........	555	11,744	116	1 663	1,150	563,697	10,241	451	1,100	*Nil.*	1,590
1900........	862	11,551	123	1,445	891	544,119	14,435	1,586	750	70	4,704
1901........	4,911	7,000	137	963	3,212	563,096	(*e*)	(*e*)	610	*Nil.*	6,976

(*a*) From the official reports of the respective governments. The sulphur recovered as a by product by the Chance-Claus process in the United Kingdom, amounting to about 31,000 long tons in 1898 is not included. (*b*) Crude. (*c*) Raw mineral; limestone impregnated with sulphur. (*d*) Crude rock. (*e*) Statistics not yet published. (*f*) Production of crude rock was 58,922 metric tons in 1899; 64,864 in 1900 and 49,856 in 1901.

Nevada.—The Nevada Sulphur Co. operates at Rabbit Hole Springs, 35 miles from Humboldt, Humboldt County. The sulphur rock occurs in beds of considerable thickness and extent included between limestone and magnesian rocks, and are worked by means of tunnels. All rock containing over 8% S is mined, this being considered the minimum limit that repays extraction, but a large portion of the material averages very high. From the mines the rock is carried in cars to the refinery, which treats about 225 tons per month. Thirty men are employed. The sulphur is drawn by wagons to Humboldt for shipment. It is said to be of superior quality and finds a ready market on the Pacific Coast in spite of the competition of Japanese sulphur.

Utah.—The Utah sulphur deposits are situated in the vicinity of Gold Mountain and Marysvale. About 1·5 miles west of the deposits is an old crater, and the country northwest of it shows a recent flow of lava. The country south and west is porphyritic, but on the north is more basic. On the west bordering on the deposits are low hills of honeycombed gypsum from which building stone has been taken. It is possible that the sulphur owes its formation to volcanic action, but the presence of gypsum in the vicinity indicates that the beds have been formed in a manner similarly to those of Texas and Louisiana. The principal deposit from which most of the sulphur has been mined is located in Beaver County near the Millard County line; the outcrop extends for 7 or 8 miles north along which the Utah Sulphur Co. have 8 or 10 promising claims. The deposits were known to the early pioneers, who obtained small quantities of almost pure sulphur from the numerous caves. Soon after 1870 the deposits were located under the mining laws, and a small furnace installed. The plant was afterward enlarged and successfully operated until about 1885. In 1891 the Meyer Bros. Drug Co. of St. Louis bought control of the property, and the smelter was rebuilt, and a new mill for grinding the sulphur installed. Since then the mines have been worked continuously with success. The smelter is not usually operated during the winter season, as the mines are worked by open cutting. The smelter has six stacks or retorts; four of which are generally operated at one time, handling 50 tons of 20% rock per day. The capacity of the mill is from 15 to 18 tons of sulphur in 10 hours. The refinery will yield about 2,000 lb. of flower sulphur and 1,000 lb. of pure rock sulphur per day. The rock sulphur is used for making roll sulphur or is ground and sold as flour sulphur.

Chile.—The native sulphur mines near Arica were actively worked during 1901 as well as the deposits at Taltal; the total output of the country being consumed by the nitrate works in Tarapaca and Atacama for the manufacture of blasting powder and in the extraction of iodine. The Taltal deposits, at an elevation of about 12,000 ft. were worked during the summer months only. The export of sulphur from Chile during 1901 was 9 metric tons, valued at $854 (Chilean currency). The sulphur beds in the vicinity of the extinct volcanoes of Tacora and Chupiquina, 45 miles from Tacua, extend over an area of 1,100 acres and are estimated to contain 9,000,000 tons of sulphur per meter of depth. The average grade is 70% S, although in some localities of Chupiquina as high as 96% S has been obtained. The Compañia Anglo-Chilena, Barron y Cia, Koch, Duran y Cia and Filomena Cerda, with an aggregate capitalization of 500,000 piasters, are engaged in exploiting these deposits. The output averages 15,000 quintals per month which is sufficient for the domestic consumption of 130,000 quintals per annum—60,000 quintals of refined sulphur for the industries of northern Chile and 70,000 quintals of sublimated sulphur for the vineyards of the south and center—and leave 50,000 quintals for possible exportation. For this latter purpose, however, it will be necessary to construct good roads and a railroad to the port of Arica. An estimate has been made that if a railroad should be built to Arica, refined sulphur could be delivered c. i. f. New York at a net cost of 82c. per quintal. The present price is $1·04 per quintal.

Hungary.—In Borgo-Prund near the border of Bukowina there was discovered in the summer of 1902, a sulphur deposit which has been bought by the Hungarian Sulphur Syndicate for 3,000,000 crowns. The company proposes to develop the property and to connect it by railroad to the surrounding sulphur deposits.

Italy.—The sulphur deposits in Italy occur in veins or in lenticular masses in rocks of Miocene age, mainly in the provinces of Caltanisetta and Girgenti. During 1901 there were 945 mines in operation giving employment to 35,618 workmen and an output of 3,726,616 tons of sulphur-bearing rock.

SHIPMENTS OF SULPHUR FROM SICILY TO THE UNITED STATES. (IN LONG TONS.)

Port.	1896.		1897.		1898.		1899.		1900.		1901.		1902.	
	Seconds.	Thirds.	Seconds.	Thirds.	Seconds.	Thirds.	Seconds.	Thirds.	Seconds.	Thirds.	Seconds.	Thirds.	Seconds.	Thirds.
New York	50,557	17,796	57,174	13,300	49,614	22,475	56,746	26,650	70,446	24,307	72,104	19,631	76,183	27,045
Charleston	2,330	5,370	1,500	3,630	500	1,600	......	......	......	......	......	......	......	......
Philadelphia	500	5,500	199	5,210	1,200	5,400	2.740	8,000	1,600	5,100	2,300	9.595	3,500	10,899
Baltimore	3,650	10,500	3,798	10,033	2,350	12,015	3,800	8,600	6,800	5,400	7,550	2,900	9,065	2,400
Boston	4,600	700	7,220	1,000	4,500	1,550	600	1,000	1,500	2,500	3,497	3,200	2,205	2,300
Savannah	8,370	1,025	4,700	......	1,980	......	......	......	1,750	......	......	......	......	......
Wilmington, N C.	1,260	1,400	......	1,550	500	1,200	......	......	......	......	......	......	......	......
New Orleans	2,100	......	8,340	......	500	2,000	......	800	......	3,000	......	1,400	......	1,000
Portland, Me.	2,550	......	4,343	......	13,750	......	18,915	......	27,612	......	21,990	......	26,828	......
Other ports (*a*)	5,425	1,290	540	600	14,101	3,200	590	......	12,490	......	650	......	8,495	......
Totals	81,342	43,581	82,814	35,323	88,905	49,440	83,391	45,050	122,198	40,307	108,091	36,726	125,776	48,144

(*a*) Norfolk, Mobile, San Francisco, Bangor, and Portland, Ore.

The Anglo-Sicilian Sulphur Co., Ltd., for the fiscal year ending July 31, 1902, reports as follows: gross profit, £127,064, from which, after deducting working expenses (not stated) and writing off depreciation (£7,465) and special (£3,000), the net profit was £89,278. A 6% per annum interim dividend up to July 31, 1902, was paid on preference shares (£17,167 less income tax), and a second

TOTAL EXPORTS OF SULPHUR FROM SICILY, 1893-1900. (*a*) (IN LONG TONS.)

Country.	1894.	1895.	1896.	1897.	1898.	1899..	1900.	1901.	1902.
Austria	11,494	12,170	18,799	15,993	15,796	18,519	21,594	18,843	19 085
Belgium	5,644	6,410	7,527	9,258	8,402	7,481	9,721	7,471	12,322
France	56,932	69,696	76,739	84,895	88,657	96,043	108,647	74,394	67,634
Germany	16,437	15,472	15,680	19,721	27,048	25,933	28,708	23,448	25,908
Greece and Turkey	16,870	16,195	18,556	18,866	24,908	18,656	19,647	21,708	20,499
Holland	2,365	3,335	3,834	8,599	5,646	6,408	18,595	10,848	8,648
Italy	49,895	49,349	54,009	73,052	62,652	87,230	101,073	74,516	45,601
Portugal	8,670	14,562	12,001	7,054	8,257	12,269	10,987	11,835	12,842
Spain	3,445	3,753	5,910	4,089	3,283	7,757	6,187	2,979	....
Sweden and Norway	*b*7,887	*b*5,730	*b*14,540	*b*11,226	*b*12,831	*b*12,476	*b*22,681	*b*24,486	*b*24,918
Russia	17,977	17,962	18,752	17,532	12,285	19,211	22,090	15,110	17,294
United Kingdom	22,165	24,043	21,913	24,520	26,983	25,088	23,978	22,464	25,475
United States	105,773	99,227	124,923	118,187	133,435	128,441	162,505	144,817	166,930
Other countries	3,376	7,733	8,562	7,651	12,791	13,569	6,610	9,887	18,171
Totals	328,930	347,686	396,745	410,538	447,394	479,081	558,163	462,299	467,317
Stock in Sicily at end of year	198,518	208,756	222,999	240,367	248,028	277,098	221,204	302,410	324,268

(*a*) From report of A. S. Malcomson, New York. (*b*) Includes exports to Denmark.

dividend for the balance of the year (£18,430 less income tax) was proposed, making a total distribution in preference shares of £35,597. Of the balance, £10,736, or 20%, has been credited to the capital guarantee fund which now amounts to £64,626. An additional sum of £20,499 has been added to the reserve for depreciation of stock, increasing it to £57,029. The general reserve fund is £121,982.

Japan.—The production of sulphur in Japan during 1901 amounted to 16,577 tons, valued at $192,229, as compared with 14,435 metric tons, valued at $165,000 in 1900. The output during 1902 was derived mainly from the provinces of Hokkaido, Rikuzen, Asumi and Shenaro. In recent years a considerable quantity of Japanese sulphur has been imported into the United States amounting during 1901 to 10,705 long tons, valued at $206,899.

Mexico.—Apart from the immense quantity of native sulphur contained in the crater of Popocatepetl (negotiations for the purchase of which from the Mexican Government by Standard Oil interests have been reported), there are very large deposits of native sulphur in the states of Chiapas, Durango, San Luis Potosi and Zacatecas, which have not been exploited except to a very limited extent. At Mapimi and Cerritos in Durango, a very large output could be maintained for years to come. The total consumption of sulphur in Mexico is estimated at 1,000 metric tons, of which about one-half is imported. A sulphur mine in Zacatecas on the Mexican Central Railroad is reported to have been sold for $100,000 gold to a New York dealer.

Peru.—Sulphur is found in sedimentary deposits in the Department of Piura, and although it occurs in large quantities on all of the volcanoes of the Andes, but little is produced—the output for 1900 being 634 kg.

Russia.—The production of sulphur in Russia during 1900 was 1,587 metric tons, as compared with 1,018 tons in 1899. The output for 1900 was obtained from Daghestan, Poland and Turkestan.

Spain.—In addition to the sulphur contained in cupreous iron pyrite, there are mines of native sulphur in the provinces of Albacete and Murcia from which 49,856 metric tons of crude sulphur ore, valued at 296,561 pesetas, were obtained during 1901, as compared with 64,364 tons valued at 549,733 pesetas in 1900.

PYRITE.

The continued prosperous trade conditions throughout the United States during the last two years has stimulated the production of pyrite for manufacture into sulphuric acid to the largest annual outputs yet recorded, *i.e.*, 228,198 long tons valued at $971,796 in 1902, and 234,825 long tons valued at $1,024,449 in 1901. Of the total output during 1902, Virginia contributed more than one-half, followed by Georgia, North Carolina, Colorado, Massachusetts, California, Indiana and Ohio, Missouri and New York, in the respective order of the quantities of their outputs. The production of iron pyrite from Indiana and Ohio was in the form of the so-called "coal brasses," which was obtained as a by-product in mining coal in these States. No new mines of importance were opened during the year, although development work was carried on in localities which have long been known as probable producers, notably in New York, Virginia and North Carolina. At present the pyrite mines of the United States are almost wholly owned by the manufacturers of sulphuric acid, and before another season ends, it is reasonable to suppose that the strong combinations controlling the acid manufacture of the United States will secure the remaining mines. The largest consumers of sulphuric acid,—the Virginia-Carolina Chemical Co., the American Agricultural Co. and the Standard Oil Co.,—now purchase ores from which the acid is manufactured. Fully 90% of the entire output of acid in the United States is consumed for the different uses of these corporations.

PRODUCTION, IMPORTS AND CONSUMPTION OF PYRITES IN THE UNITED STATES. (*a*)
(IN TONS OF 2,240 LB.)

Year.	Production.		Imports. (*b*)			Consumption.	
1898	191,160	$589,329	252,773	47%	$717,813	443,933	$1,307,142
1899	178,408	583,323	269,868	47%	1,077,061	448,276	1,660,384
1900	201,317	684,478	322,484	47%	1,055,121	523,801	1,739,599
1901	234,825	1,024,449	403,706	47%	1,415,149	638,531	2,439,598
1902	228,198	971,796	440,363	47%	1,650,852	(*c*) 668,561	2,622,648

(*a*) These statistics do not include the auriferous pyrites used for the manufacture of sulphuric acid in Colorado. (*b*) For immediate consumption. (*c*) Includes deduction of 3,060 short tons of pyrite valued at $19,860 during 1902. There were no exports during 1901.

Experiments have been conducted during the year which, if ultimately successful, will have a very important bearing on the future of the pyrite industry. The first is the utilization of the by-product gases resulting from the roasting of zinc blende ores, the practicability by which has been demonstrated with financial profit at the zinc plants of Peru and La Salle, Ill., and of Argentine, Kan. It is practicable to save from 25 to 28% of the sulphur content of the ores, the roasted product, or cinders, containing not more than 2% S; a subsequent roasting in a Chase or similar furnace, whereby the remainder of the sulphur will be expelled, will render possible the extraction of the zinc by very cheap methods.

The second is the utilization of the pyrrhotite ores of the South for the manufacture of sulphuric acid. It is claimed that the sulphur contained in these ores can be so effectually removed by roasting that the residual product will be of value in the manufacture of pig iron or even steel. In like manner the cinders or residues from the roasting of pyrite for the manufacture of sulphuric acid might be utilized to advantage. It is well known that the residues from Spanish ores, treated by the Henderson process, have been sold either in the form of "fines," or after briquetting, for the manufacture of steel direct, but, so far, roasted pyrite residues have not been so utilized in the United States on account of the large percentage of sulphur remaining in them after treatment in the chemical works. The utilization of pyrite residues for the manufacture of pig iron would result in the saving of several hundred thousand tons of iron annually, from what is now a waste product.

The Canadian mines at Capelton have made no increase in the shipment of pyrite to the United States and the sulphur in these ores continues to be consumed by Boston chemical works and the Nichols chemical works of New York.

In Newfoundland an American company capitalized at $500,000 is operating the deposit of pyrite on Pilley's Island adjacent to the old Pilley's Island mine, through the workings of which the ore is removed. Several thousand tons of pyrite were shipped to New York during 1902, and early in 1903 a quantity of pyrite was shipped to the works of the Dominion Iron & Steel Co. at Cape Breton, N. S., for the manufacture of sulphuric acid used to collect the ammonia from the producer gases by washing them before they enter the open-hearth furnaces.

Imports and Exports.—In addition to the large increase in the production of pyrite in the United States during 1901 and 1902, there was a very large increase in the quality of pyrite imported, the statistics of imports for 1902 and 1901 being, respectively, 440,363 long tons ($1,650,852), and 403,706 long tons ($1,415,149). Since 1891 the quantity of pyrite annually imported has exceeded the annual domestic production. The exports of pyrite from the United States during 1902 were 3,060 long tons, valued at $19,860, as compared with *nil* in 1901.

Market.—The purchase of all domestic and foreign pyrite and other ores used for the sulphur content in the United States continues practically in the hands of four trade combinations, and, as the total purchases of the ores amount annually to about 500,000 tons, stocks of foreign ores can be accumulated at the seaboard and shipped inland in quantities to secure lowest freight rates. These conditions favor the importation of foreign ores and leave but little incentive to develop domestic mines of uncertain character. Notwithstanding the large increases in both the production and the imports of pyrite in 1901, the price of the domestic product advanced from $3·67 per ton in 1900 to $4·36 per ton in 1901, although it declined to $4·28 in 1902. In a similar manner the value of pyrite imported increased from $3·27 per ton in 1900 to $3·51 per ton in 1901 and to $3·74 in 1902.

PYRITE MINING IN THE UNITED STATES DURING 1902.

Massachusetts.—The mine of the Davis Sulphur Co. in Franklin County was the only producer during 1902; the output being practically the same as that of 1901.

New York.—(By W. H. Adams.)—The production of pyrite during 1902 was considerably less than that of 1901, owing to the continued idleness of the Stella mines at De Kalb Junction. The High Falls Pyrites Co., in St. Lawrence

County, was the only producer. It is expected that the Stella mines will become a large producer under the new management, and as this well-known high-grade ore has been favorably received by the trade, the energetic development of the properties in this section of St. Lawrence County should make them an important factor in the trade of the Northern States.

Virginia.—The producers of pyrite in this State during 1902, (which contributed more than one-half of the total output in the United States), were the Sulphur Mining & Railroad Co., the Arminius Chemical Co. and the Pyrites Mining & Chemical Co. operating in Louisa County, and the concern of F. D. Detrick, P. E. & S. R. Bradley, in Prince William County. The output from the mines in Louisiana County can be maintained at the rate of from 250 to 350 tons per day for many years to come. The mines are fully equipped with modern plants for handling every grade of ore, and the product is so uniform and so easily handled by the chemical manufacturers, that these ores will always command a market. The total output of pyrite in the Southern States during the year was consumed by the Virginia-Carolina Chemical Co.

Tennessee.—(By W. H. Adams.)—The experiments that were made during 1902 on the pyrrhotites of Ducktown and of southwestern Virginia, aiming to utilize them in the manufacture of sulphuric acid, have been very successful. It is expected that these sections of the country, with their enormous deposits of low grade sulphur ores will soon become important factors in the trade, especially if the roasting can be so thoroughly accomplished that the sulphur in the roasted material will be sufficiently reduced to admit of its utilization in the manufacture of pig iron or even steel.

Domestic Consumption of Sulphur and Pyrites.—The use of iron pyrite as a raw material in place of sulphur for the manufacture of sulphuric acid continues to increase steadily, and very nearly the entire quantity of the sulphur consumed in the United States is used in the manufacture of paper stock by the sulphide process. The wood pulp is digested under pressure with sulphurous acid or the acid sulphite of calcium and magnesium, which, reacting upon the lignin and other incrusting material of the fiber, transforms them into soluble products which are subsequently removed in the liquor. There is but one sulphite mill in

CONSUMPTION OF SULPHUR IN THE UNITED STATES. (IN TONS OF 2,240 LB.)

	1899.	1900.	1901.	1902.
Domestic production of sulphur	1,565	4,630	6,866	7,443
Imports of brimstone	140,841	166,457	175,210	174,912
Total	142,406	171,087	182,076	182,355
Exports of brimstone	477	540	207	1,253
Consumption	141,929	170,547	181,869	181,102
Sulphur contents at 98%	139,090	167,136	178,232	177,480
Domestic production of pyrites	178,408	201,317	234,825	228,198
Imports of pyrites	310,008	329,449	403,706	440,363
Sulphur in domestic pyrites at 44%	78,500	88,579	103,323	100,407
Sulphur in foreign pyrites at 47%	145,704	154,841	189,742	193,760
Total sulphur consumed in pyrites	224,204	243,420	293,065	294,167
Total sulphur consumed in brimstone	139,090	167,136	178,232	177,480
Grand total	363,294	410,556	471,297	471,647

In the above table the imports and exports are for crude sulphur or brimstone only; the figures of consumption, therefore, differ slightly from those given in the preceding table on page 573.

the United States using pyrite in place of sulphur in the treatment of wood pulp, although in Europe a considerable quantity of pyrite is utilized for this purpose. Another important factor in the industry has been the increased production of phosphate rock from Florida and Tennessee and the domestic manufacture of superphosphates; for which purpose a chemically pure sulphuric acid is not essential, that made from pyrite serving the purpose equally as well as that made from sulphur.

Assuming that the stocks carried forward from one year to another are practically the same, and estimating the domestic consumption by combining the imports and the domestic production, it will be seen that the quantity of iron pyrite consumed in this country in 1902 was 668,561 long tons, as compared with 638,531 long tons in 1901, and 527,099 long tons in 1900.

WORLD'S PRODUCTION OF PYRITES. (*a*) (IN METRIC TONS.)

Year.	Belgium.	Bosnia.	Canada.	France.	Germany.	Hungary.	Italy.	Newfoundland.
1897	1,828	3,670	35,299	308,448	133,302	44,454	58,320	33,816
1898	147	240	29,228	310.972	136,849	58,079	67,191	33,100
1899	283	480	25,117	318,832	144,623	79,519	76,538	31,500
1900	400	1,700	36,316	305,078	169,447	87,000	71,616	*Nil.*
1901	....	4,570	32,311	307,447	157,433	93,907	89,876	7,653

Year.	Norway.	Portugal. (*c*)	Russia.	Spain. (*d*)	Sweden.	United Kingdom.	United States.	Totals.
1897	94,484	210,265	19.880	217,545	517	10,753	123,468	1,295,046
1898	89,763	248,218	24,570	260,016	336	12,302	194,219	1.465,086
1899	95,636	275,658	23,251	319,285	150	12,426	181,263	1,584,511
1900	98,945	345,330	(*b*) 25,000	356,018	179	12,484	204,538	1,743,011
1901	101,894	215	....	(*e*) 393,397	*Nil.*	10,405	(*e*) 290,978	....

(*a*) From the official reports of the respective governments except the figures for Spain in 1897, which are taken from C. Le Neve Foster's report. (*b*) Estimated. (*c*) Under Portugal is included only the output of pyrites carrying less than one per cent. of copper. Considerable amounts of the richer sulphides are also used in sulphuric acid manufacture. (*d*) Does not include the production of copper-iron pyrites, from which the copper is extracted in Spain. (*e*) Long tons.

Sulphuric Acid.—The average prices of chamber and concentrated sulphuric acids in 1901 and 1902 are given in the subjoined table, which has been compiled from the *Engineering and Mining Journal:*—

Month.	Conc. Acid. 66° B. per 100 Lb.		Chamber Acid. 50° B. per Ton.		Month.	Conc. Acid. 66° B. per 100 Lb.		Chamber Acid. 50° B. per Ton.	
	1901.	1902.	1901.	1902.		1901.	1902.	1901.	1902.
January	$1·20	$1·20	$14·00	$15·00	July	$1·20	$1·20	$14·00	$14·50
February	1·20	1·20	14·00	15·00	August	1·28	1·20	14·00	14·50
March	1·20	1·20	14·00	15·00	September	1·12½	1·20	14·00	14·50
April	1·20	1·20	14·00	15·00	October	1·10	1·20	14·00	14·50
May	1·20	1·20	14·00	14·60	November	1·20	1·20	14·50	14·50
June	1·20	1·20	14·00	14·50	December	1·20	1·20	14·50	14·50
					Average	$1·17½	$1·20	$14·08⅓	$14·67½

PROGRESS IN THE SULPHURIC ACID INDUSTRY IN THE UNITED STATES DURING 1902.

By FREDERICK J. FALDING.

SINCE the year 1900, the manufacture of sulphuric acid has been improved by the introduction, and the establishment upon a firm commercial basis, of the contact process. A more intelligent attention to structural details and a clearer understanding of the principles involved in the process, have resulted in a much higher grade of work being done in the lead chambers. A large output per cu. ft. of chamber space, and small consumption of nitric acid on the sulphur burned, which hitherto were only obtained at a few of the best managed works, are now quite common. The increase in the number of factories and also in the size of existing factories during this period has been phenomenal.

The Contact Process.—In the year 1899, the Schroeder-Grillo patents were acquired by the New Jersey Zinc Co., and early in 1900, the first installation of a contact plant in America was completed and the first fuming acid made at the Mineral Point works of this company in Wisconsin. The raw material used was a zinc blende carrying a large quantity of arsenic, which was roasted in furnaces of the Grillo-Rhenania type. The operation of this plant at first was very unsatisfactory and the excitement caused in the United States by the publication of the patents of the Badische Anilin-und Soda-Fabrik and others, was considerably cooled. After painstaking experiments and alterations had been made, which secured the thorough purification of the gas and made possible the use of these highly arsenical ores, the process became more and more satisfactory, and it has long ago proved itself a commercial and technical success.

Plants have also been erected under the above patents by the Peyton Chemical Co. in California, where gold and silver arsenical concentrates are burned; by the Repauno Chemical Co. and the Dupont Powder Co. near Wilmington, Del., where Spanish fines ore are burned; by the New Jersey Zinc Co., at Hazard, Pa.; by Harrison Bros. & Co., near Philadelphia, Pa., and several others are about to be erected in different localities. Some of the early plants are being doubled in size. A plant has also been built by the Nobels in Mexico. A contact plant has also been started in Buffalo under the patents of the Verein Chemische Fabriken Mannheim, using ferric oxide as catalyzer, and the Frasch converter[1] is being exploited by the United Zinc & Chemical Co. at Argentine, Kan. The General Chemical Co. has also erected contact plants at two factories near New York, and are about to extend the manufacture to other of their works.

Patents relating to the technique of the contact process which have originated in the United States are those of the New Jersey Zinc Co.[2] and of the General Chemical Co.[3] Papers relating to the contact process were read before the New York section of the Society of Chemical Industry by Dr. T. Meyer,[4] Dr. Reece,[5] and Mr. Geo. C. Stone.[6]

The Chamber Process.—In 1901, the first installation of the Meyer tangential system was made at the Griffith & Boyd Works at Baltimore, Md. This system has been successfully operated and several further installations are being made. The use of fans between the Glover tower and the first chamber and at the exit of the Glover tower has been increased. Some installations have also been made of special cast iron fans immediately after the burners and before the Glover tower. This seems to be specially advantageous where "fines" burners are em-

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[1] United States Patent No. 664,680, Dec. 25, 1900.

[2] United States Patents No. 695,180, March 11, 1902, and Nos. 711,186, 711,187, and 711,188, Oct. 14, 1902.

[3] United States Patents Nos. 719,332 and 719,333, Jan. 28, 1903.

[4] *Journal of the Society of Chemical industry*, Sept. 29, 1900, 823 [5] *Ibid.* [6] *Ibid.*, Nov. 29, 1902, 1395.

ployed. Surface condensers of several varieties, both air and water-cooled, are commonly used between the lead chambers. The new furnace of the MacDougall type invented by A. O. O'Brien, of Richmond, Va., has been operated very successfully. This six-shelf furnace has a large capacity and possesses several very advantageous features. The construction of the Glover and Gay-Lussac towers has been much improved, especially as regards the care used in packing, and a proper proportioning of their capacity. Two Gay-Lussac tandem towers are now in almost universal use. An output of 1 lb. of sulphur to from 10 to 12 cu. ft. of chamber space with a yield of from 95 to 97% of the theoretical quantity and a consumption of not over 3% of sodium nitrate in proportion to the sulphur burned, while not universal is by no means uncommon.

The following table shows a partial list of sulphuric acid plants, built or enlarged since January, 1900. This table, however, does not give any adequate idea of the increase in manufacture of sulphuric acid, as nearly every existing plant has been enlarged or has made additions to its apparatus, in order to obtain an increased output. Since the above was written, contracts have been made for the erection of a 50-ton tangential plant in Kansas and of two 25-ton tangential plants, the one in Philadelphia and the other at Moosic, Pa.

LIST OF SULPHURIC ACID PLANTS COMPLETED OR IN COURSE OF CONSTRUCTION SINCE 1900.

Name and Locality.	Equipment.	Chamber Capacity. Cu. Ft.
Richmond Guano Co., Richmond, Va	4 intermediate towers	178,000
E. Frank Coe & Co., Barren Island, N. Y		225,000
Southwest Chemical Co., Argentine, Kan	15 Gilchrist columns and fan	435,000
Lazaretto Guano Co., Baltimore, Md	9 Gilchrist columns and fans	336.000
Western Chemical Co., Denver, Colo		450,000
Meridian Fertilizer Co., Meridian, Miss	Pratt system	148,000
Bussey & Sons, Columbus, S. C	Pratt system	90,000
Greenville Fertilizer Co., Greenville, S. C		185,000
Virginia-Carolina Chemical Co., Memphis, Tenn		185,000
Anderson Fertilizer Co., Anderson, S. C		124,000
Georgia Chemical Works, Rome, Ga		206,000
Dominion Iron & Steel Co., Sydney, C. B		187,000
Philip Carey Manufacturing Co., Lackland, Ohio		158,000
E. Rauh Sons Fertilizer Co., Indianapolis, Ind	2 Gilchrist columns	101,000
Jackson Fertilizer Co., Jackson, Miss	3 Gilchrist columns	220,000
Scott Bros. Fertilizer Co., Elkton, Md		83,000
C. H. Dempwolf & Co., York, Pa		170,000
A. P. Brantley Sons Co., Blackshear, Ga		101,000
Virginia State Fertilizer Co., Lynchburg, Va	4 intermediate towers	148,000
Grasselli Chemical Co., Birmingham, Ala		400,000
Jarecki Chemical Co., Cincinnati, Ohio		140,000
Detroit Chemical Co. of Detroit, Mich	5 Gilchrist columns	173,000
Federal Chemical Co. of Nashville, Tenn	18 Gilchrist columns	278,000
Southern States Fertilizer Co., Savannah, Ga	Pratt system	180,000
Virginia-Carolina Chemical Co., Dothan, Ala	Hoffman	100,000
Ohio Farmers' Fertilizer Co., Columbus, Ohio		204,000
Armour Fertilizer Co., Atlanta, Ga		166,000
Virginia Chemical Co., Savannah, Ga	Hoffmann intensifier	120,000
Merrimac Chemical Co., Boston, Mass		202,000
Sayles-Bleacheries, Saylesville, R. I		10,000
Bowker Fertilizer Co., St. Bernard, Ohio		141,000
T. P. Shepard Co., Providence, R. I		140,000
Virginia-Carolina Chemical Co., Albany, Ga		160,000
Standard Chemical & Oil Co., Troy, Ala		150,000
F. S. Royster Guano Co., Columbus, S. C	7 Gilchrist columns	173,000
Griffith & Boyd	Meyer tangential	75.000
Virginia-Carolina Chemical Co., Greenville, S. C		200,000
Total cubic feet		6,537,000
Total cubic meters		1,853,000

TALC AND SOAPSTONE.

THE production of fibrous talc in 1902 was 71,100 short tons, valued at $615,350, as compared with 69,200 short tons, valued at $483,600 in 1901. The production of common talc during 1902 is included with soapstone; the output in 1902 amounting to 21,640 short tons, valued at $413,497, as compared with 28,643 short tons, valued at $424,888 during the preceding year.

PRODUCTION AND IMPORTS OF FIBROUS TALC AND SOAPSTONE IN THE UNITED STATES. (IN TONS OF 2,000 LB.)

Year.	Production.									Imports. (*b*)		
	Fibrous Talc.			Common Talc.			Soapstone.			Tons.	Value.	Per Ton
	Tons.	Value.	Per Ton	Tons.	Value.	Per Ton	Tons.	Value. (*a*)	Per Ton			
1898....	54,807	$285,759	$5·21	9,112	$78,645	$8·63	18,862	$158,685	$8·41	445	$5,526	$10·70
1899....	57,120	272,595	4·77	6,671	51,763	7·71	20,011	189,504	9·47	254	3,534	13·91
1900....	45,000	236,250	5·25	7,770	60,217	7·75	18,956	189,560	10·00	79	1,070	13·50
1901....	69,200	483,600	6·99	(*c*)	(*c*)	(*c*)	*d*28,643	424,888	14·83	2,386	27,015	11·32
1902(*e*).	71,100	615,350	8·65	(*c*)	(*c*)	(*c*)	*d*21,640	413,497	19·11	2,859	35,836	12·36

(*a*) In reporting the value of their output of soapstone producers generally give the figures for the finished articles which they make. Since a varying proportion of labor enters into these, such figures are apt to be misleading. Few producers are able to name a value of the crude stone, or roughly dressed blocks. We have therefore valued the material arbitrarily at this stage at $10 per ton, except in 1898 when a large production of inferior stone reduced the average. The value in 1899 is that reported by the producers. (*b*) Talc, ground, powdered or prepared. (*c*) Included with soapstone. (*d*) Includes common talc. (*e*) Through the courtesy of the U. S. Geological Survey.

According to Dr. Joseph Hyde Pratt, there has been a considerable decrease in the quantity of rough talc sold in 1902, nearly one-half of the output being mined in North Carolina. Despite the decrease in the tonnage of manufactured articles the value has increased, due to the increase in the manufacture of tailors' pencils and gas tips from North Carolina talc, and of expensive articles from Virginia soapstone. Most of the output of New Jersey, Pennsylvania and Maryland was sold as ground talc. The entire production of fibrous talc was obtained from St. Lawrence County, N. Y.

Although the United States Circuit Court of Appeals has decided that talc is dutiable at 20% ad valorem, the Treasury Department has ordered that talc like French chalk must pay a duty of 1c. per lb., and will appeal the case on these grounds.

TIN.

BY D. H. NEWLAND.

THE development of the tin deposits of the United States received more than usual attention from the public during 1902, but as heretofore there were no mines engaged in active commercial operations. Some experimental work was done near Hill City and Bear Gulch in the Black Hills, resulting in the formation of two companies to exploit the deposits, and operations were resumed in the district of the Santa Ana Mountains in southern California. In the light of previous unsuccessful ventures in these fields, the future of the new companies does not appear encouraging. Prospecting was also carried on in the vicinity of King's Mountain, N. C., where the occurrence of cassiterite in pegmatite dikes and residual clays was noted several years ago. Recent developments, it is stated, have shown the ore to be widely distributed. The deposits of the Franklin Mountains near El Paso, Texas, have proved disappointing in that the veins die out near the surface. There is reason, however, for believing that the ore bodies have been thrown by local faults, in which case they might be located in depth by cross-cutting. The upper portions of the veins carry good values in tin ore.

Technology.—The recovery of tin from tin-plate scrap was continued during 1902 by the Vulcan Detinning Co. at its plants in Sewaren, N. J., and Streator, Ill., by the Ammonia Co., of Philadelphia, and the Johnston & Jennings Co., of Cleveland and Chicago. Several new companies have been formed to engage in the industry.

According to H. Mennicke, in *Zeitschrift fuer Elektrochemie,* VIII., xxi., 1902, there are nine works in Europe, chiefly in Germany, which use the stannate process for the recovery of tin from tin scrap. In this process sodium hydrate is electrolyzed into Na and OH, which react upon the tin forming soluble sodium stannate. The latter compound is then decomposed, thus: $Na_2SnO_3+2H_2=2NaOH+H_2O+Sn$. The electrolytic bath is originally made up to contain 10% of caustic soda and is used at about 70°C. The temperature and the percentage of free alkali have great influence on the result. The absorption of carbon dioxide from the air must be guarded against, inasmuch as it reduces the conductivity, extends the time required, and causes a precipitation of tin hydroxide, forming a coating on the scrap, which interferes with the solution of the tin. The absorption of carbon dioxide cannot be prevented completely, and as the carbonate increases in quantity the electrolyte must be regenerated. This is done by removing a portion of the solution daily, and treating it first with carbon dioxide to throw down the tin as hydrate, and then after filtration with calcium oxide to convert the sodium carbonate into caustic soda. About 10% of the tin recovered from the scrap is obtained from this process of regeneration of the electrolyte. Fresh scrap usually yields from 2 to 3·5% of tin. The electrolytic stripping is stopped when the scrap attains a brown color, at which stage about 0·2% Sn remains undissolved. The best precipitate is obtained when the electrolyte is maintained at 70°C. At higher temperatures there is a tendency toward the deposition of spongy tin, and the metal is more likely to reoxidize than in cooler solutions. When the tin is crystalline, coherent and free from oxide, there is no difficulty in melting it, but it may conveniently be pressed first into briquettes. Lead, iron, arsenic and antimony pass into solution and deposit with the tin, wherefore an impure scrap always yields an impure product.

(By H. A. Mather.)—At the plant of the Vulcan Detinning Co. the scrap is digested in alkaline solutions and the tin electrolytically precipitated therefrom in the form of a powder averaging 80% metal. The remaining sheet iron containing a little tin is melted and cast into window sash weights and other objects of which tin is a desirable feature. The National Lead Co. absorbs the total output of the Vulcan Detinning Co. and the American Can Co., and refines the crude product by liquation in reverberatory furnaces. This tin subsequently appears in the form of Babbitt metal after being proportionately mixed with copper, lead and antimony.

The larger amount of the tin dross recovered from dyers' wastes as well as the tin "kettle skimmings" (the by-product of the solder refineries) are commonly mixed with lead drosses and smelted in reverberatory furnaces to form crude tin-lead solder. The crude pigs containing iron, copper and sometimes zinc are then liquated or "sweated" with hard coal dust in a reverberatory furnace at a temperature lower than the melting point of the harder metals, with the result that these accumulate as "skeletons" or "sweatings" in the furnace, to be intermittently raked out of the charging door, while the purified tin-lead alloy is tapped at regular intervals and cast into pigs. In some instances several sweatings are necessary before the solder is clean enough to pour into solder bars.

Practically all of the solders manufactured in this country contain antimony in amounts from 1 to 10%. Even the so-called "half and half" solder guaranteed to contain equal amounts of tin and lead, rarely assays better than 50% lead, 46% tin and 4% antimony. It is noteworthy that the "cone test" for solder, supposedly an infallible register of metallic percentages in tin-lead alloys, does not indicate the presence of properly proportioned amounts of antimony. The latter imparts a bright metallic sheen to the alloy, and beyond diminishing the covering quality of the solder does little damage. The can companies and other users of high-grade solder thus commonly pay for a considerable quantity of antimony on the basis of tin.

Nearly all varieties of Straits tin may be melted directly into solder or other alloys, but the Bolivian tin, containing copper and sometimes arsenic as impurities, needs treatment previous to alloying, otherwise when alloyed with lead in solder, the latter will show dirty and spotty, making a difficult saleable product. This effect is due in part to the presence of antimony in the lead, and is emphasized by any arsenic contained in the tin. The physical characteristics of "spotty" solder are similar to the phenomena recognized under the designation "sickening" of metals. The crystallization or grain of the solder is altered as well as its surface appearance. Solder of the same character may be produced also from arsenical tin dross, or even improperly fluxing in the reverberatory furnace, especially when salt cake is the flux. In the latter event the phenomenon of sickening is probably due to a series of complex reactions between salt cake and iron and antimony oxides, whereby first iron sulphate is formed, and then the antimony takes the place of the sulphur in the iron sulphate, forming in the end reaction an antimoniate of iron, which oxidizes at the moment of casting. The use of a proper amount of coal, a hot furnace and a reasonably clean furnace hearth will do much to alleviate this trouble.

IMPORTS OF TIN INTO THE UNITED STATES.

Year.	Pounds.	Value.	Year.	Pounds.	Value.	Year.	Pounds.	Value.
1897........	55,172,671	$7,415,983	1899.......	71,248,407	$16,746,107	1901.......	74,560,487	$19,024,761
1898........	62,748,899	8,770,221	1900.......	69,989,502	19,458,586	1902.......	85,048,358	21,263,337

THE PRINCIPAL TIN SUPPLIES OF THE WORLD. (*a*) (IN LONG TONS.)

	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.
English production..............	6,648	4,887	4,453	4,648	4,018	4,268	4,125	3,950
Straits shipments to Europe and America...	47,840	47,180	41,700	43,350	44,460	46,070	50,839	51,881
Australian shipments to Europe and America	4,902	4,820	3,466	2,420	3,337	3,178	3,276	3,206
Banka sales in Holland......................	6,221	6,735	8,900	9,038	9,066	11,820	14,978	18,765
Sales of Singkep in Holland................	644	839	800	*Nil.*	*Nil.*	*Nil.*	*Nil.*	
Billiton sales in Java and Holland..........	4,539	5,040	5,100	5,842	5,057	5,820	4,387	
Bolivian arrivals on Continent...............	....	210	1,208	1,000	813	1,900	9,670	10,150
Bolivian arrivals in England................	4,097	3,829	4,298	3,464	3,940	5,037		
Straits shipments to India and China........	4,674	6,118	3,214	2,551	1,484	1,785	2,650	1,925
Totals in long tons.........................	79,655	79,108	73,139	71,763	72,557	79,878	89,425	89,827
Totals in metric tons.......................	80,930	80,374	74,309	72,911	73,718	81,156	90,856	91,264

(*a*) This table is based on the statistics compiled by William Sargant & Co., and Ricard & Freiwald, but the figures of English production are taken from the British blue-book. This table does not include the production of Germany, Austria, Spain, Portugal, and various other countries.

PRODUCTION OF TIN IN THE WORLD. (*n*)

Year	Australia. (*a*)			Austria. (*b*)			Banka and Billiton. (*c*)	Bolivia. (*d*)	England. (*e*)			Germany. (*f*)		
	Met Tons.	Value. (*o*)	Per M Ton.	Met. Tons.	Value. (*o*)	Per M Ton.	Metric Tons.	Metric Tons.	Met. Tons.	Value. (*o*)	Per M Ton.	Met. Tons.	Value. (*o*)	Per M Ton.
1897..	1,159	$350,640	$308	48	$16,806	$350	14,224	5,594	4,524	$1,456,680	$322	929	$287,829	$310
1898..	908	302,825	333	48	19,074	397	14.610	4.535	4,722	1,729,060	366	993	372.252	375
1899..	835	490,690	587	41	24,639	601	14,496	8,012	4,077	2,540,470	623	1,481	870,750	590
1900..	915	600,160	656	40	27,651	691	18,234	10,245	4,336	2,039,345	678	2, 81	1,332,750	651
1901..	677	384,255	568	49	30,264	618	19,365	14,932	4,634	2,782,855	601	1,451	849,000	585

Year.	Japan. (*g*)	Mexico. (*h*)	Portugal. (*i*)	Russia. (*j*)			Singkep. (*k*)	Straits Settlements. (*l*)	Tasmania. (*m*)			Total Met. Tons.
	Met. Tons	Met. Tons.	Met. Tons.	Met. Tons.	Value (*o*)	Per M Ton.	Met. Tons.	Met. Tons.	Met. Tons.	Value. (*o*)	Per M Ton.	
1897........................	47	1	1	2	$476	$238	818	45,632	3,484	$749,970	$302	75,400
1898........................	43	*Nil.*	*Nil.*	*Nil.*	......	......	685	46,635	2,088	705,810	346	75.211
1899........................	18	*Nil.*	*Nil.*	*Nil.*	......	......	678	46,679	2,275	1,355,433	596	78,592
1900........................	12	*Nil.*	*Nil.*	4	(*q*)	(*q*)	575	46,795	2,061	1,349,165	655	85,244
1901........................	(*p*)	*Nil.*	*Nil.*	(*p*)	(*p*)	(*p*)	793	51,339	1,818	1,062,710	584	95,058

(*a*) From *Report of Secretary of Mines and Agriculture of New South Wales*, which is the only Australian state that produces metallic tin. Tin ore is also exported from New South Wales. Tin ore is produced in Victoria, Queensland, South Australia, and Western Australia, but its metal contents are reported in the productions of other countries.

(*b*) From the *Statistisches Jahrbuch des K. K. Ackerbau-Ministeriums*. The tin production of Austria is derived partly from domestic ores, and partly from Bolivian ores and impure tin from the East imported for refining.

(c) Total sales in Holland and Java as reported by William Sargant & Co.

(d) Exports of tin and tin in ore from Bolivia to England and the Continent. Some of this tin may be produced in Peru. It is all exported through Peruvian and Chilean ports.

(e) From *Mineral Statistics of the United Kingdom.* These figures give the amount of tin estimated to be obtainable in smelting the ore of domestic production. They differ considerably from the figures used by William Sargant & Co., which are possibly obtained directly from the smelters.

(f) From *Vierteljahrs und Monatshefte zur Statistik des Deutschen Reichs.* By far the larger part of this production is from Bolivian ores.

(g) From the *Resumé Statisque de l'Empire du Japon.*

(h) According to export returns. Small amounts produced by natives for domestic consumption are not included.

(i) From official returns furnished by the Portuguese Government. The figures for 1896 include tin ore.

(j) From Russian official reports.

(k) The figures represent sales in Holland, reported by De Mouchy & Havelaar and W. Sargant & Co.

(l) Shipments from the Straits to Europe and America, as reported by William Sargant & Co., and to India and China by Boustead & Co, the quantity shipped to the latter countries in 1901 is estimated at 700 tons.

(m) From *Report of the Secretary of Mines.* The statistics for 1900 and 1901 represent exports.

(n) It will be observed that this table differs from the statistics usually referred to for the world's production of tin, namely, those of William Sargant & Co., and of the *Metallurgischegesellschaft Frankfurt-am-Main.* This is because (1) they reckon Australian shipments to Europe and America, instead of the Australian production, whereby a good deal of Australian tin consumed at home is not included; (2) shipments from the Straits to India and China and the production of several minor countries are not included. A small amount of tin produced in Spain is necessarily omitted, owing to the absence of statistics for that country.

(o) In cases where the statistics in the above table have been taken from official sources, wherein values of product have been stated, a calculation of unit values has been made. This developed some amazing differences, which are undoubtedly due to making value calculations at different stages of the product; *i.e.*, more or less cost of carriage is included.

(p) Statistics not yet published.

(q) Value not stated.

Alaska.—The year's operations in the York region of Alaska have been confined mostly to prospecting and experimental work. The stanniferous area, so far as known, is limited to the creeks and gulches which have their sources in a range of hills lying about 10 miles east of Cape Prince of Wales. The hills are from 1,000 to 1,300 ft. in height and extend in a north and south direction for a distance of about 3 miles. The ore consisting of cassiterite is irregularly distributed along the bedrock and in the overlying wash, and probably has been derived from numberless small veins that traverse the slate strata underlying the region. Its occurrence is confined to the flood-plains of the modern streams which are included between banks of tundra; the width of the productive area along a stream ranges from a few feet to more than 100 ft. The richest deposits have been found on Tillery and Buck creeks. In the former locality this surface wash averages about 16 in. in depth, and carries about 8 lb. of 60% cassiterite to the cu. yd. Exploration in the tundra benches has failed to show the presence of ore in this formation. Tests as to the practicability of operating the deposits under present conditions show that there is no large extent of ground that would repay working.

STOCKS OF TIN IN ENGLAND, AMERICA AND HOLLAND. (*a*) (IN LONG TONS.)

	1896.	1897.	1898.	1899.	1900.	1901.	1902.
Stocks, December 31—							
Stock of foreign in London	18,097	15,146	8,110	5,486	4,286	5,114	4,557
Foreign landing in London	1,174	673	165	1,212	1,297	689	712
Straits afloat for London, including wire advices	2,792	2.500	1,050	2,900	3,835	2,780	2,845
Australian afloat for London, including wire advices	525	600	400	450	350	522	518
Banka on warrants in Holland	1,616	2,877	2,228	1,160	837	696	644
Billiton in Holland	1,638	1,328	1,036	470	330	329	60
Billiton afloat for Holland	1,742	1,193	1,322	1,050	350	440	333
Straits stock in Holland	789	377	454	100	60	30	....
Straits afloat for Holland	950	100	215	....	....	....	....
Straits afloat for Continent	650	600	560	450	590	873	650
Bolivian in Liverpool	250	710	300	550	495	846	184
Total stocks	30,223	26,104	15.840	13,828	12,430	12,319	10.503
Estimated stock in America and quantity floating	3,925	4,500	4,300	2.500	2,600	6,050	4.450
Grand totals	34.148	30.604	20,140	16,328	15,030	18,369	14.953
Trading Co.'s res'v's of unsold Banka stock in Holland	5,953	4.333	3,218	4,353	5,347	7,251	1,466

(*a*) From the annual metal circulars of William Sargant & Co and A. Strauss & Co.

CONSUMPTION OF TIN IN ENGLAND, AMERICA AND HOLLAND. (*a*) (IN LONG TONS.) (*b*)

	1895.	1896.	1897.	1898.	1899.	1900.
Consumption—						
Deliveries from London after deducting all shipments to America	17,222	19,015	17,118	15,472	13,519	16,061
Deliveries from Holland after deducting exports to London and America	9,029	10,150	11,680	12,130	13,094	14,416
English consumed at home	988	5,000	4,400	4,600	4,400	3,500
Exports of English, minus quantity shipped to America	5,530					
American consumption of all sorts	22,500	29,500	22,500	28,500	31,500	31,100
Billiton sent to other ports than Holland	1,532	1,603	1,370	2,120	1,930	2,400
Straits direct to Continent, less re-exports to America and England	7,622	11,400	9,170	12,740	6,470	5,400
Bolivian delivered from Liverpool	4,099	4,071	3,838	3,874	3,690	5,092
Bolivian delivered from Continent	....	210	1,208	1,000	813	1,900
Totals	68,522	71,949	71,284	80,436	75,416	79,869

(*a*) From the annual metal circular of William Sargent & Sons. (*b*) Not classified for 1901 or 1902; the totals for these years are 87,700 and 93,982 tons respectively.

Bolivia.—(By J. B. Minchin.)—The tin deposits occur at intervals over a tract of country comprising the mountain ranges along the eastern edge of the great tableland, and extending some 300 miles from north to south with a width of about 20 miles. The more important deposits at present known are those of Huaina Potosi and Quimsa-Crur in the Department of La Paz; of Colqueri, Negro Pabellon, Morococala, Huanuni, Anteguera and Avicaya in the Department of Oruro; and Llallagua, Uncia, Potosi and Chorolque in the Department of Potosi. The lodes are inclined at angles of from 50° to 70°, and usually cut through highly inclined metamorphic shales, but occasionally they pass into the adjacent igneous rocks. They lie at altitudes varying from 13,000 to 15,000 ft. above sea-level, the mines at Chorolque and Quimsa-Crur even exceeding the latter limit. The width of the deposits varies greatly; every gradation is encountered from the narrowest veins up to lodes of 2 and 3 m. These lodes usually carry streaks of more or less pure tin ore, the rest of the lode matter being composed of compounds of silica and alumina, and of iron oxide with tin ore intermingled. In some cases the lodes are filled with soft clay carrying a large percentage of tin oxide in the form of grains and nodules, and occasionally rich pockets are found in which the whole lode is filled with nearly pure tin ore as a coarse sand. In these cases it is, of course, mined with great ease, but, as a general rule, the lode-matter is solid, and the country rock unusually hard.

The concentration mills are usually at altitudes of from 12,000 to 13,000 ft. above sea level, or from 1,000 to 2,000 ft. below the mines. Until recently the transport of ores to these mills was carried on exclusively by means of llamas and donkeys, and constituted one of the miners' chief difficulties, owing to the insufficient number of animals available, and the considerable cost, amounting to $1·25 per ton-mile. The Avicaya, Huanuni and Chorolque enterprises have lately put up ropeways for carrying their ores, which have a capacity of 8 tons per hour, and work by gravity, the cost of transport being reduced to about 12c. per ton-mile. The most important of the lines is that at Avicaya with an approximate length of 3 km.

No coal exists on the Bolivian plateau and the imported article from England, the United States or Australia, costs $30 per ton. Native fuel, "yareta," or llama dung, is efficient for steaming, and is comparatively cheap, but in many districts it is becoming scarce. At the amalgamation works of Bella Vista-Poopo, a Deutz anthracite suction gas-motor was recently erected, of 80 H.P. at sea level. Brake trials at Poopo gave from 50 to 55 H.P., a result considered satisfactory, in view of the altitude of 12,300 ft. The consumption of anthracite was 0·7 kg. per horsepower hour, but it is expected that this will be reduced to 0·6 kg. Similar motors are in course of erection for the Avicaya and Huanuni enterprises, which will then be enabled to run their concentration plants with regularity. Petroleum motors are employed at Avicaya for electric lighting and for running Wilfley tables.

The average content of the ores in Huanuni and Avicaya, as they come from the mines, is from 10 to 12% metallic tin. The degree of fineness to which they are ground depends on their quality. They are pulverized as little as possible, so as to avoid the formation of slimes. At Avicaya from 4 to 8-mesh sieves are employed in the stamps and ball mills, while at Huanuni, owing to the tin oxide being more disseminated through the gangue, 25-mesh is necessary in the batteries. The pulverized ore passes through hydraulic separators, which, with an upward current of water, carry off the slimes to settling tanks, whence they are treated in round buddles and Wilfley tables, while the coarser material is classified in trommels and concentrated in automatic jigs. The concentrates undergo a final treatment by washing in sieves, after which they are dried and sacked for export. At Avicaya the average content of the finished product, or "barrilla," is over 70% fine tin; while at Huanuni, in spite of the finer grinding, it does not usually exceed 67%. The Huanuni tailings still contain 2% of tin, and though they admit of good concentration to 10%, the tin oxide cannot be separated without further pulverizing. Huntington mills are to be used for this purpose.

The Llallagua-Uncia mines occupy another important tin region, but as they have been more recently opened up and are about 45 miles distant from the railroad, with which they are not yet connected by a coal road, the ores are still treated in a primitive manner, being ground under hand-worked rockers and concentrated in simple buddles. The Potosi production is so far chiefly derived from the old silver amalgamation tailings, which are roughly concentrated, and then reduced with charcoal in small water-jacket furnaces and run into bars for export. The Quimsa-Crur region appears to be promising, though it has as yet been but little investigated, owing to its distance from the railroad, to bad roads, scarcity of labor and the great elevation at which the lodes exist. Many of them are about the perpetual snow line. This has, however, the great advantage of affording ample water supply for power purposes. The rich mines belonging to Señor Aramayo in the great Chorolque Mountain, near the southern extremity of the tin belt, are some 80 miles from the Antofagasta Railroad, and at an elevation of 17,000 ft. above sea level, the concentration mill itself being nearly 16,000 ft.

In addition to the tin mines proper, many of the silver ores, as in the case of the Oruro mines, contain a small percentage—2 to 4%—of tin, which is, however, advantageously extracted by the inexpensive concentration of the lixiviation tailings.

The depth to which the tin ores extend in the Bolivian mines has not yet been clearly established. Some of the principal lodes in Huanuni and Avicaya are still rich at from 300 to 400 m. below the outcrops. In other cases there appears to be a tendency for the value to fall off in depth, the tin ore being replaced by more or less poor iron pyrite.

Reliable statistics of Bolivian tin production are not readily obtainable. The approximate output of the principal enterprises may, however, be given as follows, in tons of black tin ("barrilla") per month: Huanuni Tin Mining Co., Huanuni, 65 tons; Teller Hermanos, Huanuni, 60 tons; other mines at Huanuni, 75 tons; J. Juleff, Antequera, 50 tons; Totoral Mining Co., 65 tons; Avicaya, 100 tons; Llallagua, 45 tons; Compañia Minera Uncia, Uncia, 35 tons; S. Patiño, Uncia, 80 tons; Chorolque, 90 tons; silver ore tailings, Oruro, 130 tons; total, 795 tons, equivalent to 525 tons metallic tin. To this total may be added a monthly production of 135 tons bar tin from the Potosi mines and 140 tons bar tin from all of the smaller workings, making the aggregate production of Bolivia about 800 tons bar tin per month, or about 9,600 tons per year.

Malay States.—The mining industry in the States of Perak, Selangor, Negri-Sembilan and Pahang is gradually passing into the control of large companies who work the deposits directly; consequently the number of small operators and tributers has shown a marked decrease in recent years. In 1901 there were 162,577 coolies employed in the mines as compared with 168,000 in 1900. The production in the individual States during these years was as follows:—

States.	1900.			1901.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
Perak	21,166	21,506	$13,714,865	22,920	23,288	$12,462,750
Selangor	16,041	16,298	10,398,655	18,010	18,299	9,792,935
Negri-Sembilan	4,900	4,869	2,786,155	4,478	4,550	2,434.910
Pahang	985	950	605,825	1,566	1,591	851,510
Total	42,442	43,123	$27.500,000	46,974	47,728	$25,542,105

The Pahang Corporation, Ltd., during the fiscal year ending June 30, 1902, earned a net profit of £22,240, out of which a dividend of 10% on the preferred stock was paid. The quantity of stone treated was 22,763 tons, yielding 622 tons of black tin valued at £48,501. The Kinta Tin Mines, Ltd., an English company which has secured a large property near Gopeng, Perak, began active operations in July, 1902, with eight monitors.

The tin industry of the Malay Peninsula has been described by Mr. Frank Owen in THE MINERAL INDUSTRY, Vol. IX. The following notes abstracted from an article by R. A. F. Penrose, Jr., appearing in the *Journal of Geology,* February-March, 1903, give some further details relative to the district of Kinta, Perak, one of the most productive fields of the Malay States.

The ore from the Kinta district is mined mostly from alluvial deposits, which vary considerably in character. In the larger valleys, the alluvium is commonly composed of sandy or gravelly clay, containing small quartz fragments together with pebbles and boulders of granite, gneiss, schist, limestone, etc. The alluvium in the hills, however, shows a greater variation in character in accordance with the different rocks from which it has been derived. It is frequently stained with iron and carries layers and masses of ferruginous material composed of granite and quartz colored by rusty pyrite, and of sand cemented by iron. The tin is sometimes scattered through the alluvium from top to bottom in comparatively uniform quantities, and at other times it is concentrated in layers in the interior and along the bedrock. Usually there is an overburden of barren alluvium of from 10 to 40 ft. in thickness. The richest deposits are found immediately at the foot of the mountains. The ordinary tin-bearing formation varies from 1 to 30 ft. in thickness, sometimes reaching an extreme of 100 ft. At Gopeng, alluvium is worked which contains tin from the surface down to a depth of from 5 to 30 ft., but at Campar, the tin-bearing stratum, as shown by the open beds, is from 2 to 10 ft. in thickness, and is overlain by a barren overburden of about 40 ft. At Tronoh, the tin-bearing material has been penetrated by an open pit and an inclined shaft, the overburden here being from 30 to 40 ft. in thickness. This incline is about 400 ft. long, extending 140 ft. vertically without reaching the bottom of the tin deposit; such thickness of ground, however, is exceptional.

The alluvium generally rests either upon granite or limestone, which, however, may be concealed beneath beds of barren alluvium or decayed rock. The surface of the granite is often altered to a soft kaolinized mass. The limestone bedrock frequently shows the effect of leaching, which has opened deep hollows and caves such as are seen at Chongkat Pari and near Tronoh, but it also exhibits an undulating surface following regular lines and resulting in a series of natural riffles behind which the cassiterite has concentrated.

The cassiterite often occurs in good crystals, and varies in color from black or brown to gray and lighter colors. When found in the mountains near its source, the ore is angular and in comparatively large fragments, measuring from an inch to a foot or more in diameter; which become rounded and finer grained progressively with the distance from the source.

On the average the ore assays about 70% Sn, ranging between the limits of 69 and 73%. The average value of the alluvium in the Kinta district is about 1% cassiterite, and ground of this grade when favorably situated yields good profits. Alluvium containing 2% ore is considered exceptionally good, and with 3 to 4% it is considered remarkably rich. The strata have been known to yield from 40 to 60% cassiterite, but only in very rare cases. Associated with the ore are many other minerals of which tourmaline, hornblende, wolframite and magnetite are the most important, while mica, topaz, scheelite and sapphire are found in smaller quantities. Thorium and cerium minerals have been found in certain parts of the Peninsula, and gold in small quantities.

As to the origin of the tin in the alluvium there is little doubt but that it has been derived from the neighboring rocks. It is found in notable quantities as a constituent of the granite and sometimes of the limestone. Efforts have been made to work some of the deposits in the granite, notably at Sorakai in Perak and at the Rin mine in Selangor, but the operations have been only partially successful, as the ore is usually too scattered to be worked at a profit. In the granite it occurs in the form of small pockets or veins, sometimes in a combination of stringers which intersect each other in various directions like a network. Here it is associated with quartz, tourmaline, fluorite, pyrites and other minerals. The occurrence of the ore in limestone is much rarer than in the granite. At the mine operated by the Leh Chin Tin Mining Co., it is found in the limestone along a zone of fracturing sometimes as an impregnation, sometimes as lenses or irregular pockets, and again along the cracks in the rock either longitudinally or transversely with the zone of fracturing. It is associated here with large quantities of iron pyrites and arsenical pyrites, and smaller quantities of chalcopyrite and bornite. At Bruseh in Perak, the ore has been found in seams and films along the bedding planes of a soft, fine-grained sandstone, where it seems to have been deposited by tin-bearing solutions which had leached through the older rocks.

The methods of operating the mines are exceedingly crude, although in some localities, such as Gopeng and Campar where English and French companies are in operation, the work is carried on in a systematic manner. The smaller mines are operated by Chinamen. The laborers are mostly coolies from southern China, and Indians from the east coast of India. Native Malays do not take kindly to labor, and Europeans cannot stand hard work in this climate.

The tin-bearing alluvium is generally worked in open cuts or large pits, but where the overburden of barren ground is very heavy shafts are sunk. The excavations when made by the Chinese are mostly shallow, owing to the difficulty of handling the water which is found in depth. On the average the pits are not more than 40 ft. deep. Some of the more progressive Chinamen have recently introduced pumps to handle the water, and bucket pumps operated by a human tread-mill are commonly seen in this district. The tin alluvium after being mined is carried to the surface in small baskets hung on both ends of a stick suspended on the carrier's back. The material is dumped into a wooden trough supplied with a stream of running water, where, if there is much clay present, it is stirred with shovels and hoes to separate the tin ore. The materials are carried by the water from the troughs into the sluices, where the ore and other heavy minerals sink to the bottom, and the lighter materials are carried away by the stream. The sluices vary from a few feet to several hundred feet in length according to conditions, and are made of wood or are cut in the sandy clay of the region. After operations have been carried on for several hours, the flow of water is stopped, and the material at the bottom of the sluice is further concentrated by panning in flat wooden bowls which resemble in shape the ordinary sheet-iron gold pans. The final processes in the preparation of the ore consists in hand-picking the magnetite and other heavy minerals associated with the tin, which leaves a product varying from 69 to 73% Sn.

Hydraulic monitors for handling alluvium have been introduced at Gopeng by the Gopeng Tin Mining Co.; and at Cacha an English company has erected a stamp mill with concentrating tables to crush and concentrate the masses of ore. At the latter locality, the alluvium has been indurated by infiltration of iron compounds, so that crushing is necessary. The Sorakai Tin Mining Co. has erected roasting, crushing and concentrating machinery at Sorakai to treat the ore mined in the granite at that locality. The roasting of this ore is made necessary by the presence of arsenic.

The tin from the Kinta district was formerly smelted largely at local works, but most of it is now handled by the Straits Trading Co., which has a large smelting plant at Singapore. This company has established numerous agencies for the purchase of ores throughout the Malay Peninsula.

New South Wales.—The output of ingot tin and ore in 1902 was 468 long tons, valued at £53,706, against 667 tons, valued at £77,315 in 1901. In addition the smelting works obtained metal valued at £78,428 from imported ores. The marked decline in output during 1902 was a result of the protracted drought, which greatly curtailed the available water supply. The larger part of the ore is obtained from alluvial deposits. At Tingha there were two companies engaged in dredging operations, and both were successful in proving that a considerable area of rich ground exists in the bed of Cope's Creek and tributaries. Two additional dredges are to be constructed. The mine owned by the Leviathan Tin Lode Mining Co. was inactive during a large part of the year, owing to the lack of water. In the Emmaville field most of the ore was extracted from small workings, the total output being 466 tons. Increased attention was given to the lodes at Silent Grove in the Deepwater district, and a reduction plant has been constructed which will hasten its development. In the Broken Hill district much activity was manifested, and there are prospects that several good mines will be developed.

Queensland.—Despite the unfavorable season for conducting mining operations due to the extreme drought, the production of tin ore showed a very satisfactory increase in 1902, the total being 2,085 long tons, valued at £116,171, as compared with 1,661 tons, valued at £93,723 in 1901. The Herberton district, which comprises an area of 750 sq. miles, produced the bulk of the output, while small quantities were mined in several other districts, including Cookstown, Kangaroo Hills, Palmer and Stanthorpe. In the Herberton district Irvinebank is the principal center of the mining industry, as two of the largest producers—the Vulcan and the Tornado—are situated in its vicinity. The former mine employs 30 men in its workings, which have now reached nearly 800 ft. in depth. Its output in 1902 was 528 tons of black tin; since 1890 the mine has produced ore to the value of £181,000, one-third of this sum being distributed in dividends. The Tornado mine yielded 243 tons of ore in 1902 and gave employment to 25 men. Development work was prosecuted vigorously in the Great Southern mine, 12 miles from Irvinebank, and large ore reserves have been opened up ready for production. At Eureka Creek in the Herberton district the Stannary Hills Mines & Tramway Co. has continued to explore its mines, and has nearly completed the construction of a 20-stamp mill and ore-dressing plant. The Lancelot mine at Newellton is said to be located on a remarkable lode, which has a length of several hundred feet and a thickness of from 2 to 3 ft., and carries as high as 20% black tin. The concentrates from this mine are smelted in Germany. The Amalgamated Coolgarda Tin Mining Co. in the Coolgarda field limited its operations almost entirely to the Alhambra mine, where some important bodies of oxidized ore were encountered. During the year 11,000 tons of ore were crushed for a yield of 272 tons black tin. In the new district known as the Kangaroo Hills, some encouraging developments have been made in lode mining, but crushing operations have been hampered by the lack of water. A company has acquired a large area of stanniferous ground at Collingwood in the Cookstown district, and a large tin dressing plant is to be erected. Water is to be taken from the Finlayson River 7 miles away. The Stanthorpe district contributed 120 tons of tin ore from alluvial ground that could not be worked during seasons of average rainfall. The dredges built to operate in this district were idle during the entire year.

Tasmania.—The output of tin in 1902 was 1,958 long tons of metallic tin valued at £237,828 and 131 tons of ore valued at £5,162. During the fiscal year ending June 30, 1902, there were produced 2,807 long tons of ore valued at £198,127. The Mount Bischoff Tin Mining Co. in the last six months of the fiscal year crushed 50,044 tons of stone for a yield of 636 tons of concentrates. The cost of mining, crushing and dressing was 5s. 7d. per ton. The smelter treated 1,666 tons of concentrates, producing 1,176 tons of metal, of which 1,062 tons yielding 753 tons of tin were smelted on public account. The ingot tin assayed on the average 99·82% Sn. During the year the company earned profits of £62,612 and distributed dividends of £54,000. In the Blue Tier district the Anchor, Australian and Liberator mines were engaged in productive operations. The Anchor mine with its two 50-stamp batteries and complete dressing plant treated 48,174 tons of stone and obtained 167 tons of ore. With full water supply the mill could handle 100,000 tons of stone a year at an expense of about 2s. 6d. per ton; but the average number of stamps dropping in 1902 was only 34. A new water-race to the North George River, a distance of 27·5 miles, has been completed, and a further extension to the South George River will be constructed, which it is believed will afford an ample supply of water. The battery returns for the year showed an average extraction of 0·39%. At the Australian mine the milling facilities have proved inadequate to treat the stone, which averages less than 1% ore, on a profitable commercial scale, and many improvements have been undertaken to remedy this defect. The developments already made in the Blue Tier district show that there are immense quantities of low-grade material, the exploitation of which in the future will depend upon the supply of cheap water power. The Briseis mine on the Ringarooma River, owned by the Venture Corporation, has carried its scheme of water supply to completion, and is now provided with 40 miles of sluices that deliver a maximum of 2,088,000 gal. per hour. Mining operations so far have been restricted to removal of the overburden, which is being carried off at the rate of 10,000 cu. yd. a week. It is intended to continue this work until the tin-bearing drifts can be attacked on a large scale without fear of serious stoppage. A new electric plant is being installed for lighting and other purposes; while the method of elevating the material below sluicing-level by hydraulic pressure is to be adopted on a large scale. The quantity of tin stone secured from the overburden averages about 15 tons per month. At Bradshaw's Creek the Pioneer Tin Mining Co. earned a profit from the year's operations, obtaining 218 tons of stream tin from 227,900 cu. yd. of drift. At Branxholm the Arba Co. has made preparations for working on a more extended scale. In the Gladstone district the Scotia mine was the principal producer, furnishing 36 tons of ore out of a total of 77 tons. Operations at the Mount Rex mine were suspended for a part of the year, as some difficulty was experienced in finding a suitable market for the ore, which contains variable amounts of copper and lead. It is expected, however, that a successful method of treatment will soon be devised. The Heemskirk tin field has attracted much attention, owing to the discovery of a rich ore deposit at Mount Agnew. The productive area has been extended by new discoveries. The properties of North Dundas, including the Renison Bell, Cornwall, Mount Lyell Copper Estates and Penzance, were exploited on a small scale, but capital is needed before entering upon a more extensive plan of operations.

United Kingdom.—The Dolcoath Mine, Ltd., during the second half of 1902 earned a profit of £12,039, as compared with £14,394 for the first half-year. A call of 2s. 6d. per share was made on the partly paid shares, increasing the capital stock paid in by £2,162. Another call of 2s. 6d. per share was made in January, 1903. The cost of production has been reduced to 18s. 8·5d. per ton of stone; the company's profit on each ton being 4s. 7·25d. Although profits were earned during the year, no dividends were paid, the money being used in shaft sinking and other development work. The work has now reached an inclined depth of 2,580 ft., corresponding to a vertical depth of 2,100 ft. The statistics of production for several years are given in the subjoined table:—

Six Months.	Tin Ore Crushed.	Black Tin Sold.				Product per Ton. of Ore.	Average Value per Ton of Ore.			Average Price per Ton of Black Tin.			Amount Realized.		
	Tons.	T.	c.	q.	lb.	Lb.	£	s.	d.	£	s	d.	£	s.	d.
June 30, 1898	38,089	1,140	7	2	22	67·07	1	3	8·94	39	16	4	45,221	15	1
December 31, 1898	40,608	1,162	0	0	0	64·10	1	6	10·09	46	18	0	54,497	6	8
June 30, 1899	41,101	1,037	19	1	23	56·57	1	13	8·21	66	12	7	69,222	12	0
December 31, 1899	41,639	1,040	18	1	10	56·00	1	19	8·39	79	7	11	82,651	16	0
June 30, 1900	45,102	1,043	9	0	0	51·80	1	23	3·57	82	15	4	86,364	18	10
December 31, 1900	48,254	960	19	1	21	49·76	1	15	11·4	80	18	2	77,750	14	4
June 30, 1901	47,608	1.001	18	1	5	47·14	1	10	8·69	73	19	10	73,183	0	11
December 31, 1901	48,975	1,033	13	1	13	47·28	1	8	10·35	68	7	6	70,676	2	9
June 30, 1902	48,155	934	15	2	21	43·48	1	7	10·76	71	17	1	67,168	6	6
December 31, 1902	52,295	898	13	2	19	38·28	1	4	9·0	72	8	4	64,716	7	4

The Wheal Grenville Mining Co., at Camborne, during the year ending April 24, 1903, stamped 35,784 tons of stone which yielded 43·6 lb. ore per ton. The total sales of ore for the year amounted to £56,615, and dividends of 18s. per share were paid.

Western Australia.—The output of tin ore in 1902 was 620 long tons valued at £39,783, as compared with 734 tons, valued at £40,000 in 1901. The Greenbushes field produced 403 long tons, and the Marble Bar district 216 tons. The alluvial deposits in Greenbushes are worked on a small scale, and there can be no extensive development until a larger water supply is secured. The ore carries from 40 to 73% Sn, and is associated with tantalite. A tin-dressing plant has been erected in the district by the Government as an aid to the mining industry.

THE TIN MARKETS IN 1902.

New York.—The average price of tin in New York for 1902 was somewhat higher than for 1901, due to the article being in an exceptionally strong position in the relation of supply and demand. Shipments from the East have been normal, while consumption in Europe and especially in the United States was very large. Heavy inroads seem to have been made on the available supply of Banka tin. Strange to say, as yet no tin has been profitably mined in the United States.

Fair quantities of Bolivian tin are now being shipped, but sold at a discount, owing to inferior quality. Speculation again had full sway on both sides of the Atlantic, and prices showed wide fluctuations. Futures were selling at a discount practically throughout the year, which at times amounted to as much as 1c. per pound, and it was not until the latter part of December that the backwardation disappeared. The year opened rather dull, with spot tin selling at 22·75c., but as January progressed the market developed considerable strength, as high as 24·5c. being paid. Toward the end of the month a reaction set in, only to be followed by another upward movement, which assumed very large proportions. There was an exceedingly brisk demand, business in all lines being very satisfactory indeed, and prices advanced from month to month, culminating in a quotation of 30c. at the beginning of June. The lower cables from abroad and free offerings from the East caused quotations in July to decline, but spot tin remained scarce throughout the summer, all metal being forwarded direct from the steamers to the interior for consumption there. Bear sales in London and rumors regarding a strike at the mills of the American Tin Plate Co., which broke out later, caused a further drop during August, and in September as low as 25·375c. was accepted. Owing to a somewhat better demand prices advanced again during October to 26c., the demand being stimulated by a cut in the price of tin-plates and the settlement of the strike. Toward the end of November the decline in the silver market commenced to play havoc with tin, and continued to exercise a depressing influence for several weeks, consumers becoming afraid of the article and covering only their immediate wants. At one time the market ruled as low as 25c. At this figure, however, the trade evidently thought it safe to take hold of the article again, and large orders were placed for prompt as well as future delivery. The year closed with spot tin selling at 26·75c.; futures at about the same price.

AVERAGE MONTHLY PRICES OF TIN PER POUND IN NEW YORK.

Year.	Jan.	Feb.	Mar.	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1898	13·87	14·08	14·38	14·60	14·52	15·22	15·60	16·23	16·03	17·42	18·20	18·30	15·70
1899	22·48	24·20	23·82	24·98	25·76	25·85	29·63	31·53	32·74	31·99	28·51	25·88	25·12
1900	27·07	30·58	32·90	30·90	29·37	30·50	33·10	31·28	29·42	28·54	28·25	26·94	29·90
1901	26·51	26·68	26·03	25·93	27·12	28·60	27·85	26·78	25·31	26·62	26·67	24·36	26·54
1902	23·54	24·07	26·32	27·77	29·85	29·36	28·38	28·23	26·60	26·07	25·68	25·68	26·79

London.—The close of 1901 was marked by a general feeling of depression and weakness in this market; the gradual falling away from the high prices touched in the middle of the year, the expectation of increased production and the failure of a prominent dealer shortly before the New Year, all tending to cause a lack of confidence in the future of the article. This feeling found evidence in the backwardation in forward tin prevailing at the end of the year, and prices at end of December closed at about £106 for cash and £103 for three months. The visible supply of tin at the end of December amounted to 17,523 tons, showing a decrease for the month of 1,394 tons, but an increase of about 2,000 tons, compared with the end of 1900. In the first week of January prices declined gradually, and at one time touched £101 for spot and £98 15s. for three months. Toward the middle of the month, however, higher prices from the Straits and a good American demand caused values to become firmer, and the market at the end of January was strong at £109 cash and £106 three months. Spot tin was very tightly held throughout the month and at one time touched £111 15s. Very good prices were obtained at the Banka sale in the last half of the month. February started with a firm market for cash and near dates, spot tin being largely in the hands of the bulls, and values advanced until £111 was reached for cash and £106 for three months. Prices then eased off somewhat in consequence of free selling from the Straits. Prices throughout March were very steady indeed, and although an attempt was made by the bears to break prices, values remained during the first three weeks in the neighborhood of £114 for cash and £111 for three months. In the last few days, however, renewed buying from America, and the covering of bear sales by Straits dealers caused a sharp advance, and cash was done at £119, with a backwardation of £1 to £2 for forward. The month of April opened very firm at £118 for cash and £115@£116 for three months, the London stocks showing a decrease of nearly 1,000 tons on the month. The total visible supply stood at about 2,000 tons over end of February figures, but this included about 2,500 tons ex. the Banka sale. With good buying from America, and reports of good consumptive demand from all quarters, prices quickly rose and at the middle of the month touched £131 for spot and £127 10s. for forward. The rapid rise was assisted materially by considerable bull speculation and covering purchases from Chinese sources. Throughout May, June and the first part of July prices generally advanced, reaching £136 in June and selling from there to £132. In the latter half of July, however, there was a decline, £120 10s. being reached, but with a recovery to £127 10s. August was flat and uneventful. At the commencement of September the visible supply was 16,741 tons, and the stock in London 2,670 tons. About this time it was reported that the Dutch Government might not have enough tin to enable it to sell the usual quantities at the auctions during 1903, but notwithstanding this bull argument the market became very flat, declining from £124 for cash to £114, three months metal dropping from £120@£113. The chief cause of this setback was the fact that Americans were practically out of the market. October showed some recovery, chiefly on American buying, and prices recovered to £121 10s., for spot, with £1 less on futures. In November, however, there was a decline, chiefly owing to the lower price of silver, the close being weak at £112 10s. for spot, with a backwardation of 15s. on futures. December commenced with a visible supply of 17,350 tons, the increase being again due to the inclusion of metal sold at the last Banka sale. The market continued to fluctuate considerably, being depressed by the uncertainty of the future course of the silver market, but being helped at times by spasmodic demands from America. Toward the middle of the month there were one or two rallies, caused by purchases on behalf of prominent dealers, who seemed to be getting the control to a certain extent out of the hands of those who have been so closely identified with the metal for some years past. Stimulated by a large demand from America, the market developed considerable strength during the last week of the month, and closed very firm at £120 12s. 6d.@£120 15s. for spot; £121 5s.@£121 7s. 6d. for three months.

TUNGSTEN.

The production of tungsten ore in the United States during 1902 amounted to 250 short tons of concentrated ore, valued at $38,600 (which were derived from 3,730 short tons of crude ore), as compared with 179 short tons of concentrated ore, valued at $27,720, derived from 220 short tons of crude ore in 1901. The tungstic acid content of the ore produced in 1902 ranged from 50 to 65%, and the value of the high quality ore ranged from $100 to $300 per short ton, averaging $150. The production of tungsten metal in the United States during 1902 amounted to 82,000 lb., as compared with 13,000 lb. in 1901; ferrotungsten, 14,000 lb., as compared with 13,000 lb. in 1901, and tungstic acid and tungsten salts, 3,500 lb., as compared with 3,000 lb. in 1901. During 1902 there was no change in the prices for tungsten metal and ferrotungsten, the quotations remaining the same as in 1901, *i.e.,* from 58c. to 64c. per lb. for the former, and from 27c. to 31c. for the latter. The value of tungsten ore containing from 45 to 55% WO_3 is about $2 per unit, while ores containing from 55 to 65% WO_3 command from $2·50 to $4·50 per unit, if free from sulphur and phosphorus. The greater part of the output of tungsten metal and alloy during 1902 was derived from Colorado ores. Until recent years, the bulk of the supply of tungsten ores for consumption in the United States has been obtained from England; Austria-Hungary; Saxony, Germany and Australia. The chief use for tungsten is in the manufacture of tungsten steels and the growing demand for steels possessing the special property of self-hardening, has encouraged the exploration for tungsten minerals in the United States. A deposit of tungsten ore is being developed on the Ima Mining Co.'s property at Patterson Creek, a tributary of the Pahsimaori River, in Lemhi County, Idaho. The tungsten occurs as megabasite (manganese tungstate), and wolframite (iron tungstate), in brown and black crystals in a quartz gangue, the vein varying from 5 to 15 ft. in width, and assaying from 5 to 50% WO_3. Several other deposits are being exploited and much of the present importation of foreign ferrotungsten alloys may soon be replaced by metal and alloys made from domestic ores. This possibility is particularly pertinent, as tungsten minerals in some localities occur with gold and silver ores and tungsten metal may be produced from them cheaply as a by-product.

The chief use of tungsten is in the use of self-hardening tungsten steel, the metal being used either as ferrotungsten or as the powdered metal. Recently it has been added with very satisfactory results to a copper-aluminum alloy in order to impart greater strength and toughness. It is claimed that the self-hardening property of steel, ordinarily obtained by the addition of tungsten to chrome steel, may also be obtained by the addition of molybdenum, and in the latter case but one-half the quantity, as compared with tungsten, is needed to produce the same effect. The alloy known as tungsten-ferrochrome was imported into the United States during 1902 to the value of $7,046, as compared with $9,839 in 1901, Germany supplying the bulk of the import.

ZINC AND CADMIUM.

By Joseph Struthers, D. H. Newland and Henry Fisher.

The production of zinc or spelter in the United States during 1902 was the largest annual output yet recorded, and amounted to 158,237 short tons, as compared with 140,822 short tons in 1901 and 123,231 short tons in 1900. The production by districts is shown in the subjoined table.

PRODUCTION OF ZINC IN THE UNITED STATES.

States.	1897.	1898.	1899.	1900.	1901.	1902.
Illinois and Indiana	38,680	46,693	49,290	37,558	44,896	49,672
Kansas	33,395	38,543	55,872	57,276	74,270	87,321
Missouri	18,412	21,063	15,710	20,138	13,063	10,548
South and East	9,900	7,805	8,803	8,259	8,603	10,696
Total tons of 2,000 lb.	100,387	114,104	129,675	123,231	140,822	158,237
Total tons of 2,240 lb.	89,623	101,879	115,781	110,028	125,734	141,283
Total metric tons	91,071	103,514	117,644	111,794	127,751	143,552

Despite the very large increment in production, which amounted to 17,415 short tons or 12% over the total for the preceding year, the market conditions during 1902 were highly satisfactory. The consumptive demand for spelter in the United States was sufficient to absorb the entire output, and no effort was made to sell a portion of the product in European markets, for the purpose of maintaining a high level of prices, as has been done in previous years. The greatest increase in production was shown by Kansas and Illinois-Indiana, in which States the smelting industry is now largely centered. An important feature of the year was the increased quantity of ore supplied by Colorado, and the plans that have been made for utilizing it on a still larger scale. Some ore was shipped to the Kansas smelters from Utah and from mines in the Slocan district of British Columbia, while Kentucky also contributed important quantities from the mines near Marion. Details of the progress in mining and metallurgy are given by Walter R. Ingalls later in this section under the title "Progress in the Metallurgy of Zinc in the United States during 1902."

Zinc Oxide.—There was a large increase in the production of zinc oxide in 1902, the total being 52,730 short tons valued at $4,023,299 as compared with 46,500 tons valued at $3,720,000 in 1901. Most of the output was made by the New Jersey Zinc Co., operating at Jersey City and Newark, N. J., Bethlehem and Palmerton, Pa., and Mineral Point, Wis. This company has secured the plant of the Renfrew Zinc Co. at West Plains, Mo. The Ozark Zinc Oxide Co. of Joplin, Mo., which began operations in 1901, has enlarged its plant. Among the smaller producers are Page & Kraus, of St. Louis, Mo., and the G. & G. Zinc Oxide Co., of West Plains, Mo. The shipments of zinc oxide in 1902 exceeded the output by nearly 3,000 tons. In addition to the output of zinc oxide, the

United States Smelting Co. (formerly the American Zinc & Lead Co.) at Cañon City, Colo., manufactures a pigment called zinc-lead which is a mixture of oxidized compounds of lead and zinc. The production of this special pigment in 1902 was 4,000 short tons valued at $225,000 as compared with 2,500 tons valued at $150,000 in 1901.

PRODUCTION OF ZINC OXIDE IN THE UNITED STATES.

Year.	Quantity.		Value.		Year.	Quantity.		Value.	
	Short Tons.	Metric Tons.	Totals.	Per Short Ton.		Short Tons.	Metric Tons.	Totals.	Per Short Ton
1897........	26,262	23,825	$1,686,020	$64·20	1900............	47,151	42,775	$3,772,080	$80·00
1898........	32,747	29,708	2,226,796	68·00	1901............	46,500	42,266	3,720,000	80·00
1899........	39,663	35,982	3,331,692	84·00	1902............	52,730	46,929	4,023,299	76·30

IMPORTS OF ZINC AND ZINC OXIDE INTO THE UNITED STATES. (IN POUNDS.)

Year.	Sheets, Blocks, Pigs, and Old.		Manufactures.	Total Value.	Oxide.	
					Dry.	In Oil.
1898................	2,742,357	$109,624	$13,448	$123,072	3,342,235	27,050
1899................	2,965,463	151,956	14,800	166,756	3,012,709	41,699
1900................	2,018,196	97,762	36,836	134,598	2,618,808	38,706
1901................	775,881	30,920	42,648	73,568	3,199,778	128,198
1902 (a).	1,666,121	46,926	40,693	87,619	3,271,385	163,081

(a) In addition to the imports given in the above table there were imported during 1902, 1,247,936 lb. of white sulphide of zinc, valued at $32,879.

EXPORTS OF ZINC AND ZINC OXIDE FROM THE UNITED STATES. (IN POUNDS.)

Year.	Ore and Oxide.		Plates, Sheets, Pigs, and Bars.		Manufactures.	Total Value.
1898............	a 31,418,859	$552,064	20,998,418	$1,083,959	$138,165	$1,724,188
1899............	b 67,126,506	1,092,542	13,509,316	742,521	143,232	1,978,295
1900............	c 95,514,893	1,630,043	44,820,577	2,217,968	99,283	3,947,294
1901............	d 97,434,283	1,560,943	6,780,221	288,906	82,046	1,931,895
1902............	e 119,942,244	1,882,826	6,473,135	300,557	114,197	2,297,580

(a) Includes zinc oxide, 7,849,059 lb. ($252,194). (b) Zinc oxide, 10,685,226 lb. ($366,598). (c) Zinc oxide, 11,891,693 lb. ($496,380). (d) Zinc oxide, 9,122.283 lb. ($393,259.) (e) Zinc ozide, 10,716,364 lb. ($433,722).

Arkansas.—Some exploratory work was done in the northern part of the State, but the year's record on the whole, was disappointing. The deposits so far opened are of limited extent and have scarcely repaid the cost of development.

Colorado.—The ores of this State are rapidly becoming an important factor in the zinc industry. The Leadville district alone produced 85,699 tons of ore in 1902, and deposits were worked at Kokomo, Creede, Rico and elsewhere. The Kansas smelters took an increased quantity of these ores, which are purchased at a liberal discount from the Joplin prices and can be mixed in considerable proportions with the higher quality ores without materially affecting the smelting results. A large portion of the output is consumed by the United States Smelting Co., at Cañon City, Colo., for the manufacture of zinc-lead pigment, and some ore is marked at Mineral Point, Wis., and in Europe. The Colorado Zinc Co. at Denver and the Empire Zinc Co. at Cañon City have installed magnetic separating plants.

Kentucky.—Much activity was shown during 1902 in the zinc mining industry, and the output of zinc ore assumed considerable proportions. The principal developments have been made in Crittenden County where there are deposits of calamine, smithsonite and blende, with fluorspar. The Old Jim mine near Marion which was opened in 1901 shipped several thousand tons of calamine to Mineral Point, Wis., and Joplin, Mo. In the same locality are the Columbia, Tabb and Blue & Nunn mines. The last named mine produces smithsonite from a vein that is from 10 to 30 ft. wide and is included between limestone and an altered dike. At present the deposit is worked by an open-cut some 300 ft. long from which the ore is hoisted to the surface by a gasoline engine. Sphalerite is distributed through the ore in small quantities, and it is probable that it will replace the smithsonite below the water level, which occurs at a depth of about 150 ft. At present the output is 50 tons of crude ore per day. The coarse lumps are hand cobbed and shipped without further treatment, but the fine material is run through a log washer which is to be replaced in the near future by a jig. The ore contains no lead, and the presence of zinc oxide gives it a very high assay.

Missouri and Kansas.—There was a further increase in the production of spelter in 1902, and as for several years past, the natural gas region of Kansas contributed most of the output. Outside of this district the only large smelting works in operation were those of the Edgar Co., at St. Louis, Mo. The principal centers of the industry in Kansas are Iola, Laharpe, Cherryvale and Gas, the first named being of great importance, producing lead, sheet zinc and sulphuric acid as well as spelter. While these smelters draw their ore supplies almost entirely from the Joplin district, an increasing quantity is being purchased each year from the Colorado mines, and during 1902 a few shipments were made from Utah and the Slocan district of British Columbia. It is stated that one smelter has contracted recently for a large supply of ore from mines in British Columbia. A freight rate of $11 per short ton from Slocan to Iola has been secured, which, to be sure, is a heavy tax on the ore, but as the zinc blende is largely a by-product in silver-lead mining, it can bear high freight charges and still yield a satisfactory profit to the miner. The new ore supplies from the West have relieved the smelters to some extent from the danger of concerted action on the part of the miners, such as would be hostile to their interests. Full details of the progress in mining and milling in the Joplin district are given in the separate article by Frank Nicholson later in this section.

PRICES PER SHORT TON OF ZINC ORES AND LEAD ORES IN THE JOPLIN DISTRICT DURING 1901 AND 1902.

Month.	Zinc Ore.				Lead Ore.			
	Highest.		Average.		Highest.		Average.	
	1901.	1902.	1901.	1902.	1901.	1902.	1901.	1902.
Jan	27·00	32·50	23·73	26·75	46·00	42·00	45·61	42·00
Feb........	29·00	33·00	23·96	27·00	46·00	43·50	45·00	43·22
March.....	29·00	37·50	23·70	28·00	46·50	43·50	46·21	43·80
April......	29·50	38·00	24·58	28·85	46·00	43·50	45·52	43·50
May.......	29·00	35·00	24·88	29·23	46·50	44·50	46·38	45·00
June......	28·00	35·00	24·22	34·10	47·50	46·00	47·04	45·60
July.......	28·00	42·00	24·88	34·87	47.50	48·00	46·96	48·00
Aug........	27·50	39·50	23·88	32·50	46·50	49·00	45·80	48·21
Sept.......	27·00	38·50	22·82	33·00	46·50	49·50	46·32	49·00
Oct.........	30·00	40·00	24·63	33·58	46·50	49·50	46·30	49·50
Nov.	30·00	39·00	26·15	32·10	46·50	50·00	46·20	49·90
Dec.........	34·00	36·00	28·24	29·25	46·50	50·00	44·70	50·00
Year....	34·00	42·00	24·57	30·73	47·50	50·00	46·01	46·35

New Jersey.—The mines of the New Jersey Zinc Co., at Franklin Furnace, produced 209,386 tons of ore during 1902, an increase of 18,165 tons over the output in 1901. The Trotter mine and the Stirling Hill mines were inactive. At the Parker mine the work has consisted in extending the several levels in a southerly direction, while the open cut in the Taylor mine has been carried from the fold down nearly to the tunnel level. The two mines are now in communication, so that ventilation can be maintained throughout all the workings.

Virginia.—There were no new developments of importance during 1902, and operations were limited, as heretofore, to the mines of the Bertha Mining Co., in Pulaski and Wythe counties, and the mine of the Wythe Lead & Zinc Co., at Austinville. The capital stock of the latter company has been purchased by the Bertha Mining Co., which will probably develop its properties on a large scale. The mill at the Clark mines, in Pulaski County, was run steadily, producing a very satisfactory grade of ore. At the Bertha mines the work of stripping the limonite ore was continued. There is an accumulation of from 30,000 to 40,000 tons of tailings from the old zinc mill containing about 18% Zn which it is thought can be utilized.

PRODUCTION OF ZINC IN THE WORLD. (IN METRIC TONS.)

Year.	Austria. (*a*)	Belgium. (*b*) (*f*)	France (*b*)	Germany (*b*) (*f*)	Italy. (*b*)	Russia. (*b*)	Spain. (*b*)	United Kingdom. (*c*)		United States. (*e*)	Totals.
								Native Ores.	Foreign Ores.		
1898	7,302	119,671	37,155	154,867	250	5,664	6,031	8,711	19,676	108,514	462,237
1899	7,192	122,843	39,274	153,155	251	6,331	6,184	8,837	23,385	117,644	485,246
1900	6,742	119,317	36,305	155,799	547	5,963	5.611	9,214	21,093	111,794	472,389
1901	7,558	127,170	37,600	166,283	511	(*d*)	5,354	8,555	21,322	127,751	502,104
1902	7,960	(*d*)	(*d*)	174,927	500	(*d*)	(*d*)	40,244		602	....

(*a*) The statistics for Austria are taken from the official reports of the Mines Department, except for 1902, for which the figure reported by Henry R. Merton & Co. has been used.

(*b*) Official statistics, except for 1902.

(*c*) The statistics for the United Kingdom are arrived at by deducting the zinc produced from domestic ores, as reported in the official Blue Books, from the total output of the smelting works as stated in the reports of Messrs. Henry R. Merton & Co.

(*d*) Statistics not yet available.

(*e*) Statistics compiled from direct returns by the producers to THE MINERAL INDUSTRY.

(*f*) According to Henry R. Merton & Co., Belgium, Holland and the Rhine district of Germany in 1902 produced 203,342 metric tons of spelter, against 202,474 metric tons in 1901, 189.301 in 1900 and 192,994 in 1899.

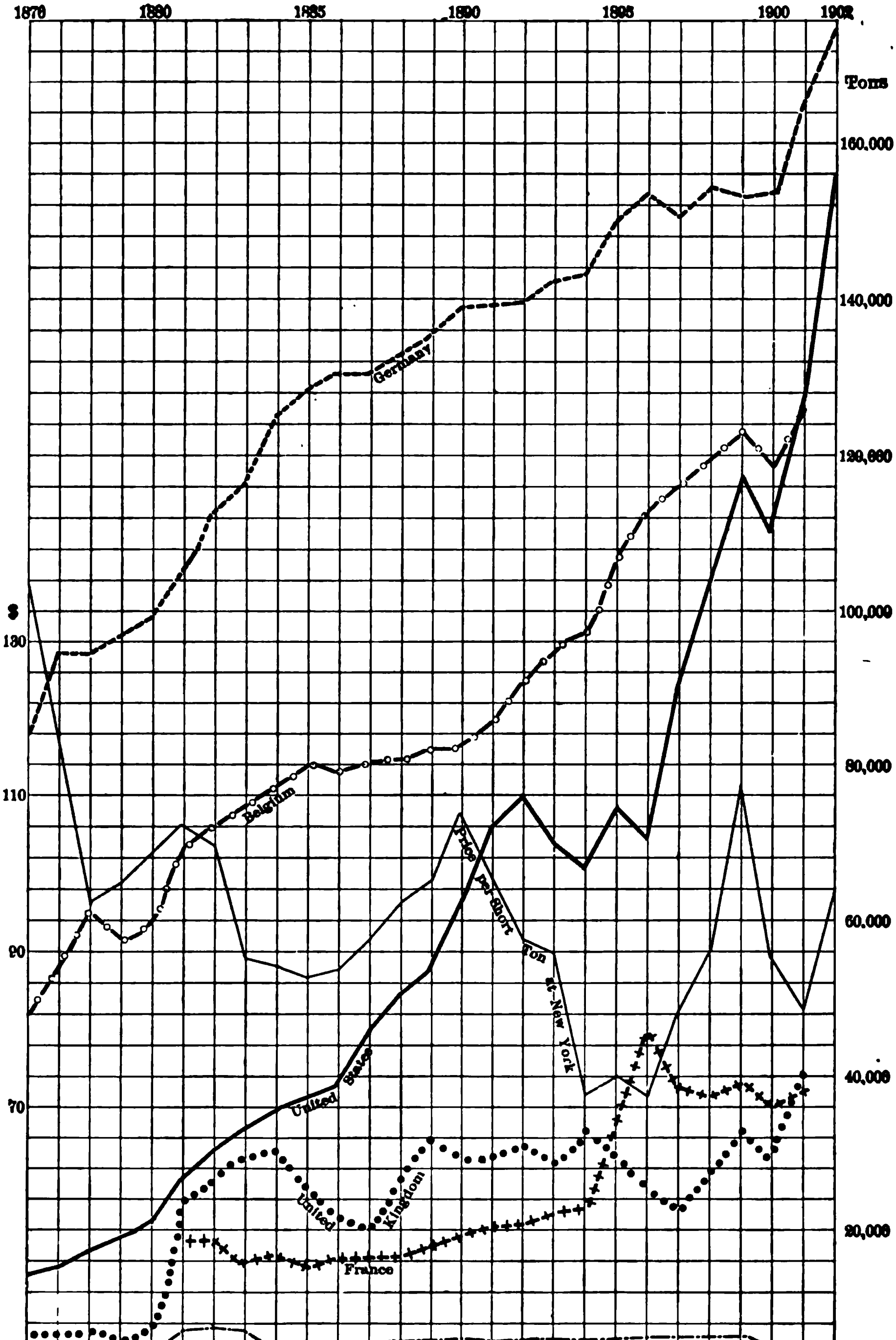
PRODUCTION OF ZINC ORE IN EUROPE AND AFRICA. (IN METRIC TONS.)

Year.	Algeria	Austria	Belgium.	France.	Germany.	Greece. (*a*)	Italy.	Norway.	Russia.	Spain.	Sweden	Tunis	United Kingdom
1897	32,269	27,463	10,954	83,044	663,850	30,906	122,214	908	54,524	73,848	56,636	11,830	19,587
1898	29,800	27,395	11,475	85.550	641,706	32,045	132,099	320	(*b*)	99,836	61,627	21,477	23,929
1899	42,970	37,100	(*b*)	84,813	664,536	22,907	150,629	379	(*b*)	119,710	65,159	20,079	23,505
1900	30,281	38,243	144,033	67,059	639,215	18,751	139,679	204	(*b*)	86,158	61,044	16,596	25,070
1901	26,913	36,072	(*a*)6,645	61,539	647,496	18,218	135,784	90	(*b*)	119,708	48,630	17,879	23,967

(*a*) Including blende and calcined calamine. (*b*) Not reported.

PRODUCTION OF ZINC AND CADMIUM IN FOREIGN COUNTRIES.

Algeria.—The output of zinc ore in 1901 amounted to 26,913 metric tons, valued at 1,312,660 fr., as compared with 30,281 metric tons, valued at 1,537,970 fr. in 1900. This production was obtained from the provinces of Constantine, Algiers and Oran. The entire production was exported, being shipped to Bel-



THE WORLD'S PRODUCTION OF ZINC. (IN METRIC TONS.)

gium, France and Tunis. In the mines of Guerrouma, Sakamody, R'arbau and Nador-Chaïr, the ore occurs as zinc blende in stratified marls, loam and calcareous formations. In the Constantine district the ore occurs as calamine in chalky gangue rock, the principal mines here being the Hammam, Sakiet Sidi Yaussef, Compagnie Royale Asturienne, Compagnie Minière Tunissienne, Ban Kadis, Ban Jaber and D'jebel D'jedda. These mines together produce annually about 25,000 metric tons of zinc ore. In the Oran Department there are but two zinc mines, the Mazès and D'jebel Massen.

Australia.—The exports of zinc spelter and zinc concentrates from New South Wales in 1902 were 1,261 long tons, valued at £10,625, as compared with 632 long tons, valued at £4,057 in 1901. In the Broken Hill district the quantity of zinc in the lead and zinc concentrates was estimated at 29,432 long tons in 1902, but no value is placed upon the zinc content of the ore. Experiments are now being carried on with new methods for profitably treating zinc ores. The Sulphide Corporation, Ltd., has produced at its zinc distillation works at Cockle Creek a quantity of spelter from slimes.

Austria.—Zinc ore is mined in the provinces of Bohemia, Styria, Carinthia, Tyrol and Galicia. In Bohemia, the Mies, Mirklin and Wrbitz mines are operated by the Erste Böhmische Zinkhütten und Bergbau Gesellschaft; in Styria, mines at Deutsch Feistritz, Guggenbach, Rabenstein and Uebelbach are operated by the Märkisch-Westfälischer Bergwerk Verein; in Carinthia, at Raibl and Wolfsberg, and the mine of Bleiberg-Kreut, Windisch-Bleiberg Eisenkappel, Feistritz, and Meiss Schwarzenbach by the Bleiberger Bergwerke Union Actien Gesellschaft; and in the Tyrol, at Klausen, Schneeberg, Silberleiten, Nagelseekahr, Innst and Roncegno. The plants for smelting the zinc ore are at Cilli, Neidzieliska, Kiesz, Trzebinia and near Szczakowa. Practically all of the zinc ore exported is shipped to Germany, and nearly all the zinc ore imported is obtained from the same country.

Belgium.—The output of spelter from Belgium, Rhineland and Holland in 1902 was 200,140 long tons, as compared with 199,285 long tons in 1901. There are 12 zinc smelters, three of them owned by the Société Anonyme des Mines et Fonderies de Zinc de la Vieille-Montagne, which operates the Valentin-Cocq works at Hollogne aux Pierres, the Flone works at Hermalles-Huy and the Angleur works at Angleur, in Belgium, and at Bray-Ecos, Viviez, Dangu and Penchot, in France. This company owns mines in the departments of Gard, Herault and Lozère, in France, in the provinces of Santander, Almeria, Granada and Murcia, in Spain, and at Hammam and Ouarensis, in Algeria. Its output during 1902 amounted to 70,872 tons of spelter, 62,945 tons of sheet zinc, 8,642 tons of zinc oxide and 48,840 tons of sulphuric acid. The acid was manufactured at its plant at Baelen-Wezel. The gross receipts were 5,736,018 fr., general expenditures 1,210,686 fr., reserved for sinking fund, 815,067 fr., administration expenses 507,535 fr., interest 450,000 fr., dividends 2,700,000 fr., and the directors were paid 101,883 fr., leaving a balance on hand at the end of the year of 67,507 fr.

France.—In 1901 the production of zinc ore was 61,500 metric tons, which was obtained chiefly from the Malines mine in the Department of Gard, and the

Bormettes mines in the Department of Var. The output of the former consisted of 10,000 metric tons of calcined calamine, 5,000 tons of leady zinc blende (calcined), and 1,300 tons of galena and silver-lead ore, the total valued at 1,410,000 fr. The Bormettes mines produced 9,800 metric tons of zinc blende, valued at 795,000 fr. In addition to these mines, there were smaller producers at Pierrefitte in Hautes-Pyrénées, at Villefranche in Aveyron, at Sentien and Saint-Lary in Ariège, and at Menglon in Drôme. The imports of zinc ore in 1902 amounted to 36,564 metric tons, valued at 17,555,000 fr., as compared with 29,812 metric tons, valued at 14,250,000 fr. in 1901. The exports of zinc ore in 1902 were 43,075 metric tons; of spelter, 16,145 metric tons, the corresponding figures for 1901 being 54,665 tons of zinc ore and 12,712 tons of spelter.

Germany.—The production in Germany in 1902 was 702,504 metric tons ($7,452,750) of zinc ore, and 174,927 metric tons ($15,451,000) of spelter, as compared with 647,496 metric tons ($5,375,500) of zinc ore, and 166,283 metric tons ($13,696,750) of spelter in 1901. The exports of ore in 1902 amounted to 46,965 metric tons, valued at $657,500, and the imports to 61,407 metric tons, valued at $1,316,250. The ore was chiefly exported to Belgium and Austria-Hungary, and chiefly imported from the United States and Austria-Hungary. The exports of spelter in 1902 were 70,292 metric tons ($6,539,250); of zinc white, zinc ashes, and lithophone, 28,400 metric tons ($2,424,000); of sheet zinc, 17,015 metric tons ($1,776,000); of fine manufactured zinc wares, 1,616 metric tons ($1,394,000); the imports during the same period being 25,946 metric tons ($2,373,250) of spelter; 3,986 metric tons ($367,500) of zinc white, zinc ashes, and lithophone, 134 metric tons ($14,000) of sheet zinc, and 105 metric tons ($69,000) of fine manufactured zinc wares. In the Bonn district, during 1902 there were produced 107,209 metric tons of zinc ore valued at $2,112,775. According to the report of the Oberschlesischen Berg- und Huettenmaennishchen Verein, the output of 23 mines in Silesia in 1902 was 357,933 metric tons of zinc blende, valued at 15,995,962 marks, and 212,824 metric tons of calamine, valued at 2,440,979 marks. The largest producers of zinc ore were the Bleischarley and Samuelsglück mines at Birkenhain, the Brzozowitz mines at Brzozowitz, and the Neue Helene mines at Scharley. There were 23 smelters in operation in 1902 producing 116,979 metric tons of spelter, valued at 40,575,347 marks, and three of these also produced 12,825 kg. of cadmium, valued at 61,500 marks; seven works produced 41,188 metric tons of sheet zinc, valued at 17,719,181 marks, and one works produced 202 metric tons of zinc white valued at 429,352 marks, and 43 metric tons of zinc gray, valued at 24,708 marks.

Italy.—The output of zinc ore is derived from 110 mines in the Iglesias and the Milan districts. In the former zinc ore is mined at Cagliari, Sassari and Iglesias, and in the latter, at Bergamo, Brescia and Lecco. The Società delle Miniere di Malfidano produced in 1902 at its zinc mines at Iglesias 35,910 metric tons of zinc-lead ore, assaying from 45 to 50% Zn, and from 60 to 65% Pb. This ore was smelted at the company's plant at Noyelles-Gōdault. The Monteponi mines, operated by the Società delle di Monteponi Fonderia di Zinco, produced 12,085 metric tons of zinc ore assaying 46% Zn. In 1902, the exports were 114,894 metric tons of zinc ore ($2,527,668) 328 metric tons ($31,096) of spelter, 122 metric tons ($14,676) of zinc oxide, and 66 metric tons ($10,586) of manufactured zinc. The imports during the same period amounted to 131 metric tons ($2,882) of zinc ore, 3,805 metric tons ($350,097) of spelter, 904 metric tons ($108,468) of zinc oxide, and 4,167 metric tons ($496,925) of manufactured zinc.

Spain.—The exports of zinc ore in 1902 amounted to 95,705 metric tons as compared with 75,755 metric tons in 1901. The district of Aguilas exported 366 tons; Almeria, 800 tons (£800) of calamine and 1,814 tons (£6,350) calcined ore, all to Antwerp; Carthagena, 63,830 tons of zinc blende and 1,840 tons of calamine, mostly to Belgium, Mazarron 302 tons and Motril 233 tons (£622).

Sweden.—In 1902 there were 43,854 tons of zinc ore exported from Sweden, as compared with 41,251 tons in 1901. It is reported that zinc is being produced by an electric process from zinc-lead sulphide ores at the Onan plant of the Trollhattans Elektriska Aktiebolag, at Trollhattan. The new company, which is operating the process of Dr. De Laval, is capitalized at $26,800, and is obtaining zinc ore from the deposit at Saxberget, near Ludvika. A plant using Dr. De Laval's process has also been started at Hoslund, Norway.

United Kingdom.—In 1902 the output of zinc ore was 25,060 long tons, as compared with 23,752 long tons in 1901. Of the total in 1902, the Newcastle district produced 12,806 long tons and the Liverpool and North Wales district 7,566 long tons. The exports in 1902 were: 16,454 long tons (£54,216) of zinc ore, 6,650 long tons (£99,495) of spelter and 1,324 long tons (£37,563) of manufactured zinc; the imports during the same period being 44,598 long tons (£205,647) of zinc ore, 88,276 long tons (£1,528,962) of spelter, and 21,374 long tons (£489,554) of manufactured zinc. The English Crown Spelter Co., Ltd., produced 6,165 long tons, and Dillwyn & Co., 6,520 long tons of spelter during 1902.

THE SPELTER MARKETS IN 1902.

New York.—The year under review was fairly prosperous for the zinc industry of the United States, home consumers absorbing practically all the metal that was produced, in spite of a heavy production, and it was not until the very end of the year that stocks began to accumulate. Under these circumstances it was not necessary to export spelter in order to keep up domestic prices, as has been the case in former years. The higher prices of fuel and labor tended somewhat to raise the cost of production. Galvanizers, brass mills and sheet zinc manufacturers were very busy, and an increased quantity of spelter was again used for electrical purposes. The paint and oxide business also was satisfactory. One or two new smelting works were erected in the Iola Gas Belt, some of the older ones enlarged, and several smaller ones consolidated, thus creating a number of strong concerns. The result was an introduction of new business methods, which in the course of time will no doubt have beneficial results.

Larger quantities of ore are being shipped every year from Colorado and British Columbia—a plant having been built in Colorado to treat ores from the former locality—and it is evident to the intelligent observer that the newly found prosperity will come to an early end if new outlets cannot be found for an increased production. This fact has been recognized by the smelters, who have given the matter much thought. It will for the present probably result in a larger output of sheet zinc, the use of which in this country is not nearly as large as it is in Europe.

The year opened with the market rather dull and somewhat irregular. The ruling quotations were 4·125@4·175c., St. Louis; 4·275@4·325c., New York. As January progressed several of the producers became free sellers, and values declined to 3·90c., St. Louis; 4·05c., New York.

Toward the middle of February, higher prices for ore and a continued good demand on the part of consumers, both for galvanizing and brass purposes, combined to stop the downward tendency, and for a while considerable activity resulted, prices advancing to 4·10c., St. Louis; 4·25c., New York. The market ruled steady throughout April and May, when a further advance set in, in consequence of threatening labor troubles. A strike broke out at the beginning of June, and several of the smelters had to close down, which, naturally, caused quite a flurry in the market, values rising rapidly to 4·75c., St. Louis; 4·875@5c., New York. During the month of July the market was very active, and as it became evident that the supply of ores was rather short and the consumption of spelter very heavy, manufacturers were unable to supply themselves fully, and 5·125c., St. Louis; 5·25c., New York, was freely paid. August witnessed a further advance, spot metal being especially scarce. The quotations were 5·25c., St. Louis; 5·375@5·5c., New York. It was not until the latter part of October that prices showed a tendency to ease off, and they would no doubt have declined very sharply had it not been for a fire which destroyed four blocks of one of the largest works in Kansas. As it was, the falling off in the consumption, which usually makes its appearance toward the end of the year, did not make itself felt until the second half of November. Inasmuch as production continued at a very heavy rate, stocks began to accumulate and prices declined sharply, closing considerably lower, 4·375@4·40c., St. Louis; New York, 4·55 to 4·575c.

AVERAGE MONTHLY PRICE OF SPELTER PER POUND IN NEW YORK.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts
1898	3·96	4·04	4·25	4·26	4·27	4·77	4·66	4·58	4·67	4·98	5·29	5·10	4·57
1899	5·84	6·28	6·81	6·67	6·88	5·98	5·82	5·65	5·50	5·32	4·64	4·66	5·75
1900	4·65	4·64	4·60	4·71	4·53	4·29	4·28	4·17	4·11	4·15	4·29	4·25	4·39
1901	4·13	4·01	3·91	3·98	4·04	3·99	3·95	3·99	4·08	4·28	4·29	4·31	4·07
1902	4·27	4·15	4·28	4·37	4·47	4·96	5·27	5·44	5·49	5·38	5·18	4·78	4·84

London.—The month of January opened with a rather better demand at about £16 10s. for ordinaries, and £16 15s. for special brands, but renewed negotiations between the principal producers on the Continent caused a more hopeful feeling, and prices improved to about £17 7s. 6d. for ordinaries. The demand at this time for sheet zinc and yellow metal was good, and this resulted in more liberal buying by consumers. February commenced with a renewal of the strong tone, and under active trading prices quickly improved to £17 5s. for ordinaries. Producers of sheet zinc raised their prices by £1 per ton on account of the big demand. March started with a firm tone, engendered by renewed inquiry from galvanizers, who were exceedingly busy, but toward the middle of the month, owing to sales of speculative parcels and second-hand metal, prices took a turn downward, and as low as £17 7s. 6d. was accepted, eventually rallying to £17 17s. 6d., which was about the opening price for April. A further active demand was experienced from makers of galvanized iron, and as large orders were placed for spelter, values rose steadily to about £18 2s. 6d., the month closing strong at the highest level. Makers on the Continent having sold freely and finding a scarcity of ores were inclined to hold for full prices. May witnessed a large demand from all consumers, including brass and yellow metal makers, and producers being sold out for some time ahead allowed dealers to command high prices, up to £18 10s. being paid for Virgin brands. Just at the end of the month a few speculative sales were made, which reduced values to £18 5s. for ordinaries and £18 7s. 6d. for specials. June saw the conclusion of peace in South Africa, which event was attended with large buying orders for galvanized iron, causing a rally in spelter values to £18 5s., and at this level the market remained until about the middle of July, when there was a spurt to £19 5s., based on the expectation of small supplies. Values remained steady until the first and second weeks of August, when there was a decline to £18 12s. 6d., owing to pressure of sales by dealers, but when the liquidation had ceased the continued good demand quickly caused values again to run up until by the commencement of September, £19 7s. 6d. was paid. A large trade was done round about this level, but when consumers had bought freely there was a setback, owing to Continental bear selling, and as low as £18 15s. was accepted. October saw an irregular market, but with a tendency toward a higher level, the highest point touched being £19 10s., but closing somewhat lower. A good business was done with Continental consumers, and galvanizers on this side also purchased with considerable freedom. November commenced quietly with £19 5s. to £19 7s. 6d., ruling as the nearest figures, but owing to a scarcity of near metal and an increasing demand, the price rose to £19 15s., only to fall later to £19 7s. 6d. In consequence of severe weather on the Continent, which delayed metal in transit, there was a recovery to £19 17s. 6d., which was practically the opening price for December, and was maintained throughout the month.

Breslau.—The price in marks for 50 kg. of zinc at Breslau for the 12 months of 1902 were as follows: January, 16·25@16·75; February, 16·75@17·75; March, 17·50@17·10; April, 17·50@17·80; May, 18@18·50; June, 18·25@18·75@18·50; July, 18·50@19·50; August, 19@19·25; September, 18·85@19·25; October, 19@19·50; November, 19·25@19·60; December, 19·50@19·10. The quarterly average prices of spelter, during 1902, as reported by the Royal Mining Office at Breslau, were as follows, the quotations being in marks (23·8c.) per 50 kg.:—

	1896.	1897.	1898.	1899.	1900.	1901.	1902.
First quarter..........	13·50	16·00	16·50	25·00	20·00	16·00	16·00
Second quarter........	15·50	15·50	17·50	26·00	20·00	15·50	17·00
Third quarter..........	15·50	15·50	19·00	22·50	18·00	15·00	17·50
Fourth quarter........	11·10	16·50	22·00	19·50	17·50	15·00	18·00
Average............	15·12	15·87	18·75	23·25	18·87	15·88	17·13

A REVIEW OF PROGRESS IN THE METALLURGY OF ZINC IN 1902.

BY WALTER RENTON INGALLS.

THE prices for ore and metal which prevailed during a large part of 1902 enabled American smelters to realize satisfactory returns. They utilized to the full extent their already large capacity and still further increased their means. Early in the spring the new works of A. B. Cockerill and the Standard Acid Co., each three-block plants in the Iola district, were put in operation. The works of the latter were soon afterward purchased by the interests that had been operating the Southwestern Chemical Works at Argentine, Kan., and the two were consolidated under the name of the United Zinc & Chemical Co. This company makes sulphuric acid from the gases given off in blende roasting, and is the first concern west of the Mississippi to undertake that process. In May the New Jersey Zinc Co. purchased the plants of A. B. Cockerill and the Prime Western Spelter Co. at Gas, near Iola, and later bought the works of George E. Nicholson at Nevada, Mo., and Iola, Kan. The works at Nevada, which uses coal as fuel, have been closed, and the three in the gas field are operated under the name of the New Prime Western Spelter Co. A new plant of three blocks, erected by the Lanyon Brothers Spelter Co., at Neodesha, Kan., was put in partial operation during July, and was completed about the end of November. Construction was begun on the works of the United States Zinc Co., affiliated with the American Smelting & Refining Co., at Pueblo, Colo., and it is expected that this will be in operation in 1903. There is now but little Western spelter produced outside of the natural gas districts of Kansas, and the large plants at Lasalle-Peru, Ill. The recent prices for ore and spelter afforded such a margin, however, that some of the old direct-coal-fired furnaces could be run profitably, and during the second half of 1902, the plant at Collinsville, Ill., was put again into commission, while the Edgar Works at St. Louis, Mo., continued in steady operation. A plant at Sandoval, Ill., was operated by the Sandoval Zinc Co. The rolling mill of the Lanyon Zinc Co., at Laharpe, Kan. (near Iola), was put in operation during 1902, and the Cherokee-Lanyon Spelter Co. erected and blew in a small lead blast furnace to smelt the lead and silver-bearing residues remaining after the distillation of Colorado zinc ore in Sadtler retorts, which are now used by that company to the exclusion of all others, refractory ore alone being distilled.

THEORETICAL.—The principles governing the reduction of zinc oxide by carbon have been discussed from the standpoint of modern physical chemistry by G. Bodlaender, in a masterly paper,[1] which is too long and complex for satisfactory abstract.

PHYSICAL PROPERTIES.—Ernest A. Lewis[2] has examined the microstructure of zinc, pure and contaminated with 0·5% of an impurity, added intentionally. Pure zinc consists of large primary crystalline grains, and inside the primary crystals, on deeper etching, are seen secondary crystals. The fractured surface shows brilliant, large, bluish-white crystals. Zinc containing 0·5% Pb consists

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[1] *Zeitschrift fuer Elektrochemie*, VIII., xliv., 888 to 948, Oct. 30, 1902.

[2] *Chemical News*, LXXXVI., 211, Oct 31, 1902; *Engineering and Mining Journal*, Dec. 20, 1902.

of both primary and secondary crystals. The primary crystals are similar to those of pure zinc, but the secondary crystals are surrounded by what is probably a solid solution of lead in zinc. The fractured surface is similar to that of pure zinc. Zinc containing 0·5% Cd consists of small crystals of a cadmium-zinc alloy surrounded by zinc. The fractured surface is very finely crystalline. In zinc containing 0·5% Fe, the latter separates out in the crystalline form; it does not appear to form a true alloy with zinc. It probably is dissolved by molten zinc, and on cooling it is thrown out again as crystals of iron. The fractured surface is fibrous.

BLENDE ROASTING.—E. Prost and E. Lecocq[3] investigated the roasting of zinc blende containing fluorspar and found that a portion of the fluorine of the latter is set free in the state of hydrofluoric acid which is very harmful to the lead chambers when the furnace gases are employed for the manufacture of sulphuric acid. This is important to know, inasmuch as zinc ores frequently contain fluorspar.

The increasing importance to the zinc smelter of ores containing lead and silver, which may be partially recovered as by-products from the residuum remaining after distillation of the zinc, attracts attention to the behavior of those metals in the zinc smelting process. It is well known that in roasting galena there is a large loss of lead by volatilization which is the larger the higher the temperature in the furnace. In roasting galena the lead sulphide goes largely into the form of sulphate which can be completely decomposed only by means of silica, but this involves a high temperature and the loss of lead is so large that the practice of slag roasting has now been generally abandoned, at least in the United States. The temperature required for the desulphurization of zinc blende is also high and when the ore contains lead, as is the case with most of the ore now treated by European smelters, the loss of that metal by volatilization is important. What such loss may amount to has recently been investigated by K. Sander,[4] who reported the following results:—

Sample.	I.	II.	III.	IV.	V.
	%	%	%	%	%
Loss in weight	9·90	8·60	9·65	9·70	9·80
Lead assay, raw ore	9·84	11·88	6·60	7·78	6·00
Lead assay, roasted ore	9·88	11·47	6·10	6·98	5·20
Lead volatilized, per cent	9·53	7·88	16·44	19·05	21·80

The determinations of lead were made gravimetrically.

The lead in zinc blende exists almost always as sulphide, which is changed to oxide and sulphate in the roasting. The latter compounds react with the still undecomposed sulphide, forming sulphur dioxide and metallic lead, which volatilizes. Lead sulphide and oxide are also directly volatile, though at a higher temperature than the metal.

The volatilized lead compounds are partially recovered in the dust chambers of the furnace (probably to a very small extent, in view of the great difficulty of condensing and settling lead fume), partially by the acid dripping

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[3] *Bulletin de l'Association Belge des Chimistes*, XVI., ii., 99 to 104.

[4] *Berg- und Huettenmaennische Zeitung*, LXI., xlv., 561, Nov. 7, 1902; *Engineering and Mining Journal*, Dec. 6, 1902.

down in the Glover tower, and partially as slime in the acid chambers. Sander considers that the presence of silver in the chamber slime indicates that it must come to some extent from the furnaces, through the Glover tower, and not wholly from the chamber lead, which is usually almost free from silver.

Sander[5] also investigated the loss of silver in roasting, and found that in the case of ores containing from 230 to 413 g. per 1,000 kg., the volatilization amounted to from 10 to 12%, the results being nearly the same in the roasting of five different ores, which was done in Maletra and Eichhorn-Liebig furnaces.

These determinations with respect to both lead and silver are quite in accord with the results of other practice.

ROASTING FURNACES.—The new plants built in Kansas in 1902 were provided with hand-roasting furnaces, except that of the United Zinc & Chemical Co., which was installed with a large Hegeler furnace (muffle) for the purpose of making sulphuric acid. Otherwise the adoption of mechanical furnaces was restrained by the litigation affecting the two which have been most successful in blende roasting. A final decision of the courts was rendered in favor of the Brown furnace, against the Ropp furnace which had been in use by the Lanyon Zinc Co., but in the meanwhile that company had altered its furnaces according to the design of Mr. Cappeau, referred to later in this review, and although the owners of the Brown patents applied for an injunction against its use, as being also an infringement, the application was denied. At Neodesha a Davis furnace has been built, which is something quite new; results have not yet been reported.

The Davis furnace is a long reverberatory, heated by lateral fireplaces. On each side of the hearth there are pockets in which spur wheels are set on short horizontal shafts, the latter being parallel with transverse lines through the furnace. Outside of the furnace, a bevel gear on the end of the short shafts meshes with a pinion on a main driving shaft, which is parallel with the longitudinal axis of the furnace. The rabble consists of a rake with adjustable teeth, which is fixed between long side bars at each end. These side bars have on their lower sides long racks, which engage with the spur wheels above referred to. Consequently, when the spur wheels are turned by means of the driving shaft, outside of the furnace, the rabble is caused to travel forward. At the end of the forward movement, the direction of revolution of the driving shaft is automatically reversed and the rabble is thereby caused to move backward, the rake blades being then turned to a horizontal position. The rabble remains always in the furnace. It consists of the two side bars, which are open at the top, like troughs, and three hollow transverse bars, the middle one bearing the rakes. The side bars and the transverse bars are kept full of water, the loss by evaporation being automatically replaced after every trip through the fire. The rakes are set so as to insure a thorough stirring of the ore and the rabble is so designed as to prevent any pinching of the racks with the spur wheels upon which they travel. The furnace erected at Neodesha, Kan., has hearth dimensions of 150×12 ft., giving an area of 1,800 sq. ft.

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[5] *Zeitschrift fuer angewandte Chemie*, 1902, XV., xv., 335.

Joseph P. Cappeau, of Joplin, Mo., patented[6] a roasting furnace of the Ropp type in which the roasting hearth is supported on transverse beams, so that the space beneath is clear. The stirring carriage passes beneath the hearth, the rake arm protruding upward through a slot in the usual manner. Tripping gates are arranged in the slot to keep the latter closed and regulate the admission of the air.

William A. Lorenz, of Hartford, Conn., also patented[7] a roasting furnace of the Ropp type, but the hearth is covered by twin arches, with a slot between them, the arches being supported by transverse overhead beams, so that the stirring carriage passes over the roof of the furnace instead of under the hearth as in the case of the Ropp and Cappeau furnaces.

RETORTS.—Increasing attention is given to the manufacture of the retorts, the aim being to improve the quality, which is important inasmuch as they are the key to success in the distillation process. The proper ageing, or rotting, of the clay increases greatly its plasticity and diminishes the tendency to crack in drying and firing. Just why this should result is not clear. E. C. Stover, in a recent paper[8] attributes it to a readjustment of the affinities in the batch, brought about by bacterial action. He has detected a bacillus in clay mixtures which produces hydrogen sulphide and develops well at from 37° to 38°C. If a fresh mixture be allowed to stand in the slip state, the fermentation will be complete in from six to twelve weeks, according to temperature, etc., but if inoculated with organisms, the change is complete in from two to four weeks under the same conditions. The properties of the St. Louis fire clay, which is used exclusively by the Western zinc smelters, have been investigated exhaustively by Dr. Otto Mühlhaeuser,[9] who finds that although the clay is of satisfactory refractoriness, corresponding to Seger cones 30 to 31, it is of a character which leads to rather porous retorts.

DISTILLATION.—Considerable attention, especially in England, has been directed to the Picard & Sulman method of zinc smelting, which has been applied on a commercial scale at Cockle Creek, N. S. W., whence consignments of spelter have already been received in England. Before the erection of the works in Australia, the process was given a trial at the Emu works, in Wales, where upward of 4,000 tons of ore were treated during 1901. Its details were communicated by the inventors, Messrs. H. Kirkpatrick Picard and H. Livingstone Sulman, in a paper entitled "A Dry Process for the Treatment of Complex Sulphide Ores," read before the Institution of Mining and Metallurgy, June 19, 1902, of which paper the following is an abstract:

"The roasted ore is mixed with about 20% of its weight of crushed coking coal, and the mixture is briquetted in any suitable type of machine, pitch or other carbonaceous material being employed as binding agent. The briquettes are then distilled in the ordinary manner and in the normal time. They coke into coherent masses and thereby form a skeleton which holds up the particles of reduced lead and the corrosive matte and slag, and thus protect the walls

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[6] United States Patent No. 691,112, Jan. 14, 1902.

[7] United States Patent No. 691,787, Jan. 28, 1902.

[8] *Transactions of the American Ceramic Society*, 1902, IV., 183 to 188.

[9] *Zeitschrift fuer angewandte Chemie*, XVI., 148, 222, 278.

of the retort. The distillation furnaces at the Emu Works were of the direct fired, Welsh-Belgian type, with 144 retorts arranged in six rows, the lowest being cannon pots. The ore treated assayed 25% Zn and 24% Pb; it was mixed with 20% of crushed coking coal and 5% of pitch. The residues assayed from 5 to 8% Zn. The recovery of zinc was about 70%. The consumption of retorts was 3·7 per furnace per day, the average life being from 35 to 42 days. The retorts were made by hand and cost 6s. apiece, which is high even for Wales. The residues (coked briquettes) drawn from the retorts, are smelted in the ordinary manner for recovery of their silver and lead contents. The loss of lead during the distillation of the zinc is claimed to be insignificant, and but very little lead goes over into the spelter, the latter averaging 99% Zn and only about 0·5% Pb."

The charge for a retort was about 15 briquettes; the charging is effected by means of a shaped iron paddle. The furnace of 144 retorts took 7 tons of briquettes. The cost of briquetting 30 tons of roasted ore per day was 5s. 6d. per ton, or a total of 165s. 6d., of which 6 tons of coal at 8s. 6d. per ton accounted for 51s., and 1·5 tons of pitch at 45s. per ton came to 72s. 6d. Deducting the cost of the coal, which would be used as reduction material under any circumstances, the actual cost of the briquetting for labor and material was about 3s. 10d. per ton of roasted ore, but this was partially offset by the smaller percentage of coal employed.

The Picard & Sulman process does not appear to present much novelty, the briquetting of the charge with coal and pitch as binding material having been tried by Binon & Grandfils 20 years ago, with claims of about the same advantages as are now made. It is likely that these claims have some foundation, but as to whether the advantage is due to the briquetting or to the use of the pitch, or both, is open to question. The metallurgists connected with the smeltery at Overpelt, Belgium, who have given much attention to this subject, attribute it to the pitch alone. F. Kiessling (Superintendent of the Overpelt Works), in commenting on the Picard & Sulman process, stated that there appeared to be only small quantities of metallic lead in the residues, the major part of the lead being slagged with silica, iron and lime. The briquettes, upon removal from the retorts, have a very porous constitution, and it is questionable whether the material can be smelted in a blast furnace without a previous sintering. The high zinc tenor of the residues (from 5 to 8%), together with the loss of from 20 to 33% of zinc, indicate that the small percentage of lead in the spelter obtained is due to operation of the furnace at low temperature. The favorable results as to maintenance of the retorts, which is ascribed by Messrs. Picard & Sulman to the briquetting of the charge, is, in Mr. Kiessling's opinion, due only indirectly to that, the true reason being the use of tar and pitch as binding material in the charge. These substances penetrate the charge, and upon decomposition carbon is set free, which envelops every particle of ore, and at the extremely high temperature in the furnace becomes converted into graphite, preventing fusion of the single particles. The ashes drawn out from the retorts show a shiny, black graphitic appearance. As to the commercial possibilities of the new method, he mentions that in 1898, at the Birkengang Works, at Stolberg, 24% Pb was treated without difficulty by the usual method of smelting.[10]

Mr. Kiessling's views are shared by the other metallurgists of the Overpelt works, of whom Mr. Wilhelm Schulte has patented the process of replacing part of the coal used as reduction material by tar, asphalt or some other liquid or liquefiable hydrocarbon, whereby it is claimed that the quantity of coal can be greatly reduced, increasing the capacity of the retort for ore and enabling the smelting of more corrosive ores. For example the use of 25% of coal with ore mixed with 3% of tar is said to be as effective as 50% of coal without the tar. When the charge is heated, finely divided carbon separates from the hydrocarbon before the temperature at which reduction of zinc oxide begins, and enveloping every particle of ore insures a satisfactory reduction of zinc oxide and renders infusible the slag-forming elements.[11]

E. Prost, J. Charon, and M. Marissal[12] tested residuum from the distillation of a charge containing 6·64% Pb and 131 g. of silver per 1,000 kg. On screening the residuum 73·78% of the total lead was recovered, of which 37·7% was present in the fine material which passed a 2-mm. sieve, the fine material containing 57·8% of the total silver. On treating the cinder by amalgamation, it was found that about 13·5% of the total lead existed in the metallic state.

Karl Sander[13] made experiments as to the effect of barium sulphate in the ore subjected to distillation. He charged 10 retorts with roasted blende containing 9·2% of barytes and 10 more with ore free from barytes. The residues from the former assayed 2·08% Zn; those from the latter 2·92% Zn. A repetition of the experiment gave 2·70% and 3·54% Zn respectively. These experiments confirm the results of Prost and others to the effect that contrary to the general belief the calcium and barium sulphates do not interfere with the reduction of zinc oxide.

A new arrangement for the ventilation of the distillation furnace houses installed at Overpelt, Belgium, was described recently by Kiessling.[14] The Overpelt smeltery has two large furnaces, with three rows of muffles, in each house, as shown in the accompanying engraving. (Figs. 1 and 2.) The working floor is 2·5 m. above the ground level. The ashes drawn from the retorts are dropped into the chutes *xx*, falling into a roomy cellar. Formerly the chutes had gates, so that there would be no draught through them, but in spite of the hoods arranged in front of the furnace the development of dust and smoke during the maneuver was so great that the men were much inconvenienced. The closed chutes had the disadvantage moreover that sintering or easily fusible charges gave residues which would cake together and cause difficulty in removal. In the present arrangement the ashes are dropped directly into the cellar. The cellar is shut in with walls and a wall-closing sliding iron door *a*. The air from the cellar is exhausted by means of a fan *v*, which is connected with the cellar by the canal *k*, and discharges through the tube *s* into a chimney, which is 20 m. high.

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[10] *Berg- und Huettenmaennische Zeitung*, LXI., xxxviii., 482, Sept. 19, 1902.

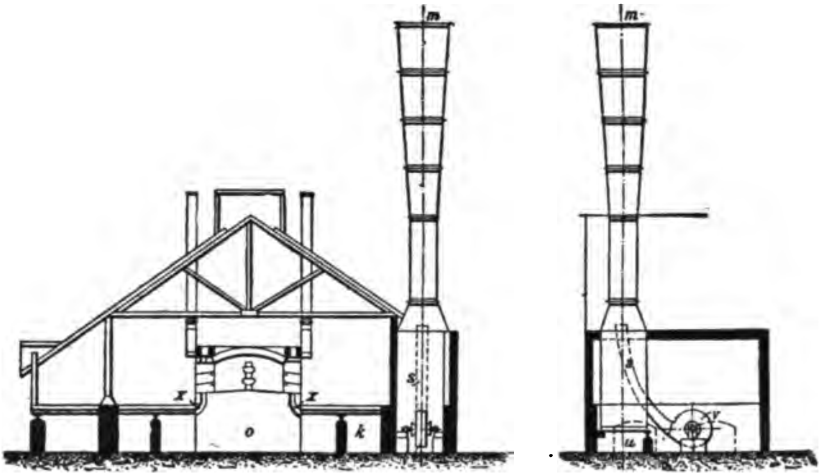
[11] French Patent No. 318,265, Jan. 31, 1902: United States Patent No. 718,222, Jan. 13, 1903.

[12] *Bulletin de l'Association Belge des Chimistes*, XVI., i., 41 to 54.

[13] *Berg- und Huettenmaennische Zeitung*, LXI., 465.

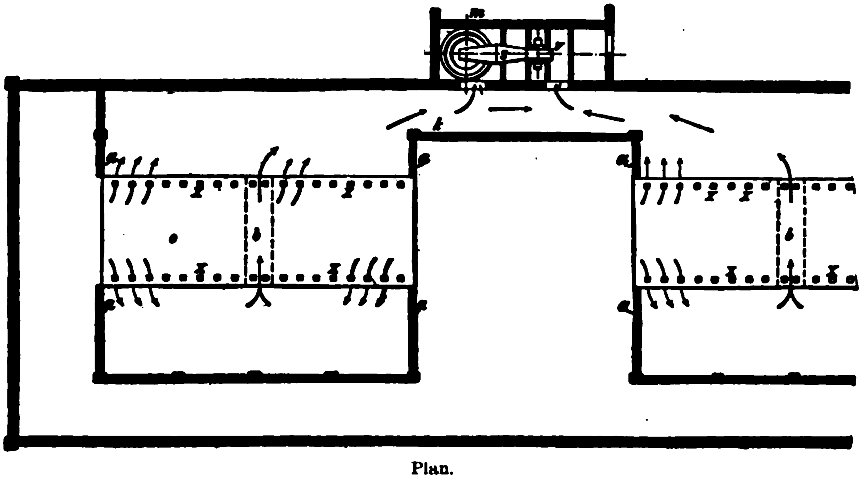
[14] *Berg- und Huettenmaennische Zeitung*, LXI., xxxviii., 478.

and 2·5 m. in diameter at top and bottom, narrowing in the lower third. The fan is 1·8 m. in diameter and makes from 550 to 600 r. p. m., exhausting about 50 cu. m. of air per second. With this installation the ventilation is excellent, and moreover there is the advantage that the hot air is drawn away from the face of the furnace, making it more comfortable for the men, with the result that the maneuver is performed in a shorter time than formerly. The work in the cellars is also facilitated.



Cross Sections.

FIG. 1.—VENTILATION AT THE ZINC SMELTER AT OVERPELT, BELGIUM.



Plan.

FIG. 2.—VENTILATION AT THE ZINC SMELTER AT OVERPELT, BELGIUM.

Jules L. Babé and Alexis Tricart, of Paris,[15] propose to distil a mixture of zinc ore, soda and charcoal in an ordinary furnace; for example, 1,000 kg. of zinc ore, 150 kg. of soda and 100 kg. of charcoal. The distillation is said to be effected in one-third the time of a mixture of ore and coal alone.

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[15] British Patent No. 10,915, of 1900; United States Patent No. 702,764, June 17, 1902.

L. Braunfels, of Frankfurt am Main, Germany,[16] mixes the ore with coal dust and makes into briquettes, which are then heated sufficiently to expel tarry matter. The zinc is then distilled from the briquettes in an iron retort, a vacuum being induced, and a current of carbon monoxide being finally passed through to lead the zinc vapor to the condenser.

C. H. T. Havemann, of Paris, France, patented[17] a process of decomposing mixed sulphide ore by means of molten iron, the reduced zinc being volatilized and the lead tapped off.

H. M. Taquet, of Argenteuil, France, proposes[18] to roast zinc blende to neutral and basic sulphate and distil with admixture of carbon and lime (or calcareous calamine) according to the reaction:—

$$ZnSO_4+CaO+5C=Zn+CaS+5CO.$$

DISTILLATION FURNACES.—In Upper Silesia a new plant is in course of construction at Hohenlohehuette by the Furstl. Hohenloheschen Berg- und Huettenverwaltung. It is expected to be in operation about the end of 1903. This plant will be noteworthy for its departure from the common Silesian practice in smelting. It is to have six double furnaces, each with 192 muffles arranged in two rows. Furnaces of this type were tried at the Hohenlohehuette 10 years ago, and also at the Guidottohuette, but were abandoned. Since then all the furnaces at the Hugohuette have been installed with three rows of small muffles, which are reported to have given excellent results. These innovations indicate a tendency in Upper Silesia to approach the type of furnace used in Rhenish Prussia and Westphalia, which has been predicted by several well-known Silesian metallurgists in view of the increasing proportion of roasted blende used in the charge for distillation and the increase in the zinc content of the charge because thereof.

In the United States the use of the old direct-fired Belgian furnaces has been almost entirely abandoned by the Western smelters, Collinsville, Carondelet, Rich Hill and Girard being the only places where they continue in use. The Matthiessen & Hegeler Zinc Co. uses long, gas-fired furnaces, and the Illinois Zinc Co. uses Siemens furnaces, modified by Neureuther, as previously described.[19] This company has abandoned the large elliptical retorts in favor of the smaller cylindrical ones of conventional dimensions. The natural gas smelters of Kansas use a long furnace, described previously in this series of reviews, which is essentially a modification of the Hegeler furnace. The Lanyon Zinc Co. has increased its number of furnaces with only 400 retorts, in place of the usual 600-retort Iola furnace. Several new distillation furnaces have been described during 1902.

Erminio Ferraris, of Monteponi, Italy, patented[20] in the United States the improved form of heat recuperative distillation furnace, which has already been described.[21] This furnace is in use at the works of the Societa di Monteponi in Sardinia, where it continues to give good results.

George G. Converse and Arthur B. De Saulles, of the New Jersey Zinc Co.,

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[16] British Patent No. 17.415, Aug. 30, 1901.

[17] British Patent No. 10,105, May 15, 1901.

[18] German Patent No. 137,004, March 21, 1901.

[19] THE MINERAL INDUSTRY, X., 167.

[20] United States Patent No. 714,685, Dec. 2, 1902.

[21] THE MINERAL INDUSTRY, X., 669.

patented[22] a distillation furnace with a single combustion chamber, which is designed to afford a construction permitting the retorts to be discharged and recharged without removing the condensers, and also to improve the recovery of zinc by locating the condensers within a chamber whereof the temperature can be controlled. The retorts are open at the rear ends, through which they are charged and discharged, the ends being properly luted during the distillation. The front of the furnace is arranged with deep niches in which the condensers are supported. Each niche constitutes a cooling flue, provided with a sheet iron chimney, having a damper, by which the draft through the flue can be regulated and the temperature of the condensers thus governed.

Messrs. Converse and De Saulles patented[23] also an improved distillation furnace for gas firing and heat recuperation by the counter current system, which is perhaps one of the best developments of that system. The furnace has a single combustion chamber covered by a broad arch springing from side to side. The rear ends of the retorts rest on interior benches in much the same way as in the Rhenish type of furnace. The recuperative flues are situated in a pair of chambers, beneath the combustion chamber, one on each side of the furnace. The products of combustion pass downward through a central shaft, from which they enter the numerous flues of each recuperative chamber in which they make a return pass before reaching the flue leading to the chimney. The air for secondary combustion passes up through the recuperative chambers, around the flues through which the products of combustion escape, while the gas from the producer enters through a central flue between the pair of recuperative chambers, whereby it is also preheated. The hot air and gas enter the combustion chamber through alternate ports arranged in about the same way as in the Siemens-Belgian furnace. This furnace is said to have given improved results in operation, as compared with the usual form of Belgian furnace.

The same inventors patented[24] a distillation furnace especially for the production of zinc dust. This furnace is in principle similar to the ordinary distillation furnace with a single combustion chamber, but the retorts, set horizontally, are charged from the rear end, which is properly luted up during the distillation. The front ends of the retorts communicate with a permanent condenser. Two forms are shown; one in which there is a single row of retorts communicating with a cylindrical condenser, about 2 ft. in diameter and 4 ft. high, set vertically outside of the furnace, and another form in which the furnace has several rows of retorts arranged in the usual manner, communicating with a common condensing chamber. In both cases the condenser is arranged with openings in the front through which a sheet iron cone can be passed through for each retort so as to collect separately the zinc dust rich in oxide which forms especially at the beginning and at the end of distillation. The inventors state that the recovery of zinc dust as a by-product in the manufacture of zinc has been heretefore practiced, but the amount thus obtained has borne but a slight ratio to the furnace charge, while their invention is designed especially to recover the entire percentage of zinc in the charge as dust, which at prevailing market

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[22] United States Patent No. 694,187, Feb. 25, 1902.

[23] United States Patent No. 712,502, Nov. 4, 1902.

[24] United States Patent No. 695,376, March 11, 1902.

rates is more valuable than spelter or zinc oxide. The zinc vapor issuing from the retorts expands in the condensers while still at the temperature of volatilization and condenses immediately in the form of dust.

Samuel Davies, of Iola, Kansas, patented[25] the process of smelting zinc with the use of natural gas as reduction material instead of coal and coke, the gas being introduced into the retorts through a pipe inserted in the latter nearly to the rear end. It is claimed that this method will have the advantage of avoiding the introduction of sulphur into the charge and also of increasing the capacity of the retorts for ore. Both of these claims are undoubtedly true, but for other considerations the process does not appear practicable.

Oskar Nagel, of New York, patented[26] a method of distilling zinc ore in a blast furnace. He reports that he has found in his experiments that zinc vapor diluted with nitrogen will always condense to dust instead of to liquid metal, and, moreover, that if in addition to the inert gas there be present oxygen or carbon dioxide, a corresponding part of the dust will be immediately oxidized. If inert and oxidizing gases be excluded from the furnace the zinc vapor may be condensed to spelter. The new process consists in distilling ore mixed with coal in an atmosphere of water gas, this being an active reducing agent, which is preferably heated before being introduced into the furnace, thereby doing away with the necessity of using other fuel and overcoming the difficulty which other experimenters have found, namely, the dilution and oxidation of the zinc vapor by the agency of combustion gases. Coal mixed with the ore is employed only for the purpose of reducing any gases which become oxidized by the reduction of the zinc oxide. The zinc vapor is obtained in as concentrated condition as in the ordinary process of distillation, and condensation to spelter is readily effected, a yield of from 90 to 95% of zinc being obtained. The water gas, which contains approximately equal volumes of carbon monoxide and hydrogen, having been prepared by well-known methods, is heated by ovens by means of the waste gases coming from the condensation apparatus. The water gas is preferably forced into the furnace by means of a blower. The furnace in which the reduction is effected may be constructed similarly to the ordinary blast furnace for lead smelting, or upon the lines of furnaces used for distilling mercury. It should be provided with the usual charging hopper and with a slag tap at the bottom. The tuyeres will be located about one-third of the height of the furnace from the bottom. Leading out of the furnace near its top is a fire-clay lined flue through which the vapor is conveyed to the condensation apparatus. With a furnace of capacity for 25 tons of zinc oxide per day, about 5 tons of the oxide will be reduced in from 4·5 to 5 hours, the water gas being introduced at a temperature of about 1,000°C. In practice it is found that 1·5 tons of water gas containing 1·4 tons of carbon monoxide and 0·1 ton of hydrogen, occupying a bulk of 10,415 cu. m. at 1,000°C., will be sufficient for the reduction of 8·1 tons of zinc oxide.

Dorsemagen proposes[27] to smelt a mixture of calcined siliceous zinc ore and coal in an electrical furnace (see Fig. 3), reducing and volatilizing the zinc, which is condensed in the ordinary manner, and reducing the silica of the ore

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[25] United States Patent No. 694,947. March 11, 1902

[26] United States Patent No. 699,969, May 13, 1902.

[27] German Patent No. 128,535, Dec 25, 1900.

to silicon carbide. The charge in the crucible is heated by the carbon electrodes; the zinc distils off into the condenser extending horizontally from the upper part of the crucible (retort) and the silicon carbide remains behind. The reduction temperature of the silica is said to be only a little above that required for distillation of the zinc. The same idea is proposed for the reduction of ferruginous ores, ferrosilicon being obtained instead of silicon carbide. This method may be adapted to continuous operation, the ferrosilicon being tapped off from time to time, together with such slag as might be formed.

REFINING FURNACES.—Alfred J. Ash, of Peterswood, England, patented[28] a furnace for refining crude spelter, which is substantially the same as the ordinary reverberatory furnace employed for that purpose, but the hearth is divided into a series of sumps, so that the metal may overflow from one to the next; the lead which settles out remains behind in the first, second or third sump, from which it may be tapped off separately. Refined spelter is drawn from the last sump.

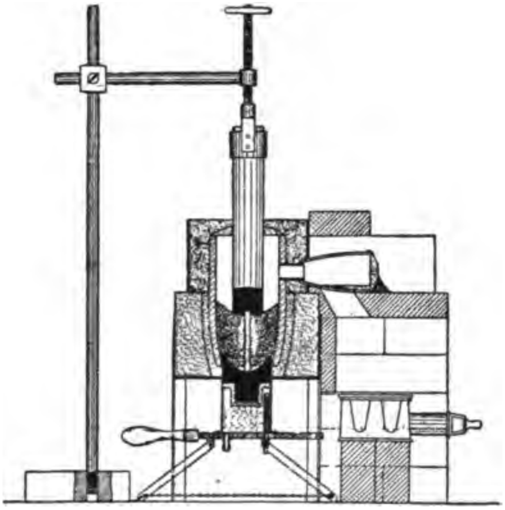

FIG. 3.—DORSEMAGEN'S ELECTRIC ZINC DISTILLATION FURNACE.

TREATMENT OF MIXED SULPHIDE ORES.

As usual a large number of patents for the treatment of mixed sulphide ores by hydrometallurgical and electrometallurgical processes have been taken out. Experiments with certain of them, including the Ashcroft & Swinburne process, have been in progress in England and America, but so far nothing has been accomplished to indicate a commercial solution of this problem. In the meanwhile real progress has been made in magnetic concentration and the smelting of the impure concentrate generally obtained thereby. The Wetherill and the Mechernich separators, both of which are of the intense type, capable of separating raw ores, are generally employed. Interesting experiments have been made with the Blake electrostatic machine.

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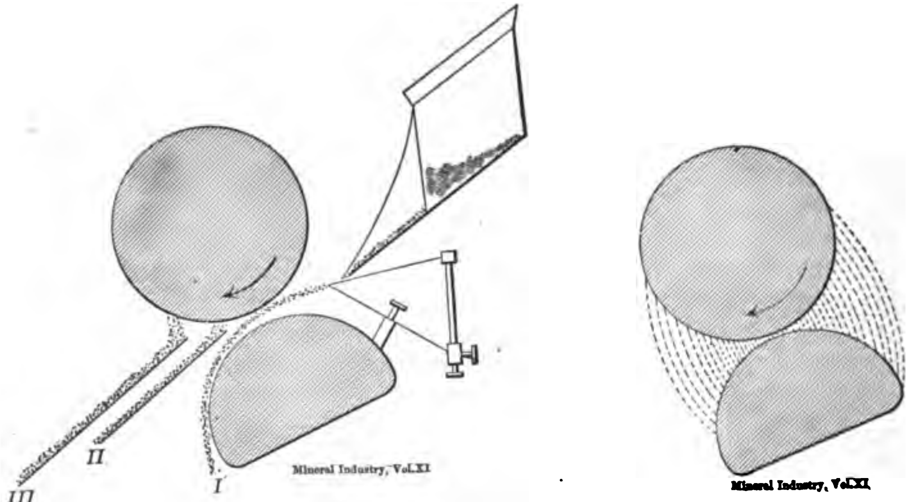
[28] United States Patent No. 702,526, June 17, 1902.

MAGNETIC CONCENTRATION.—In the Mechernich system the ore is delivered by an adjustable chute between two magnetic poles, the upper one of which (the north pole) is rotated. (See Figs. 4 and 5.) As the ore arrives in the magnetic field the permeable particles are attracted by the north pole and are carried around by it into zones of progressively diminishing intensity until the centrifugal force imparted to the particles overcomes the magnetic attraction and they fall into collecting chutes, being classified according to their magnetic properties. The non-magnetic material falls directly into a chute close against the lower pole. This arrangement is claimed to have the advantages of dispensing with belt carriers, which weaken the magnetic field, and also of permitting the use of small magnetic fields and very narrow air spaces, thus minimizing the loss of energy and making it possible to attract feebly magnetic particles by a very weak current. The rotating pole being the only moving part of the machine, wear and tear is very small. Hassreidter reports[29] that in separating blende and siderite from the Upper Harz, the grains being of 0·5 mm. size, 98·7% of the zinc has been recovered. With dolomitic Silesian blende of from 2 to 3 mm. size, the recovery was of 91·8%, which was increased to 93·5% by reducing the grains to 2 mm. In treating ore from Broken Hill a yield of 81% of the lead and 69% of the zinc was obtained. A plant of this type installed at Broken Hill for the treatment of middlings assaying 28% Zn, 10% Pb and 9 oz. silver per ton furnishes a product with from 44 to 45% Zn and 4·5% Pb.



FIGS. 4 AND 5.—MECHERNICH SYSTEM OF ORE CONCENTRATION.

The magnetic separation of zinc blende from mixed sulphide ores by means of the Wetherill machines, which has already been done with more or less success at Broken Hill, N. S. W., is now being carried out as a regular process by the Colorado Zinc Co., at Denver, Colo., treating ore from Leadville. The ore is first broken by means of a Gates crusher, and is then reduced by rolls to 30-mesh size. This product is distributed among eight Wilfley tables, which sep-

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[29] *Journal of the Society of Chemical Industry*, Sept. 30, 1902.

arate it into galena-pyrite and pyrite-blende classes. The latter is dried and is then passed over the Wetherill magnetic machines, of which there are two, each having three magnets. These produce a blende product, assaying about 50% Zn, from 10 to 12% Fe and 1% Pb, which is sold to zinc smelters, and a pyrite product, containing some lead and from 5 to 7% Zn, which is united with the galena-pyrite heads from the Wilfley tables, the mixture being sold to the lead smelters, for whom it is a desirable ore, the excess of iron being high. The capacity of the zinc mill at Denver is from 40 to 45 tons of crude ore per day.[30]

HYDROMETALLURGICAL PROCESSES.—Among the numerous patents of the year in this line have been the following:—

Erminio Ferraris, of Monteponi, Italy, patented[31] the process of decomposing the mixed sulphide ores containing zinc by means of concentrated sulphuric acid, employed in the ratio of two molecules of the acid to each molecule of sulphide contained in the ore, without the aid of extraneous heat. The best results are said to be obtained when acid of 66°B. strength is employed. The sulphur which is liberated in the reaction may be either distilled off or burned to sulphur dioxide.

M. M. Haff, of New York,[32] mixes sulphide ore with an alkali metal acid sulphate and roasts, thereby producing lead and zinc sulphates and sulphur dioxide. The zinc sulphate is leached with water, and zinc is precipitated from the solution by means of barium hydrate, barium sulphate also going down. The alkali metal sulphate is recovered from the solution and treated with sulphuric acid, produced from the sulphur dioxide given off in the roasting process, for the purpose of regenerating the acid sulphate.

Hargreaves[33] mixes a concentrated solution of iron chloride with calcium carbonate and heats the paste in the presence of air, whereby calcium chloride is formed which can be leached out, leaving ferric oxide. Magnesium or zinc chloride may be produced in an analogous manner.

Havemann proposes[34] to smelt in a blast furnace, and by means of a fan to pass the fume into a solution, wherein a deposit containing about 55% Pb, and only 2 or 3% Zn settles out. The gases escaping from this treatment are subjected to a rain of zinc liquor, or water, to ensure final condensation. The solution of zinc which is obtained is treated in lead-lined vessels with an excess of ammonia gas, whereby there is obtained a precipitate of ferrous hydroxide and an ammoniacal solution of zinc hydroxide. The zinc solution thus freed from iron is diluted with water, zinc hydroxide precipitating in gelatinous form. The ammonia is recovered from the waste liquor, in which it exists as sulphate, by treatment with lime.

C. Hoepfner patented[35] a process of treating roasted ore with water and sulphur dioxide gas and adding sufficient sodium chloride to form a concentrated solution at a temperature above normal. Sodium sulphite, or bisulphite, then separates, leaving zinc chloride in solution, which is freed from remaining

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[30] *Engineering and Mining Journal*, Aug. 6, 1902.

[31] United States Patent No. 707,506, Aug. 19, 1902.

[32] United States Patent No. 695,306, March 11, 1902.

[33] British Patent No. 18,498, of 1900.

[34] French Patent No 318, 590, Feb. 11, 1902.

[35] United States Patent No. 704,641, July 15, 1902.

sulphite by a suitable precipitant. The zinc is then precipitated as oxide by means of lime, and the resulting solution of calcium chloride is treated with the sodium sulphite obtained as described above, reproducing sodium chloride.

Jabez Lones, E. Holden and Joseph Lones, of Smethwick, England, patented[36] the process of leaching zinc oxide from ore by means of a solution of hot acetic acid, purifying the solution and then precipitating zinc as sulphide by means of hydrogen sulphide, prepared by leading the sulphurous acid, evolved in roasting the ore, through a chamber filled with red hot coke and aqueous vapor. In an alternative process the zinc is dissolved with a solution of caustic soda and is precipitated with sodium sulphide.

Herman C. Meister, of St. Louis, Mo., patented[37] a process of recovering zinc from galvanizers' skimmings, which consists of treating skimmings with the oxide of an alkali, or of an alkaline earth, preferably common lime, in the presence of moisture. The skimmings and lime are ground together in the proportion of from two to five parts of the former and approximately one part of the latter, depending upon the quantity of chlorides present in the skimmings. The mixture is then thrown into a tank of water, where chemical reaction takes place, which is facilitated by heating, although this is not essential. The zinc is oxidized by the lime, the latter being transformed into calcium chloride. The zinc oxide is filtered off and treated for the recovery of zinc by distillation in the usual manner. In another patent[38] the process of treating zinc skimmings in the same manner, but with the use of sodium carbonate instead of lime, is covered, the zinc in this case being converted into zinc carbonate.

James W. Neill and Joachim H. Burfiend, of Salt Lake City, Utah, patented[39] the process of recovering zinc by treating roasted ore with sulphur dioxide, blown through a series of special vats in which the ore is held in suspension in water. The solution of zinc bisulphite thus obtained is boiled down to precipitate zinc as monosulphite, a portion of the sulphur dioxide being thus liberated and returned to the process. The precipitate of zinc monosulphite is calcined for the production of zinc oxide. The claims of the patent relate especially to the apparatus employed and the method of carrying out the process.

ELECTROMETALLURGICAL PROCESSES.—The Hoepfner process, improved by Dr. Mond, continues in use at Winnington, near Chester, England, but electrolytic zinc is nowhere else produced. The various processes proposed in 1902 have presented no promising new suggestions.

Borchers and Dorsemagen chlorinate raw ore in the presence of salt solutions (sodium chloride, magnesium chloride) at from 30° to 40°C. in revolving lead-lined barrels, into which chlorine gas from a subsequent stage of the process is introduced through the trunnions. Lead, zinc and silver chlorides are then leached out with hot water, or the hot dilute liquors of the process. From the residuum the free sulphur is distilled off under steam pressure by Schaffner's method. The final residuum which still contains a large percentage of zinc in the form of undecomposed blende together with the greater part of the silver, is then to be worked up as a zinc ore in the ordinary manner. The results of

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[36] British Patent No. 10,865, May 25, 1901.

[37] United States Patent No. 714,502, Nov. 25, 1902.

[38] United States Patent No. 714,508, Nov. 25, 1902.

[39] United States Patent No. 702,582, June 17, 1902.

a test of a magnetically concentrated product from Broken Hill, computed on the basis of 1,000 kg., are given in the following table:—

	Ph.	Zn.	Ag.	S.
	Kg.	Kg.	Kg.	Kg.
1,000 kg. of ore contained	140	810	0·69	…………
Leached as chlorides	140	175	0·11	…………
Remaining in residuum	…………	135	0·58	115

After distillation of the sulphur there remained a final residuum assaying 39·1% Zn and 0·168% Ag. (These figures are instructive in showing the preference of lead sulphide to chlorination over zinc sulphide, but they fail to convey all the information we should like to have. The 115 kg. of sulphur in the residuum is doubtless free or volatile sulphur corresponding to the decomposed sulphides. If all the 135 kg. of zinc remained in the final residuum, which assayed 39·1% Zn, the weight of the latter must have been 135÷0·391=345 kg.).

The chloride solution from the ore is purified by means of zinc oxide, or roasted zinc ore, and then is boiled down and dehydrated as completely as possible. The anhydrous, fused chlorides are electrolyzed, yielding chlorine gas for further use in the process and a mixture of metallic lead and zinc, which can be separated and refined in the ordinary manner.

Borchers and von Kuegelgen propose to recover zinc from galvanizers' wastes by digesting with hydrochloric acid to obtain a saturated solution of zinc chloride, purifying it from iron by means of chloride of lime or other oxidizing agent, evaporating in lead-lined iron kettles, mixing the dry, pulverized zinc chloride with copper oxide and calcium carbide and smelting for brass. The reaction between zinc chloride, copper oxide (or other metallic oxides) and calcium carbide is exothermic and continues without extraneous heating after it has once been started, but to obtain a thoroughly liquid metal a subsequent heating of the crucible is advisable. The reactions between metallic oxides and chlorides and calcium carbide have been described in detail by von Kuegelgen.[40] These and the process based on them have recently been discussed by B. Neumann,[41] who stated that in the preparation of alloys it is necessary to use pure compounds, else the alloys will be impure, and in any case the composition of the alloy does not correspond to that which would be theoretically expected. Neumann computed that the cost of producing copper by the carbide process would be considerably higher than the present price of electrolytic copper and also showed it to be inapplicable to lead-zinc ores, concluding therefore that the carbide process has neither practical nor economic advantages.

Ludwig Mond patented the process[42] of obtaining zinc in a solid, instead of a spongy, form when deposited electrolytically by the use of cylindrical cathodes, two or more drums being pressed together by springs. The cylinders compress the zinc as soon as it is deposited. The anodes are shaped with corrugations corresponding to the contour of the cathode drums, so that the inter-electrode spaces are fairly uniform.

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[40] *Zeitschrift fuer Elektrochemie*, 1901, Vol. VII.

[41] *Chemiker Zeitung*, 1902, XXVI., lxii., 716 to 719.

[42] British Patent No. 5,764, March 11, 1901.

THE PROGRESS IN THE ZINC INDUSTRY IN MISSOURI DURING 1902.

BY FRANK NICHOLSON.

PERHAPS the most striking fact in the history of the Joplin zinc district during 1902 is the unmistakable decline in the productive capacity of the outlying districts, and a counterbalancing increase in the production of the older camps.

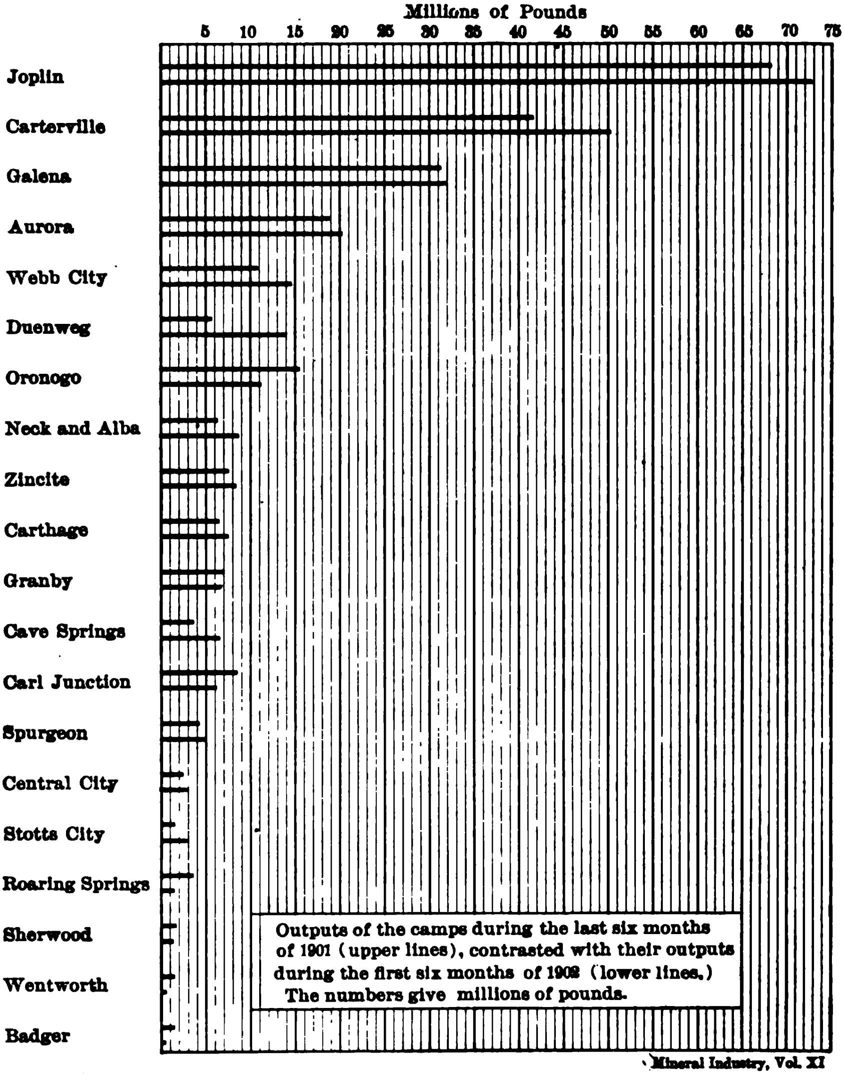

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FIG. 1.—CHART SHOWING THE PRODUCTION OF ZINC ORE IN MISSOURI BY DISTRICTS.

The accompanying chart (Fig. 1) gives the production of the various districts for the last half of 1901 and the first six months of 1902.

The largest gains were made by Carterville and Duenweg, followed by Joplin and Webb City. The greatest decline is shown by Roaring Springs, Carl Junction and Oronogo. It is true that Oronogo is one of the oldest producing camps, and it is therefore an exception to the rule that the older inside districts have shown an increase in production for 1902. On the other hand, Neck City and Alba are outlying districts, and are also an exception to the general rule in that they show a material increase in production for 1902.

The district, as a whole, is fairly steady, as shown in the following table of production for the past four years:—

Year.	Zinc Ore.	Lead Ore.	Year.	Zinc Ore.	Lead Ore.
	Lb.	Lb.		Lb.	Lb.
1899	511,657,470	48,212,720	1901	516,612,270	70,580,450
1900	484,660,410	59,018,890	1902	525,090,880	63,230,840

It will be seen that while 1902 is the banner year in the production of zinc, yet the increase amounts to only 1·6% over that of 1901, which has heretofore held the record.

Prices for lead and zinc during 1902 were fairly steady and most satisfactory. The average price per ton has been $30·70 for zinc and $46·44 for lead concentrates. The output of zinc ore shows a slight increase over 1901, while the output of lead shows a decrease of about the same quantity.

A matter of great interest to the district has been the consolidation of various smelting interests and the reappearance of the New Jersey Zinc Co. in the Joplin field. The effect of this concentration of the smelting interests into fewer hands has not yet been particularly felt in the district, and various opinions exist as to whether the results, when ultimately disclosed, will be beneficial to ore producers or otherwise. While there has been a partial merger of the zinc smelting interests, the number of producers has not been lessened, the actual operators probably being quite as numerous to-day as they were a year ago.

A large amount of speculation has been indulged in, and on every hand is heard the report that this or that syndicate is about to secure control of the output of the district. The large number of operators, however, together with the varying fortunes of any individual mine, makes it highly improbable that any general merger of interests in this district can be effected among the producers. Suggestions have been made looking toward the formation of an ore purchasing company, which shall buy the entire output of the district, warehouse and grade the product and resell to the smelters at an advance of $1·50 a ton. It is estimated that this amount will be more than saved by economies effected in the new method of handling the ore. It is proposed that this company shall pay to all producers a uniform price, which shall in no case be below $30 per ton, and its efforts shall be directed toward the maintenance of a steady and uniform price for the output of the mines. This proposed company would export any surplus production that might tend to interfere with the market price, and thus work in harmony with the commercial law of supply and demand. Any attempt to maintain the price without this export feature must, of course, fail, as the entire proposition would be based upon an economic fallacy, that the law of supply and demand could be disregarded.

Producers representing over 40% of the entire output were induced to sign contracts to deliver all ore produced to this purchasing company, but the capitalists financing the company refused to undertake the work until at least 60% of the output was under contract.

The plan attracted a great deal of attention from the smelters and ore buyers, and resulted in a material advance in the price of ore. This advance in the price of ore cooled the enthusiasm of the operators who, when ore reached a $35 basis, no longer cared to enter into contracts with a company whose avowed purpose was to prevent excessive fluctuations in the price and keep it as nearly as possible at $30 per ton. The plans of the ore purchasing company were thus necessarily postponed until such time as the condition of the market should again make its efforts desirable. It is probable that some such plan will ultimately be consummated, and will result in great benefit to the operators as well as to the smelters, as both are interested in a steady market.

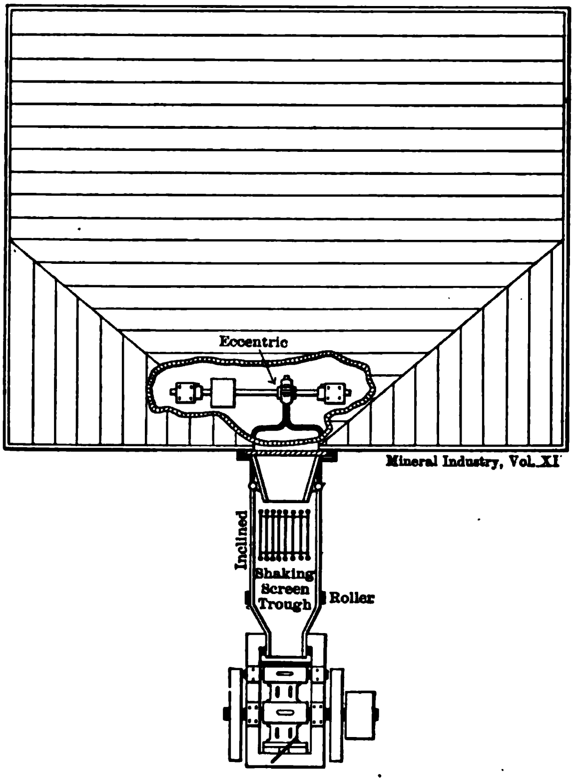


FIG. 2.—IMPROVED ARRANGEMENT OF DECKHEAD (PLAN).

There were slight changes in mining methods, and the general situation, both as to mining and milling in this district shows but trivial variation from the practice of 1901. The only change to be noted in the mining practice is the use of heavier hoisting devices and buckets of larger capacity. Thus 1,000-lb. buckets have generally been added to the new plants in place of the 500-lb. buckets formerly used. This, of course, has necessitated heavier cables and stronger hoisting engines. The number of air drills used has greatly increased during the past year.

Very few new mills have been built during the year, but a large number of old ones have been moved to new locations. The number of operating mills is about the same as a year ago. The chief changes in milling practice have been the more general use of the Wilfley tables and a different and better construction of the deckhead. The most improved mills now being built raise the ore from the mine to the top of the derrick, about 40 ft. above the collar of the shaft. The ore is dumped over a grizzly, the finer material passing direct to the ore bin, and the coarser material dropping on a floor, where it is fed into the rock breaker, which delivers it into the same ore bin already mentioned. From this ore bin, with a capacity of about 200 tons, the ore is fed automatically into the rolls and follows the usual channel through the mill. This improved arrangement of the deckhead saves at least one man in the mill, and feeds the rolls more uniformly than is possible in the usual practice. The accompanying illustrations (Figs. 2 and 3) show this style of deckhead.

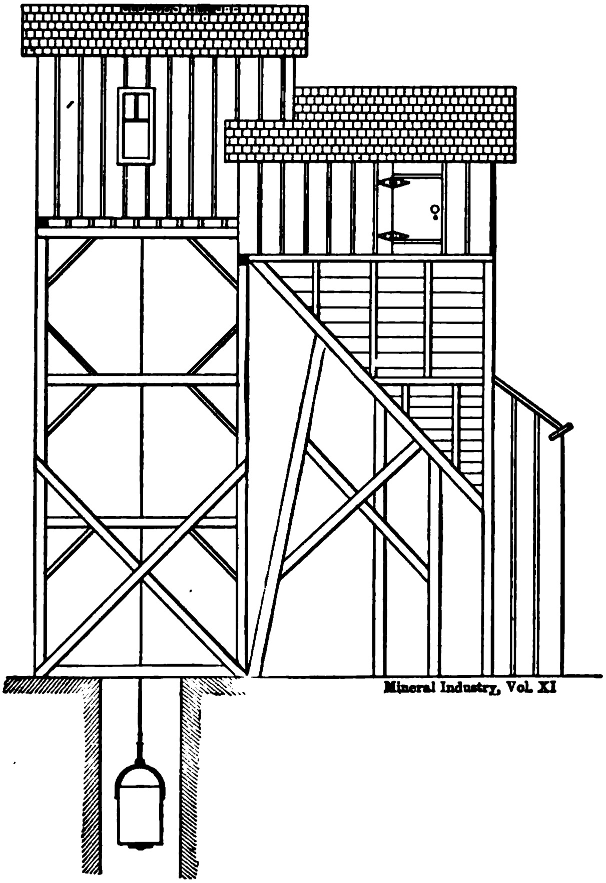
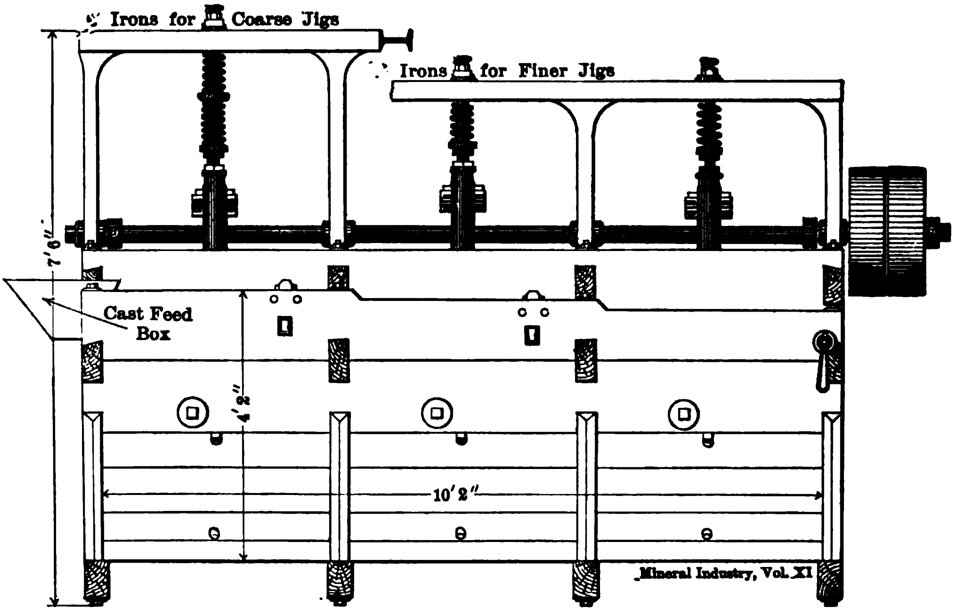


FIG. 3.—IMPROVED ARRANGEMENT OF DECKHEAD (ELEVATION).

During the past year a number of minor improvements have been made in milling appliances, among others the New Century jig has been improved and simplified. Figs. 4, 5 and 6 show the present type of this machine. The improvements are chiefly of mechanical construction, which makes the jig simpler and more certain in its action. These jigs have not as yet gained a foothold in the Joplin district, although exhibition tests have been all that could be desired.

During the past year the Joplin Separating Co. has been operating its plant continuously, and it is the intention to enlarge its capacity during the summer of 1903.

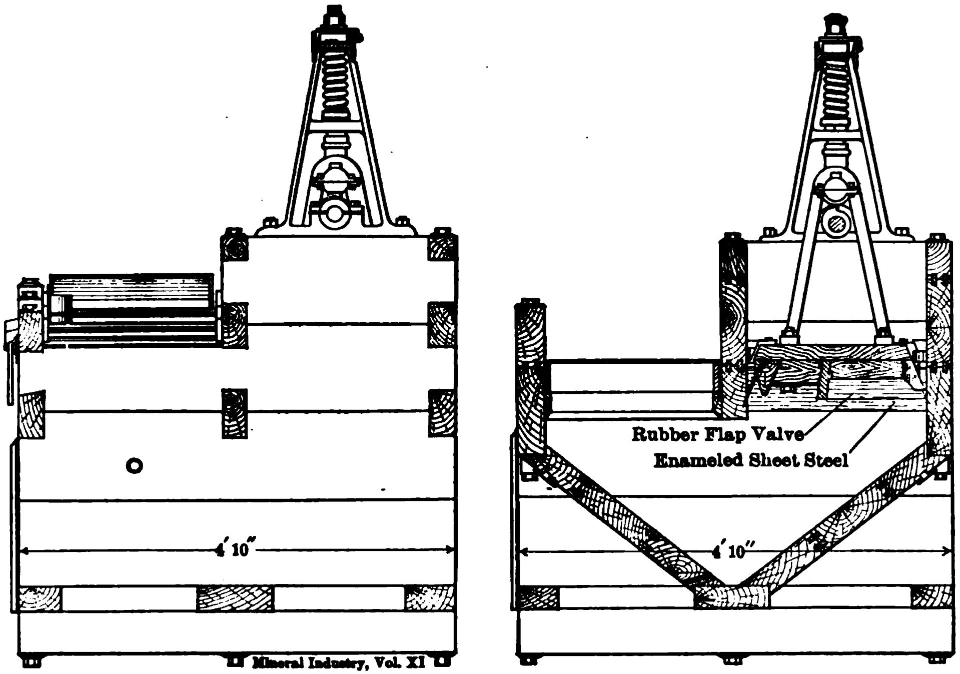
No Joplin ore was exported during 1902, although there was serious talk of export during the early part of the year. A marked drop in the price of ore set in about September, when the top price was $39·50. From that time a steady decline ensued, until on December 8 the top price had dropped to $33, and the basis to $28 per ton for 60% ore. This decline was assisted by a car famine that became acute about the middle of November, and seems to have been brought about partly by the general prosperity of the country and the inability of the railroads to furnish the requisite cars to handle their offerings of freight, and in some degree by the slowness of the smelters in unloading the cars.



FRONT ELEVATION OF A THREE COMPARTMENT JIG.
FIG. 4.—IMPROVED NEW CENTURY JIG.

On Dec. 8, 1902, there was a visible supply in the ore bins of the district amounting to about 10,000 tons, half of which had been bought and paid for by the smelters, but which, on account of the shortage of cars, still remained in the bins of the producers. This large accumulation undoubtedly tended to unsettle prices. The Miners' Association thereupon determined to export at least a portion of this surplus. With this idea in view bids were asked for 1,000 tons of ore for export, and producers were requested to contribute this at a price that would make it possible to take the ore out of the country. Several meetings of the producers were held, and 1,000 tons of ore were promptly subscribed. A contract for export was awarded to me at a flat price of $23 per ton, without deduction for iron or moisture.

Heretofore the great difficulty in the matter of export has been the fact that no one was in possession of sufficient detailed information to determine accurately the cost of exporting one ton of ore from Joplin to Antwerp, I undertook the export of 1,000 tons, with the intention of determining accurately the various items of expense enumerated below. These items are calculated for 1,022·0125 tons of 2,000 lb. each, which was the total tonnage exported. The material was shipped in bulk by rail to Galveston and thence to Antwerp by steamer. The hauling and loading expense amounted to $561·11, or $0·55 per ton. Switching expenses were $329·51, or $0·3224 per ton. Incidentals were $177·40, or $0·173 per ton. Railroad freights were $5·80 per ton. Actual losses in transit amounted to 49,103 lb., or 2·4% of the total Joplin weight, or $0·72 per ton. Draftage, which is the Antwerp custom of allowing 3 kilos over weight per 1,000 kg. delivered (a sort of *pourboire* to the Belgian smelters) amounted to 0·29 of 1%, or $0·087 per ton. Incidental charges on the other side (including reception charges, cables, interest, insurance, etc.) amounted to $265, or $0·259 per ton.



TAILS END ELEVATION

CROSS SECTION OF LAST COMPARTMENT

FIG. 5.—IMPROVED NEW CENTURY JIG.

The question of difference in assays is one of considerable interest, as the methods used in Joplin and Antwerp are altogether different, the ferrocyanide method obtaining in Joplin, while in Antwerp, Schaffner's method is generally used.

The export was effected in two shipments of 500 tons each. The assays were as follows: *First shipment:*

Joplin assay, 58·85%. Analysis upon which settlement was made, 58·7735%. Loss per ton, $0·0765.

Second shipment:

Joplin assay, 58·34%. Analysis upon which settlement was made, 57·645%. The loss in this case per ton was, $0·695. The average loss was therefore, $0·3857.

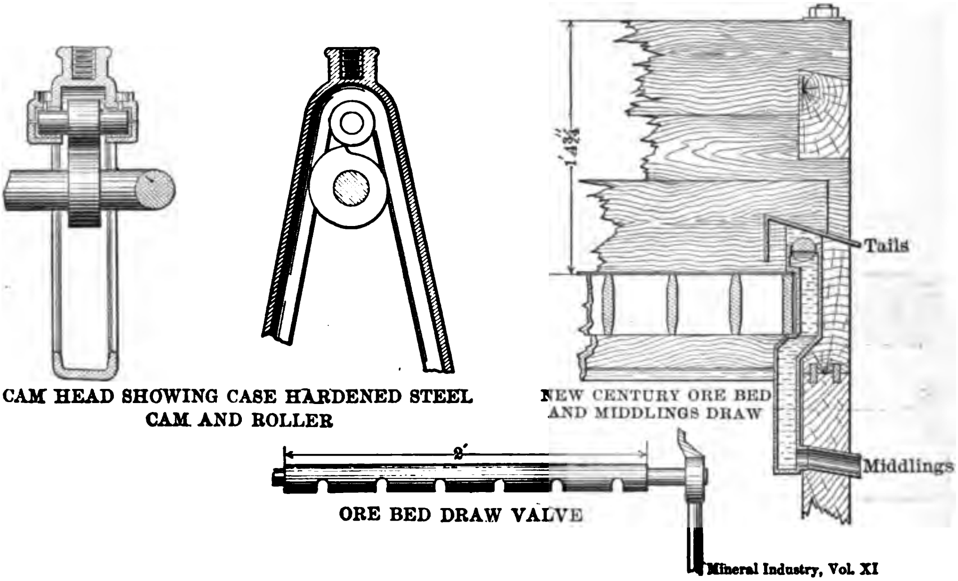


FIG. 6.—IMPROVED NEW CENTURY JIG.

Tabulating these charges and assuming a purchase price in Joplin of $30 per ton for zinc concentrates, it may be considered fairly approximate to place the total cost of exporting one ton of zinc concentrates from Joplin to Antwerp at $8·2971.

	Total for Shipment.	Per Ton.		Total for Shipment.	Per Ton.
Joplin:			Antwerp:		
Hauling and loading....	$561·11	$0·55	Draftage, 0·29 of 1%............	....	$0·087
Switching expenses were	329·51	0·3224	Incidentals (covering interest. cables, reception charges, etc.)	$265·00	0·259
Incidentals...............	177·40	0·173	Difference in assays............	....	0·3857
Railroad freights........	....	5·80			
Loss in transit..........	....	0·72	Total cost of exporting 1 ton of ore	....	$8·2971

Comparatively little Eastern capital has been invested in the district during the past twelve months, and of that which was invested, the greater portion came from Boston.

The price of properties has advanced fully 25% over the figures obtaining in 1901, and for this reason, in part at least, is owing the fact that Eastern capital has kept out of the district. The Joplin mine is a plant of quick growth. From the date of sinking the shaft to that of the exhaustion of the property ordinarily occupies from one to five years. The result is that the investor who loses money in the Joplin district loses it so quickly as to bewilder him. Larger sums are lost in the Western mining districts, but the process is so long drawn out that the loser gets used to it.

As the mode of occurrence of the Joplin deposits becomes better understood and the methods of investigation are adapted to the requirements of the existing conditions, fewer mistakes are made in the determination of the value of properties; and as a field for investment the Joplin district becomes more inviting. The boom of 1899 has passed, and the business has settled down to a conservative basis that is full of promise for the future.

A REVIEW OF THE GENERAL LITERATURE ON ORE DEPOSITS DURING 1901 AND 1902.

BY J. F. KEMP.

IN several of the previous volumes of THE MINERAL INDUSTRY reviews have appeared which have outlined the progress of thought with regard to the structural features, classification and origin of ore deposits. The object of the reviews has been to present, in brief space, the gist of the more important contributions of the few preceding years. In the interval which has elapsed since the publication of the last article much has been done, and one may fairly say that interest in this attractive branch of geology has never been greater than at the present time. It is of the highest importance to keep active the minds of the mining fraternity, and to urge that records be made in the form of sketches and descriptions of significant phenomena in veins which often pass from sight with the advance of excavation, and are thus lost to science unless promptly noted.

Geologists and mining engineers in America are profiting in these later years by the great and notable literature which has grown up under the auspices of the State and National Surveys, in the proceedings of our scientific and technical societies, and in the columns of the mining press. Many of the larger reports, similar to those of Arthur Winslow on Lead and Zinc, published by the Missouri Geological Survey; and that of R. A. F. Penrose on Manganese, issued by the Geological Survey of Arkansas, have been encyclopædic in scope, and have become books of reference, certain to remain standard for many years. Other detailed monographs on particular districts have been especially valuable for their thorough treatment of special cases; while the shorter papers have furnished a vast array of facts upon which to base generalizations. The influence of all these sources of knowledge is apparent when one, while reading the later works, has a point of view established by familiarity with the earlier contributions.

The general progress of reasoning about ore deposits, and more particularly about vein formation, may be best set forth under the following heads: 1. The primary derivation and distribution of the metals in the earth. 2. The primary concentration of the metals in veins or other forms of ore deposits. 3. The secondary changes, rearrangements and enrichments of ore deposits.

1. *The Primary Derivation and Distribution of the Metals in the Earth.*— At the outset it is necessary to go back to the speculative hypotheses about the origin of the solar system. Of these the nebular hypothesis, despite the objections

which have been raised to it, still commands in general the most respect. Reasoning along the line that the earth was once a molten mass and that its present composition and physical properties lead to the inference that it consists of a metallic core with a crust of more or less acid silicates, L. De Launay[1] likened its early stages to a metallic button in a scorifier. The corrosion of the core has caused the involution of metallic masses in certain parts of the outer crust, which are, therefore, richer in the metals than are others. During the long course of geological rearrangements, and in the districts where the outer crust has been thus provided with the special richness of the metals, the ore deposits have been produced. This paper has been previously reviewed in THE MINERAL INDUSTRY, but it is here cited again in order to establish a point of departure. While obviously speculative, it is still a serious and reasonable attempt to account for the anomalies encountered in the distribution of the metals over the globe. Within the last year, J. E. Spurr has attacked somewhat the same problem from a different point of view. Mr. Spurr starts with the general conceptions, which are now fairly well established, regarding the differentiation of one parent magma of general composition into several fractional derivatives of compositions varying from acid to basic. Just the cause of the change and the exact process whereby it is developed are yet somewhat obscure, but there seems to be little doubt that this separation takes place, and that the resulting igneous rocks exhibit marked contrasts. Mr. Spurr presents the view that not alone does this breaking up bring about the contrasts which are observed in the more abundant elements in the original magma, but that even the sparsely distributed metals are similarly affected and that they are thereby brought into a state of concentration in one or more of the derivatives. Platinum and its allied metals pass into the rocks rich in magnesium. Chromium does the same. Copper often favors gabbro, as does nickel. Other metals show less marked preferences, although in a complicated series of eruptive outbreaks they are often associated very markedly with some one flow. In this way the metals are localized, both geologically and geographically, and the productive districts become possibilities. The rearrangement of elements or oxides which vary from 75 to 2% of a magma may be reasonably produced by differentiation, yet it seems more difficult to understand how metals, which in the enriched magma vary only from tenths to ten thousandths of 1%, may be affected, or how such exceedingly small quantities could respond to the call to muster in, when so sparsely distributed in a more or less viscous medium. Nevertheless, Mr. Spurr attacks the actual condition of things and presents an ingenious suggestion for its explanation.[2]

2. *The Primary Concentration of the Metals in Veins or Other Forms of Ore Deposits.*—Probably the most important suggestions which have been made in this connection within recent years have been derived from the study of contact zones. The location of bodies of copper, lead and zinc ores in these geological situations was earliest appreciated by the Norwegian geologists, and some years

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[1] L. De Launay, "Contribution à l'étude des gites métallifères," *Annales des Mines*, XII., 1897, 119.

[2] J. E. Spurr, "A Consideration of Igneous Rocks and their Segregation or Differentiation as Related to the Occurrence of Ores." A paper read before the meeting of the American Institute of Mining Engineers, at Philadelphia, May 18, 1903.

ago emphasis was laid by them upon the contact zones and their ores in the Christiania district. To Waldemar Lindgren is due the credit of recognizing this character in certain copper deposits in the Cordilleran region of the West, and by him their characters were first described.[3] Subsequent papers have shown that the type is widespread, especially in Mexico and the Southwestern United States, and that contact, garnet zones of great magnitude have often been developed from limestone by the action of neighboring eruptives and by their contributions of silica and especially of copper ores. W. H. Weed[4] has given to those copper deposits which have formed in some special bed near the contact, the name of the Cananea type, after the notable occurrence of ore in the northwestern claims of the Cananea group, Sonora, Mexico: Great developments of this same type have been also described from San Pedro, New Mexico.[5]

The bearing of all these phenomena on the formation of veins lies in the fact that eruptive rocks have thus been shown to contribute vast quantities of silica, undoubtedly in association with water or its dissociated elements and with metallic sulphides and oxides. The inference, therefore, follows that, had not this silica been locked up in combination with lime next the eruptive, it would have circulated to more remote points and developed veins. A well established point of departure has thus been afforded for reasoning about more obscure phenomena.

Another extremely important contribution to the study of contact effects[5a] has been made by Joseph Barrell, who has shown the extraordinary shrinkage which has taken place in the conversion of calcium carbonate into a mass of silicates. The loss of the carbon dioxide does not find entire compensation in the entrance of silicic acid and a more or less open-textured rock is thereby afforded, which may well be a place of deposition of ores, subsequently introduced.

In the previous review in THE MINERAL INDUSTRY by Dr. Raymond, a general statement was made regarding the papers which had been prepared up to the time of going to press two years ago. Several of these were important contributions to the general thesis that ores and gangue minerals in veins have been deposited by the meteoric waters, which percolate downward after falling as rain upon the surface, and which return again after a more or less protracted journey. The head afforded by a place of entry higher than the point of emergence has been urged as the chief cause of movement, and this is supposed to have been reinforced by the normal increase in the temperature of the earth with depth, which causes expansion and decrease in density in the uprising heated column, as compared with the descending cold one. The latter increment, however, has been shown to be practically negligible for 10,000 ft.,

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[3] W. Lindgren, "Copper Deposits of the Seven Devils," *Mining and Scientific Press*, Feb. 4, 1899, 125; "The Character and Genesis of Certain Contact Deposits," *Transactions of the American Institute of Mining Engineers*, XXXI., 226, 1901.

[4] *Engineering and Mining Journal*, Feb. 14, 1903, 256. Presented also at the New Haven meeting of the American Institute of Mining Engineers, October, 1902.

[5] Yung and McCaffery, "The Ore Deposits of the San Pedro District, N. M." A paper read before the American Institute of Mining Engineers at the New Haven meeting, October, 1902. *Engineering and Mining Journal*, Feb. 21, 1903, 297.

[5a] Joseph Barrell, The Physical Effects of Contact Metamorphism, *American Journal of Science*, April 1902, 279.

but the former remains as an important cause of underground circulations. The rain water falling upon heights may naturally circulate by a siphonic course to very considerable depths and again reach the surface. Intrusive masses of eruptive rocks in depths would contribute important stores of localized energy to the circulations. The assumption that underground circulations reach any great depth is not confirmed by the experience of the miner, which shows that in deep mines the rocks are dry, and that, according to actual observation the descent of meteoric waters is limited to from 2,000 to 3,000 ft.[6] Anything more than this is purely hypothetical, and observers in the field should be conservative about placing undue confidence in the work of meteoric waters.

A valuable contribution to the study of springs has been made by L. De Launay,[7] who has passed in review many of the famous ones in Europe, and has described their relations to the structural geology of the regions in which they occur. Mr. De Launay upholds the derivation of the waters from meteoric sources and runs counter in this respect to much that has been written in America since the appearance of his work.

As regards the deposition of ores by hot springs, a very important study of the Boulder Hot Springs, Montana, has been prepared by W. H. Weed.[8] In this paper, as well as in many other places in the recent discussions of the origin of ores, and as the result of extensive experience with hot springs in the Yellowstone Park, Mr. Weed reaches the conclusion that the hot waters are yielded by cooling bodies of eruptive rocks situated below the vents. The same view is taken of some of the more important European hot springs by observers who have studied them and have published their conclusions abroad. The results have a very important bearing upon vein formation, because of the strong probability that the minerals forming the ores and gangue have been deposited in this way.

During the preparation of this paper a comprehensive and valuable review of the gold-producing districts of the United States by Waldemar Lindgren is in press for the American Institute of Mining Engineers. Its generalizations are of comprehensive significance in that Mr. Lindgren makes quite clear that vein formation has taken place at definite and restricted epochs in the course of geologic time, and has then ceased. These epochs have followed the fracturing of the rocks now forming the walls and the entrance of igneous intrusions, in connection with whose expiring vulcanism the ore bodies are believed to have been formed.[8a]

In a number of mining districts the close study of the location of the rich shoots in the veins has revealed the fact that they coincide with lines of intersection of the main fissure with one or more subordinate cross fissures. It is supposed that ore-bearing solutions following the one fracture have encountered precipitants following the other, and that thereby the shoots have resulted. Relationships of this kind have been recently established in some of the mines in the

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[6] This point, although brought out by me in the earlier discussions, has had especial development more recently by T. A. Rickard in the *Engineering and Mining Journal*, March 14, 1903, 402, and by W. H. Weed, *Ibid.*, April 18, 1903, 589.

[7] *Recherche, captage et aménagement des sources thermo minérales*, Paris, 1899.

[8] "Mineral Vein Formation at the Boulder Hot Springs," *Twenty-first Annual Report U. S. Geological Survey*, Part II., 227.

[8a] The paper has recently been distributed.

Cripple Creek district.[9] Very interesting connections have been shown by the late E. A. Stevens, of Victor, Colo., to exist between the eruptive dikes and the ore shoots. Thus, where certain kinds of dike rocks intersect fissured belts, the ore makes strongly.[10] All of these coincidences are highly suggestive to prospectors in other districts.

W. P. Jenney has suggested an explanation for certain blind veins, which are met in districts in the arid regions, by enunciating the principle of the "Mineral Crest." One belt of ores at Tintic, Utah, is known to become barren at a certain fairly definite altitude, although ore-bearing below this horizon. Jenney explains this crest as having been established by the neighboring gulches, which cross the line of the fractures. Ore-bearing solutions uprising when the topography was similar to its present relations, would be prevented passing a certain level by this side drainage.[11] The explanation coincides very well with the phenomena of the belt to which it is applied, but it has been controverted by S. F. Emmons and G. O. Smith,[12] with whose views, as expressed in the Tintic Special Folio, it is at wide variance, since they consider that the ore bodies were formed when the places of deposition stood at very considerable depths and beneath a great overlying load of rocks now removed. Nevertheless, Jenney's suggestion may well be borne in mind in the study of other districts.

The chemical reactions, by which ores and gangue minerals have been precipitated, have received the greatest amount of attention in the papers to be reviewed under the next head, because the reactions which are even now taking place near the surface are open to observation. In the past, and largely to-day, we are obliged to refer in a general way to diminishing pressures and temperatures. The precipitation of sulphides from metallic solutions may be obviously brought about by sulphuretted reagents, or, if the metallic salts are sulphates, as is highly probable in many cases, by reducing agents. Base sulphides like pyrite, FeS_2, may likewise be enriched by the reducing action of their own substance upon solutions with which they come into contact. Attacking this problem along the line of reducing agents, W. P. Jenney has published recently by far the most important paper of its kind.[13] The effects of carbon and hydrogen and their compounds are first discussed, then the sulphur compounds and their relatives, followed by a review of the individual metals of importance in this connection. Finally a table of the relative reducing efficiency of the several ores discussed is given as a summary. They range from hydrogen, which is taken at 100, down to magnetite, taken at 0·46. The great efficiency of the reducing action of the hydrocarbons, as compared with other minerals, comes out most forcibly, and the applications to many mining districts are set forth in the text. It can be readily understood from these facts why it is that bituminous

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[9] T. A. Rickard, "The Formation of Bonanzas in Gold Veins," *Transactions of the American Institute of Mining Engineers*, Richmond meeting, 1901; "The Lodes of Cripple Creek," a paper read before the American Institute of Mining Engineers at the New Haven meeting, October, 1902.

[10] Basaltic Zones as Guides to Ore Deposits in the Cripple Creek District, Colorado." A paper read before the American Institute of Mining Engineers at the Philadelphia meeting, May, 1902.

[11] W. P. Jenney, "The Mineral Crest; or, The Hydrostatic Level Attained by the Ore-depositing Solutions in Certain Mining Districts of the Great Salt Lake Basin." *American Institute of Mining Engineers*, 1902.

[12] G. O. Smith and S. F. Emmons. Discussion of the above, *Idem*.

[13] W. P. Jenney, "The Chemistry of Ore Deposition." A paper read before the American Institute of Mining Engineers, at the New Haven meeting, October, 1902.

beds, as in the case of the famous "Indicator" of the Australian gold fields, have at times exercised such a favorable precipitating influence.

3. *The Secondary Changes, Rearrangements and Enrichments of Ore Deposits.*—For many years past it has been known to all interested in mining sulphides that the character of the ore has an intimate relation to the ground-water, and that while oxidized above this horizon, it always changes to sulphides below. It was known also that in deposits of copper and at least one of gold, the primary metals were leached out of those portions of the veins which were above the ground-water, and were redeposited at or very near it, affording, especially in the case of copper, great bonanzas. It is one of those strange coincidences, which are so often noticed in scientific discoveries, that a number of observers were realizing at the same time that these old views ought to be expanded, and that the enrichment did not cease at the ground-water level, but continued to considerable depths below it. W. H. Weed, in particular, became convinced that enriched sulphides were produced in this way by the deposition of more copper or silver, as the case might be, upon relatively low grade, base sulphides, such as pyrite or pyrrhotite or chalcopyrite. Bornite, chalcocite, the ruby silver ores, and other similar enriched products might thus result. The more important papers bearing on this subject are listed below in chronological order, and from the appended dates the coincidence remarked above will appear.[14] Dr. Raymond has already reviewed and summarized the major part of these papers in his contribution in THE MINERAL INDUSTRY, Vol. IX., back of which it has not been my intention to go in this review, but the papers are briefly mentioned here in order to establish a point of departure, and to add several of later date. In many of these papers, especially in the one of W. P. Jenney, cited under the preceding head, the chemical reactions are worked out in accordance with which the changes in the oxidized zone and the enrichments lower down take place. In this accuracy and definiteness of statement great advances have been made. An exceedingly important paper was contributed in this connection by H. V. Winchell at the meeting of the Cordilleran Section of the Geological Society of America, at Berkeley, California, in December, 1902, which is now in press in the *Bulletin of the Geological Society of America*. By laboratory experiment, Mr. Winchell has shown that chalcocite, Cu_2S, will be precipitated from acid solutions of copper by metallic sulphides in the presence of SO_2, and that SO_2 is developed under the circumstances met in the Butte mines. The deposition of chalcocite therefore at depths far below the ground-water level, and so far as it results from descending waters is thus explained. The additional question, however, has been raised for Butte as to whether the enrichment was all from

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[14] L. De Launay, "Sur le rôle des phénomènes d'altération superficielle, et de remise en mouvement dans la constitution des gites métallifères," *Annales des Mines*, August, 1897; W. H. Weed, "Enrichment of Mineral Veins by Later Metallic Sulphides." Read December, 1899, printed in *Bull. Geol. Soc. Amer.*, April, 1900, Vol. XI., 179; W. H. Weed, "The Enrichment of Gold and Silver Veins," *American Institute of Mining Engineers*, February, 1900; S. F. Emmons, "The Secondary Enrichment of Ore Deposits," *Ibid.*; L. De Launay, "Les variations des filons métallifères en profondeur," *Revue générale des Sciences*, XI., 575, April, 1900; see, also, "Geologie pratique," by the same author, Paris, 1900; C. R. Van Hise, "Some Principles Controlling the Deposition of Ores," *American Institute of Mining Engineers*, February, 1900; L. De Launay, "Secondary Enrichment of Ore Deposits," *Idem*, February, 1901; Arthur L. Collins, "Secondary Enrichment of Ore Deposits," *Idem*; T. A. Rickard, "The Formation of Bonanzas in the Upper Portions of Gold Veins," *Idem*; G. J. Bancroft, "Secondary Enrichment at Cripple Creek," *Engineering and Mining Journal*, Jan. 17, 1903.

descending surface waters. W. H. Weed[15] has urged that after the first deposition of a relatively lean pyritic vein material, the solutions changed once and probably oftener and enriched the older base sulphides by new deposits of metallic compounds. At the New Haven meeting of the American Institute of Mining Engineers, October, 1902, Mr. Weed presented a note regarding the enrichment of veins by ascending alkaline solutions, in which it was shown that Dr. H. N. Stokes of the U. S. Geological Survey had obtained in the laboratory the following reaction from pyrite and marcasite with CuO or other metallic oxides in a sodium bicarbonate solution:—

$$2FeS_2+6CuO+H_2O=3Cu_2S+Fe_2O_3+H_2SO_4.$$

This result is of far-reaching importance and makes it desirable to study the paragenesis of minerals in ore deposits with great care, since if a primary filling of some base sulphide like pyrite is in a vein, it may prove to be a reagent of great efficiency upon solutions entering later. Mr. Weed suggests that other ores such as enargite, polybasite, pearcite, proustite and pyrargyrite may be produced in this way, and that experiments are under way to verify the supposition.

The papers above cited, especially that of S. F. Emmons, have also dealt with the level of the ground-water in an important manner, and have served to emphasize its irregular upper surface. In broken ground it may stand very low, relatively to neighboring portions, being naturally drained away by lower outlets. Alteration, therefore, may extend to much greater depths in some places than in others.

The only remaining topic which might be touched upon in this review is the classification of ore deposits. A very interesting discussion upon this theme was started by the presentation of a scheme of classification before the Geological Society of America at the Washington meeting, December, 1902, by W. H. Weed. This and a second one by J. E. Spurr were afterward the subject of extended discussion before the Geological Society of Washington and were reported in the *Engineering and Mining Journal,* Feb. 14, 1903. These discussions are too detailed for reproduction here, but it may be said that in Mr. Weed's scheme the effects of eruptive intrusions and expiring vulcanism are especially emphasized, and that under five comprehensive heads types of ore bodies are established based on mineralogical characters. The five heads are, I. Igneous (magmatic segregations); 2. Pneumatolytic deposits; 3. Fumarolic deposits; 4. Gas-aqueous deposits; 5. Meteoric waters. Mr. Spurr establishes three "orders" as follows: 1. Original, formed during the cooling processes of igneous rocks; 2. Subsequent, formed from cold rocks; 3. Transitional. In the former scheme the growing appreciation of the rôle played by the eruptive rocks is manifest.

In addition to the papers mentioned above, many other important ones have appeared in which descriptions of particular districts are given, but only those have been discussed here which deal with the general principles of the science of ore deposits.

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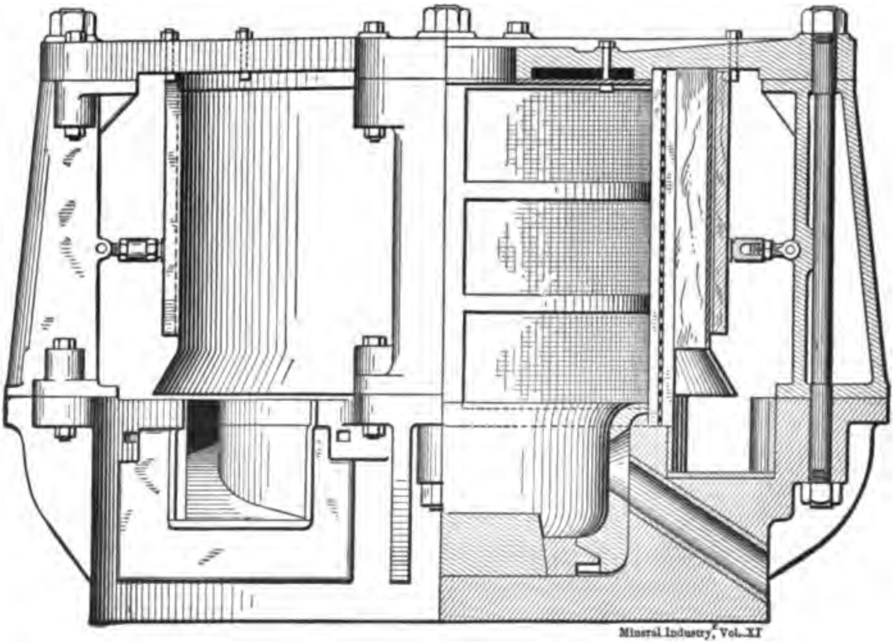
[15] W. H. Weed, "Ore Deposits at Butte, Mont.," *Engineering and Mining Journal*, April 18, 1903, 589.

REVIEW OF THE LITERATURE ON ORE DRESSING IN 1902.

BY ROBERT H. RICHARDS.

CRUSHING MACHINERY.

The Parnall-Krause Stamp Mill Mortar.[1]—This type of mortar is designed for the steam stamps used to crush copper-bearing rock in the Lake Superior region. The stamp is enclosed by a cylindrical screen perpendicular to the direction of the splash, surrounding which is a removable splash-pan open at the bottom, thus affording a free and constant discharge of the crushed material.



Half Section and Elevation.

FIG. 1.—THE PARNALL-KRAUSE STAMP MILL MORTAR.

Feed water is introduced through an inclined hole in the side of the mortar, the top of the hole being slightly above the level of the die. (See Fig. 1.) The feed pipe has a valve or gate at the end, and a T, near the mortar, through which the water is introduced. This arrangement acts as a classifier;

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[1] *Engineering and Mining Journal*, Vol. LXXIII., (1902), p. 488.

the coarse copper escapes from the mortar at once, and is not subjected to continued stamping. In comparison with former types the effective discharge area is increased to a maximum, while the area of the permanent parts of the mill exposed to the abrading effect of the splash is reduced to a minimum. The capacity of the mill is greatly increased, the loss of slimes is reduced, the quality of the metal is improved, and the expense of renewing linings and abraded parts is appreciably diminished. The screens and splash-pan being easily removed, the mill is more accessible for inspection and repair than when partly inclosed on the sides by a permanent casing.

The Perfection Ore Crusher.[2]—This crusher is designed for laboratory use, and is a combination of jaw and roll crusher. The stationary jaw in ordinary crushers is replaced by an upper movable jaw and a steel roll; it can be adjusted to crush to 100-mesh size.

Mills in Australia.[3]—At the Great Boulder mine seven Griffin mills crushed 150 tons of auriferous sulphide ore per day from 1-in. through a 15-mesh woven wire screen; the ore contains less than 3% moisture, and the time includes all stoppages. Wages and repairs amount to from $0·42 to $0·46 per ton.

At the Lake View Consols and Kalgurli, Nos. 8 and 5 ball mills using 30 and 15 H.P. respectively, crushed from 50 to 55 tons and from 25 to 30 tons of ore per day respectively, from 1·5 to 2·5 in. through 40-mesh woven wire screens. Wages, repairs, and conveying to furnaces amount to from $0·26 to $0·30 per ton.

The screen analyses of the crushed ore were as follows:—

Great Boulder, Griffin Mills, 15-*Mesh Screen.*—On 20 mesh, 0·91%; through 20 mesh on 40 mesh, 3·92%; through 40 mesh on 60 mesh, 6·92%; through 60 mesh on 80 mesh, 3·10%; through 80 mesh on 100 mesh, 6·19%; through 100 mesh on 120 mesh, 4·74%; through 120 mesh, 74·10%.

Lake View Consols Limited, Ball Mills, 40-*Mesh Screen.*—On 60 mesh, 6·51%; through 60 mesh on 100 mesh, 26·23%; through 100 mesh on 150 mesh, 6·69%; through 150 mesh, 60·57%.

Kalgurli Gold Mines, Limited, Ball Mills, 40-*Mesh Screen.*—On 80 mesh, 24·86%; through 80 mesh on 110 mesh, 14·89%; through 110 mesh, 60·24%.

CONCENTRATING MACHINERY.

The Sturtevant Toggle Separator.[4]—This separator consists of a series of four inclined screens arranged one above another in a box 6 ft. long, 2 ft. wide, which is agitated vertically by means of a toggle.

Screen vs. Hydraulic Sizing.[5]—S. I. Hallett calls attention to the enormous final losses in modern concentrating mills from the final *spitzkasten* overflow. While no remedy is recommended he thinks that the problems on all steps of concentration preceding *spitzkasten* have been solved, in other words, that vibrating screens eliminate the use of the classifier. The mill recently built at Silver-

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[2] *Engineering and Mining Journal*, Vol. LXXIII., (1902), p. 420.

[3] *Australasian Institute of Mining Engineers*, Vol. VIII., p. 40. Frank Moss.

[4] *Engineering and Mining Journal*, Vol. LXXIII., (1902), p. 558.

[5] *Mining and Scientific Press*, Vol. LXXXIV., (1902), p. 118.

ton, Colo., is equipped with shaking screens from the coarsest size to 100-mesh, which afford perfect satisfaction, and do away with hydraulic classifiers. The claim is made that the laws governing bodies in an upward current of water under pressure can never be thoroughly understood, because of the effect of varying currents and eddies, that are always present. Furthermore, that in a sized product the ore and rock particles of approximately the same size, can be separated more easily upon a table than by water-sorting.

The chief objections to a sizing method have been: the clogging, the short life and the low capacity of the screen. These evils are now claimed to have been removed by striking a blow to the screen at an angle of 45° to the pitch, which gives an upward and forward bump simultaneously. In extremely fine sizing the capacity of the screen is regulated by its width and not by its length. Mr. Hallett gives also a statement of uncompleted experiments which show sizes, percentages, inclination, revolutions per minute of motive power, length of stroke, with spray and without. The product passing through the 100-mesh is fed directly to a *spitzkasten,* to which it is eminently suited.

NOTE.—In August, 1902, I visited this mill and found Meinecke classifiers treating everything below 14-mesh size; I have not yet corresponded with Mr. Hallett to ascertain whether close sizing was unsatisfactory, or the reason for the adoption of classifiers.—R. H. RICHARDS.

Klein's Hydraulic Classifier.[6]—This type of classifier is used at Desloge, Mo., and at Philipsburg, Neihart, and Butte, Mont., and is made in three sizes: (1) for coarse material ranging in size from 6 mm. to 2 mm.; (2) for medium material ranging from 3 mm. to 1 mm.; (3) for fine material below 1 mm. in size. The machine acts on the principle of separating the fines from the coarse material by constant agitation produced by compressed air (see THE MINERAL INDUSTRY, Vol. X., p. 747). It is claimed that the quantity of water required for this classifier is less than one-half that ordinarily used for hydraulic classification. The classifier for coarse materials requires 50 gal. of water per minute, while for the fine sizes 15 gal. are required. The air is at 40-lb. pressure, and the coarse classifier requires 40 cu. ft. per minute, while the fine classifier requires but 10 cu. ft. For ordinary work the capacity of the coarse classifier is 75 tons per day, while that of the fine classifier is 50 tons.

The Cammett Table.[7]—The use of the Cammett table is guaranteed free from infringement as a result of private agreement between the manufacturers and A. R. Wilfley.

SAMPLING MACHINERY.

The Byrnes Automatic Pulp Sampler.[8]—This sampler consists of two concentric cones, the inner one being divided into 10 spiral chambers, of which nine discharge direct, while the tenth extends beyond the outer cone and discharges a portion of the pulp into a slotted tube at every revolution. The standard machine is designed to furnish a sample of $\frac{1}{3000}$ part of the material handled.

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[6] *Mining and Scientific Press*, Vol. LXXXV., (1902), p. 221.

[7] *Mines and Minerals*, Vol. XXII., (1902), p. 334.

[8] *Engineering and Mining Journal*, Vol. LXXIII., (1902), p. 488.

The Johnson Automatic Sampler.[9]—This sampler designed by Paul Johnson, is described in detail under "Recent Improvements in Lead Smelting," elsewhere in this volume.

Sampling and Dry Crushing in Colorado.[10]—Under this title an important contribution to the literature of dry crushing has been made by Philip Argall, who presents data largely from his experience at the works of the Metallic Extraction Co. at Cyanide, Colo., where the fine crushing of the hard Cripple Creek ore is practiced on a large scale. Mr. Argall does not discuss coarse crushing, but advocates a reduction ratio of not more than 4:1 for any one machine. A 12×20-in. breaker, reducing to a maximum size of 1·7 in., will easily crush 25 tons per hour of ordinary quartzose ores. Talcose and wet ores cause trouble, and very wet ores should be dried before breaking.

In sampling ores containing from 10 to 15 oz. gold per ton, the following ratio between the average size of the ore cubes and the proportional weight of the sample has been found to give accurate results:—

	Diameter, in Inches.	Quantity, in Per Cent.	Pounds, in 100 Tons.
Maximum size of cubes...........	1·00	20	40,000
....	0·25	1·25	2,500
8-mesh cubes........................	0·0625	0·0785	157
80-mesh cubes	0·0171	0·005	10

As an extra precaution in practical work, larger quantities of the finer material would be taken. In machine sampling the following important points should be noted:—

(1) Take out a sufficient quantity in the first cut to represent accurately a thorough sample at that size. (2) Always crush and thoroughly mix the ore between each cut unless it is already quite fine, and in this case the greatest possible care should be exercised to mix thoroughly before making the second cut. (3) Use riffles to reduce the size of samples after leaving the last automatic sampler. Abandon all forms of coning and quartering.

In fine crushing it is essential to reduce the moisture in the ore to about 1%, also to raise the temperature to about 250°F., more particularly if the ore is of a clayey nature; cold ores of this character lie dead on the screens, and tend to clog them; but if heated they are quite lively, and screen as well as hard, gritty ores. The efficiency of the Argall tubular dryer is shown in the following table:—

Name and Location of Mill.	Number of Dryer	Water.		Quantity of Ore Dried per 24 Hours.	Quantity of Coal Used per 24 Hours.	Remarks.
		Before.	After.			
		%	%	Tons.	Tons.	
Bessie, Telluride, Colo.	2....	8·06	1·22	177	2·66	Coal, poor (slack); ore clayey.
Cyanide, Leadville, "	1....	10·00	1·00	70	1·00	Coal, fair; ore talcose and clayey.
Metallic, Cyanide, "	2....	4·00	1·00	....	....	Coal, good; ore siliceous.

The data in the above table show an average evaporative effect of 7 lb. water to 1 lb. coal; on this basis the cost of reducing the moisture from 6% to 1% will average $0·05 per ton.

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[9] *Engineering and Mining Journal*, Vol. LXXIII., (1902), p. 514.

[10] *Institution of Mining and Metallurgy*, Feb. 20, 1902.

Generally in ore milling the heaviest standard wire to be had for any given mesh is used for the screens, but sometimes the lightest wire gives better results. Ordinarily the heavier wire is the better for coarse, gritty ores, but for soft, clayey ores which tend to choke the screens, the finer wire is preferable in a dry crushing mill. For coarse screening, about 0·25-in. size, circular perforated steel-plate trommels give the best service; from 0·25 to 0·1-in. wire-cloth trommels are preferable; while for finer meshes, the hexagonal form of screen of light construction is most advantageous. In crushing 99,270 tons of ore by graded crushing and screening, so that the final product was below 0·02 in., the cost of maintenance of screens was $0·02 per ton.

The many defects of rolls, as usually constructed, are intensified when used for fine crushing. They should open parallel across the face under all conditions, and should remain perfectly level. When the movable roll is mounted on a pin-jointed lever these exact conditions are not fulfilled, while a slight wear of a pin joint disturbs the horizontal position of the axis, and increases the friction; hence the movable roll should be mounted in a sliding device with anti-friction surfaces. Careful experiments show that there is a speed for each size which gives the best results, or in other words, a speed where the maximum capacity is attained with the minimum expenditure of power; these speeds have been correlated, and from them a formula and diagram have been deduced. (See Fig. 2.) This shows that to crush 2-in. cubes a 42-in. roll is required, and its proper speed is 28 revolutions per minute, etc. Two other interesting diagrams have been made, one which shows the percentage of reduction and corresponding

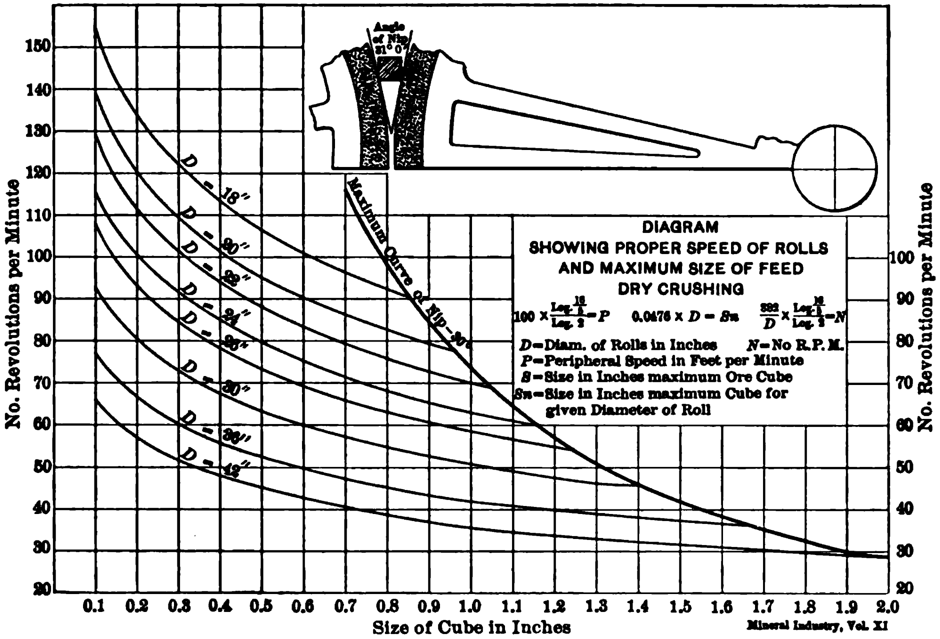

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FIG. 2.—FEED, SPEED AND CAPACITY OF ROLLS.

percentage of finished production (Fig. 3), and the other the capacity of finished product in cubic feet per hour at given speed and sizes. (Fig. 4.)

All rolls, except those used for coarse crushing, which take the ore from the breakers, should be provided with mechanical feeders; for sizes greater than 0·25-in. the stream should not exceed in thickness the maximum faces of the cubes; below 0·25-in., however, thicker streams can be used on the principle of "choke feed," so that the ore particles are crushed upon one another in passing the point of contact, thereby increasing the capacity of the rolls. A 26×15-in. roll at 110 r. p. m., crushing from 0·1-in. to 0·02-in. size has a theoretical capacity of only 86 cu. ft. per hour, or about 30 cu. ft. of finished product, whereas if run with "choke feed" on 0·25-in. size its capacity will be 75 cu. ft. per hour

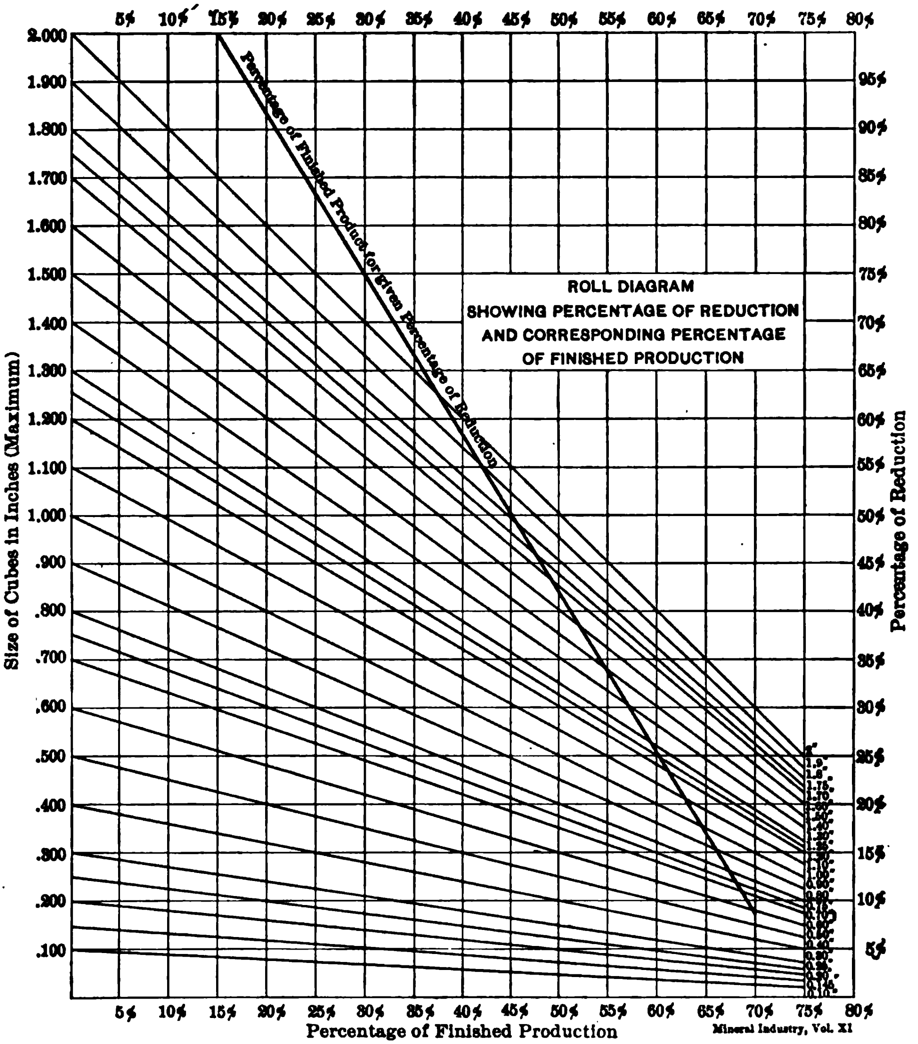

FIG. 3.—PERCENTAGE OF REDUCTION AND PRODUCTION OF ROLLS.

to 0·02 in. The average cost of the rolled steel tires used in crushing 86,000 tons of ore was $0·0181 per ton.

As a fundamental principle in fine crushing, attention is called to the importance of gradual comminution by means of a series of rolls, and interposed screens between the sets, and criticism is made of the so-called "unit" system described in THE MINERAL INDUSTRY, Vol. IX., p. 360, pointing out that it is more expensive in first cost, operation and maintenance than a system designed for gradual comminution.

In discussing mill design the assumption is made that the mill is to sample and crush dry 400 tons per day of ordinary quartzose ores to 26 mesh, 26 wire. The mill will be divided into two units, and the following estimates are for one 200-ton unit. The preliminary crushing can be done by one 12×20-in. breaker, which will reduce the ore to a maximum size of 1·7 in.; if the ore is in 12-in. cubes or larger, two breakers in series with an intervening screen should be used. Following the breaker, or breakers, a 36×16-in. roll at 35 r. p. m. will treat 600 cu. ft. per hour through a 0·75-in. screen. The sampling can be done by a Vezin sampler, a 26×15-in. set of rolls, and a fine grinder. For the fine crushing each unit will require one dryer, three elevators, and four sets of 26×15-in. rolls, with necessary screens, etc. The rolls are used in series: roll *a*, reducing the ore from 0·75 in. to 0·25 in.; roll *b*, from 0·25 in. to 0·1085 in.; and rolls *c* and *d*, from 0·1085 in. (5 mesh), to 0·02 in. Roll *a*, at 65 r. p. m., will yield 222 cu. ft. of finished product per hour, of

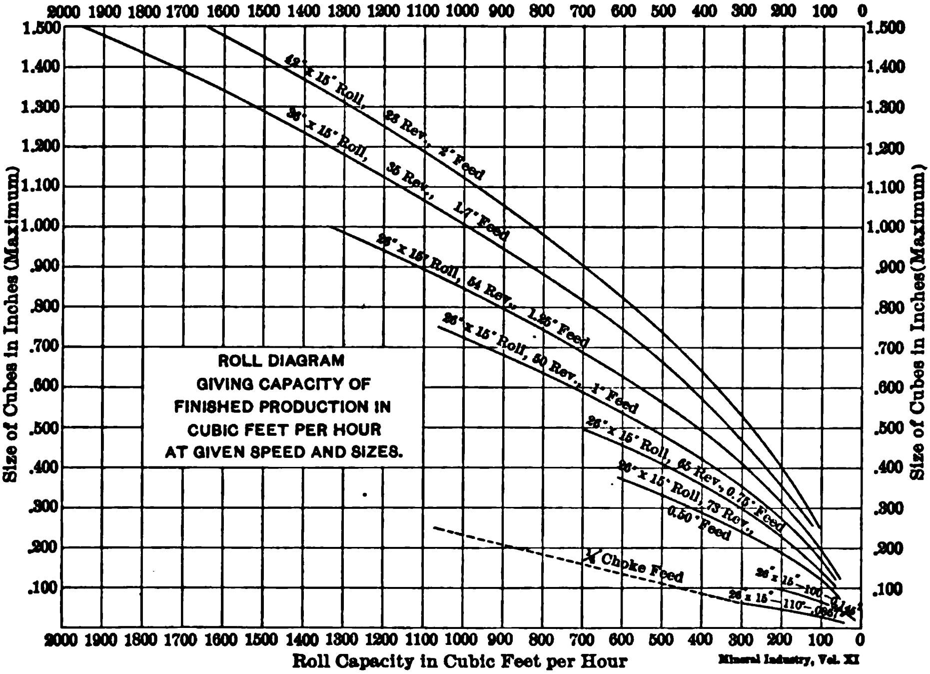

FIG. 4.—CAPACITY OF ROLLS IN CUBIC FEET PER HOUR.

which 60 cu. ft. per hour should pass 5 mesh, leaving 162 cu. ft. per hour for roll *b*, which at 90 r. p. m. will give 160 cu. ft. of product per hour passing 5-mesh screen. Adding the 60 cu. ft. already reduced to 5-mesh size gives 220 cu. ft.; of this quantity 75 cu. ft. should be reduced to 0·02 in., leaving (220—75) 145 cu. ft. for rolls *c* and *d*. In ordinary practice each finishing roll, running at 110 r. p. m., with 0·25-in. "choke feed," will furnish 75 cu. ft. per hour. The capacity of the four sets of rolls, reducing from 0·75 in. to 0·02 in. will therefore be 220 cu. ft. per hour=9·5 tons (reckoning 87 lb. per cu. ft.), which corresponds approximately to 200 tons in 21 hours. The power required will be: coarse crushing and sampling, 35 indicated H.P.; fine crushing, 50 H.P.; friction, engine and shafting, 20 H.P.; total, 105 I.H.P. The coarse crushing and sampling plant, while in operation, will require 70 I.H.P., which must be allowed for in the power provided for each unit; as the plant is operated only half of the time, the average is 35 I.H.P. In crushing 200 tons of ore to 0·02-in. size in 24 hours the work of 1 I.H.P. is 158·73 lb. per hour; in fine crushing alone it is 333 lb. per hour, data obtained from working results. The cost of sampling and crushing 400 tons per day is $0·50 per ton; not including administration, insurance, taxes, depreciation and amortization.

Notes on Sampling.[11]—The advantages claimed of the method of "*alternate shovelfuls*" over "*coning*" and "*quartering*" are: (1) greater reliability; (2) less cost; (3) rapidity; (4) economy of space, and (5) smaller capital required.

In *automatic sampling,*[11a] best results are obtained by taking the sample evenly from the whole of the stream part of the time.

The weaknesses of the *Bridgeman samplers*[12] are stated to be the lack of mixing between the apportioners: and the variability in weight of the samples obtained.

Results obtained by the *pipe* and the *single split samples* are claimed[13] to be inaccurate and unreliable.

An objection to the *old Brunton sampler*[14] is that it takes more ore from one side of the falling stream than from the other, and if a larger sample is required, a greater quantity is taken at the same intervals, and not the same quantity at shorter intervals.

The *Overstrom sampler,*[15] which operates on the same principle as the old Brunton sampler, is open to the same criticism.

The *new Brunton sampler*[16] is one of the few machines which take a correct sample. At the sampling works at Victor, Colo., the ore is crushed by a Blake breaker, set at from 1·5 to 2 in., and thence goes to sampler No. 1; this sample goes to a set of rolls 36×14 in., and thence to sampler No. 2; the sample is again crushed by 27×14-in. rolls, set to crush to 0·25 in., and thence to sampler No. 3; the sample is mixed, dried thoroughly and sent to 20×10-in. rolls, which crush to 0·0625 ($\frac{1}{16}$) in., and thence passes to sampler No. 4; each sampler takes out a sample of 20% of the ore, so that the final sample is equal to 0·2×0·2×0·2×0·2=0·0016 ($\frac{1}{625}$) part of the whole quantity sampled.

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[11] *Mining Reporter*, Vol. XLIV., Nov. 28, (1902), p. 423.

[11a] *Ibid.*, Vol. XLV., (1902), p. 99.

[12] *Ibid.*, Vol. XLV., Jan. 23, (1902), p. 119.

[13] *Ibid.*, Vol. XLV., Feb. 20, (1902), p. 206.

[14] *Mining Reporter*, Vol. XLV., March 6, (1902), p. 249.

[15] *Ibid.*, Vol. XLV., March 13, (1902), p. 272.

[16] *Ibid.*, Vol. XLV., March 27, (1902), p. 314.

The *Vezin sampler*[17] shares with the new Brunton sampler the distinction of being standard, and is preferred by many. This sampler is not patented.

At the *Park City (Utah) Sampling Works*[18] the ore is taken from the cars by a 24-in. belt conveyor to a No. 5 Gates breaker, thence elevated to a Vezin sampler, one-fifth cut out, which is subsequently crushed and sampled by Vezin samplers until a final product of 0·032% ($\frac{1}{3125}$) of the original ore is obtained. The rolls used are 36×24 in., 30×10 in., 24×8 in., and 9×14 in. It is suggested that the efficiency of the plant would be increased if the last Vezin sampler was replaced by a *Jones riffle sampler.*

The *method of sampling* adopted by the Broken Hill Proprietary Co., at Port Pirie, Australia,[19] is to divide the consignment into 30-ton lots, weigh and crush with a Gates breaker; through rolls; through a 0·375-in ($\frac{3}{8}$) screen, the oversize of which is recrushed until every particle passes through the screen. Every fourth barrow load of ore from the bin is dumped on the sample floor and is coned and quartered until reduced to about 3 cwt. This portion is weighed and broken down by hand, passed through a 0·125-in. ($\frac{1}{8}$) screen and quartered to about 5 lb., which is carefully weighed and passed through a 120-mesh screen. The hand quartering was adopted in preference to automatic machine sampling because of the great difficulty and loss of time experienced in cleaning the sampler after each parcel, and the expressed wish of the sellers that they should be able to see the whole operation without losing sight of the ore.

GENERAL MILLING PRACTICE.

The New Anaconda Reduction Works.[20]—This plant was completed early in 1902, and is the largest and the most complete modern works in the world. The concentrator building is in two parts, each of four sections. Each section may be worked independently as a separate mill, and has a capacity of over 700 tons of ore per 24 hours; consequently the capacity of the entire mill is nearly 6,000 tons per 24 hours. Each section is divided into five departments—crusher, jig, middling, regrinding, and tables or slime. In each section of the crusher department are two shaking grizzlies with 1·25-in. round holes; one 12×24-in. Blake breaker; two trommels, with 1·25-in. round holes; two 5×15-in. Blake breakers; and two lines of trommels with 22-mm., 7-mm., 5-mm., and 2·5-mm. round holes. The jig department contains six Harz jigs, 36 Evans jigs and four Evans classifiers. The middling department is fitted with two sets of 40×15-in. rolls, four sets of trommels with 1·5-mm. slotted holes, four Evans classifiers, and 18 Evans jigs. The regrinding department has four 5-ft. Huntington mills, four Evans classifiers, and 18 Evans jigs. The slime department is fitted with 35 Wilfley tables.

The Daly-West Mill, Park City, Utah.[21]—The ore treated at this mill is a lead, iron, and zinc sulphide, whose principal values are silver and lead. The mill is equipped with a breaker, rolls, trommels, jigs, Huntington mills, Wilfley

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[17] *Mining Reporter*, Vol. XLV., Apr3, (1902), p. 387. [18] *Ibid.*, Vol. XLVI., Dec. 11, (1902), p. 1482.

[19] *Australasian Institute of Mining Engineers*, Vol. VIII., p. 92. H. W. Moss.

[20] *Engineering and Mining Journal*, Vol. LXXIII., p. 811

[21] *Mining Reporter*, Vol. XLVI., Aug. 21, (1902), p. 147.

tables, and slime-saving devices. The jig and table methods do not differ essentially from the general treatment of similar ores, but special work is done to save the slimes. The treatment adopted is as follows: the tailings from Nos. 1 and 2 jigs pass to a Huntington mill; the tailings of Nos. 3 and 4 jigs are treated on Wilfley tables, the middlings of which are returned to a Huntington mill; the tailings from Nos. 5 and 6 jigs, together with the product of the Huntington mills, are passed to a Sherman classifier and distributor. The coarser material from the distributor passes to four Wilfley tables and the fines to slimes settling tanks. The four Wilfley tables make a concentrate, and a generous middling product, which is re-treated on two Wilfley tables, which also make a concentrate and a middling; the middlings pass to another similar table making a concentrate and a middling, the latter being reconcentrated on the same table. There are six round, wooden slimes settling tanks about 14 ft. deep. The first is 5 ft. in diameter, and each succeeding one is slightly larger. Within each tank is an inverted cone, open at the lower end, and extending from 6 to 8 ft. into the main tank. The slimes are received at the top and pass downward through the lower end of the cone, the water rising up and overflowing from the main tank to the next one similarly built. This action creates a current in each tank, which becomes gentle in the larger tanks. The final overflow of the last tank is pumped back to the head of the mill. The slimes product of the tanks is reconcentrated over a specially regulated set of Wilfley tables, which are given an inclination toward the heads end of 0·75 in. in the whole length. The concentrates assay 27·2% lead and 58 oz. silver per ton; the tailings assay 0·2% lead and 4·8 oz. silver per ton; the table feed assays 3·4% lead and 12·5 oz. silver per ton. About 22% of the tailings which leave the mill will pass through a 200-mesh screen. The slime values saved amount to 20% of the total mill saving, thus illustrating the importance of improved slimes treatment.

Mill Practice in St. François County, Mo.[22]—A dolomitic limestone impregnated with galena and small quantities of pyrite and chalcopyrite is crushed to 4 mm. and treated direct on Bartlett tables. Formerly the product above 6 mm. was jigged, and table treatment followed, the jigs losing about 0·5% and the tables about 2% of the lead content. With the present system the loss is less and the finished product some 75% richer. The mill has a capacity of 600 tons per 24 hours using 75 Bartlett tables.

The Standard Mill,[23] *Cœur d'Alêne, Idaho.*—A canvas plant, consisting of 52 tables of 6 sq. yd. each, handles all the tailings from the Wilfleys and vanners, together with the overflow from the settling tanks. Material caught on the canvas tables is reconcentrated on two Wilfley tables. The mill greatly resembles the Helena-Frisco mill (see MINERAL INDUSTRY, Vol. X., p. 751), the principal differences in addition to the canvas plant being that the latter uses rolls for recrushing the middlings, while the former uses rolls and Huntingtons; also the Standard mill uses Wilfley tables, whereas the Helena-Frisco mill uses Frue vanners only.

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[22] *Berg- und Huettenmaennische Zeitung*, Vol. LXI., (1902), p. 525. O. M. Bilharz.

[23] *American Institute of Mining Engineers*, February and May, 1902. J. R. Finley.

The Morning Mill, Mullan, Idaho.[24]—This mill, which is one of the largest, if not the largest, silver-lead concentrators yet erected, is equipped with a 9×15-in. Blake breaker, two conveyors, two No. 4 Gates breakers, two 14×36-in. Allis crushing rolls, two 14×29-in. recrushing rolls, eight three-compartment double jigs, eight four-compartment double jigs, four sets of 14×29-in. fine crushing rolls, four 5-ft. Huntington mills, eight double deck round tables, ten Wilfley tables, and six 6-ft. vanners with settling tanks. During 1900 the output of crude ore was 300,000 tons, and the shipment of concentrates amounted to 30,000 tons.

The Silver King Mill, Park City, Utah.[25]—This mill has a capacity of about 100 tons in 10 hours; the ores treated carry about 15% lead, 20 oz. silver per ton, and a small quantity of gold. The lead occurs as sulphide and carbonate; the silver occurs associated with the galena and also as a chloride; generally the gangue material is quartzite with some lime. The ores are treated as follows:

(1) Mill bin, to (2).
(2) Grizzly. Oversize to (3); undersize to (4).
(3) Jaw breaker, 10×7 in., to (4).
(4) Trommel, 0·5-in. holes. Oversize to (5); undersize to (7).
(5) Rolls, 12×30 in., to (6).
(6) Elevator, to (4).
(7) Three trommels with 0·0625-in. ($\frac{1}{16}$), 0·1875-in. ($\frac{3}{16}$) and 0·3125-in. ($\frac{5}{16}$) holes. Over $\frac{5}{16}$ in. to (8); through $\frac{5}{16}$ in. on $\frac{3}{16}$ in. to (9); through $\frac{3}{16}$ in. on $\frac{1}{16}$ in. to (10); through $\frac{1}{16}$ in. to (11).
(8) Two double compartment Harz jigs, 140 one-inch strokes per minute; heads to (18); tailings to waste.
(9) One jig, 180 0·75-in. strokes per minute; heads to (18); tailings to (13).
(10) One jig, 240 0·5-in. strokes per minute; heads to (18); tailings to (13).
(11) Hydraulic classifier; spigot to (12); overflow to (19).
(12) Jigs, 270 0·125-in. strokes; heads to (18); tailings to (19).
(13) Five-foot Huntington mills, slotted screens equivalent to 25-mesh; to (14).
(14) Elevator, to (15).
(15) V-shaped hydraulic classifier, about 60 ft. long; first spigot to (16); other spigots to (17); overflow to (19).
(16) Six Wilfley tables; heads to (18); tailings to (19).
(17) Four Frue vanners; heads to (18); tailings to (19).
(18) Concentrates, finished product.
(19) Slime department.

In the slime department canvas tables and other settling devices have been unsuccessfully tried on the flour-like slimes. A complete new slime plant has been recently installed, and consists of a 40-H.P. Ingersoll-Sergeant compressor, three large steel mud and air receivers and two 48-chamber filter presses, each treating about 15 tons of slime in 24 hours. The slime water taken from the ore at various steps in the process is divided among seven V-shaped settling

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[24] *Mining Reporter*. Vol. XLV., June 12, (1902), p. 555.

[25] *Mining and Scientific Press*. Vol. LXXXV., p. 204. Jas H. Steele.

tanks, 5×5 ft. by 40 ft. long. The current is very slow and the water is discharged almost perfectly clear. The thick mud is tapped at the bottom and elevated to a storage tank above the presses. It is run through the receiver into the press until the latter is full and the former nearly so. Air pressure at 90 lb. per sq. in. is then applied to force the remainder of the mud into the presses and the water through the canvas. The water leaves the presses absolutely clear. The slimes after pressing average 15% lead, 25% silver and $2 gold per ton, and contain 22% water.

The A. M. W. Mill, Leadville.[26]—The ore consists of crystals of galena, iron pyrites, and marmatite, intimately associated. The crushing is done by two Huntington mills with 40-mesh screens; 48% of the crushed material will remain on an 80-mesh screen. The ore contains approximately from 12 to 14% lead, 12 to 15% iron, 32 to 35% zinc, 5 to 8% silica, and 37 to 26% sulphur. The problem, therefore, is not one of concentration, but involves the separation of the minerals of zinc, iron and lead into commercial products. The crushed material is passed through three hydraulic classifiers, yielding coarse, medium and fine products, each being passed over 12 Wilfley tables to yield heads (lead and iron pyrites), middlings (a zinc product) and tailings. The first two products are sent to the smelter, but the attempts to treat the mill tailings have not yet been successful.

The Detroit Copper Co., Morenci, Arizona.[27]—The concentrator of this company is provided with crushers, screens, jigs, Chilian mills and various types of concentrating tables. Power is furnished by five gas engines. The ores concentrated are sulphides, 75% of the product being saved by the jigs. By means of classifiers, settlers and tables a specialty is made of the slimes. A concentration of 7 : 1 is claimed with 85% copper extraction yielding final tailings containing 0 8% copper.

Australian Practice.[28]—The treatment of low-grade copper ores is discussed by J. J. Muir, and attention is called to the existing conditions which have prevented profitable concentration by water. Experiments have shown that the concentration of 100 tons of an ore containing 3·94% copper yields 7·27 tons of concentrates containing 11·12% copper, and 92·723 tons of tailings carrying 3·37% copper.

Concentration Practice in Southeast Missouri.[29]—R. B. Brinsmade states that the milling cost in the best equipped concentrators is from 30 to 40c. per ton.

Practice in the Slocan District, B. C.[30]—For the concentration of silver-lead ores in this district S. S. Fowler recommends hand sorting and closer sizing than is now employed.

Ore Dressing at Santa Fé, Mexico.[31]—According to Henry F. Collins the ore from the Santa Fé mine consists of bornite and chalcopyrite, together with garnet, in a gangue of wollastonite; the copper minerals carry gold and silver,

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[26] *Mining Reporter*, Vol. XLIV., Nov. 28, (1901), p. 422. A. W. Warwick.

[27] *Mining and Scientific Press*, Vol. LXXXIV., (1902), p. 142.

[28] *Institution of Mining Engineers*, Vol. XXIII., p. 517.

[29] *Mines and Minerals*, Vol. XXII., (1902), p. 241.

[30] *Canadian Mining Review*, Vol. XXI., October, (1902), p. 254.

[31] *Institution of Mining and Metallurgy*, Oct. 16, 1902.

and the garnet gold; the determined specific gravities of the component minerals are: bornite, 5; chalcopyrite, 4·15; garnet, 3·89, and wollastonite, 2·90. The present system is designed to make a 40% copper concentrate and a middling product averaging 7% copper. The ore is crushed by a 7×10-in. Blake breaker, which delivers to a set of 14×24-in. rolls, thence to either of two Tulloch feeders which deliver to two sets of 14×24-in. rolls. There are three cylindrical trommels with 8, 6 and 3·25-mm. round holes, respectively. The undersize from the last trommel is sorted by *spitzlütten* into products of approximately 3·25 to 2 mm., 2 to 1 mm. and a fine meal size; the overflow passes to a settler which thickens the pulp for treatment on a convex revolving table. The five coarser sizes are treated on five pairs of three-compartment jigs. During 1901 the mill averaged 88·7 long tons per day. The ore contained 2·61% copper, and the concentrates, averaging 45·17% copper, approximated 2·7% of the weight of the original ore. The garnet middlings containing 9·53% copper, approximated 2·3%, and the tailings contained 1·41% copper. Recently the copper content of the ore was but little more than 2%, and the tailings were also of a lower grade.

The tailings from the jigs are collected in a settling pond and subsequently removed to a 30-stamp mill with amalgamated plates. From the apron plates the pulp passes to six Gilpin County bumping tables, made of amalgamated copper, the object being to save a part of the scoured amalgam and at the same time to effect a partial concentration; the results, however, have not been satisfactory. From the bumping tables the pulp passes to a three-compartment classifier; the first two spigots feed three sand jigs, the third passes to a Wilfley table; the overflow passes to a series of three-compartment classifiers, each spigot feeding a convex slime table. The stamps crush 65 tons per day; the rewashed concentrates from the jigs and table average about 8 tons monthly, assaying 34% copper, 2·4 oz. gold, and 60 oz. silver. The garnet middlings containing from 6 to 9% copper (of which about 26 tons are produced per month) are sent to the smelter. About 55 tons per month of poor middlings, assaying 3 to 4% copper, are accumulated pending the installation of a Wetherill magnetic separator. The tailings from the jigs and Wilfley tables pass into a series of settling "strips" similar to the old Cornish square buddle, but much longer and narrower; the final product averages 8 to 10% copper, 0·3 to 0·35 oz. gold, and 12 to 15 oz. silver per ton. From 4 to 5 tons are produced monthly.

The classifier overflow from the fine crushing mill passes successively to three *spitzkasten*, each feeding a convex table. The heads from the first and second tables and the middlings from the third are washed on two 4-ft. Frue vanners and two Embreys. The side shake is too violent for treating these slimes, and the end shake, while treating a smaller quantity, gives lower tailings and a better saving. These machines produce a garnet concentrate with from 8·5 to 9% copper; the tailings run about 1·5% copper; the percentage saving of even the end-shake vanners during the concentration of these products is very low. The vanner tailings are buddled; the heads and middlings of the buddle are re-treated separately on the vanner and the tailings are rejected. The buddled slimes are re-treated, feeding by means of a "strip" to one of the round tables.

A summary of the results of the system, based on the average figures for the months of November and December, 1901, is as follows:—

	Tons of 2,240 Lb.	Metal Content.		
		Gold.	Silver.	Copper.
		Oz.	Oz.	Tons.
Ore crushed	2,670·00	430·62	10,620·25	56·73
Concentrates produced	57·48	125·80	4,049·42	26·05
Middlings produced	167·35	56·37	2,274·82	18·42
Bullion produced	....	101·17	28·38	....
Total metals saved	....	283·34	6,352·62	39·47
Per cent of metals saved	....	69·85%	59·82%	70·47%

The total cost of milling was $1·075 per 2,240 lb. of ore, not including any proportion of the general expense of administration. The tailings average from 0·6 to 0·8% copper and experiments on them with the Elmore process were unsuccessful; the only chance of further reducing the loss appears to be in a repetition of concentrations on tables and buddles.

Improvements in Lake Superior Practice.[32]—At the new Osceola Mill, Lake Superior, the Parnall-Krause circular mortars are fitted with 0·625-in. (⅝) screens, the area of which is claimed to be 11·1 times greater than those formerly in use. To clean the mortar, instead of hanging up a stamp, a valve connected with the mortar is opened, which allows the removal of the coarse copper (see under the heading "Crushing Machinery" elsewhere in this article). In this way 20% of the mineral is obtained directly. Hydraulic separators between the stamps and the jigs recover 22% more. As these products average 93 to 96% copper, about 56% of the value of the rock is obtained without jigging, and the jigs are thus relieved of the coarse copper that passes through the screens of the mortars, the losses in dressing also being reduced. In the old Osceola mill. the loss in tailings averaged 0·26%, while in the new mill the tailings during 1901 averaged 0·094%. In 1899, the percentage of extraction was a little less than 84% (see the table on p. 167 of this volume); the new mill treating the same ore and producing tailings of the above quality, would show a yield of a little more than 94%. The cost of dressing in the old mill during 1901 was 29·22c. per ton of crude ore, while in the new mill it was 22·1c. per ton.

The First Modern Ore Dressing Plant in Cornwall.[33]—This plant was erected at the Mary Ann mine, Menheniot, the capacity being 75 tons per day of 10 hours, treating tailings of an average of about 3% lead and 40 oz. silver per ton.

The equipment is as follows: Hopper feed regulator, stone breaker, picking table, shaking table, two crushing rolls, two elevators, 12 trommels, 15 jigs (four roughers), 2 three-compartment classifiers, four-compartment *spitzlutte*, two-compartment *spitzkasten*, Wilfley table and two Luhrig vanners. The plant is in two sections, with the crushing and elevating machinery between them. On the one side are 10 jigs, the first four acting as roughers; all the middlings are treated by the five jigs of the second side. The sizes of the jig screens on the first side are 10 and 8 mm., 6 and 4 mm., 4 and 3 mm., 2 mm., 1·5 mm., 1 mm., 0·5

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[32] *Engineering and Mining Journal*. Vol. LXXIII, (1902), p. 468.

[33] *Ibid.*, Vol. LXXIV., (1902), p. 816. W. Ryan Lewis.

mm.; on the second side the jig screens are 5 mm., 4 mm., 3 mm., 2 mm. and 1 mm. The first and second compartments of the *spitzlutte* deliver to the Wilfley table, while the third and fourth deliver to a Luhrig vanner; both compartments of the *spitzkasten* deliver to the second vanner. It is proposed to crush the middlings below 4 mm. down to 1 mm. and under, and to treat them in the *spitzlutte*, also to replace the vanners by two rotary slime tables; an extra Wilfley table may also be added. The introduction of modern methods may add much to the Cornish mining industry.

TIN DRESSING.

Treatment of Tailings in Cornwall.[34]—The quantity of sand and slime tailings flowing into the Red River tin stream, Cornwall, amounts approximately to 900 tons per day. Round buddles and dead frames were extensively used previous to the introduction of vanners. The dead frame is an excellent concentrator for heavy minerals, as cassiterite, wolframite, etc., associated with light waste, but its capacity is limited to one ton per day while the majority in the Red River district average 0·5 ton per day. Furthermore, the capacity has been reduced by the decrease in the tin content of the ores. At three of the principal mines the average tin content per ton during 1901 was 47 lb., 28 lb., and 31 lb. The loss of tin by the mines is due to an insufficient supply of clean water. The greater part of the water used for dressing comes from the mine; it is also used for condensing, in the change house for the miner's to wash, and in stamping. In connection with the engine and stamps, large quantities of oil and grease are used. The water is collected from all sources and used for concentration. As a part of the rock is steatitic and contains a large proportion of fine tin, the treatment with impure water prevents a proper saving of values. The Elmore oil process of concentration is proposed for the treatment of these slimes. The slimes are collected in pits and thence removed to rag frames, of which there are, approximately, 8,000 along the stream, together with about 2,500 seconds and 1,000 cleaners. In addition there are about 80 buddles and 100 round frames, varying from 18 to 22 ft. in diameter. A rag frame will treat from 0·5 to 2 tons per day. The round frame averages 3 tons per 10 hours, and makes one revolution in from six to seven minutes. In the 18-ft. round frames there are 9 six-foot heads, five for pulp and four for water; these frames treat the slimes satisfactorily. The values after being concentrated, are calcined, framed and buddled until marketable.

The Cornish Stamp Mill.[35]—C. M. Myrick describes the stamp mill for crushing tin-stone in Cornwall.

Tin Dredging.[36]—The attempts to dredge for tin ore at Copes Creek, New South Wales, was a failure, due mainly to improper management and ignorance of suitable saving appliances. A recent installation, however has made a successful four months' run.[37]

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[34] *Engineering and Mining Journal*, Vol. LXXIV., (1902) p. 178. Edward Skewes.

[35] *Mining and Scientific Press*, Vol. LXXXV., (1902), p. 326.

[36] *Australian Mining Standard*, Vol. XXVIII., (1902). p. 439.

[37] *Ibid.*, Vol. XXVIII., (1902), p. 724.

CORUNDUM DRESSING.[38]

At the Robillard property, North Renfrew County, Canada, corundum rock, associated with pink feldspar and small quantities of mica and magnetite, is being milled. The process is as follows:—

(1) Mill bin, to (2).

(2) No. 2 Gates breaker, to (3).

(3) Elevator, to (4).

(4) Ore bin, to (5).

(5) One set 14×24-in. Gates rolls, to (6).

(6) Elevator, to (7).

(7) No. 1 trommel, with 5, 8, 11-mm. holes; oversize to (5); through 11 mm. on 8 mm. to (10); through 8 mm. on 5 mm. to (9); through 5 mm. to (8).

(8) No. 2 trommel with 1·5 mm. and 3-mm. holes; oversize to (11); through 3 mm. on 1·5 mm. to (12); through 1·5 mm. to (13).

(9) Hartz jig, 6·5-mm. screens; concentrates to (14); tailings to waste.

(10) Hartz jig, 9·5-mm. screens; concentrates to (14); tailings to waste.

(11) High speed jig, 4-mm. screens; concentrates to (14); tailings to waste.

(12) High speed jig, 2·5-mm. screens; concentrates to (14); tailings to waste.

(13) Classifier to remove excess of water, to slimes tank; spigot to (16).

(14) One set 30×6-in. high speed Colorado rolls, to (15).

(15) No. 3 trommel with 1 mm. and 1·5-mm. holes; oversize to (14); through 1·5-mm. on 1 mm. to (16); through 1 mm. to (17).

(16) Wilfley table; concentrates to (18); tailings to waste.

(17) Bartlett table; concentrates to (18); tailings to waste.

(18) Dryer, to (19).

(19) Magnetic separator; magnetite to waste; corundum to (20).

(20) Splitters (screens) 30, 80, 90-mesh; on 30-mesh to (23); through 30 on 80-mesh to (22); through 80 on 90-mesh to (24); through 90-mesh to (21).

(21) Graders (screens) dividing product into 90, 100, 120, 150, 180, 200-mesh, each to (24).

(22) Graders (screens) dividing product into 70, 60, 54, 46, 36, 30-mesh, each to (27).

(23) Graders (screens) dividing product into 24, 20, 16, 14, 12-mesh finished products; oversize to (14).

(24) Wilfley table; concentrates to (25); tailings to waste.

(25) Dryer, to (26).

(26) Graders (screens) dividing product into 80, 90, 100, 120, 150, 180 and 200-mesh finished products.

(27) Hooper jig; heads, finished product; tailings to waste.

NOTE.—Rewashing without sizing proved useless. The Hooper pneumatic jig was found to be of limited application, as the air blast is not sufficient for sizes finer than 90-mesh, and "blows through" sizes coarser than 30-mesh without

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[38] *Institution of Mining Engineers*, Vol. XXIII., p. 446, and private information.

concentrating them. It cleans intermediate sizes successfully with the advantage that drying and regrading is obviated.

The output is about 3 tons of concentrates per day, and the quantity of fines is proportionately small.

MAGNETIC CONCENTRATION.

Wetherill Separators at Washington, Arizona.[39]—These concentrators are used on ore averaging 5% copper, 11% zinc, 7% lead, 20% garnet, 30% silica and 2% lime. After crushing and roasting, the ore is fed to four Wetherill four-pole magnetic separators, each treating 25 tons per day. All poles carry 110 volts; the first two consume three amperes, while the last two require five. The heads consist of roasted chalcopyrite and the tailings carry all the lead, zinc, garnet and silica. The last named product is treated on Wilfley tables, the middlings of which are re-treated yielding heads which are added to the first table heads, and treated on Wilfley tables yielding final concentrates of 70% lead; the concentrates are dried and fed to two 6-pole high power Wetherill magnetic separators, each treating 15 tons per day; the magnets carry 110 volts, the first two poles are set to four amperes, the second to ten amperes, and the last two to 25 amperes. The first two poles lift chalcopyrite that has escaped the first four machines; the second two poles lift the garnets that were concentrated with the zinc, and the last two poles lift the zinc. The tailings are inconsiderable in quantity and consist of silica or lead that has escaped from the concentrating tables; this material is re-run when a sufficient quantity has accumulated.

The Wetherill Separator[40] *at Kalk-am-Rhein, Germany.*—These separators have been applied successfully for the separation of galena, blende, spathic iron, and 12% manganese in a quartz gangue. Ordinary mechanical concentration yielded an impure spathic iron, containing from 15 to 22% zinc and 2·5% quartz. Using the Wetherill separator, on ore crushed to 3-mm. size, the blende concentrates showed from 42 to 46% zinc, and the spathic iron obtained as a separate product, carried from 1 to 3% zinc. The tension of the current used was 65 volts, with 12 amperes. Each machine, with 14-in. belts traveling 125 ft. per second, had a capacity one ton per hour, with a treatment cost of 20c. per ton.

The Wetherill Separator at Denver, Colo.[41]—The magnetic separation of zinc blende from mixed sulphide ores is now carried on as a regular process by the Colorado Zinc Co., at Denver. The ore is broken by a Gates breaker and reduced by rolls to 30-mesh size. This product is passed to eight Wilfley tables which separate it into galena-pyrite and pyrite-blende classes. The latter is dried and passed over the two Wetherill magnetic machines, each having three magnets, yielding a blende product containing about 50% zinc, from 10 to 12% iron and 1% lead, which is sold to zinc smelters, and a pyrite product containing some lead and from 5 to 7% zinc, which is added to the galena-pyrite heads from the Wilfley tables, the mixture being sold to the lead smelters. The separation of the blende is due to the fact that it contains chemically combined

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[39] *Mining and Scientific Press*, Vol. LXXXV., (1902), p. 340.

[40] *Ibid.*, Vol. LXXXV., p. 126.

[41] *Engineering and Mining Journal*, Vol. LXXIV., (1902), p. 217.

ferrous sulphide which is susceptible to the intense effect of the magnets, while the galena and pyrite are not attracted. The capacity of the mill is from 40 to 45 tons of crude ore per day.

The Mechernich System of Magnetic Concentration.[42]—Hassreidter states that in separating blende and siderite in the Upper Harz a recovery of 98·7% of the zinc was obtained, the grains being 0·5-mm. size. With Silesian dolomitic blende of from 2 to 3-mm. size, the recovery was 91·8%, which was increased to 93·5% by reducing the size of the grains to 2 mm.

The Magnetic Separation of Zinc-Iron Sulphides.[43]—This subject is ably discussed by Guy H. Elmore.

Wenström Separators at Grängesberg, Sweden.[44]—Two of these machines treat 350 tons of magnetite ore per day, the one operating on 5 to 31-mm. size, and the other on coarser material up to about 100 mm.; the product is 200 tons of ore containing from 60 to 62% iron and from 0·7 to 0·8% phosphorus, 50 tons of fines containing from 58 to 60% iron and 0·8 to 0·9% phosphorus, and 100 tons of waste. In a few districts Monarch separators are in use.

Separating Lead, Zinc and Iron Sulphides at Rico, Colo.[45]—The ore is crushed and passed over Wilfley tables, to separate the lead and silica from the zinc and iron. The latter product is then passed through a magnetic separator to remove the iron which leaves a clean commercial product, carrying from 55 to 60% zinc. It is claimed that a sulphide carrying 20% zinc can be treated successfully, making three commercial products: a high-grade lead concentrate, an iron sulphide with practically no zinc, carrying silver, and a high-grade zinc product. The plant at Rico handles 60 tons per day, and the separated zinc ore is shipped to the Belgium spelter works. Another plant is to be installed at Leadville.

Frödings Magnetic Separator.[46]—This separator is practically a convex slime table with a series of underlying magnets extending around six-sevenths of the circumference. The magnetic particles adhere to the surface of the table, while the non-magnetic particles are washed off; the heads finally leave the table after passing the magnetic field. There are 12 magnets carrying 100 volts and 8 amperes. At Herräng a machine of this type treated 2 tons of 28% iron ore per hour, produced heads containing from 62 to 64% iron, and tailings carrying 8% iron, of which 0·5% is magnetic, the remainder being in the form of silicate. The results of concentrating unsized ore from Norberg containing 21% iron, were: heads 57% iron and tailings 6% iron.

OIL CONCENTRATION.

Experimental Results with the Elmore Process.[47]—The Elmore process of concentration of ores with oil is under experiment in London at a mill of a capacity of from 10 to 20 tons per day. A recent test on copper ore from

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[42] *Journal of the Society of Chemical Industry*, Sept. 30, (1902).

[43] *Mining Reporter*, Vol. XLVI., Dec. 18, (1902), p. 504.

[44] *Berg- und Huettenmaennische Zeitung*, Vol. LXI., (1902), p. 58.

[45] *Mining and Scientific Press*, Vol. LXXXIV., (1902), p. 74.

[46] *Oesterreichische Zeitschrift fuer Berg- und Huettenwesen*, Vol. L., (1902), p. 241.

[47] *Mining and Scientific Press*, Vol. LXXXIV., (1902), p. 230.

Copperopolis, Cal., which could not be concentrated by water, has been very successful, and on low-grade ore from Rossland, B. C., the process yielded concentrates of 6·08% copper as compared with 2·6% copper by water concentration; in addition the silver and gold contents were proportionately higher. The tailings showed a much higher recovery of metals with oil. Successful tests have also been made on Colorado silver ores in which gray copper and brittle silver mineral were disseminated through a gangue, partly of barite.

A 50-ton mill in Norway is in operation on ore consisting of copper and iron pyrite with gold in quartz. The ore is crushed by 15 stamps to 20-mesh size, and is passed to three McDermott "sizers," or submerged 30-mesh screens. The coarse discharge from the sizers is delivered to a Wilfley table, while the fines are treated on three 6-foot Frue vanners, the tailings from which pass through the oil process plant, consisting of two units, each of three mixing cylinders. The results at this plant have not been published at the time of writing; two 100-ton and one 50-ton mills are now being constructed for English copper mines.

Concentration results[48] on a 2·2% copper showed a loss by water concentration of from 30 to 58·6% owing to float mineral; while by the oil process the loss was only 7%.

Chas. M. Fassett[49] describes *experiments on a highly siliceous ore* carrying from 15 to 20 oz. silver per ton, a trace of gold, small quantities of antimony, copper and lead, and from 8 to 10% iron pyrite. It was possible by ordinary methods to save only from 20 to 25% of the values, because in crushing the hard gangue to 30-mesh size, the friable mineral is ground to an impalpable powder and is floated off. The oil process using a heavy petroleum residue, however concentrated the ore from 18·8 oz. to 169 oz. silver per ton, the quantity of concentrates produced amounting to 8·9 per cent.

COAL WASHING.

The Allard coal screening method[50] used in the vicinity of Charleroi and Mons, is based on the difference in the shape of the coal and the associated slate. Coal fragments are nearly always in cubes, while slate is generally flat. To insure more efficient separation Allard uses at the lower end of the ordinary screen, a series of wedge-shaped iron bars tapering along their length, the intervening spaces thereby becoming wider as the material to be screened is passed along. The swinging motion of the screen causes the flat pieces of slate to tip on edge and to fall through while the cubes of coal pass on. An ordinary screen beneath the bars separates any coal which may have passed through the bars. Both coal and slate dross are delivered to picking belts. At the Nord de Charleroi pit, an Allard screen driven by an 85-H.P. engine, treats 1,000 tons in 10 hours. Six classes of coal are obtained, and sorting on the picking belt is required only for lumps exceeding 2 in. in size. A similar 2,000-ton plant is being erected at the Grand Hornue Colliery in the Mons district. At another

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[48] *Mining and Scientific Press*, Vol. LXXXV., (1902), p. 207.

[49] *Ibid.*, Vol. LXXXIV., (1902), p. 348.

[50] *Colliery Guardian*, LXXXIV., (1902), p. 1898.

colliery an Allard screen is successfully used to remove 2% of dross left in the coal after washing.

The Maurice centrifugal coal washer[51] treating coal from a mine near St. Etienne, France, gave the following results: First operation, 2,852 tons, containing 30% residue (ash and slate), yielded 1,550 tons, containing 9% residue, and 1,302 tons containing 55% residue. Second operation, 1,302 tons containing 55% residue, yielded 525 tons containing 18% residue (coal for boilers), and 777 tons of slate, containing 20% of coal.

The Craig coal washer[52] was originally designed to treat gold-bearing sands, but is now doing good work on coal up to 1·5-in. size. Before feeding to the table, the coal is thoroughly mixed with water, and allowed to fall through openings to the tables or washer. The latter is Y shaped, and the coal is fed to it at the junction of the arms where the inclination is 1 in 6 (adjustable). The table, mounted on wheels on inclined rails, is actuated by a cam, the return stroke being taken up by springs which pull it to strike against a buffer. A 5-in. stroke is used at 60 r. p. m., both stroke and revolutions are adjustable. The coal is discharged by spouts at the base of the Y and the impurities at the arms. At Coanwood colliery a washer of this type reduced the quantity of ash from 11·51 to 4·80%. Smudge containing 25% dirt has been treated with a reduction by washing to 5 per cent.

The Campbell Coal-Washing Table[53] was used on coal which passed through bars set 0·75 in. apart; the proportion of sizes being through 0·75 in. and over 0·5 in., 27%; through 0·5 in. and over 0·3125 in. ($\frac{5}{16}$), 42%; and through 0·3125 in. ($\frac{5}{16}$), 31%. A test run of 1,500 tons yielded the following results:—
results:—

	Pounds.	Per Cent.	Sulphur.	Ash.
			%	%
Raw coal	3,166,024	100	1·910	5·810
Washed coal	2,970,429	93·9	0·857	4·800
Refuse	195,595	6·1	17·617	44·996

In the Baum washer at Gelsenkirchen,[54] about 53·5 tons of coal from 0 to 80 mm. (3¼ in.) in diameter are treated per hour, two machines dealing with the 0 to 10 mm. size, and one each for the sizes, 10 to 15 mm., 15 to 30 mm., 30 to 50 mm. and 50 to 80 mm.

At Bruay and Marles, France,[55] the sizes of coal handled varies from 15 to 25 mm., and contain from 16 to 20% ash; which is reduced to 8 or 9% after washing.

The Seitz portable coal loading and screening machine[56] is operated by steam. The machine is run to the edge of a coal pile, where by means of an automatic endless-chain, belt-raking device, the material is brought to upright buckets, and thence to the screens which are placed on both sides. This machine is recommended for use in reclaiming coal from culm banks, as it would yield a saving over the machinery now in use.

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[51] *American Manufacturer and Iron World*, Vol. LXX., (1902), p. 267.

[52] *Institution of Mining Engineers*, Vol. XXIII., p. 179. Wm. Scott.

[53] *Ibid.*, Vol. XXIII., p. 485. C R. Claghorn.

[54] *Colliery Guardian*, Vol. LXXXIV., (1902), p. 1717.

[55] *Ibid.*, Vol. LXXXIV., (1902), p. 1119.

[56] *Engineering and Mining Journal*, Vol. LXXIII., (1902), p. 767.

PROGRESS OF METALLOGRAPHY IN 1902.

BY WILLIAM CAMPBELL.

DURING the year 1902 the number of publications bearing directly or indirectly upon metallography shows a marked increase over that of past years. In the eighth edition of "The Microscope," Prof. S. H. Gage alludes to the microscopical examination and photomicrography of metallic surfaces. Macmillan & Co. has published a book on metallography, by A. H. Hiorns, which is severely criticised in the *Metallographist,* Vol. V., p. 342.

In the technical schools there has been great activity. At Harvard a new metallographic laboratory has been equipped. At Columbia University and the Massachusetts Institute of Technology, a great deal of work has been done, while at the School of Mines of the University of Missouri, McGill University, Michigan College of Mines, Worcester Polytechnic and many other institutions, metallographic equipment has been added to the laboratories.

Many industrial firms have added to their equipment or installed new outfits, notably the Pennsylvania Railroad Co., at Altoona, the Westinghouse Machine Co. of Pittsburg, the Crucible Steel Co. of America, at Syracuse, and others From an industrial point of view, metallography seems to be making giant strides forward, and in the near future every metallurgical laboratory will doubtless be equipped with an outfit for the microscopical examination of metals and alloys.

One of the most important publications during the year appears in the *Journal of the Iron and Steel Institute* (1902, I., 90), under the title of "The Nomenclature of Metallography." In view of the fact that, with the development of metallography, the nomencluture is becoming more and more involved, the Council of the Institute (at Mr. Stead's instigation) appointed a committee to consider the matter. A "Glossary of Terms" has been drawn up in the hope that it will tend to promote the unification of terms, the simplification of those used and the elimination of many of them. As far as possible the exact equivalents in French and German have been added. The glossary will prove of great value especially to those who are accustomed to read French and German papers in the original.

The Société d'Encouragement pour l'Industrie Nationale has published a volume entitled *"Contributions à l'Etude des Alliages."* In it will be found the results of researches undertaken by the Committee on Alloys of the Society. Many have been already published in the Bulletin and elsewhere. The volume contains sixteen articles, including the following ones of metallographic importance: On Microscopic Metallography, H. Le Chatelier; Microscopical Study of Metallic Alloys, G. Charpy; General Method for the Microscopic Analysis of Carbon Steel, F. Osmond. The various papers are beautifully illustrated.

THE CRYSTALLINE STRUCTURE OF METALS.

The Crystalline Structure of Platinum has been worked out by Andrews.[1] When a small ingot of pure platinum was polished and etched with boiling aqua regia, the crystalline structure developed appears to resemble that of gold and silver. Photographs were taken, and under a magnification of 360 diameters, primary and secondary crystals are seen resembling those found in lead, iron, etc. The size of the primaries varies from 0·002 to 0·04 in., and those of the secondaries from 0·0002 to 0·007 in.

The Microscopic Effects of Stress on Platinum, by T. Andrews and C. R. Andrews,[2] show results practically the same as those of Ewing and Rosenhain, published in their paper on "The Crystalline Structure of Metals." It was found that many of the large or primary crystals had developed innumerable fine slip bands in consequence of strain, and the results confirm the observations of Ewing and others that stress alone, without etching, sometimes renders the lines of intercrystalline junction visible, providing, of course, that the stress is of sufficient intensity.

The effect of strain in altering the structure of a metal, especially a soft one, is pointed out in a note on "The Crystallization Produced in Solid Metal by Pressure," by W. Campbell.[3] In the preparation of sections of soft metals and alloys it was found that particles are apt to cling to the file, and if allowed to remain they tend to tear the surface of the metal. The effect is not immediately noticeable, but on etching the polished surface there appear besides the usual structure of the metal lines of much smaller crystals with irregular boundaries, but possessing different orientation. If the tearing effect of the file has been extreme these crystals may blot out the initial crystallization produced by the original cooling. Fig. 1 (× 80 diameters, vertical illumination shows this structure produced in cast tin and the effect has been to blot out the structure due to casting. This action occurs also when a soft metal is cut with a saw and unless the metal thus modified is removed during subsequent treatment, this crystallization appears along with the original structure on etching. Fig. 2 (× 33 diameters, oblique illumination) shows a vertical section of slowly cooled tin. The large granular structure is due to the original cooling, but in addition there appears a much finer crystallization produced by the tearing effect of the saw. This effect is only on the surface however, for on regrinding and polishing carefully the large granular structure alone remains.

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[1] *Proceedings of the Royal Society of London*, 69, 433.

[2] *Ibid.*, 70; *Metallographist*, V., 286.

[3] *Metallographist*, V., 57.

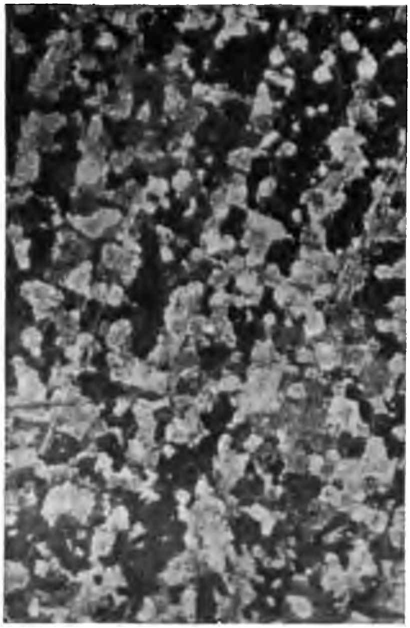

Fig. 1. (x 80 Diameters. Vertical Illumination.) Cast Tin Filed and Etched. Showing change in structure.

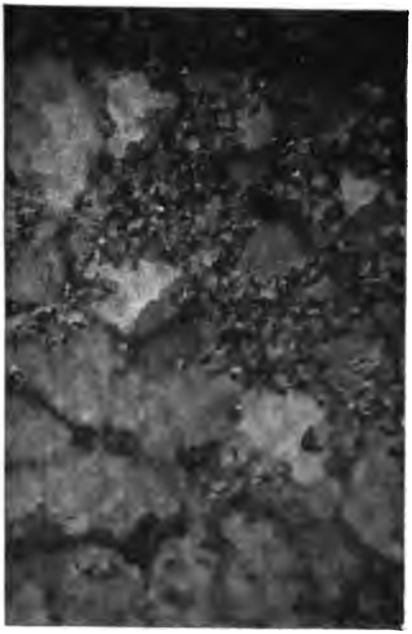

Fig. 2. (x 33 Diameters. Oblique Illumination.) Tin Slowly Cooled. Sawed and Etched. Showing change in structure.

Fig. 3. (x 35 Diameters. Vertical Illumination.) Dendrites on Surface of Aluminum.

Fig. 4. (x 33 Diameters. Vertical Illumination.) Dendrites on Surface of Platinum.

Fig. 5. (x 35 Diameters. Vertical Illumination.) Dendrites on Surface of Silver.

Fig. 6. (x 16 Diameters. Vertical Illumination.) Dendrites on Surface of Silver. Showing relation to crystallization.

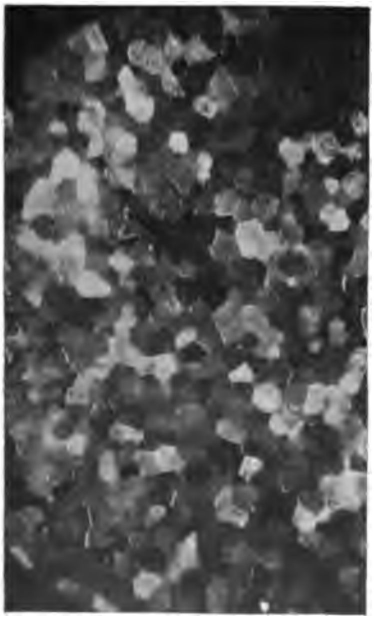

Fig. 7. (x 30 Diameters. Oblique Illumination.) Cadmium Cast in Iron Mold and Etched with Nitric Acid.

Fig. 8. (x 33 Diameters. Vertical Illumination.) Dendrites on Surface of Cadmium. (Same Ingot as Fig. 7.)

The crystalline growth of most metals is markedly shown when the surfaces of cast ingots are examined. Besides the ordinary granular or crystalline structure are often found dendritic growths which stand out above the surface of the ingot, because in the process of solidification, the mass contracts more or less, the molten part sinks and the growths are left standing out in relief. A trace of impurity in the metal often intensifies this effect. Fig. 3 (× 35 diameters, vertical illumination) shows the dendrites common to bars of aluminum. They consist of two axes or arms at right angles, and as a rule only one quadrant of the dendrite is fully developed. Fig. 4 (× 33 diameters, vertical illumination) shows the surface of a platinum bead with dendrites similar to those of aluminum. If a cupellation button of silver be examined, there can be seen in places huge dendritic crystals, whose complexity is shown under the microscope; they consist of two axes at right angles, usually equally developed. From each axis perpendicular spines grow out until they meet those of the next axis. These spines themselves have knobs, grains and spines growing perpendicularly from them, and therefore parallel to the axis to which they belong. The nearer the center of symmetry the smaller the structure. In Fig. 5 (× 35 diameter vertical illumination) is seen a small dendrite of a silver button. It will be noticed that the dendrite is really the skeleton of the grain or crystal, which almost covers the whole field. The relation of these crystals, which form the general structure of the silver, is seen in Fig. 6 (× 16 diameters, vertical illumination). The polygonal boundaries are very marked. Along with this there is the structure due to shrinkage during cooling. As a rule this structure (which may be compared with the columnar structure of basalt) coincides with the crystallization of the metal, but occasionally it takes a course of its own, and it is found taking a short cut across a crystal. On looking closely into the illustration the structure due to crystallization can be seen as distinctly finer boundaries, and the markings on the crystal faces (probably slip-lines set up by the strain) are seen to pass across the structure due to cooling.

Metals with a comparatively low melting point show very distinct structures, both when slowly cooled and when cast. Fig. 7 shows the base of a cadmium ingot cast in an iron mold (× 30 diameters, oblique illumination). The specimen has been etched with nitric acid. Fig. 8 (× 33 diameters, vertical illumination) shows the dendritic structure on the surface of the same ingot. The difference in size between the structure of the base and of the surface is due entirely to the difference in the rate of cooling. The dendrites of cadmium form six-rayed stars, showing a decidedly hexagonal symmetry. As in the case of silver, so here, it is seen that these dendrites are the skeletons of the grains or crystals enclosing them. This is shown in Fig. 9 (× 33 diameters, vertical illumination), which is the same surface deeply etched with nitric acid. The granular structure is markedly shown, with the dendrite in the center of the largest grain.

The development of slip-lines when a metal is strained beyond its elastic limit, so well demonstrated by Ewing and Rosenhain, is easily shown by slightly bending an ingot with a clean surface. Fig. 10 (× 30 diameters, vertical illumination) shows a surface of a cadmium ingot which has been thus strained. It has been etched with dilute nitric acid. The slip-lines can be seen, changing in direction as they pass from one grain to another, but in one grain parallel to some one or more constant directions.

Fig. 11 (× 70 diameters, vertical illumination) shows the dendritic structure found on the base of an ingot of bismuth. It is quite distinct from that of cadmium, being apparently built up of grains or crystals, with more or less plane faces. This is what is to be expected when the strongly crystalline structure of bismuth is remembered. If bismuth be strained, slip-lines and broad bands are produced. Fig. 12 (× 33 diameters, vertical illumination) shows a strained ingot of bismuth, etched with dilute hydrochloric acid. The broad lines produced seem to resemble the twinning of a plagioclase, and it would seem probable that the bands do represent a twinning of the bismuth. For on revolving the specimen through 90° the dark parts become light and the light areas dark. In other words the black bands are those parts of the grain whose orientation has been revolved through, say 90°, just as a crystal of calcite can be twinned with a sharp blow with a knife. In lead for instance, the usual appearance is that of fine lines, hence it may be judged that lead merely slips, but does not twin.

Fig. 13 (× 30 diameters, vertical illumination) shows the dendritic structure of tin cast on stone in which the junction of three dendrites is clearly illustrated. Fig. 14 is another view of the same surface (showing a finer dendritic growth in one of the grains) after straining. Broad slip bands have been produced even more markedly than in the case of bismuth.

If zinc is examined the same structures are found. Fig. 15 (× 30 diameters, oblique illumination) shows the base of a small zinc ingot cast in stone and etched. The coarse crystallization and the twin or slip bands have been brought out. Deep etching serves to reveal the cause of the difference in orientation of crystal grains, as has been pointed out by Stead. Fig. 16 (× 33 diameters, oblique illumination) shows tin cast on stone and etched with very dilute hydrochloric acid for a considerable time. The differential etching action has laid bare the upturned plates or secondary crystals which go to form each grain and as each set is differently oriented a difference in the reflection of light is obtained.

When strain on a metal is prolonged and great, the grains tend to split up, as Prof. Ewing has shown, and a finer crystallization takes the place of the old. Fig. 17 shows the structure of cast tin which has been hammered down to about 0·02 in. thick. Annealing causes a rearrangement and the tin tends to assume a coarser structure. Fig. 18 shows the same hammered tin after annealing below 180°C. for 15 hours. The difference between the two structures is striking.

The dendritic structure of lead is apparently much finer than that of zinc, tin, etc. Fig. 19 (× 33 diameters, vertical illumination) shows the base of lead cast on stone. The crystallization is extremely small and is developed more or less along parallel axes with shorter branches at right angles. All of these parallel axes belong to the same grain or crystal, as is seen when the specimen is etched or strained, as in Fig. 20 (× 33 diameters, vertical illumination). The fine structure is composed of two series of parallel slip-lines in marked contrast with the bands developed in bismuth, cadmium, zinc, etc.

If a grain of lead is etched deeply the secondary crystals are revealed, as in the case of iron, platinum, tin, etc. Fig. 21 (× 33 diameters, vertical illumination)

Fig. 9. (x 33 Diameters. Vertical Illumination.) Dendrites of Cadmium. Showing relation to crystallization.

Fig. 10. (x 30 Diameters. Vertical Illumination.) Slip Lines on Strained Cadmium Ingot.

Fig. 11. (x 70 Diameters. Vertical Illumination.) Dendrites on Surface of Bismuth.

Fig. 12. (x 33 Diameters. Vertical Illumination.) Slip Lines on Strained Bismuth.

Fig. 13. (x 30 Diameters. Vertical Illumination.) Dendritic Structure of Tin Cast on Stone.

Fig. 14. (x 30 Diameters. Vertical Illumination.) Another view of Fig. 13 after straining.

Fig. 15. (x 30 Diameters. Oblique Illumination.) Base of Small Ingot of Zinc Cast on Stone.

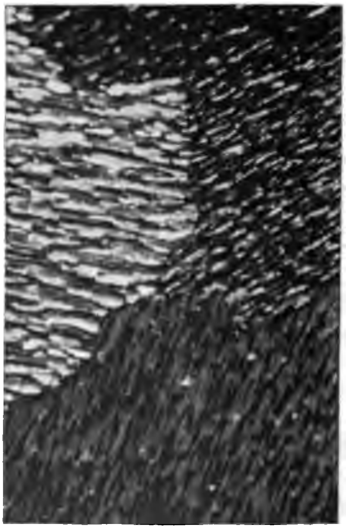

Fig. 16. (x 33 Diameters. Oblique Illumination.) Tin Cast on Stone and Etched.

shows a grain which has been etched with nitric acid. In it are seen numerous tetrahedra eaten out. They are all arranged in the same direction and it is noticed that on straining the specimen, the slip-lines are parallel to one of the sides of the tetrahedron. Further straining results in the production of three series of slip-lines parallel to the sides of the triangle and no more. The fourth possible one is parallel to the plane of the photograph. Hence there apparently exists an intimate relation between the secondary crystals and the slip-lines.

When zinc, tin, lead, etc., are rolled the same effect is obtained as that described in the hammering of tin (Figs. 17 and 18). Fig. 22 (× 33 diameters, oblique illumination) shows a strip of cadmium rolled out to about 0·075 in. thick. It was rolled from the bar shown in Figs. 9 and 10. The structure has been entirely destroyed and replaced by a much finer crystallization. Fig. 23 shows the same strip annealed at about 180°C. for seven days (× 33 diameters, oblique illumination) etched with dilute nitric acid. The growth of crystals is very marked.

The structure of electrolytically deposited metals varies greatly. Fig. 24 (× 33 diameters, oblique illumination) shows a section of a knob from a sheet of electrolytically deposited copper. The crystalline structure is very decided. In Fig. 25 (× 15 diameters, oblique illumination) are seen several crystals of electrolytic silver. In marked contrast with the above is Fig. 26 (× 15 diameters, oblique illumination), which shows a section through a knob of electro-nickel in which there is merely a concentric growth and no distinct crystal grains. Iron electrolytically deposited closely resembles nickel in appearance.

The Fracture of Metals under Repeated Alternations of Stress[4] has been studied by Ewing and Humfrey. Swedish iron was used for the experiment. A bar (0·3×0·1 in.) was taken and one of the surfaces was polished and etched; it was then subjected to reversals of stress by bending so that the polished surface was alternately extended and compressed. This was done by making the rod project from a revolving shaft with a load on the projecting end. As the process went on the rod was examined from time to time under the microscope. Slip-lines were developed and after many reversals they changed into comparatively wide bands. Finally some of the crystals cracked along the broadened bands and then a long continuous track was developed across the surface of the specimen. Fracture shortly followed.

IRON AND STEEL.

In the *Encyclopedia Britannica,* 1902, Prof. Howe discusses the constitution and thermal treatment of steel. He first describes the different microscopic entities which constitute the different varieties of iron, then by means of a temperature-composition or equilibrium curve, shows the position of each. Lastly he deals with thermal treatment, such as hardening, tempering and annealing of steel, the chilling and annealing of cast iron, etc. This article is remarkable for its clearness and quality and in a few pages is found a concise and clear summary of the present state of our knowledge of this important branch of metallography.

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[4] *Philosophical Transactions of the Royal Society of London,* 1903, A 1; *Metallographist,* VI., 96.

S. A. Houghton[5] has published a large paper with numerous photomicrographs on the Internal Structure of Iron and Steel, with special reference to defective material. The photographs deal with the several kinds of material, starting with mild steel boiler plate, medium steel, high-carbon steel, cast iron, pig iron and finally spiegeleisen.

The microstructure of hardened steel has been carefully worked out by Arnold and McWilliam.[6] Three specimens of steel were taken, unsaturated, saturated and supersaturated with carbon. Their critical points were first determined and then each was quenched at varying temperatures. The paper contains numerous excellent photographs and comes to the following summary:—

1. That the clear and definite constituents of hardened steel consist of (*a*) Hardenite ($Fe_{24}C$), of which the whole mass consists only in the case of 0·89% carbon steel.

(*b*) Ferrite, Fe, which segregates more or less in unsaturated carbon steel in spite of the rapid action of quenching.

(*c*) Cementite, Fe_3C, which segregates more or less in supersaturated steels in spite of the rapid action of quenching.

The indefinite portions of hardened steels consist in unsaturated carbon steels of Hardenite containing more or less unsegregated ferrite, or in supersaturated carbon steels of hardenite containing more or less unsegregated cementite.

2. Martensite is not a constituent but a crystalline structure developed at high temperatures. It is marked in saturated carbon steels by preferential etching lines, in unsaturated carbon steels by striæ of ferrite, and in supersaturated carbon steels by striæ of cementite.

3. The existence of constituents sorbite, troostite and austenite is extremely doubtful.

The paper called forth a great deal of discussion, especially on the alleged constituents, sorbite, troostite and austenite.

In a paper on the Overheating of Mild Steel[7] by Prof. Heyn the changes of a purely physical effect unaccompanied by chemical change are discussed. The paper contains the results of many physical tests and shows that when low carbon mild steel is annealed at temperatures above 1,000°C. there occurs an increase in the degree of brittleness if the annealing period is sufficiently long. Prolonged annealing at temperatures between 700° and 890°C. produces no increase in brittleness. By suitably annealing, the brittleness of overheated low-carbon mild steels can be eliminated. If annealing is carried on at about 900°C. a short period of about half an hour is sufficient, while by annealing for several days at temperatures between 700° and 850°C. this object can be obtained.

The Effect of Reheating upon the Coarse Structure of Overheated Steel[8] has been worked out by Mr. Goransson for a steel containing 1·2% C. His experiments show that refining occurs when the steel reaches a point where all the cementite is redissolved by the martensite and this occurs where the reheating has

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[5] *Institute of Marine Engineers*, April 21, 1902; *Mechanical Engineer*, IX., 617.

[6] *Journal of the Iron and Steel Institute*, 1902, I., p. 120.

[7] *Ibid.*, 1902, II., p. 73.

[8] *Jernkontorets Annaler*, LVII., p. 170; *Transactions of the American Institute of Mining Engineers*, 1902

Fig. 17. Structure of Cast Tin Hammered to a Thinness of 0.02 in.

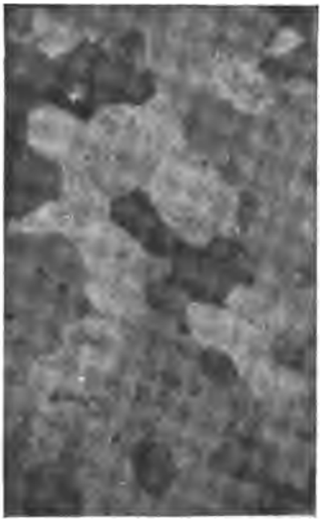

Fig. 18. Same as Fig. 17 after annealing below 180° F. for 15 hours.

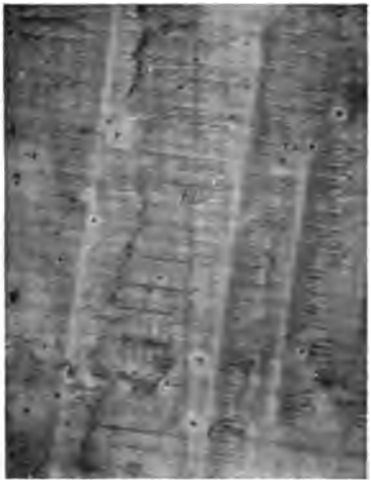

Fig. 19. (x 33 Diameters. Vertical Illumination.) Dendritic Structure of Lead Cast on Stone.

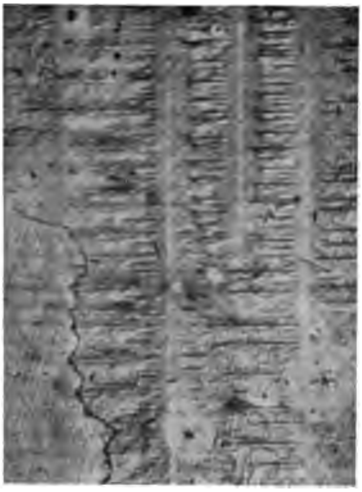

Fig. 20. (x 33 Diameters. Vertical Illumination.) Same as Fig. 19 after straining.

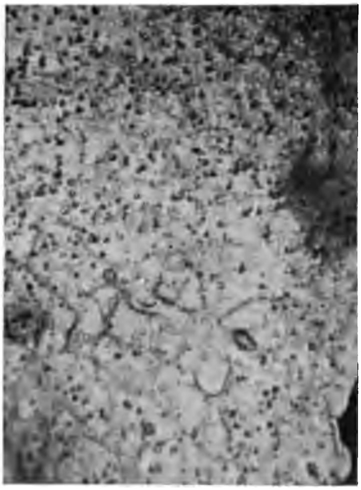

Fig. 21. (x 33 Diameters. Vertical Illumination.) Lead Etched with Nitric Acid.

Fig. 22. (x 33 Diameters. Oblique Illumination.) Strip of Cadmium Rolled to 0.075 in. in Thinness.

Fig. 23. (x 33 Diameters. Oblique Illumination.) Same as Fig. 22 after annealing at 180° C. for seven days.

Fig. 24. (x 33 Diameters. Oblique Illumination.) Section of Knob from Electrolytic Copper.

reached some 887°C., in other words refining occurs above $Ac_{2\text{-}3}$. It would seem that for most steels the refining temperature was $Ac_{2\text{-}3}$ and not Ac_1.

Several papers upon steel rails have appeared. R. Job in a paper on "Steel Rails: Relations between Structure and Durability,"[9] points out that specifying chemical composition alone ensures neither a durable rail nor often a bad rail. Structure played a considerable part. Defective rails were either of a coarse regular granular structure or contained an excess of foreign matter, such as oxides, slag, etc. Good rails of the same composition in general were of a fine interlocking, broken-up granular form with relative freedom from foreign matter. Numerous microphotographs illustrate the paper.

Sauveur discussed the Structure and Finishing Temperature of Steel Rails at the fifth annual meeting of the American Section of the International Association for Testing Materials, June, 1902. The paper appeared in THE MINERAL INDUSTRY, Vol. X.

Mr. S. S. Martin has published several papers on the structure of steel rails. In the *Metallographist,* Vol. V. (p. 245, *et seq.*), he gives some excellent microphotographs to illustrate the striking manner in which the sawing operation influences the structure of the metal in immediate contact with the saw. Specimens were hot sawed and cold sawed. The former had a much finer structure than the normal rail, while the cold sawed surface is, if anything, coarser. On removing 0·07 in. of metal the normal structure was obtained. The very great difference between the two structures can be readily accounted for. Upon leaving the finishing rolls the temperature of the rail (at least the center of the head) was still well above the critical point. On slow cooling the metal crystallized, giving the normal structure. Hot sawing of the rail means that the metal in contact with the saw did not cool undisturbedly, but work was continued and a fine structure was thereby obtained.

Quoting from another paper by Mr. Martin:[10] "To obtain a non-granular structure throughout the rail the temperature must be reduced earlier in the rolling—in fact, the bar or bloom must not be reheated, but should be rolled direct from the ingot. In the latter case the bloom will be delivered to the rail rolls at a temperature of 850°C., while a reheated bloom will be delivered at 1,000°C. or more. I want to emphasize the fact that while the rail is held before the final pass, at a temperature above the critical point, it crystallizes, and the single pass which it subsequently receives is incapable of breaking up the granular structure for more than a certain depth. This practice of direct rolling has been carried on for years in some mills in this country, and in almost all mills abroad."

Mr. P. H. Dudley, in a report to the New York Central & Hudson River Railroad Co.,[11] deals at length with the Rolling and Structure of Steel Rails. Fourteen excellent photographs illustrate the paper.

Nickel steel is discussed in *The Railroad Gazette,* Aug. 8, 1902. The article is illustrated by numerous photographs, which contrast the structures of carbon and nickel steels which have undergone the same treatment. Leon Guillet has

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[9] *Journal of the Franklin Institute,* 1902.

[10] *Iron Age.* Dec. 26, 1901, p. 4.

[11] *Metallographist,* V I., p. 8.

studied the Microstructure of Nickel Steels[12] with special reference to certain treatments.

Mathews,[13] in a paper entitled "A Comparative Study of Some Low Carbon Steel Alloys," has worked upon several alloys of iron with nickel, chromium and molybdenum. He first gives the results of testing both the annealed and unannealed specimens, then he discusses the microscopical examination with 24 photomicrographs, while the latter part of his paper is devoted to the electrical conductivity. For this work he was awarded the Carnegie gold medal by the Iron and Steel Institute.

Charpy and Grenet, in their paper on "The Equilibrium of Iron-Carbon Systems,"[14] come to the following conclusions:—

1. The separation of graphite begins at a temperature which is lower the greater the percentage of silicon.

2. The separation of graphite once begun continues at temperatures lower than those at which it begins.

3. At constant temperature the separation of graphite is effected progressively more visibly as the temperature is lowered and the amount of silicon is less.

4. The amount of combined carbon which corresponds to the equilibrium at a given temperature diminishes when the amount of silicon increases.

5. The amount of combined carbon which corresponds to the equilibrium diminishes as the temperature decreases. They studied a large number of samples of iron of varying compositions, and their results are based upon chemical analyses and microscopic examination. Several excellent microphotographs are shown.

In a paper read before the American Society for Testing Materials, Prof. Howe discusses the Constitution of Cast Iron.[15] This enlarges upon the views set forth in the *Transactions of the American Institute of Mining Engineers*, Vol. XXXI.

Prof. Arnold, writing on the "Properties of Steel Castings,"[16] states that his experiments show that pure iron and carbon steel is not suitable material for fulfilling the modern specifications drafted by engineers for steel castings. Ductility and tenacity do not accompany each other. The paper is but the first of a series to determine among other things the influence of chemical composition and of annealing as the mechanical properties and microstructures of steel castings. The paper is of great interest, for it summarizes the microstructure of material varying from 0·07 to 1·95% C.

W. M. Carr, in a paper on "The Annealing of Steel Casting,"[17] illustrates three types of steel (of same composition) by three photographs. The first, unannealed steel, shows coarse banded crystallization. The second is properly annealed steel, whose structure is very, very minute, while the third is over-annealed steel, showing the coarse crystalline structure once more.

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[12] *Comptes rendus*, 1903, 136. p. 502.

[13] *Journal of the Iron and Steel Institute*, 1902, I., p. 182.

[14] *Bulletin de la Société d'Encouragement*, March, 1902.

[15] *Proceedings of the American Society for Testing Materials*. II., p. 246, 1902.

[16] *Journal of the Iron and Steel Institute*, 1901, I., p. 175; *Metallographist*. V., p. 2.

[17] *Foundry*, October, 1901.

ALLOYS.

In the *Metallographist*, April, 1902, is a reprint of Mr. Stead's excellent paper on "Metallic Alloys."[18] After discussing the various constituents of alloys, he deals with the different methods employed for studying the constitution and properties of alloys. At the end of the paper he gives two excellent alloy charts for representing the structural, constitutional and physical properties of alloys. The paper is well worth the reading, and, like all of Mr. Stead's work, is absolutely clear and lucid.

Another paper by Mr. Stead deals with the "Alloys of Copper and Iron."[19] The microchemical results obtained are:—

1. Copper and iron alloy in every proportion by direct fusion, and in none of the alloys is there any tendency for metals to separate into two conjugate liquid layers.

2. The complete series of alloys may be classified into three distinct sections:—

A. Alloys with traces to 2·73% Fe and 97·2% Cu.

B. Alloys between 2·73 and 92% Fe.

C. Alloys containing between 8% and traces of Cu.

Class A consists of isomorphous crystal grains of iron and copper. They all have the appearance of pure copper.

Class B. As soon as 2·73% Fe is exceeded the cold alloys are found to contain a separate constituent consisting at first of six-rayed crystallites of a constituent rich in iron. As 10% Fe is approached these crystallites change their form and assume the dendritic or cruciform character of octahedral skeletons. As the percentage of iron is further increased, these crystallites also increase and eventually mutually interfere and assume the form of rounded crystal grains surrounded by envelopes of copper containing 2·73% Fe in solution. These envelopes disappear at 8% Cu, and from this onwards, the alloys belong to Class C, which consist of crystal grains of iron holding up to 8% Cu in solid solution.

The second part of the paper deals with the influence of carbon on copper-iron alloys. When carbon is present, it limits the quantity of copper which can be alloyed with iron, for alloys with about equal parts of copper and iron, which do not separate into two conjugate liquid layers before solidification, when remelted at a white heat on charcoal, absorb carbon. This causes them to separate into two liquid layers, one containing about 2% C and 10% Cu, the heavier about 10% Fe and 0·08% C. This accounts for the somewhat conflicting statements of the authorities in our text-books, for they may not have taken into account the effect of carbon in preventing the alloying of copper with iron.

ANTIMONY AND TELLURIUM.—These alloys have been studied by Fay and Ashley,[20] who have worked out the cooling curves for the series. This shows the alloys to consist of two groups. Group A. Alloys consisting of solid solutions of antimony and antimony-telluride Sb_2Te_3, or from 100 to 39% of antimony.

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[18] *Cleveland Institution of Engineers*, December, 1900; *Metallographist*, V., 110.

[19] *Journal of the Iron and Steel Institute*, 1901, II., p. 104.

[20] *American Chemical Journal*, 1902, 27, p. 95.

Group B. Simple alloys of Sb_2Te_3, and tellurium having a eutectic alloy 87% tellurium melting at 421°C.

LEAD AND TELLURIUM.—Fay and Gillson[20a] have determined the cooling curves, which together with the microstructure show these alloys to be divisible into:—

A. 100 to 64% Pb. Consisting of lead-telluride (PbTe) surrounded by decreasing amounts of lead.

B. 64% Pb to pure tellurium, consisting of simple alloys of PbTe and tellurium with a eutectic point at 21·5% lead, freezing at 400°C.

LEAD, TIN AND BISMUTH.—E. S. Shepherd[21] has discussed these alloys very carefully from all sides. He gives a careful summary of the previous work, and then attacks the tenary alloys from the point of view of the phase rule, and shows that no compounds are formed, but that tin crystallizes out pure (often in an unstable denser form), whereas lead and bismuth form two series of solid solutions.

COPPER AND TIN.—An appendix to the *Reports of the Alloys Research Committee of the Institution of Mechanical Engineers,* England, has appeared, entitled the "Microscopical Examination of the Alloys of Copper and Tin." It is illustrated by 140 figures. One of the best papers as yet published on these or any other alloys is by Heycock and Neville, on the Constitution of Copper-Tin alloys.[22] In their wonderful diagram they have taken advantage of Rooseboom's theory of solid solutions, and are able to explain the whole series of alloys through all ranges of temperature and composition. Their work is based on evidence of microstructure and cooling curves, and is a monument of painstaking and care.

ALUMINUM ALLOYS.—Leon Guillet[23] has isolated a number of compounds of aluminum with iron, manganese, copper, tin, tungsten, molybdenum, etc., by heating the oxides with granulated aluminum and treating the products with acids. Brunck[24] has isolated other aluminum compounds in a similar manner. In the copper-aluminum series of alloys there are three distinct compounds according to Guillet. They are Cu_3Al, CuAl and $CuAl_2$. Leverrier found Cu_3Al and Cu_3Al_2 to be the compounds at the copper end of the series, while Le Chatelier was able to separate a diffusion alloy into five distinct zones. At the top came crystallites and dendrites of aluminum in a eutectic of Al and Al_2Cu. Next came cubic crystals of Al_2Cu in the same eutectic. Below this, crystals probably of AlCu are found in a ground mass of Al_2Cu. Then followed similar crystals in a eutectic alloy, whose structure can be seen under high magnification. At the base came crystals of $AlCu_3$ passing down into dendrites of copper.

The copper end of the series is very interesting, for in it is found the aluminum bronze series. It is remarkable, for there are several changes in the solid similar to those found in the copper-tin alloys and in the steels. These changes can be very simply demonstrated by means of a diffusion alloy, ranging from about 80% to 90% Cu. Two alloys, containing 80 and 90% copper respectively, were made, and the former was carefully poured onto the latter, and the whole allowed to cool.

[20a] *American Chemical Journal*, 1902, 27, p. 81.

[21] *Journal of Physical Chemistry*, 1902, 6, 519.

[22] *Proceedings of the Royal Society of London*, 1902, 69, 320.

[23] *Comptes rendus*, 132, pp. 1112 and 1322; 133, pp. 684 and 935; 134, p. 236.

[24] *Berichte*, 1901, 34, p. 2733.

Fig. 25. (x 15 Diameters. Oblique Illumination.) Crystals of Electrolytic Silver.

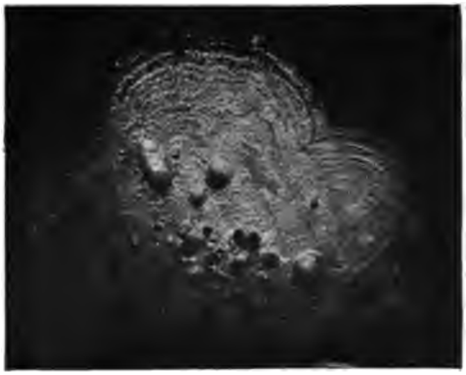

Fig. 26. (x 15 Diameters. Oblique Illumination.) Section of Knob of Electrolytic Nickel.

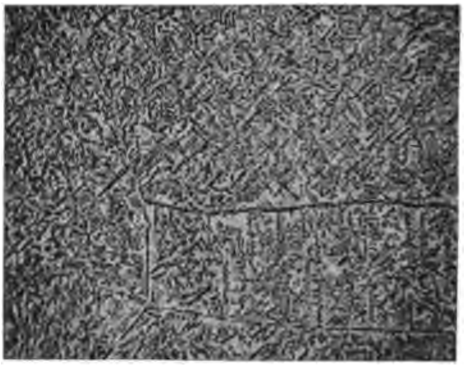

Fig. 27. (x 35 Diameters. Vertical Illumination.) Polished Section near top of Cu-Al Alloy.

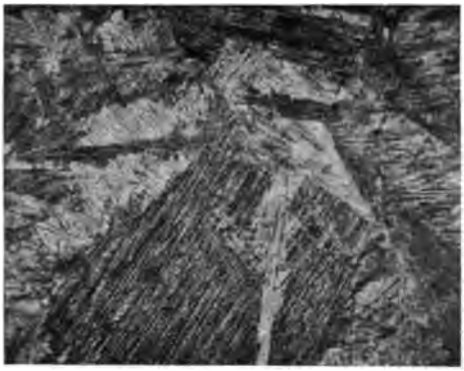

Fig. 28. (x 35 Diameters. Vertical Illumination.) Same as Fig. 27 after quenching.

Fig. 29. (x 35 Diameters. Vertical Illumination.) Polished Section near top of Cu-Al Alloy, after being heated, quenched, reheated, and slowly cooled.

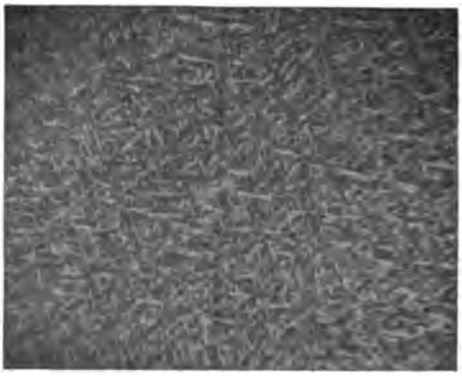

Fig. 30. (x 200 Diameters. Vertical Illumination.) Polished section near center of Cu-Al Alloy.

Figs. 31, 32 and 33 have been reduced to thirteen-fifteenths of original size.

Fig. 31. (x 35 Diameters. Vertical Illumination.) Polished Section near center of Cu-Al Alloy. Shows new structure.

Fig. 32. (x 35 Diameters. Vertical Illumination.) Same treatment as Fig. 29, but lower down in Cu-Al Alloy.

Fig. 33. (x 35 Diameters. Vertical Illumination.) Polished Section near base of Cu-Al Alloy. Shows dendrites.

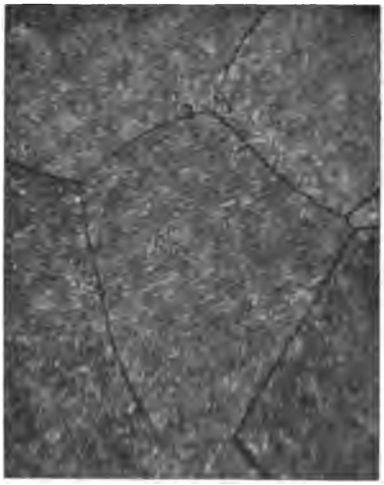

Fig. 34. (x 35 Diameters. Vertical Illumination.) Polished Section near base of Cu-Al Alloy. Shows granular structure.

Fig. 35. (x 35 Diameters. Vertical Illumination.) Polished Section near base of Cu-Al Alloy, corresponding to Figs. 33 and 34.

Diffusion took place, and the series from about 80% to 90% Cu was obtained. A vertical section was cut and polished. At the top of the alloy large grains were seen, and these were found to be composed of darkly etching crystals set in an increasing matrix progressing down the section. Fig. 27 (× 35 diameters, vertical illumination) is a view near the top of the alloy and shows small black dendrites set in a bright matrix. The boundaries of the grains are made up of the same black material, which may be AlCu or Al_2Cu_3. Passing down the alloy it is observed that these black dendrites disappear, the whole field being composed of the bright matrix. Under high powers this is seen to resemble a eutectic as seen in Fig. 30 (× 200 diameters, vertical illumination). On passing down the alloy, bright whitish yellow dendrites make their appearance, and these have been isolated by Le Chatelier and found to be $AlCu_3$. Fig. 33 (× 35 diameters, vertical illumination) is a view from near the base of the alloy and shows the dendrites set in the matrix or eutectic.

Now if the alloy be reheated to a dull red and quenched, its former structure disappears and a new one is obtained in its place, just as in quenched steel, martensite is formed by the change of pearlite and ferrite or cementite. Fig. 28 (× 35 diameters, vertical illumination) shows the structure of the quenched alloy and corresponds to Fig. 27. A peculiar striated or chevron-like structure is seen, which resembles martensite very closely.

Fig. 31 (× 35 diameters, vertical illumination) is a view of the center of the alloy, and shows the new structure of what formerly was the eutectic. The structure is similar to Fig. 28, but is coarser.

In Fig. 34 (× 35 diameters, vertical illumination) is the view near the base corresponding to Fig. 33 of the slowly cooled alloy. The structure is granular, each grain being composed of fine parallel striæ in various groups. On heating to higher temperatures and quenching, the grain boundaries become less distinct, but the striated appearance becomes as marked as in Figs. 31 or 28.

If the alloy is reheated to a dull red once more and allowed to cool in the air, it is found that the structure has almost returned to the normal. Fig. 29 (× 35 diameters, vertical illumination) shows a view near the top of the alloy. Large grains are seen as in Fig. 27, and these are made up of dark dendrites set in a lighter matrix. These dark grains disappear as we pass down the alloy, and in Fig. 32 (× 35 diameters, vertical illumination) is seen the structure of what was the eutectic. It has not returned to the original form, but it shows a marked change from Fig. 31. Passing down the alloy, bright dendrites of $AlCu_3$ make their appearance. Fig. 35 (× 35 diameters, vertical illumination) shows a view near the base corresponding to Figs. 34 and 33.

The reheating was done in a Bunsen flame for a few minutes. A second sample of the alloy which had been quenched was annealed at a dull red for under half an hour; on examination its structure was found to be almost identical with that of the original slowly cooled alloy.

Figs. 27, 28 and 29 are from near the top of the alloy, Figs. 30, 31 and 32 from the center, while Figs. 33, 34 and 35 are near the base.

That a great change takes place on reheating is abundantly proved by the above examples. It seems probable that at temperatures above a dull red the alloys of copper and aluminum (between 80 and 90% Cu) exist as homogeneous solid solutions like those of the copper-tin series between 61·8 and 75% Cu, or like martensite. On cooling they rearrange themselves in the solid; when the cooling curves for this series have been worked out like those of copper and tin by Heycock and Neville and Roberts-Austen, an explanation of these changes in the solid will be obtained.

It is becoming more and more recognized that metallography and pyrometry must be used together, and the theory of solid solutions of Bakhuis Roozeboom is throwing light upon very many problems, which up to now have defied all efforts to unravel them. At last the nature of an alloy is beginning to be understood.

ALLOY STEELS.

By John Alexander Mathews.

Steel itself is an alloy, and a very complex one, but the term alloy-steel has acquired a special significance, meaning any steel to which, in addition to iron and carbon and the impurities common to all steel, other metals or metalloids have been added purposely to change or improve its natural properties. Pure iron may properly be classed among the "rare metals"; thousands of tons of iron alloyed with impurities from a fraction of 1% upward are produced annually, but not a pound of iron in its pure, elemental condition has ever been made under ordinary smelting conditions. By "pure" we mean in a condition comparable with that in which the precious metals are produced, or as pure as the best electrolytic copper or nickel. I have never seen more than a few grams of iron which might properly be called pure. This metal was made by the late Sir William Roberts-Austen and used by him in determining the critical points of iron; its chief impurity was hydrogen. According to information given privately an electrolytic process for the production of iron is nearly perfected, by which the pure metal may be obtained as readily as copper by electrolysis.

In cooling pure iron from a molten condition, Roberts-Austen[1] found that its freezing point is about 1,600°C. All of its alloys with carbon up to 4·3% melt at increasingly lower temperatures down to 1,130°C. Below the initial solidifying point of pure iron there are two other temperatures at which cooling momentarily stops. These temperatures are 895°C., designated as Ar$_3$, and 765°C., designated as Ar$_2$. When carbon is present a third very well marked arrest of cooling occurs at 690°C., known as Ar$_1$, the ordinary "recalescence point."

It is believed by many that the molecular transformations occurring at Ar$_3$ and Ar$_2$ indicate allotropic changes in the iron itself. At temperatures above Ar$_3$ we recognize the γ-iron of Osmond, non-magnetic and a solvent for both elemental carbon and iron carbide. Between Ar$_3$ and Ar$_2$, iron exists in the condition designated as β-iron, also non-magnetic, but not a solvent for free or combined carbon. Below Ar$_2$ iron exists in its magnetic condition, known as α-iron, in which iron carbide is not dissolved or only slightly.

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[1] Fifth Report of Alloys Research Committee of Institute of Mechanical Engineers, 1899.

There are many who do not accept the allotropic theory; but whatever significance these critical points may have, all concede that they do occur, and that at certain critical temperatures the character of iron undergoes profound changes. Those who do not admit the allotropy of iron neither dispute the allotropy of carbon nor its occurrence in commercial iron in at least two conditions—free, as graphite, and combined, as iron carbide, and it is generally supposed that this combined carbon may exist in steel either in isolated particles or in a dissolved state. By means of these hypotheses or facts in regard to iron and carbon, we can explain many things which were but recently veiled in mystery and speculation. For this knowledge of the constitution of steel we are indebted to many of the world's ablest chemists and physicists. In the following discussion it is assumed that the reader is acquainted with the principal ideas concerning the constitution of alloys in general, and of steel in particular; but further information will be found in my article on "Alloys as Solutions," in THE MINERAL INDUSTRY, Vol. X., and in Prof. Albert Sauveur's contributions to recent volumes of this work.

Just as pure iron is a chemical curiosity, so also is an alloy containing only carbon and iron. In practice at least four other solid elements occur fortuitously in all steels, *viz.*, manganese, silicon, sulphur and phosphorus. The two elements first mentioned occurring in tenths of 1%, while sulphur and phosphorus, when present in quantities of a few hundredths of 1%, must be reckoned with in their influence upon the general properties of the steel. As yet there are no laws or generalizations relating to such complex alloys as those of six constituents; indeed little is known about ternary alloys.

In general it may be said that the influence of other elements upon iron-carbon alloys is (1) to change the temperatures of the critical points, (2) to modify the condition in which the carbon occurs, (3) to remove harmful occluded gaseous impurities, (4) to combine chemically with the iron or carbon, or both, and (5) either combined or free to form isomorphous solutions with the iron or to separate into distinct microscopic particles. In thus deporting themselves these other elements are found to improve or injure the steel; to make it harder or stronger; more ductile or more brittle; a better magnet or a better tool. The effects of these additions have been the subject of long and careful study, but the exact manner in which the added elements influence the iron-carbon system so as to produce new and useful properties in steel is not so well understood. These deeper questions are being studied by a host of able investigators, and every day new truths are discovered, which, it is hoped, will soon form a basis for rational and intelligent experimentation in revealing the hidden possibilities of the iron alloys.

In the following pages the subject will be taken up under three different heads: (1) The chemical constitution of steel alloys. (2) Some late discoveries of general theoretical interest and of practical value, and (3) the specific properties conferred upon iron-carbon alloys by other elements, considered both scientifically and practically.

THE CHEMICAL CONSTITUTION OF STEEL ALLOYS.—A number of important researches have been published recently which throw light upon the chemical behavior of the elements in steel and of the chemical compounds which steel contains. Iron and carbon are known to combine at least in one combination, Fe_3C, and many other carbides of doubtful existence have been mentioned from time to time. Eight of these have been found in the literature, but *not* in the steel. The probable existence of a new carbide of iron has been made known recently by E. D. Campbell and M. B. Kennedy,[2] who decomposed white iron by electrolysis and obtained residues in which the carbon percentage was higher than that required by the formula, Fe_3C (cementite), and the residues are believed by them to consist of a mixture of Fe_3C and Fe_2C.

Manganese seems to form an isomorphous solution with iron, and lowers the critical points. When over 12% Mn is present the temperature of transformation known as Ar_1 is below 0°C. Manganese prevents the separation of graphite, and thus raises the saturation point of iron for carbon. In its direct chemical affinities it seems to unite readily with several elements; it forms a carbide, Mn_3C, analogous to cementite, and it unites with phosphorus giving a phosphide, Mn_3P_2.

Phosphorus unites also with iron to form the phosphide, Fe_3P. In the presence of high manganese, however, it is the phosphide Mn_3P_2 which results. Not all of the phosphorus is combined in these forms, but it seems to exist in an evenly disseminated condition through the steel and is liberated as hydrogen phosphide when the steel is dissolved in weak acids. The phosphide phosphorus, however, generally separates out in nodules, sometimes also forming a eutectic alloy, as shown by Stead. In this latter condition it is least harmful toward the mechanical properties, which explains the fact that high manganese counteracts the deleterious effects of phosphorus, for manganese takes up just twice as much phosphorus as iron does to form its phosphide. A practical application of this has been made recently in a patented alloy, the characteristics of which are high phosphorus and manganese.

Silicon never occurs free in iron or steel. Carnot and Goutal[3] have isolated several iron silicides from steels and ferrosilicons. A magnetic silicide, Fe_2Si, was derived from the latter source, and a silico-spiegel gave a mixed iron and manganese silicide $(FeMn)_3Si$. They state that iron may contain both FeSi and Fe_2Si, and Moissan has prepared both of these silicides artificially.

Sulphur occurs in steel generally as manganous or ferrous sulphide, MnS or FeS; but there may be present small amounts of copper, titanium or other sulphides, and these latter are not decomposed by hydrochloric acid in the usual evolution methods for determining sulphur in steel. Of the sulphur liberated, not all exists in the form of hydrogen sulphide, but, as shown by Schulte and Phillips, a portion is liberated as methyl sulphide $(CH_3)_2S$.

Chromium occurs both dissolved in the main mass of the iron and also combined in the form of various double iron-chromium carbides, which are not easily attacked by acids. Behrens and Van Linge isolated two of these from ferrochromium, Cr_3FeC_2 and $Cr_2Fe_7C_3$. Carnot and Goutal isolated a sub-

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[2] *Journal of the Iron and Steel Institute*, 1902, Vol. II., p. 288.

[3] *Annales des Mines*, October, 1900, and *The Metallographist*, IV., p. 286.

stance whose formula may be represented as $Fe_3Cr_9C_7$ (or $Fe_3C.3Cr_3C_2$). In low chromium steel, they found a carbide of composition, $3Fe_3C.Cr_2C_3$.

Tungsten combines directly with iron, forming Fe_2W, according to Behrens and Van Linge, or Fe_5W, according to Carnot and Goutal.

Molybdenum forms a compound with iron, Fe_3Mo_2, isolated by Carnot and Goutal.

Nickel forms isomorphous mixtures with iron in all proportions. Copper is dissolved in large quantities by iron without the formation of any compounds. Manganese in excess above that uniting with phosphorus and sulphur behaves like nickel; titanium in excess is believed to act similarly, but it is reasonable to expect that it would unite with both sulphur and nitrogen if they were present in the steel. Arsenic exists free in steel, and according to Stead has no bad effects upon structural steel in amounts below 0·15%. In hardened steel the arsenide of iron occurs. All commercial irons and steels contain small quantities of oxygen, hydrogen and nitrogen, and perhaps cyanides.

RECENTLY OBSERVED GENERAL PROPERTIES OF IRON ALLOYS.—*Segregation in Steel Alloys.*—Having considered briefly the chemical combinations likely to be met with in steel, it may be well to study the effects of these upon the steel as modified by heat treatment. In general the various constituents of the steels are expected to be uniformly distributed either in solution in the main mass of the iron or separate from it in minute particles microscopically discernible when the steel is suitably prepared by polishing, etching, staining or heat-tinting. When a steel is allowed to cool slowly without disturbance, the constituents may and do separate out into more or less distinctly recognizable components. When an element is added to steel in amounts beyond the solubility limit of iron for that element, eutectic alloys are likely to be found. The effects of annealing at various heats upon alloy steels have been studied by John E. Stead,[4] who, in observing the effect of such treatment upon eutectics, made a very important and extremely valuable discovery. In studying iron and phosphorus alloys, he observed that at temperatures below but near the eutectic temperature, the two constituents of the eutectic were capable of migrating. This comes as a great surprise to those who believe eutectics to be of unalterable composition. In this connection, it may be mentioned, however, that Mr. Göransson[5] discovered rings of cementite in steel "soaked" for two hours at a heat "just below Ar_1," which he thought was due to a "flow" of the cementite, although the heat was not great enough to change the laminations of pearlite. Upon further studying the migration of the constituents of eutectics, Mr. Stead found that large crystalline masses in solids have an attractive force for smaller particles of the same kind, and under suitable conditions draw the latter to themselves. If the alloy consists of the eutectic mixture, there is no tendency toward segregation; but active segregation occurs when the eutectic exists in isolated patches surrounded by large masses of one of the constituents. Under such conditions both constituents of the eutectic draw together and cease to be eutectic in character. This is true for pearlite as well as for real eutectics formed

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[4] *Journal of the Society of Chemical Industry*, Vol. XXII., p. 340, 1903.

[5] *The Metallographist*, July, 1902, p. 216.

at the moment of final solidification. The zone of temperature immediately below the recalescence point is that in which segregation is most marked; it is also the zone in which the maximum softening effect is produced by annealing, and in which the minimum elastic limit is obtained. These discoveries by Mr. Stead are of the utmost practical importance in annealing mild steel.

Electrical Conductivity of Steel Alloys.—During the past year Prof. Barrett,[6-7] of Dublin; Dr. Benedicks,[8] of Upsala, Sweden, and myself[9-10] observed independently and at about the same time, that there was a connection between the resistance offered by steel wires to electric conduction and the atomic weight of the elements present in the iron. This again calls attention to the close relation existing between alloys and ordinary solutions. I simply predicted from a study of the work of Barrett, Brown and Hadfield, Le Chatelier, and Matthiessen, supplementing my own measurements that a law would be found connecting the specific resistance of the alloy with the atomic weight of the metals added to iron. Prof. Barrett's recent paper points out a relation between increased resistivity and the specific heat of the added element. But when we recall that *specific heat* × *atomic weight* = *a constant,* we see that the increased resistivity is as closely connected with atomic weight as with specific heat.

In studying the relation of electrical resistance to the constitution of the conducting alloy, the complex character of steel must be kept in mind. It has already been pointed out that steel always contains carbon, manganese, silicon, phosphorus and sulphur; that the iron may exist in two or three modifications, and that carbon also may exist in a variety of ways. The limits of solubility of various elements in iron are in most cases unknown, and the intermetallic compounds of iron with another metal, or of two metals with carbon forming a double carbide, have been but imperfectly worked out. Yet, notwithstanding these complications, a broad view of existing evidence leads to the belief that the atomic law is in some way connected with the problem. Prof. Osmond shares my view in this matter when he says in discussing my recent paper to the *Iron and Steel Institute:* "It is remarkable that Mr. C. Benedicks should have arrived independently and simultaneously at the conception of the idea of atomic equivalents of dissolved bodies. It is true there are some considerable discrepancies between the results of Benedicks and Mathews, but there is nothing very surprising in these discrepancies any more than in those on which Mr. Mathews commented as existing between results of M. Le Chatelier and other physicists in the case of tungsten-, molybdenum- and chromium-steels. If the law of atomic weights is exact, it is applicable, as its very enunciation implies, only to the dissolved fraction of the alloyed substances, but this fraction varies according to the treatment, and is unknown in many cases. Notably, chromium and tungsten, and probably molybdenum, too, form double carbides, which, when liquated, have but feeble influence. Before concluding it will be necessary to

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[6] *Scientific Transactions of the Royal Dublin Society*, VII., p. 67.

[7] *Proceedings of the Royal Society*, Vol. LXIX., p. 480.

[8] *Zeitschrift fuer Physicalische Chemie*, 1903, Vol. XL., p. 545.

[9] *Journal of the Iron and Steel Institute*, 1902, Part I., p. 207.

[10] *Electrical World and Engineer*, 1902, p. 531.

know in each particular case what is dissolved and what is not, and also what is the state of the substance in solution."

At the time this remark was made, Mr. Benedicks, at the University of Upsala, was bringing forth the most conclusive evidence that for small concentrations the increase in resistivity of steel is a function of the atomic weight, *i.e.*, equi-atomic solutions of metallic elements in iron produce equal increase in electrical resistance. Mr. Benedicks determined the electrical resistance of a number of samples of steel which had been carefully analyzed. They contained varying quantities of carbon, silicon, manganese, sulphur and phosphorus, the last two elements being low and fairly uniform. The steels were tested in both the hardened and annealed state. From his determinations he found that one atomic per cent. of various elements dissolved in iron produces an increase in resistance which is equal to 5·9 microhms per cm.^{3}. He also calculated that the resistance of absolutely pure iron would be 7·6 microhms per cm.^{3}, but this value is lower than has ever been obtained experimentally, for perfectly pure iron has not been investigated. By means of the following formula it was found possible to calculate the resistance of steel with considerable accuracy:—

$S = 7{\cdot}6 + 26{\cdot}8\,\Sigma C$, in which S=resistance in microhms per cm^3, and $\Sigma C = \%$ foreign substances calculated as equivalent quantities of carbon. In order to apply this formula it was necessary to ascertain the effect of carbon itself upon the conductivity. This Dr. Benedicks has done very skillfully. In annealed steel the carbon for the most part exists in separate particles of cementite, Fe_3C. When steel is heated to temperatures above 720°C. and suddenly cooled, this cementite disappears and the structure known as martensite results. The carbon of martensite may be combined or simply dissolved without combination. Prof. Arnold thinks that a sub-carbide, $Fe_{24}C$, exists in hardened steel. However, when hardened steel is reheated and slowly cooled, cementite again appears, accompanied by ferrite. This ferrite has usually been considered to be pure iron, and ferrite and cementite when existing in alternating bands constitute pearlite. Dr. Benedicks shows that ferrite is not free of carbon, but that annealed steels containing from 0·40 to 1·70% C, consist of cementite and iron which contains about 0·27% dissolved or hardening carbon. According to Benedicks, the carbon segregated in the free cementite exerts little influence upon the conductivity. Le Chatelier, however, gives the resistance of ferrite as 9·5 and cementite as 45.

A steel with 0·4% C or lower, if annealed or slowly cooled, shows the pearlite structure, but the ferrite in such steels contains less than 0·27% C. For example, Benedicks states that the ferrite of a 0·2% C steel would contain 0·06 to 0·07% of dissolved carbon. Benedicks' work thus confirms the chemical researches of Osmond and Werth, Carnot and Goutal, Brustlein, Arnold, and Stansfield in regard to the existence in annealed high-carbon steels of 0·27% of hardening carbon in solid solution.

All this work strengthens me in the opinion expressed repeatedly, that, in the separating or crystallizing out of the constituents of any alloy, no pure metal ever separates but metal containing more or less of the other constituents of the alloy in solid solution. From my own observations and from results communicated privately by Mr. William Campbell, it seems that the resistance of hardened steels is not much affected by the temperature of quenching. This would seem to indicate that no chemical changes of importance occur or, if occurring, are not preserved by quenching, when steel is quenched from 720° to 1,000°C. Yet we know that very marked micrographic changes are produced by quenching from different heats between these limits. Particularly noticeable even to the naked eye is the increase in coarseness of the grain of steel as the quenching temperature increases. These facts taken together support the opinion expressed elsewhere that so far as known the size of the grain or the number of boundary faces between grains does not influence conductivity directly. In this regard the conducting power of steel alloys is widely at variance with their magnetic properties, for as is well known, the heat treatment of steels for permanent magnets is a delicate operation, and the best magnet steel can be made into a very poor magnet if it is not hardened at the proper heat.

The practical value of the observation that the resistivity of steel is related to the atomic weight of the dissolved elements in the iron is very considerable. As Barrett has mentioned, knowing the carbon contents of a piece of steel, its relative content of other elements may be judged by determining its conductivity. Benedicks' work makes it possible to judge of the electrical quality of different samples of iron by a study of their compositions without testing them at all. Barrett has also called attention to the fact that physical hardness has nothing to do with high resistivity. That is, for equal percentages of impurities hard tungsten and manganese steels conduct better than soft aluminum and silicon steels. With a few exceptions the opposite is true of the magnetic properties,—soft steels are magnetically soft, *i.e.*, highly permeable, while hard steels are magnetically hard, of low permeability and greater retentiveness.

High Speed Steels.—A great variety of steels of the class known as self- or air-hardening, has been put upon the market within the past few years. These steels are capable of doing from 100 to 300% more work in machining than can be done by tempered carbon steel, and hence the above name has been applied. Their greatest use is in making roughing cuts either in the lathe or planer; for finishing cuts they are not equal to the best tempered tools.

Hardened high carbon steel for metal working has its output limited by the fact that in removing chips from the piece being machined most of the work is transformed into heat at the point of the tool, which consequently loses its temper at that point.[11] Under normal working conditions the heat generated at the tool-point is conducted and radiated away to such an extent that the temperature is maintained uniform and proportional to the speed of cutting. This view is that taken in the report above referred to, and it seems sound; more so, in fact, than the opinions of a German scientist, whose attempted explanation of high-speed steel will be quoted later. The output of a tool depends upon its strength and upon the heat that it can endure without losing temper. For a plain

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[11] See Report on Taylor White Process of Treating Tool Steel, *Journal of the Franklin Institute*, February, 1908.

carbon steel, the temperature acquired in work must not rise higher than the temperature at which the tool was tempered after hardening. Mushet, Taylor-White, and many other steels are now made which will hold a cutting edge at a temperature more than twice as high as any plain carbon steel, and this means that the speed of lathes for roughing cuts can be safely increased from one to three times the usual limit. Thallner recommends very high speed with limited depth of cut, rather than a very deep cut and low speed. The former condition is the more economical.

J. Spueller[12] has advanced a theory in regard to rapid or self-hardening steels. He says they are all alloys of iron with varying amounts of carbon, and larger, but also varying amounts of chromium, tungsten, molybdenum, titanium and boron. He omits manganese altogether, while to the best of our knowledge neither titanium or boron is as yet included in the well-known brands. He points out that these steels, when forged in the ordinary way and allowed to cool naturally, are hard, but can be both filed and drilled. When heated to from 1,100° to 1,200°C. and cooled in an air blast or quenched in a lead bath at 650°C., followed by air cooling, these steels acquire greater hardness than ordinary tempered steel, and acquire the property of working best at those temperatures at which hardening-carbon in ordinary steel passes into carbide-carbon, accompanied by softening, which renders the tool useless. In high speed alloy steels the tool can be used where the frictional heat, at the cutting edge, is from 500° to 600°C. Under these circumstances, according to Spueller, the edge becomes extremely hard, while the rest of the tool remains unchanged. He explains this by assuming that in such steels, the iron, chromium, tungsten, etc., are present as carbides, and that after the normal forging and cooling treatment, iron carbide, which is stated to be relatively soft, predominates. At the higher temperatures, however—above 1,000°C.—Spueller thinks the iron carbide is decomposed, and that then higher carbides of chromium, tungsten, etc., are formed, which then preponderate in the steel and are of sufficient hardness to produce high speed properties without resorting to water or oil hardening. Chromium carbide appears to be the most important of these hard constituents. In support of his theory Spueller states that the cutting edges of such tools behave differently toward various reagents from the other portions of the tools. He also claims to find chromium carbide in the cutting edges.

This explanation is not consistent with the fact that manufacturers of high-speed steels (1) uniformly cut down the carbon to a percentage unheard of in ordinary tool steels, and (2) that the best high speed steels contain little or no chromium. Both tungsten and molybdenum seem to impart a hardness of their own to iron, a hardness almost, if not quite, independent of the carbon contents, and a hardness not materially improved by water-quenching and which does not lose temper at a dull red heat. I do not believe that the fundamental scientific truths at the bottom of this matter have as yet been discovered.

The adoption of high speed steels in large shops has revolutionized this kind of work and has necessitated the installation of more power and heavier machinery. The contest between the makers of lathes, planers, etc., and the makers

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[12] *Chemiker Zeitung*, 1903, Vol. XXVII., p. 165.

of high speed steel reminds us of that which has gone on for years between the makers of armor plate and of projectiles. Certain it is that shops with little available power and slowly-geared and light lathes cannot profit much by these recent metallurgical achievements. For roughing cuts, such as axle turning, a man can double or triple the output per day formerly expected of him. High speed steels are used also in wood turning, and with the same good results. A speed of 300 ft. per minute has been attained, working upon mild steel forgings; of course, with harder steel or cast iron the speed is much less, and 300 ft. is unusually good upon any sort of material. The exhibit of the Bethlehem Steel Co. at the Paris Exposition in 1900, attracted world-wide attention to the possibilities of self-hardening steels for rapid work. It is a pleasure to note that this pioneer work of Messrs. Taylor and White has been rewarded by the bestowal of the Elliott-Cresson Medal of the Franklin Institute for the discovery and development of a method for treating special steels which has made it possible to increase greatly the output of machines doing roughing work. The number of steels now on the market, all of which lay claim to the possession of properties suiting them to high speed work, is very large. They are not all of equal merit, but at the same time it is an interesting study to compare the analyses of these steels, and to see in how many different ways different makers seem to accomplish their ends. Their compositions are nearly as numerous and as different as those of bearing, or so-called anti-friction metals. Analyses of these steels cannot be given here, but I may state some of the limits met with in my own experience, or covered by patents: Carbon, 0·3 to 2%; tungsten, 0 to 25%; silicon, 0·25 to 3%; chromium, 0 to 7%; molybdenum, 0 to 15%; manganese, trace to 3·9%. Sulphur and phosphorus always low. Usually three of these elements are present in quantities which show them to have been intentionally added. Surely these limits offer a field of experiment and invention almost as attractive as was the production of acetylene generators a year or two ago.

Special Properties of Some Steel Alloys.—In the earlier part of this paper the chemical constituents of alloy steels were briefly discussed; in the concluding portion of this paper is given a short discussion of the physical effects of certain elements when added to steel, as well as special reference to some of the new alloys or new properties of old alloys to which attention has been called during the past few months. The alloys, with some of the rarer metals, will be mentioned so far as reliable information concerning them is to be had, and recent scientific work upon alloys, which has been productive of practical results, will be briefly considered.

Silicon has proved itself to be an advantageous addition to steel for a variety of purposes. Caspar and Oertel have patented in Germany a chrome-silicon steel, the silicon being greater, less, or equal in quantity to the chromium. The claim for these alloys is that they possess very high elastic limits and tensile strengths, but at the same time show 5% elongation and 23% reduction in area. When hardened and tempered they are said to be exceptionally good for machine parts, weapons, wire rope and springs. In general, silicon up to 0·8% has a relatively weak effect upon the strength and ductility of steel; it aids the machining properties and also improves the edge-holding properties of tool-steel. When high in amount it becomes injurious to annealed steel because it tends to cause a separation of graphite, as may be noticed from the dark appearance of the fracture. From its low atomic weight it is readily seen that its effect upon the electrical conductivity of steel is very great. In low carbon materials it seems to exert a beneficial effect upon the magnetic permeability. Recently as high as 3% Si has been noted in certain high-speed steels, and Jacob Holzer & Co. (Unieux) have patented a new spring steel of the following composition: Si, 1·8 to 2·2%; C, 0·35 to 0·45%; Mn, 0·45 to 0·55%. This steel is hardened at the unusually high temperatures of between 900° and 1,000°C. Silicon raises and causes to disappear Ar_3, lowers Ar_2, and slightly raises Ar_1.

Phosphorus.—Basic open-hearth steel is found by experience to be too low in phosphorus for the successful production of sheet steel for tinning. The sheets stick together in rolling. Phosphorus prevents this trouble, and Mr. J. Stevenson, Jr.,[13] has recently patented a method for re-phosphorizing such steel, and has also patented a phospho-ferro-manganese of about the following composition: Fe, 25%; P, 15 to 25%; Mn, 50 to 60%. This is produced by using a manganiferous ore, and apatite or phosphate rock instead of a limestone flux in smelting it. The alloy is added to the metal in the ladle just as ferro-manganese is.

Regarding the general behavior of the elements iron and phosphorus, either with or without carbon, no one interested should fail to consult Mr. Stead's[14] valuable monograph upon the subject. Mr. Stead shows that the lower the phosphorus, *i.e.*, the more dilute the solid solution of phosphorus in iron, the greater the proportion of that element which will be evolved as PH_3, when the steel is dissolved in dilute hydrochloric acid. The saturation point of iron for phosphorus is 1·7%. When carbon is added to such an alloy, or one with less phosphorus, it tends to throw the iron phosphide out of solution and to increase the quantity of structurally free phosphide, Fe_3P, *i.e.*, the higher the carbon the less the proportion of dissolved phosphide; but even 3·5% C will not drive it all out of solution. The quantity of hydrogen phosphide evolved from steel decreases as the percentage of carbon increases, yet notwithstanding this, phosphorus is more embrittling in high carbon than in low carbon steel. At high temperatures both the iron phosphide and the iron carbide dissolve in the excess of iron present, but by slow cooling the iron carbide separates out at Ar_1, while the iron phosphide remains for the most part dissolved in the ferrite. Even in ordinary steels, containing less than 0·1% P, a portion of the phosphide is thrown out of solution when the carbon is above 0·9%, and the phosphide so separated may produce brittleness by forming a brittle cell structure enveloping the grains of the other constituents. Phosphorus causes to disappear the transformation point, Ar_3, when present in large amounts; this means that the grain of pure phosphorus-iron alloys is not refined at or above 900°C. as is the case with pure iron. Stead states that phosphorus aids the welding properties of iron, but that the good effects it might thus produce are more than offset by

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[13] United States Patents Nos. 724,140. 724,141 and 724,142, all March 31, 1903.

[14] *Journal of the Iron and Steel Institute*, 1900, Vol. II., p. 60.

the coarsening of the grain, which it produces at the high temperature needed in welding, and the consequent weakening at the weld. In view of this statement that the weldability is increased by phosphorus, it seems rather strange that in Stevenson's patents referred to above, phosphorus should be added to prevent sheet steels, when piled in rolling, from sticking together.

Vanadium imparts to steel an increased tensile strength and elastic limit, and when annealed improves the ductility greatly. It is also said to impart great depth of hardness in quenched steels of large cross-section. There seems to be only a small quantity of ferrovanadium and vanadium steel made, and England seems to be the principal market for these products. The high price of vanadium, together with its low specific gravity and ready oxidization, both of which properties render it troublesome to add to steel, have confined the use of this metal almost entirely to the experimental state. The beneficial results, however, attending its use in quantities much below 1% are undoubted. Ferrovanadium of about 30%, and not over 1% Al and 1% Si is best adapted for use in steel making. It is not apparent from tests now at hand that these small quantities of high-priced vanadium confer any advantages not resulting from the addition of from seven to ten times as much low-priced nickel.

Samples of vanadium tool steel in my possession furnished by a dealer in ferro-alloys, show a very fine fracture in the natural forged condition, and the microscopical examination of the same, annealed, showed a very fine and uniform texture. The steel contained 0·82% C and 0·25% V. Its mechanical properties were stated to be: elastic limit, 92 tons; tensile strength, 114 tons; elongation in 2 in., 5%; reduction in area, 14%. Another sample of sheet-steel containing about 0·25% C and V, gave 28·5 tons elastic limit and 59 tons tensile strength. A. F. Wiener states in a recent number of *Engineering* that 0·25% V raises the tensile strength, by from 50 to 66%.

Nickel steel has long been in use, but its possibilitites do not seem to have been exhausted either from the standpoint of practical utility or from that of theoretical interest to students of the molecular constitution of alloys. Nickel lowers the critical points, especially Ar_1. When 25% of Ni is present Ar_1 is below 0°C.; it occurs, however, if artificial cooling be resorted to. In connection with this phenomenon it is interesting to note the microscopical researches of Guillet,[15] who experimented with three series of alloys containing respectively 0·12%, 0·35% and 0·85% C, the nickel increasing by steps of 2·5% up to 30%. The etching was done by alcoholic picric acid. Guillet found that as the nickel increased pearlite was replaced by martensite, and this in turn by polyhedral crystals indicative of Γ-iron. A synopsis of his results is given in the following table:—

	Microscopic Constituents.	0·12% C.	0·35% C.	0·85% C.
1.......	α Iron and pearlite..............	0–10% Ni.	0– 7% Ni.	0– 5% Ni.
2.......	α Iron and martensite..........	10–15% Ni.	7–12% Ni.	5–10% Ni.
3.......	Γ Iron and martensite...........	15–27% Ni.	12–25% Ni.	10–15% Ni.
4.......	Γ Iron.......	Over 30% Ni.	Over 25% Ni.	Over 15% Ni.

This explains, in part, the well-known fact that certain high nickel steels are

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[15] *Comptes rendus*, 136, 227–9.

non-magnetic. In fact the usual explanation of this phenomenon is that nickel lowers Ar_1, and when Ar_1 is at a temperature below the normal temperature, the iron is supposed to be still in the condition in which it existed at a high heat, and the carbon still in the hardening condition, and hence the alloy is non-magnetic. But why is it that the magnetic property of the 25% or so of nickel does not assert itself? α-, β-, or Γ-nickel have not been heard of, but still Hopkinson found a temperature of magnetic transformation in pure nickel, much lower than that of iron. Now is it not possible that by a reciprocal action of nickel on the iron, and iron on nickel, both have their points of magnetic transformation lowered below 0°?

Guillet's results upon the microstructure of nickel steels in general show that mild steels up to 10% Ni are like plain carbon steel; between 10 to 15% Ni there is a hardening effect; from 15 to 21% Ni they are very hard because chiefly composed of martensite; beyond this amount of nickel they again become soft because martensite is replaced by Γ-iron. The higher the carbon the less nickel is required to produce these structural changes. The passage of irreversible into reversible steels corresponds almost exactly with the appearance of the crystals of Γ-iron, and the first steel in each series which exhibits this structure is practically non-magnetic.

Nickel steels melt at a lower heat than the corresponding carbon steels; there is less segregation or liquation in them and hence such steel is very suitable for castings on account of its homogeneity. There seems to be also less tendency to form blowholes. Nickel steel forgings though tough are not difficult to machine, from 3 to 3·5% Ni in a 0·25% C steel gives a tensile strength and elastic limit equal to a 0·5% C steel but still retains 25% of elongation. At the Düsseldorf Exposition a Krupp armor plate of nickel steel weighing 106 tons, and made from a single ingot of 130 tons, was exhibited. Nickel steel shafts containing up to 3·6% Ni are forged by this firm by hydraulic pressure. One of their presses is of 5,000 tons pressure.

Guillaume[16] has continued his researches upon nickel steels, and has discovered that the 36% Ni alloy expands only 0·000001 mm. per 1°C. or only one-third that of pure iron. This property has suggested its use in pendulums, measuring rods, chronometers, etc., and its non-corrosive nature makes it still more valuable for such uses. It is also adaptable to marine, boiler and general structural purposes. Theodolites, levelling instruments and other apparatus of the United States Coast and Geodetic Survey are to be made of this alloy. Another very important application of nickel steels is suggested by the anomalous expansibility of this alloy. By adding either iron or nickel to it, alloys of almost any degree of expansibility result. An alloy having the expansibility of glass may be produced to replace the use of platinum in incandescent lights. This alloy is actually in use, and it is hoped that its extended use may reserve more of the world's platinum supply for the use of laboratories, and at a lower price. Charpy and Grenel[17] have shown that an alloy containing 36·1% Ni, 0·39% C, and 0·39% Mn, not only has an extremely low coefficient of expansion, but that it is practically constant between 15 and 200°C.

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[16] *American Machinist*, Jan. 8, 1903.

[17] *Comptes rendus* 134. pp 540–542.

Manganese steel is in some respects analogous to nickel steel. It seems to retain the iron in the Γ condition and to form isomorphous solutions with the iron, when present in quantities beyond those needed to combine with the sulphur and phosphorus of the steel. Nickel (25%) gives an alloy which is practically non-magnetic; its permeability is constant at about 1·4, but when cooled strongly becomes powerfully magnetic and remains so when warmed up to the normal temperature. Hadfield's manganese steel containing 13% Mn, and 1% C has a permeability of 1·3 to 1·5 and is nearly constant for strong or weak fields. There is no appreciable residual magnetism.

Titanium seems to increase the ductility of steel and raises the elastic limit very considerably. Its use is not very extensive, however. Titanium combines chemically with nitrogen and thus possibly improves the quality of steel by removing from it occluded nitrogen. Rossi[18] compares the effects of titanium crucible steels with results of Hadfield upon aluminum steel. For alloys of very closely corresponding compositions he finds an increase of from 16 to 100% in elastic limit, the increase being greater in proportion as the carbon increased. The ultimate strength tests did not show such great differences, but still they were very marked, while the contraction and elongation was always very highly in favor of the titanium steel. These effects in most cases were stated by Mr. Rossi to have been due to the presence of 0·10% Ti.

Copper and iron have recently been studied by Stead, who found that carbonless iron and copper would readily alloy in all proportions. The addition of carbon, which combines with the iron, drives the copper out of solution, and the resulting alloys separate into distinct layers upon slow cooling. Copper dissolves 2·73% Fe without showing any microscopical change, while iron dissolves about 8% of Cu. No compounds of iron and copper exist. Copper in foundry iron is not a dangerous constituent, but rather tends to raise its tenacity. Copper seems to retard the formation of pearlite in steel. It has not been determined as yet whether in cast irons it either assists or retards the formation of graphite. In small quantities, according to the researches of Ball and Wingham, made years ago, it has no deleterious influence upon the forging properties of steel, either cold or hot. Copper lowers the critical points, but less than either nickel or manganese.

Boron as a constituent of steel is frequently mentioned in foreign journals. I have never met with it in a commercial steel. I recall having seen the statement that boron imparts the property of water hardening like carbon. A single experiment was made upon a boron steel with negative results; the microstructure, however, was greatly changed by the boron. Charpy and Moissan[19] deny that boron causes hardening in the ordinary sense; it does raise the tensile strength when quenched. The steel used contained: B, 0·58%; C, 17%, and Mn, 0·30%. The results of quenching this steel from various heats are shown in the table on the following page:—

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[18] *Transactions of the American Institute of Mining Engineers*, Vol. XXII.

[19] *Comptes rendus*, CXX., pp. 130–132.

RESULTS OF QUENCHING BORON STEEL.

Hardening Temperature.	Tensile Strength.	Elongation.
	Tons.	%
Annealed.	29·21	11·00
800° C.	54·85	5·1
900° C.	76·20	2·7
1,100° C.	88·28	3·1
1,200° C.	58·60	0·9

A crystalline iron boride FeB, has been isolated. Specific gravity, 7·15. The critical points of this steel were found at 1,140°, 1,040°, 830°, 730° and 660°C. The last three correspond to Ar_3, Ar_2 and Ar_1.

NOTES ON PYRITIC SMELTING.

BY E. C. REYBOLD, JR.

THE Carpenter smelter at Golden, Colo., was designed to treat the siliceous pyritic ores of Gilpin County, an average analysis of which is as follows: SiO_2 35·12%, Fe 20%, S 25·25%, Al_2O_3 20%, CuO 0·08%, Cu 0·5%, gold from $10 to $16, and silver from 2 to 3 oz. per ton. The ores are far from self-fluxing, and require the addition of limestone or pyrite, or both, which involves a high percentage of barren material in the furnace; furthermore, the charge being difficult to smelt, requires much coke, which when calculated to the percentage of ore becomes very large indeed. At first the furnace was operated with cold blast, but later a hot-air stove was added, which reduced the coke consumption fully one-half and effected a saving of nearly $1 per ton of ore smelted. A smaller quantity of limestone was required, the slags were hotter and thinner, and there was a decrease in the loss of metals in the slag.

The charge as finally made up consisted of: Ore, 1,000 lb.; pyrite, 150 lb. and limestone, 800 lb.; which yielded slag of the following composition: SiO_2, from 38 to 43%; CaO and MgO, from 25 to 33%; FeO, from 12 to 18%; Al_2O_3, from 8 to 12%; Zn, from 1 to 2%; Cu, from a trace to 0·1%; silver, from 0·2 to 0·4 oz. and gold, from a trace to 0·04 oz. per ton. The composition of the matte produced was: SiO_2, from 0·5 to 0·7%; Fe, from 60 to 65%; S, from 25 to 28%; Cu, from 1 to 10%; Zn, from 0·2 to 0·6%, and silver, from 20 to 80 oz. and gold from 3 to 10 oz. per ton.

The subject of the thermal reactions of the blast furnaces has been more or less thoroughly investigated, but the widest discrepancies exist between recorded conclusions, and practically very little reliable data are available. For instance, in discussing the fuel value of iron pyrite (FeS_2), one author proves to his own satisfaction that pyritic smelting (smelting without the aid of carbonaceous fuel) is impossible without the use of hot blast, while another using identical units for the heat of formation of FeO and SO_2, proves just as conclusively that a charge containing only 46·6% FeS_2, exclusive of the quantity necessary to form matte, will generate enough heat to smelt the charge without coke. In the first instance, the author erred in the comparison of the heat of formation of FeO and SO_2 with that of CO_2, by assuming that the coke was pure carbon, and was burned completely to CO_2 before the blast, giving 14,500 B.T.U. per pound of coke. The best coke has at least 5% ash, the average being about 15%, while that produced in Colorado frequently contains 25%; furthermore, in furnace practice, it is the exception rather than the rule for carbon to become oxidized to CO_2. Of course, CO_2 is formed at first, but in contact with the incandescent coke, it is reduced to CO in accordance with the reactions $CO_2+C=2CO$.

Crookes & Röhrig state: "In practice we are pretty near the truth in saying that the heat from coke (with cold blast) is that obtained by making CO; for although at the instant of its admission, CO_2 is formed, it is almost as rapidly converted into CO by the incandescent coke. But in the hot-air stove the C is converted permanently into CO_2. Burning C to CO_2 gives 13,860 B.T.U. or 3·55 times as much as by burning C to CO, which gives but 3,996 B.T.U." It is seldom that more than one-third of the available carbon in the coke undergoes complete oxidation in the blast furnace to carbon dioxide (CO_2), the remaining two-thirds forming CO. This would give for one pound of pure carbon 7,822 B.T.U., *viz.*, $\frac{1}{3}$ of 14,644 (4,882) + $\frac{2}{3}$ of 4,410 (2,940) a total of 7,822 B.T.U. (Heat of formation of CO and CO_2 given by Reychler; see below.)

The authors first mentioned above, have also erred in omitting to allow for the loss of heat necessary to expel the CO_2 from the limestone ($CaCO_3$), and the water from the charge, also that required to form slag and matte, and the quantities lost by radiation and in escaping gases. In fact, little of their work is correct save their conclusion, which has been deduced from factors in which the errors fortunately counterbalance one another.

HEAT OF FORMATION.—From McCrae's Translation of Reychler (University of Brussels), the following values for the heat of formation are obtained, which are concordant with those from the *Annuaire du Bureau des Longitudes,* also appended:—

Reaction.	McCrae's Translation of Reychler (University of Brussels).		Annuaire du Bureau des Longitudes.
	British Thermal Unit.	Kilogram Calorie.	Kilogram Calorie.
C to CO	4,410	29·40	29·00
C to CO_2	14,646	97·65	97·00
S to SO_2	3,897	69·30	71·00
Fe to FeO	2,111	65·70	66·40

In the following calculations Reychler's results are used. The weights of materials burned are gram-molecule weights, in which the number of grams taken equals the atomic weight of the element. For instance, in the calculation of the combustion of C to CO, the number of grams taken is 12, which corresponds to the atomic weight of C. The total heat produced was 29·4 calories, which corresponds to 2·45 calories for 1 g. C; or 2,450 calories for 1 kg. C; or 2,450 $\times \frac{9}{5}=4,410$ B.T.U. for 1 lb. C. Based on these figures, the heat of formation of FeO and SO_2, when pyrite (FeS_2) is burned, may be expressed as follows:—

Atomic weight of Fe = 56
Atomic weight of S = 32
Atomic weight of S = 32

Molecular weight of FeS_2=120

The first atom of S is set free at a comparatively low temperature in the upper part of the furnace, and its heat producing value may be entirely disregarded in the calculation, so that in the combustion of 120 parts of FeS_2, 56 parts of Fe and 32 parts of available S enter into the equation; those parts in percentages equaling 46·67% Fe, and 26·67% available S. On this basis, the heat produced by the combustion of one pound of FeS_2 to FeO and SO_2 will be:—

46·7% of 2,111= 986 B.T.U.
26·7% of 3,897=1,040

2,026 B.T.U.

2,026 B.T.U. corresponds to 46% of the value of C burned to CO, or 26% of the value of C burned 0·33 to CO_2 and 0·67 to CO.

Specific Heat.—The specific heat, atomic heat and molecular heat of the various elements in the materials charged into the furnace, and the resultant furnace products being necessary for the calculation of the heat balance of a furnace, are given in the subjoined table:—

Element.	Atomic Weight.	Specific Heat.	Atomic Heat.	Element.	Atomic Weight.	Specific Heat.	Atomic Heat.
Cu	64	0·0951	6·0400	Na	23	0·2934	6·7480
C	12	0·2411	2·8932	S	32	0·1776	5·6832
O	16	0·2175	3·4800	N	14	0·2438	3·4132
H	1	3·4050	3·4050	Mg	24	0·2499	5·2976
Al	27·5	0·2143	5·8932	Si	28	0·1357	3·8000
Fe	56	0·1138	6·3728	CO	....	0·2425	....
Ca	40	0·1625	6·5000	CO_2	....	0·2169	....
K	39	0·1666	6·5000	SO_2	....	0·1544	....

The molecular heat of a solid compound is equal to the sum of the atomic heats of the elements contained, and by dividing the molecular heat by the molecular weight, the specific heat of compounds is obtained. On this basis, the following table of specific heats of substances entering into the furnace reactions, has been prepared.

SPECIFIC HEATS OF CHEMICAL COMPOUNDS.

Compound.	Specific Heat.	Compound.	Specific Heat.
Al_2O_3	0·2158	$MgCO_3$	0·2300
SiO_2	0·1793	MgO	0·2370
FeO	0·1368	FeS_2	0·1478
CaO	0·1782	CuS_2	0·1360
$CaCO_3$	0·1983		

The specific heats of the materials charged into the furnace and of the resultant furnace products are obtained by calculating the proper proportions of the molecular heats of the compounds entering into the composition of each:—

Substance.	Composition.			Specific Heat of Component Parts.		Specific Heat of Substance.
Ore	FeS_2	0·45	×	0·1478	=	0·066510
	SiO_2	0·35	×	0·1793	=	0·062755
	Al_2O_3	0·20	×	0·2158	=	0·043160
		1·00				0·172425
Pyrite	FeS_2	0·90	×	0·1478	=	0·133020
	SiO_2	0·10	×	0·1793	=	0·017930
		1·00				0·150951
Coke	C	0·75	×	0·2411	=	0·180825
	SiO_2	0·18	×	0·1793	=	0·032274
	Al_2O_3	0·07	×	0·2158	=	0·015106
		1·00				0·228205
Limestone	$CaCO_3$	0·71	×	0·1983	=	0·140793
	$MgCO_3$	0·24	×	0·2300	=	0·055200
	SiO_2	0·05	×	0·1793	=	0·008965
		1·00				0·204958
Matte	FeS_2	0·88	×	0·1478	=	0·130064
	CuS_2	0·11	×	0·1360	=	0·014960
	SiO_2	0·01	×	0·1793	=	0·001793
		1·00				0·146817
Slag	SiO_2	0·45	×	0·1793	=	0·080685
	FeO	0·16	×	0·1368	=	0·021888
	Al_2O_3	0·10	×	0·2158	=	0·021580
	CaO	0·24	×	0·1782	=	0·042768
	MgO	0·05	×	0·2370	=	0·011850
		1·00				0·178771
Flue dust	SiO_2	0·46	×	0·1793	=	0·082478
	FeO	0·30	×	0·1368	=	0·041040
	CaO	0·08	×	0·1782	=	0·014256
	MgO	0·02	×	0·2370	=	0·004740
	S	0·07	×	0·1776	=	0·012432
	Al_2O_3	0·07	×	0·2158	=	0·015106
		1·00				0·170052

The heat units produced and consumed by the furnace using hot blast during the run of July 5, 1902, is calculated from the following factors:—

Charge.	Quantity.	Product.	Quantity.
Ore	141·00 tons.	Slag	202·50 tons.
Pyrite	15·00 tons.	Matte	16·10 tons.
Limestone	94·00 tons.	Flue dust	25·00 tons.
Coke	28·00 tons.		
Hot-air stove coal	8·20 tons.		
Temperature of air	70° F.		
Temperature of blast	770° F.		
Blast per minute	6,778 cubic feet.		

In the matter of cubic feet of air blown into the furnace per minute, no definite figures were obtainable. The blower used was supposed to pass 12,500 cu. ft. of air per minute, but was acknowledged to "slip" considerably when the pressure became high (the pressure at Golden was from 2·5 to 3 lb. per sq. in.). It did not seem from the quantity of coke consumed in the furnace, or from the quantity of coal used in the stove that this great quantity of air was passed into the furnace, or could be heated to such a degree by the small quantity of coal consumed in the stove, and steps were taken to discover the exact quantity of air that could be heated to a temperature 700°F. above that of the surrounding atmosphere, with 8·20 tons of coal per 24 hours. The coal used was lignite, obtained from Trinidad, Colo., the theoretical heat of combustion of which is 10,438 B.T.U. The data required for the calculation were as follows:—

Theoretical value of coal	10,438 B.T.U.	Specific heat of products of combustion	0·2200
Temperature of escaping gases	500° F.	Temperature of atmosphere	70° F.
Air required per lb. of coal	15 lb.	Temperature of blast	770° F.
Products of combustion per lb. of coal	20 lb.	Coal used per minute	11·8 lb.
Specific heat of air	0·2377	Cubic feet of air per pound of air at Denver	16·0

At the sea level, under normal barometic pressure (30 in. of mercury, equaling 14·7303 lb. per sq. in.) there are 13·14 cu. ft. to 1 lb. of air, while at the altitude of Denver, Colo., the corresponding barometic pressure (24·6 in. of mercury, equaling 12·079 lb. per sq. in.) there are 16 cu. ft. to 1 lb. of air, *viz.:* $13\cdot14 \times \frac{30}{24\cdot6} = 16$.

Full theoretical value of coal............................10,438 B. T. U.
Losses:
Escaping gases, 20 lb. × 0·22 × 500 ....=2,200
Ashes and radiation............................=2,000
Total..4,200 B. T. U.

Practical heating value of coal, per lb...........6,238 B. T. U
6,238 + 0·2377 = 26,243 lb. of air heated 1° F.
26,243 + 700° = 37·49 lb. of air heated 700° F.
37·49 × 16 = 599·84 cu. ft. of air heated 700° F.
599·84 × 11·30 = 6,778 cu. ft. of air heated 700° F. per minute.

The following data of heat production and absorption are based on one minute's work of the furnace.

There are three producers of heat in the furnace, and nine ways in which it is consumed, carried off, or lost.

Production..............
1. **Oxidation of pyrite.**
2. **Oxidation of coke.**
3. **Heat in blast.**

Consumption............
1. **Expulsion of CO_2 from limestone.**
2. **Expulsion of water from materials of charge.**
3. **Carried off by jacket water.**
4. **Carried off by slag.**
5. **Carried off by matte.**
6. **Carried off by flue dust.**
7. **Carried off by escaping gases.**
8. **Absorbed by decomposition of water in blast.**
9. **Radiation.**

HEAT PRODUCTION.

1. *Oxidation of Pyrite* (FeS_2). (*a*) Ore..........

Quantity charged in 24 hours..............282,000 lb.
Blown out in flue dust.................... 28,200 lb.
253,800 lb.
Moisture.................................. 12,690 lb.
Net quantity smelted......................241,110 lb.
Quantity smelted per minute............... 167 lb. FeS_2
Pyrite content, 167×45% = ... 75·15 lb.

(*b*) Pyrite......

Quantity charged in 24 hours................30,000 lb.
Blown out in flue dust...................... 3,000 lb.
27,000 lb.
Moisture.................................... 1,350 lb.
Net quantity smelted........................25,650 lb.
Quantity smelted per minute................. 18 lb.
Pyrite content, 18×90% = ... 16·20 lb.
Total FeS_2 per minute.................... 91·35 lb.
Deduct quantity for the resultant matte 22×88% =........................ 19·35
FeS_2 burned per minute.................. 72·00
72×2,026.................................145,872 B.T.U.

2. *Oxidation of Coke*

Quantity charged in 24 hours	56,000 lb.
Moisture	1,120 lb.
	54,880 lb.
Ash and flue dust	3,720 lb.
Net quantity pure carbon burned	41,160 lb.
Quantity burned per minute	29 lb.
C burned to CO, 20× 4,410=	88,200 lb.
C burned to CO_2, 9×14,646=	131,814 lb.
	220,014 B.T.U.

3. *Heat in Blast*

Cubic feet of air per minute	6,778
Weight of air per minute, 6,778÷16	424 lb.
Temp. of blast above that of the atmosphere	700° F.
Specific heat of air	0·2377
424×0·2377×700°=	70,546 B.T.U.

Total quantity of heat produced in furnace	436,432 B.T.U.

HEAT CONSUMPTION.

1. *Expulsion of CO_2 from limestone*

Quantity charged in 24 hours	188,000 lb.
Blown out in flue dust	18,800 lb.
	169,200 lb.
Moisture	3,384 lb.
Net quantity of pure limestone	157,526 lb.
Quantity consumed per minute	109 lb.
109×666=	72,594 B.T.U.

2. *Expulsion of Water from Materials of Charge*

Water in ore	12,690 lb.
Water in pyrite	1,350 lb.
Water in limestone	3,384 lb.
Water in coke	1,120 lb.
Quantity charged per 24 hours	18,544 lb.
Quantity per minute	13 lb.
Water boils at altitude of Denver at	202° F.
To boil from 70° F. requires	132 B. T. U.
Latent heat of vaporization	966 B. T. U.
	1,098 B. T. U.
13×1,098=	14,274 B. T. U.

3 *Carried Off by Jacket Water*

Quantity used per minute, 250 gallons, or	2,084 lb.
Temperature of inflow	70° F.
Temperature of outflow	120° F.
Increase of temperature	50° F.
2,084×50=	104,200 B.T.U.

4. *Carried Off by Slag*

Quantity produced per 24 hours	405,000 lb.
Quantity per minute	281 lb.
Temperature of slag	2,170° F.
Temperature of atmosphere	70° F.
Degrees of heat lost	2,100° F.
Specific heat of slag	0·1788
Latent heat of fusion	90 B.T.U.
Sensible heat, 2,100×0·1788	375 B.T.U.
	465 B.T.U.
465×281=	130,665 B.T.U.

5. *Carried Off by Matte*

Quantity produced per 24 hours	32,200 lb.
Quantity per minute	22 lb.
Temperature of matte	2,170° F.
Temperature of atmosphere	70° F.
Degrees of heat lost	2,100° F.
Specific heat of matte	0·1468
Latent heat of fusion	60 B.T.U.
Sensible heat, 2,100×0.1468	308 B.T.U.
	368 B.T.U.
22×368=	8,096 B.T.U.

6. *Carried Off by Flue Dust*

Quantity per 24 hours	50,000 lb.
Quantity per minute	35 lb.
Temperatnre of flue dust	270° F.
Temperature of atmosphere	70° F.
Degrees of heat lost	200° F.
Specific heat of flue dust	0·1701
200°×0·1701=	34·02 B.T.U.
34·02×35=	1,191 B.T.U

7. *Carried Off by Escaping Gases*	Quantity per minute	1,060 lb.
	Temperature of gases	207° F.
	Temperature of atmosphere	70° F.
	Degree of heat lost	200° F.
	Specific heat of gases	0·21
	200°×0·21=	42 B.T.U.
	42×1,060=	44,520 B.T.U.
8. *Absorbed by Decomposition of Water in Blast.*	Quantity of water per minute	0·6 lb.
	Heat to decompose into H and O	52,470 B.T.U.
	0·6×52,470 =	31,482 B.T.U.
9. *Radiation (to balance)*		29,410 B.T.U.
Total quantity of heat consumed or carried off		436,482 B.T.U.

Résumé.		B. T. U.	Per Cent. of Total.
Producers	1. Oxidation of pyrite	145,872	33·4
	2. Oxidation of coke	220,014	50·5
	3. Heat in blast	70,546	16·1
		436,482	100·0
Consumers	1. Expulsion of CO_2	72,594	16·6
	2. Expulsion of water	14,274	3·2
	3. Jacket water	104,200	23·9
	4. Slag	130,665	30·0
	5. Matte	8,096	1·9
	6. Flue dust	1,191	0·3
	7. Escaping gases	44,520	10·0
	8. Water in blast	31,482	7·2
	9. Radiation	29,410	6·7
		436,482	100·0

When these heat units are expressed in horse power, the quantity of work accomplished in the blast furnace is almost incredible

1 B. T. U. = 772 foot-pounds.
1 Horse power = 33,000 pounds per minute.
1 Horse power = 42·7 B. T. U. per minute.

		Theoretical Horse power.	Practical Horse power.
Producers	1. Oxidation of pyrite	3,416	427
	2. Oxidation of coke	5,163	644
	3. Heat in blast	1,652	206
		10,221	1,277
Consumers	1. Expulsion of CO_2	1,700	212
	2. Expulsion of water	334	42
	3. Jacket water	2,440	305
	4. Slag	3,060	383
	5. Matte	190	24
	6. Flue dust	28	3
	7. Escaping gases	1,042	130
	8. Water in blast	738	92
	9. Radiation	689	86
		10,221	1,277

The average engine will give an output of about 12·5% of the theoretical value of the heat units absorbed by it.

The great loss of heat herein shown naturally raises the question of its utilization. Heating the blast both by means of the slag and by waste gases, has been tried at a number of plants, with but little success. The gases being incombustible are not available for use in gas engines, or for heating the blast by means of a fire brick stove, such as are in use at iron blast furnaces. Attempts have been made to utilize some of the heat of the gases by passing them around pipes through which cold blast air passed on its way to the furnace, but on account of the slowness with which air gives up its heat and the relatively low temperature at which the gases escape, very little heat was obtained. One scheme for obtaining the heat from slag was to have the inlet for the blower over the forehearth, and although some degree of heat was obtained, it was detrimental to the utility of the forehearth, which should be kept as hot as possible. Another unsuccessful scheme was to run the pots filled with molten slag into a brick chamber from which the blower took the air, but difficulty is encountered when the air is heated before being taken into the blower; first, on account of the impossibility of keeping the blower properly lubricated, and secondly, on account of the decreased capacity of the blower by the air being expanded before reaching it. From the preceding figures of the operations at the Golden plant, it will be noticed that if only half of the heat of the slag could be transferred into the blast air, it would heat it to a temperature nearly equalling that obtained from the hot-air stove, and if all the heat from both slag and jacket-water could be harnessed, it would give a greater number of heat units than that produced by the burning of the coke.

A greater quantity of heat is absorbed by the decomposition of the hygroscopic water in the blast air than is generally known; and in this case it equals nearly one-half of the heat units secured from the stove. An idea of possible utility is that the air before reaching the blower might be passed over hygroscopic material, as quicklime or sulphuric acid, which would absorb the water from the air and thus save the heat otherwise necessary to decompose it in the furnace. The quantity of hygroscopic material required would be very small in comparison with the saving to be made, and especially does it seem applicable to altitudes near the sea level where the air is quite moist. The mechanical difficulty, however, of accomplishing the complete removal of water from the air would probably be great.

The expulsion of CO_2 from the limestone absorbs a great quantity of heat (666 B.T.U. per lb. $CaCO_3$), but in furnace practice this can scarcely be obviated.

PROGRESS IN THE MANUFACTURE AND USE OF TITANIUM AND SIMILAR ALLOYS.

BY A. J. ROSSI.

Titanium Alloys.—The manufacture of titanium alloys of various composition was described in detail by me in THE MINERAL INDUSTRY, Vol. IX., wherein I gave also the results of experiments in mixing these alloys in the crucible or ladle with cast iron and steel. Since writing this article further tests have been carried out, especially with reference to the cupola furnace, and large manufacturers have undertaken investigations along the lines outlined in my paper.

The results of actual practice seem to show that the use of alloys containing more than 10 or 12% Ti with cast iron is not advisable, although in the converter or open-hearth furnace alloys containing 25% Ti may be used. As the fusibility of the alloys decreases in proportion to the quantity of titanium present, some difficulty is experienced in handling the higher alloys, and when a certain limit is exceeded they cannot be cast from the ordinary furnace. They can be manufactured successfully and on a large scale, however, by employing special devices for tapping, which I have introduced, and a sufficient number of furnaces, the latter being operated in a semi-continuous manner. Such alloys do not melt at the fusing temperature of cast iron or steel, and when introduced in a charge they are incorporated in the molten metal similarly to ferrochromium or high ferromanganese. With the cupola the best results are obtained by adding the alloy in small pieces, which necessitates a previous crushing, an operation that offers little difficulty in establishments provided with a drop. This crushing might be avoided, and with advantage to foundries of small size, by casting the alloy in the form of pigs and adding the latter directly to the furnace charge just as is done with ordinary cast irons. Indeed, I have found that such "titanic pig," containing up to 5% Ti, does melt at the temperature of fusion of cast iron or steel, and is readily incorporated when added in the crucible or the ladle, or when charged in the cupola. It may be noted that this pig iron cannot be obtained by smelting titaniferous iron ores in the blast furnace as the heat in a blast furnace is insufficient for the reduction of the titanium oxide by the carbon. For this reason ores with 40% or more titanic acid yield an iron containing only fractional percentages of titanium; and the presence of these small quantities seems to be due to the reactions that take place in the blast furnace between the alkali cyanides existing near the tuyeres and the titanium oxide, whereby titanium cyanonitride is formed. The latter compound, when present in pig iron is usually estimated and tabulated by chemists as metallic titanium.

The titanic pig as described can be made only in the electric furnace. It has a much lower melting point than the higher alloys, and, although containing but from 3 to 5% Ti, a mixture of from 3 to 5% in quantity gives practically the same results as with from 1 to 2% in quantity of a 10 or 12%-Ti alloy. The manufacture of this special pig does not differ materially from that of the higher alloys. Titaniferous and non-titaniferous ores are mixed in proper proportions with a sufficient quantity of carbon (in the form of fuel) to reduce iron and titanium oxides, and the mixture is then smelted; or the reduction of the titaniferous ore by carbon can be carried out in a bath of steel or iron which is so proportioned as to give the proper percentage of titanium in the final product. A 200-H.P. plant gives a daily output of about 2,500 lb. pig, or 12·5 lb. per H.P.-day.

Tests of Ferrotitanium.—The materials used in these tests were made by adding the alloy in either the cupola or the ladle, the results being nearly the same in each case. The cupola of 2,000 lb. capacity was first charged with pig iron and coke without any addition whatever, and a part of the molten iron was cast in pigs and round bars (18 in. long by 1,125 in. in diameter) or square bars (13 in. long by 1 in. square) while another portion was poured into 300-lb. ladles into which certain quantities of alloys (10 to 12% Ti) were added at the bottom. After dropping, the cupola was again charged with pig iron and coke by layers as usual with the addition in each layer of a part of the total quantity of alloy that was to be used in the charge. The alloy was added in lumps from 1 to 2 in. in size. For each mixture the cupola was charged with fresh material. The pig iron used was of two grades—No. 2 foundry coke (Warwick brand) and No. 1 best charcoal pig (Murkirk brand). The tests were made at the laboratories of Finius, Olsen & Co., of Philadelphia. With due corrections for area the results were as follows:—

	No. 2 Coke Iron ("Warwick").		No. 1 Charcoal Iron ("Murkirk").	
	Pig Smelted Alone.	Pig Smelted with 2% of Alloy.	Pig Smelted Alone.	Pig Smelted with 2% of Alloy.
	Lb. per sq. in.	Lb. per sq. in.	Lb. per sq. in.	Lb. per sq. in.
Tensile strength....	24,840 25,450 24,600	27,800 28,850 27,600	28,490 27,950 27.500	31,680 30,400 31,290
Tensile strength (average)......	24,960	28,125	27,960	30,800
Transverse strength..........	....	....	2,990 2,873 2,993	3,112 3,250 3,215
Deflection at center of bar (12 in. between bearings).........	....	....	0·14	1·155

The tests show that the addition of from 0·5 to 2% in quantity of 10 to 12%-Ti alloy increased the tensile strength of the coke iron so that the average exceeded the average tensile strength of No. 1 best charcoal Scotch pig. In other words, coke iron thus treated could be substituted for the charcoal iron, which is employed to obtain certain mixtures, and at a considerable saving in cost. At the time these tests were made, the Scotch pig cost $29 per ton, while the coke iron was worth $15 and the alloy treatment cost from $3 to $4 per ton. Furthermore, the charcoal iron when alloyed with titanium showed a maximum tensile strength of 31,230 lb. per sq. in. and a maximum transverse strength of 3,250 lb., as compared with 28,430 lb. and 2,993 lb., respectively, for the same iron without treatment. Later experiments have shown that 1% of alloy suffices to give these results. With weak irons the improvement by treatment is still more noticeable; thus pig of 20,000 lb. tensile strength and 2,000 lb. transverse strength when treated give a tensile strength of from 25,000 to 26,000 lb. and a transverse strength of from 2,500 to 2,800 lb.

The quality of titanium iron has been further tested by Mr. C. V. Slocum, of the Keystone Car Wheel Co., Pittsburg, with the following results, as personally communicated to me: "For the first half of the heat and during the time no titanium was used, the highest strength observed in bars was 3,270 lb. In the last half of the heat, during which a small part of the titanium was in the charge, the transverse strength ran up at once to 3,500 lb., and one bar which would evidently have run considerably over the limit of the machine was removed from it without breaking. We had bars breaking at 3,740 lb. on different days, each of which contained titanium." Mr. Slocum has also stated[1] that titanium gives greater density to car wheels and has the effect of hardening the tread and strengthening all the parts.

Other Applications of Titanium Alloys.—Experiments are now being conducted with the 10 to 12%-Ti alloy with reference to its use in the converter. For this purpose alloys containing carbon are employed, as they serve also as a re-carbonizer. The oxidation of titanium in the converter tends to remove the oxygen from the steel, develops a greater heat than silicon and also eliminates the occluded nitrogen, so that it seems probable that the castings will show desirable qualities. The use of titanium alloys in the manufacture of special dies in which great strength and hardness are required may also prove desirable. A large manufacturing concern has been supplied with a quantity of titanic pig, and is now engaged in testing the material on an extensive scale. Furthermore, experiments are being made with the alloys with the view of their utilization in the manufacture of special chilled castings such as rolls and crushers.

Manufacture of Ferrotungsten and Other Alloys.—As a development of the aluminum process, in which a bath of aluminum kept molten by an electric current is used as a reducer of metallic oxides—in contrast with the Goldschmidt process which employs powdered aluminum and no external heat—I have made ferrochromium, ferrotungsten and ferromolybdenum free, or practically so, from carbon. Ferrotitanium containing from 0·2 to 0·75% C and as high as 75% Ti has also been made by this process. The furnace used is of the old Siemens type, consisting essentially of graphite blocks so arranged as to leave a central cavity. The graphite forming the cathode is properly connected with one of the busbars of the current. A single or multiple carbon electrode is introduced into the cavity to form the anode, and is connected with the other busbar by means of a flexible cable, which permits the electrode to be moved vertically.

The tungsten concentrates that were used had the following composition:

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[1] Paper read before the Railroad Club of Pittsburg, Nov. 28, 1902.

WO_3 69·86%; SiO_2 5·04%; FeO 20·25%; metallic equivalents—W 55·20%; Fe 15·73%. After charging the furnace with the necessary quantity of aluminum in the form of ingots, scrap, etc., to reduce the iron and tungsten, the current was turned on. As soon as the oxides were introduced into the molten metal the reaction began, the iron being first reduced to a metallic state and forming a bath in which the tungsten dissolved. With the progress of the reaction, abundant fumes of alumina were given off in a dense white cloud, while the larger portion of the alumina, formed at the expense of the oxygen in the ores, constituted a sort of slag (artificial corundum) on the surface of the bath. The current was increased for a few minutes toward the end of the reaction and the metal was then cast. In one operation 646 lb. of ferrotungsten were made in thirty minutes with an expenditure of about 11 H.P. of current. The alloy had the following composition: W 75·91%, Fe 21·47%, Si 1·61%, S 0·08%, C 0·90%, Al *nil*. The percentage of tungsten in this case is nearly the maximum available from the ore. If a lower percentage is desired it may be obtained by adding scrap iron in the proper quantity to the charge.

The same process was employed for the manufacture of ferrochromium. The chrome ore supplied for this purpose was rather low-grade, and a quantity of current had to be used slightly greater than the normal to melt the slag. An analysis of the ore gave the following results: Cr_2O_3 50·29%. Fe_2O_3 16·01%, Al_2O_3 10·72%, SiO_2 4·62%, MgO 16·61%, S 0·01%, CaO 1·15%, P *nil*, H_2O 1·40%, metallic equivalents—Cr 34%, Fe 11·20%. It will be observed that 34·5% of the ore was gangue. The ore should have been concentrated to avoid loss of chromium in the slag. The ferrochromium obtained had the following composition: Cr 68·24%, Fe 26·92%, Si 1·85%, C 1%, Al 0·5%.

THE CONCENTRATION OF ORES BY OIL.*

BY WALTER MCDERMOTT.

THE selective action of oil and grease on certain minerals has been known for some years, and several attempts have been made to utilize this knowledge for the purpose of a commercial separation of valuable products. At the De Beers diamond mines such a process has been successfully developed and used for several years. The application is in the form of a shaking riffled table coated with thick grease, over which tailings from the washing pans are run, with the result that any diamonds present adhere to the grease, while the waste rock flows over freely. An attempt to use a thin oil for separating metallic sulphides from waste rock was made in England; and a certain measure of success was attained in small experiments by causing the oil to pass through a moistened mass of ore. It was found that the oil used had very little supporting power, attaching itself to the gangue to such an extent as to cause excessive loss; and the details of an effective separation of the sulphides from the supporting oil were not worked out.

Mr. F. E. Elmore, in experimenting to reduce the excessive loss of copper and iron pyrite from a concentration mill in Wales, took up the investigation and was successful in developing a practical and economical method of utilizing the remarkable power of some oils to absorb certain minerals and metals. The description of the action of the oil as "absorption" seems suitable to those who have seen the process in actual operation; it is entirely a surface action between the oil and the wet particles of mineral, but in effect the result is that the particles enter into the body of the oil. The essential points of the process, on which its novelty and commercial success depend, are (1) the nature of the oil used, (2) the method of its application to the crushed ore, and (3) the separation of the absorbed mineral from the oil.

1. Experiments, made with many varieties of oil and fatty substances, resulted in the discovery that an oil of the character of the thick residuum of petroleum distillation gave results far more effective than any other material. This residuum possessed additional advantages in its low first cost, in its freedom from mechanical loss even when finely broken up, and in its power of supporting a relatively heavy charge of mineral without sinking in water, all of which gave its use

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* From the *Engineering and Mining Journal*, Feb. 14 and 21, 1903. See also THE MINERAL INDUSTRY, Vol. X., p. 759.

the distinction of an absolute discovery. Besides the ordinary American residuum, having a sp. gr. of about 0·88, similar products from other parts of the world have been found equally effective, particularly some natural thick oils from the East, with a sp. gr. of 0·80. The factor of specific gravity is of importance, because the oil when charged with particles of heavy minerals has still to float freely in water. The capacity of the oil thus to support a charge is greater than would appear possible by calculation based solely on its normal specific gravity. This is due to the agitation with the pulp which results in the oil taking up a very appreciable quantity of air, giving a certain sponginess, with naturally an increase in floating power. The properly charged oil, when examined with a glass in a thin film, is seen to be literally full of particles of mineral it has taken up; and its power of still floating appears remarkable. When overcharged with mineral, a portion of the latter settles out and sinks in water, dragging down entangled oil with it; some of this oil, freeing itself from the excess of load, will again rise in globules to the surface. The degree of viscosity is of importance as regulating the charge the oil will carry, and as affecting the mechanical loss from its influence on subdivision and re-agglomeration; but, fortunately, this degree of viscosity can be easily regulated by the addition of thinning or thickening oils or wax, and in part, if necessary, by the regulation of temperature in working. It has been discovered that the action of the oil on some ores can be stimulated (at a very nominal cost) by mixing certain acids with the oil or by the addition of a very slight quantity of acid to the pulp before the contact with oil. This increase of efficiency is in some cases—such as in the treatment of atacamite ores—sufficient to make the difference between success and failure; and is secured by the addition of quantities, which are little more than traces, of acid. Mine water of acid reaction is therefore well adapted to the process. When water is scarce it can be used over again after settling the tailings, as the suspended mud is not injurious.

2. The use of thick oil allows of its application to a thin pulp, such as that produced in wet crushing operations where an excess of water is always used. Previous efforts with other classes of oils had been unsuccessful with a thin pulp. Experiments were made with differing degrees of agitation of the oil with the flowing pulp, varying all the way from a gentle rolling over of the oil and pulp in their travel down an inclined riffled launder, to a violent agitation such as produced by passing through a centrifugal pump, or a cone mixer, or an amalgamation pan. The attempt to pass the pulp as a spray through a floating layer of oil was followed by the flowing of the pulp both over and under a fixed and a traveling surface coated with oil. In the end it was found that a slowly revolving cylinder enclosing a helical launder fitted at intervals with low baffle plates gave a sufficient agitation for most ores, and caused no unnecessary breaking up of the oil. By this means also a clean concentrate was insured, because there was no mechanical driving of particles of gangue into the oil. As a consequence of the experiments with many classes of ore under varying conditions, a standard type (or unit) of three mixing cylinders has been adopted. For some ores, requiring a very close saving of a rich mineral finely divided in the gangue, extra agitation previous to treatment in the mixing cylinders has been found effective.

The application of the thick oil to a thin pulp allows of a simple, continuous and automatic treatment of the flowing product from a stamp-mill or other pulverizer. After the mixing of the oil with the pulp—which may be likened to the agitation of quicksilver with an ore in pan amalgamation—the oil with its charge of mineral is separated from the water and waste rock by running the whole into a large pointed box, from the bottom of which the rock and water flow, while the oil and mineral float on the top and overflow for subsequent treatment. This separation is the equivalent of the separation of quicksilver and amalgam from the rock and water in a settler; although in the one case the heavy absorbed mineral is floated off by the oil, and in the other case the amalgamated metal sinks with the quicksilver. The similarity of the operations to those of amalgamation seems to have been noticed by the patent examiners in Washington; for in the broad claims granted for the process the use of quicksilver was specifically excluded.

3. Having secured the proper kind of oil, the requisite agitation with a thin pulp, and the separation of the oil and its absorbed mineral from the waste rock and water, the difficulty of a simple and effective extraction of the mineral from the oil was only overcome after a great deal of experimenting. Most of the particles of mineral produced in crushing an ore by stamps are very minute, so that the problem of their extraction from the body of a thick sticky oil was not easily solved. To thin the oil sufficiently to allow the concentrates to sink, either by addition to the oil of any thinning material, or by raising the temperature, was found commercially impracticable. Filter-pressing (after heating) was found unsatisfactory for several reasons; and success was only obtained by the adoption of a system of centrifugal separation carried out under perfectly novel conditions of working. The oil is passed through a heater into a centrifugal machine consisting of a vertical pan 48 in. in diameter, which has an inwardly projecting flange at the top, around and over which the discharge takes place. Water is run first into the centrifugal and forms a wall of the depth of the flange. The heated oil flows down a pipe into the bottom of the pan (which makes 1,000 r. p. m.) and passes up in a thin layer over the wall of water, discharging over the flange at the top. During this passage of the oil over the water, the solid particles of mineral are thrown out through the supporting water, and pack against the side of the pan. When the pan is charged with mineral, it is stopped for a few minutes, the collected wall of concentrates is broken down through an opening in the bottom of the pan, and the machine is started again ready for a fresh charge. The cleaned oil flowing from the centrifugal is pumped back to the storage tanks above the mixers, for re-use after cooling. The separation of the mineral from the oil is very perfect. A sample of the oil now in circulation in the London testing works, and which has been used with a great variety of ores, contained on examination only 0·15% of solid matter. The discharged concentrates have still some oil and water mixed with them, and are dried by treatment in a second centrifugal fitted inside with a perforated pan, such as is used in drying sugar.

The first working plant erected was the gradual growth of experiments at the Glasdir mine in North Wales, and had a final capacity of 50 tons per day. Several thousand tons of ore were treated; but the mine has been closed for some time for financial reasons not connected with the process itself. A complete testing works was next erected in London with a 5-ft. Huntington mill for crushing, and an oil plant of a capacity of 25 tons per day. This plant has been running for nearly two years, making working tests on ores from various parts of the world. It is still in active operation. As a result of work done at this testing mill, in most cases under the superintendence of independent engineers, the following plants have been ordered: 75-ton plant for Norway; 50-ton plant for Lake View mine, Western Australia; 50-ton plant for Le Roi No. 2, British Columbia; 50-ton plant Tywarnhaile mine, Cornwall; 150-ton plant St. David's mine, Wales; 100-ton plant Sygun mine, Wales. Of these the last three are now in regular operation, and have been running from one to six months, respectively. The process is not at present in use in the United States, although ores from a number of American mines have been successfully tested in London, and a small hand-testing plant has been erected in the laboratory of the University of California.

At the Tywarnhaile mine a 10-stamp mill is at work with a two-unit (50 tons) oil plant, crushing old dumps of quartz and slate containing iron and copper pyrites, and assaying only 0·6% Cu. Concentrates containing 8% Cu are produced, and the results are such that the owners have decided to erect 20 more stamps with necessary oil plant for the regular mine ore. As bearing on the question of labor required for the process, it may be mentioned that one man and two boys are employed on each 8-hour shift, at wages of 75 and 37c., respectively, per day, and these hands were without skill or previous experience in mill work. The average extraction has been slightly over 80% of assay value, with a close agreement between actual and theoretical extraction. Battery screens of 20-mesh were at first employed, but as coarse as 10-mesh have since been used. Experience has shown that by reducing the agitation, and lessening the time of contact with the oil, a large percentage of the copper pyrite can be saved, while a considerable loss of iron pyrite can be allowed in the tailings, without proportionately increasing the loss of copper. As a consequence of this selective action of the oil, in aiming at the highest extraction, a higher grade concentrate can be produced for the smelters than if all mineral present were caught by the oil. Copper pyrite is particularly amenable to the oil treatment, even in the finest state of division; the rapid and complete seizure of the particles of this and some other minerals by the oil, with even a gentle agitation, having a resemblance to the operation of magnetic force.

At the Sygun mine in Wales 20 stamps of 1,050 lb. crush about 100 tons (2,000 lb.) per day through 20-mesh. The pulp passes over four Wilfley tables, and the tailings from these are treated by four units of the oil plant. For operating the oil plant portion of the mill one boy is employed at the mixers, chiefly to watch and regulate the discharge cocks of the various pointed boxes and to see that the water levels are kept fairly constant, and two hands are used on the centrifugal machines, for handling and discharging the concentrates, all on 8-hour shifts. The ore consists of slate with a little quartz, and carries both iron and copper pyrites. The average grade of the ore now being worked is about 1% Cu. The

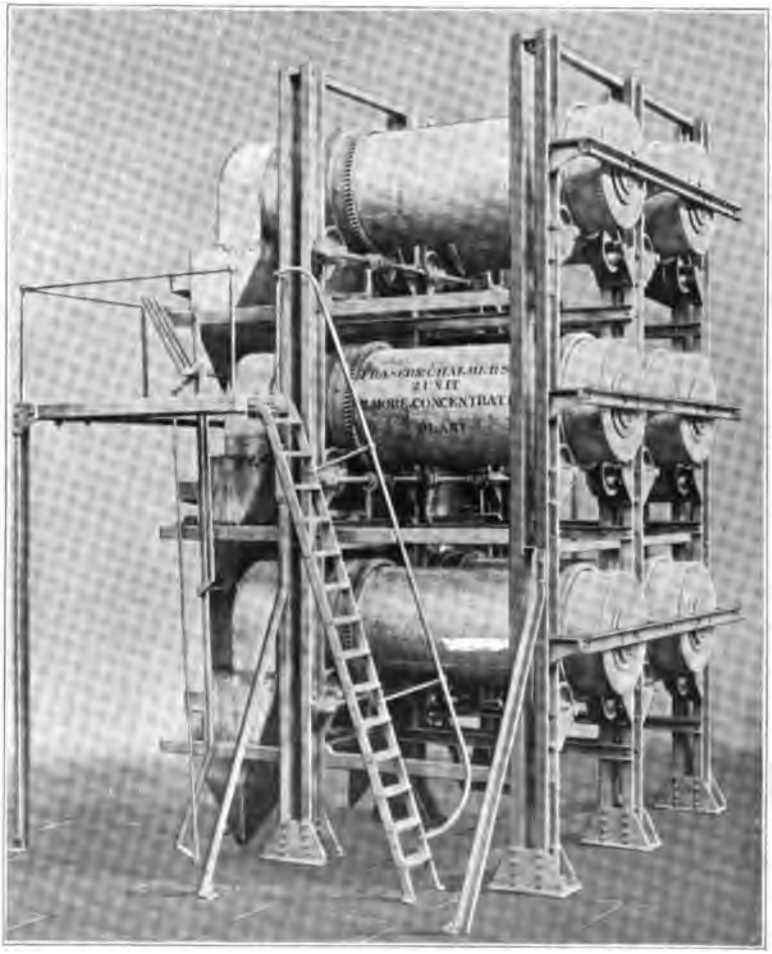

Fig. 1. Two Unit Elmore Concentrating Plant (back view).

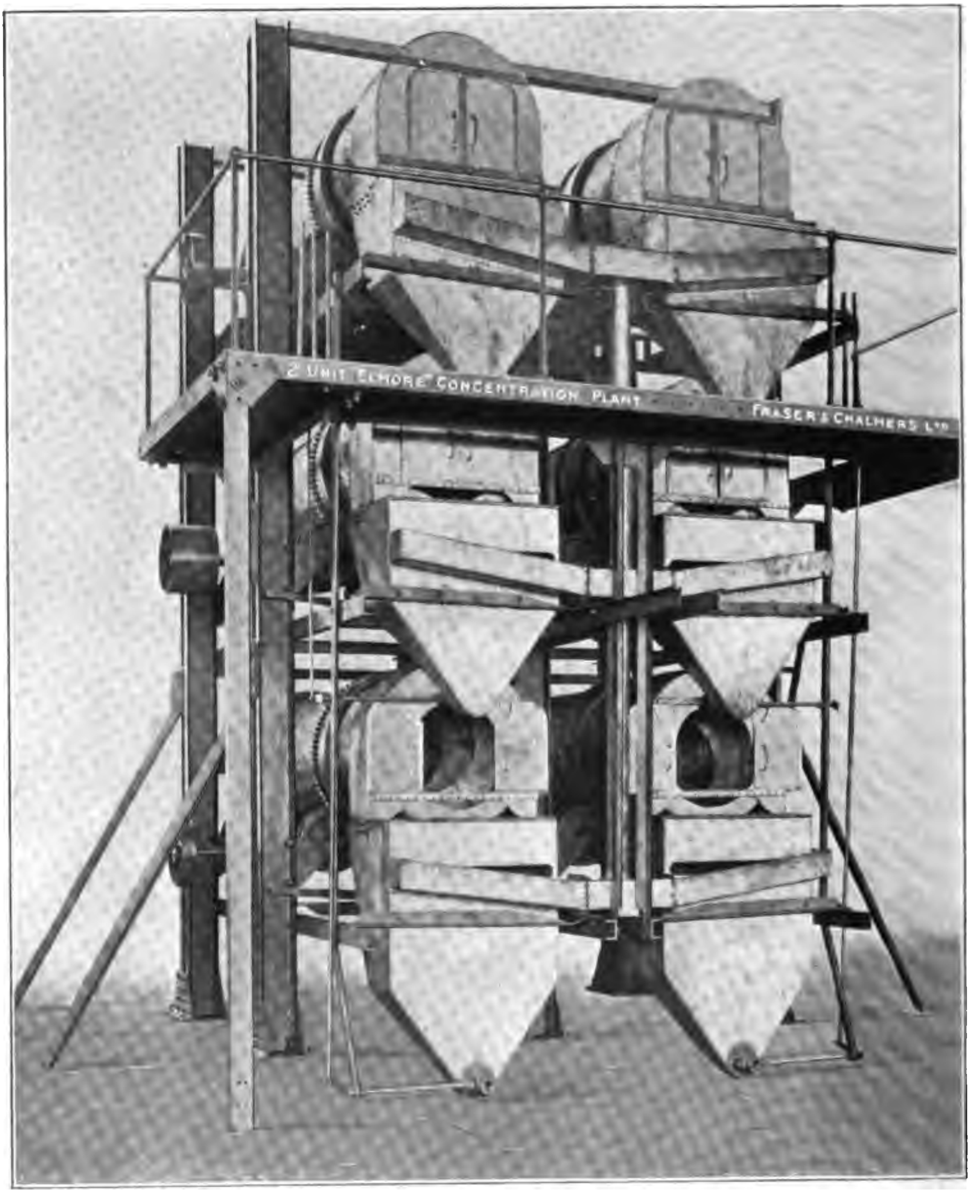

Fig. 2. Two Unit Elmore Concentrating Plant (front view).

Wilfley tables make a clean concentrate of nearly pure iron pyrite, carrying only about 3% Cu, but having an additional value, in the sulphur content, of about 50%, which allows of its sale to sulphuric acid makers, who leach out the copper from the residues, as is largely practiced in England with certain of the Spanish pyritic ores. The oil plant, following the concentrators, makes an excellent extraction in the form of a concentrate containing about 9% Cu, which is sold to the copper smelters. It has been mentioned that at the Tywarnhaile mine a partial separation of the copper from the iron pyrite is effected in the oil plant itself, by limiting the extent and time of agitation of oil with the pulp, and it is of interest to note that in the Sygun mine similar results have been established by the adoption of a system of intentionally imperfect water concentration (owing to overcrowding the Wilfley tables) as a first step, with the production of tailings relatively rich in copper pyrite on which the oil process is operated. This second method of attaining a partial separation of the two minerals has the advantage over the first of making a higher total extraction of values. The possibility of adopting either system in practice must depend on the form of distribution of the copper value in the two minerals. The mixers used in both these mills are the same and are arranged in units of three cylinders, one above the other. The cylinders are of galvanized iron and 10 ft. 6 in. long by 36 in. in diameter. They are supported horizontally on rollers and driven 6 r. p. m. by a worm gearing. Inside, a helical rib of 12-in. pitch and 6 in. high, with baffle plates at intervals, moves the stream of pulp and oil, and intermixes the same. At the discharge end of each cylinder is a pointed box, from the bottom of which the water and sand flow to the next cylinder, and from the top the charged oil overflows to the centrifugal separator. This arrangement of three cylinders allows of three separate agitations of the pulp with fresh additions of oil to insure contact with all the mineral present, and the whole operation is continuous and automatic on the flowing pulp. Figs. 1 and 2 show both back and front views of two units, and Figs. 3 and 4 show the plan and elevation of a 50-ton plant, giving the floor space and fall required. The two centrifugals shown will be the same for three or four units on most ores. The horse-power required has been carefully observed by electrical measurement of the various machines employed when in regular operation, and these powers are small. The three cylinders (or single unit mixer) require 0·7 H.P., the 48-in. centrifugal 4 H.P., the 36-in. centrifugal 2 H.P. Allowing for oil meter pumps to feed the mixers, return oil pump, and for friction of shafting, etc., the total power for a four-unit or 100-ton plant need not exceed 12 H.P., when two centrifugals are sufficient. This figure covers the extra power required during the period of acceleration of the speed of the centrifugals, when starting on new charges.

A third plant of six units has been running several months at the St. David's mine in Wales, treating the tailings of a 50-stamp gold mill, which contain a very small percentage of copper pyrite, and carry a little gold. The three mills have fully established the simplicity, efficiency and economy of the mechanical devices. The working results of the process in high percentage of extraction, in the good grade of concentrates produced, and in the small loss of oil involved, have more than equaled the estimates based on smaller suggested tests in the

London works. The loss of oil, which is one of the important questions at once occurring in a first consideration of the process, depends chiefly on the percentage of mineral in the ore, as the chief source of loss lies in the fact that the concentrates cannot be perfectly freed from oil. By the use of hot water, or hot air, in the second or drying centrifugal, the concentrates are at present dried down so as

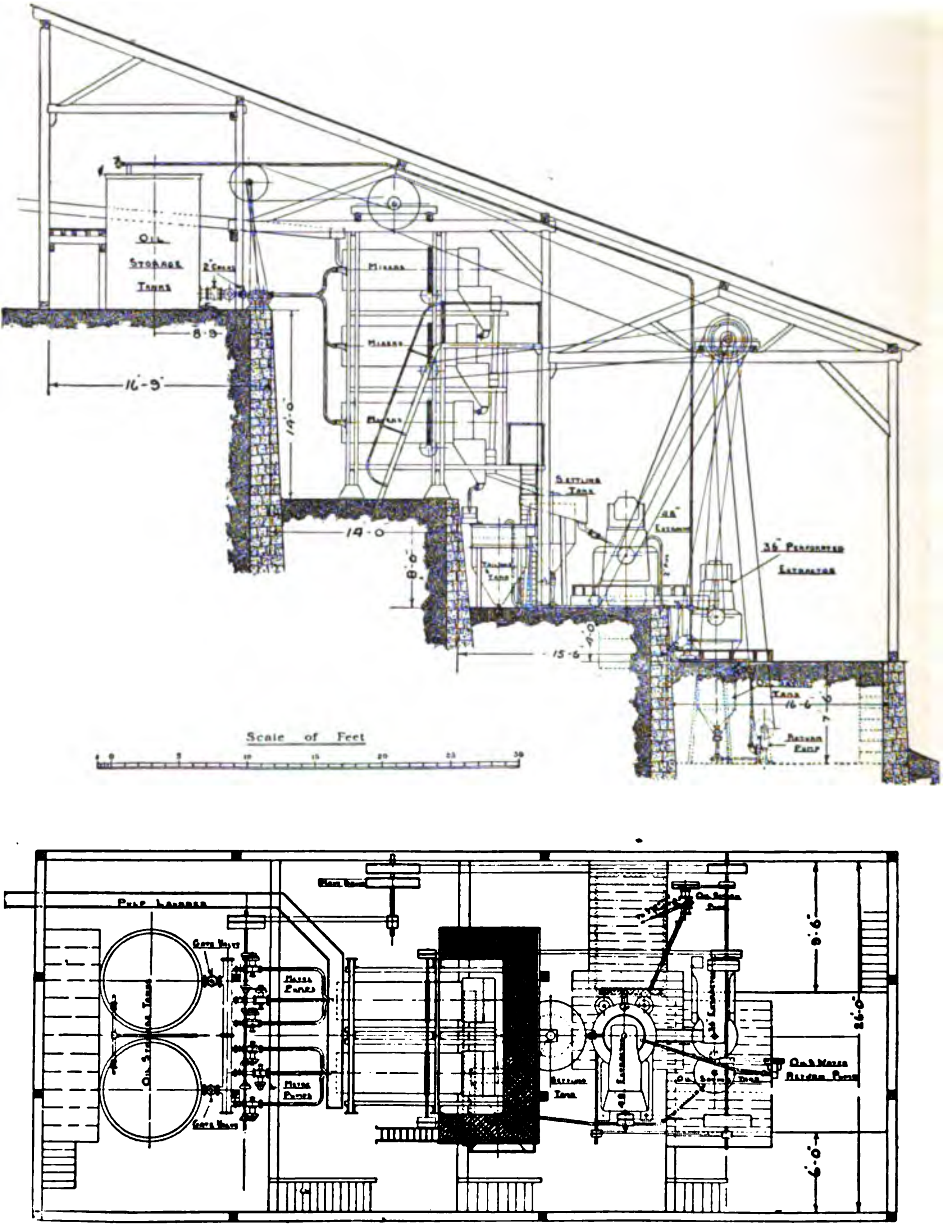

Fig. 3.—Longitudinal Section and Plan of a 50-ton Oil Concentration Plant.

to carry from 3 to 6% of oil, or, say 8 to 15 gal. to the ton (2,000 lb.) of concentrates. Assuming for illustration an ore concentrating 10 to 1, and wholly by oil treatment, this loss of oil would be equal to 0·8 to 1·5 gal. per ton of original ore treated and with mechanical loss in tailings, and all other sources the total loss, in the case taken, will be from 1 to 1·75 gal. per ton of ore. The first cost of the oil used/is only a few cents per gallon at the refineries in the United States.

The mere presence of a small quantity of oil in the concentrates is not a disadvantage, for, in nearly all cases, the subsequent treatment of this product will involve a roasting or smelting wherein the fuel value of the oil is worth considering, and, mechanically, the condition of the concentrates is advantageous for transportation, as lessening loss by "dusting," and as facilitating briquetting if this be required.

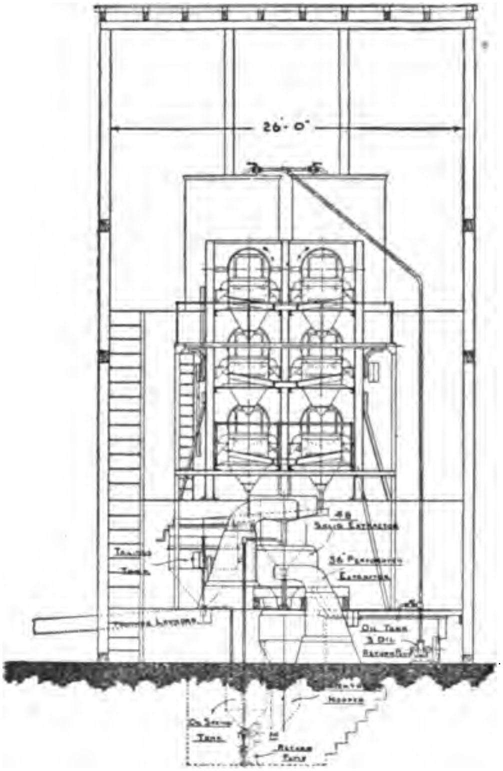

FIG. 4.—TRANSVERSE SECTION OF A 50-TON OIL CONCENTRATION PLANT.

One advantage of water concentration before the oil treatment, in the case of ores on which this is possible, is evident in the item of reduced oil loss from reduced weight of oil concentrates. In the case of certain ores with a heavy gangue, such as magnetite, barite, garnet, etc., water concentration may be so imperfect as to leave, of necessity, the whole field to the oil process. With ores containing only a small percentage of mineral suitable to oil treatment there is no need for a preliminary water concentration.

In considering the possible applications of the process the following suggestions may be offered, as based on tests already made with ores from many parts of the world. 1. Treatment of float and slimes from existing concentration mills; that is, as an auxiliary to water concentration, when present losses would justify further treatment. 2. As a substitute for water concentration in the case of certain minerals, such as molybdenite, cinnabar, some brittle silver minerals and the tellurides. 3. Concentration of minerals from a heavy gangue; for example, copper pyrite, gray copper, bornite, galena, iron pyrite and other sulphides, antimonides, arsenides or tellurides of the metals from a gangue of magnetite, heavy spar, garnet, etc. 4. The separation of two valuable minerals in the same ore, as, for example, the extraction of argentiferous or auriferous sulphides and antimonides of the metals from a rock carrying tinstone, leaving the tin oxide to be washed out in a second operation. Such ores occur in South America. This process would be applicable also to the mixed copper and tin ores of Cornwall. 5. By the increased extraction of slimes and float values, the use of the oil process would remove that fear of excessive slime production, which in some cases leads to the adoption of a complicated system of gradual reduction of an ore that must be eventually crushed fine to free all the mineral, and on which ore the simple reduction by stamps would offer decided advantages, both direct and indirect. 6. The removal of the cyanide-consuming minerals of gold and silver ores before cyanide treatment. In many ores the finely divided copper-bearing minerals, most difficult to remove by any system of water concentration, cause a great consumption of cyanide, and the oil treatment does not interfere with subsequent cyanidation.

The more general of the suggestions in the above list must, of course, be taken with the necessary limitation that the mineral to be saved is of a character susceptible to oil treatment. Broadly, it may be said that the oil acts only on native metals, sulphides, antimonides, arsenides and tellurides, and not on oxides, carbonates, silicates or sulphates. There is a great difference in the activity of the oil on different sulphides. A bright metallic surface seems favorable to the most energetic action; so that while the oil will freely and instantaneously act on copper pyrite, bornite and gray copper if in an untarnished condition, there are some occurrences of copper sulphide having a more or less earthy texture, which are very little susceptible to oil treatment. Zinc blende is in most cases not well adapted to treatment; but some experiments seem to show that the activity of the extraction varies with the different lusters of blende, between the extremes of light resinous and metallic. Cinnabar, even when in a finely divided state and of somewhat dull surface, seems to be saved with facility. Galena, and various compounds of antimony or arsenic and sulphur with copper, silver and other metals, and the tellurides, generally seem to be good subjects for the oil treatment, and these are the minerals usually subject to heavy losses in water concentration. Molybdenite is picked up with great facility, and as this mineral often occurs scattered in quartz, and is not at all easy to concentrate economically, the use of oil offers in this case obvious advantages. Mention has been made of atacamite (the copper oxychloride) as amenable to treatment under certain conditions; and it is possible that there are other minerals of the oxides of the metals which may be found later to be exceptions to the general rule above mentioned. Native gold, silver and copper are taken up freely. Two experiments with Lake Superior slimes have been unsatisfactory, and an explanation is to be found in the fact that some oxidation had occurred, shown by some of the copper being soluble in weak sulphuric acid. A merely superficial oxidation of a particle of metal or mineral will interfere with the action of the oil, so that old tailings of a mill may be untreatable, while the freshly crushed waste from the same mill will give good results.

As regards the production of clean concentrates, the results obtained with oil depend on several conditions. Taking, for example, a small particle of copper pyrite and a particle of quartz, together in water and both brought in contact with a body of the proper oil, the metallic mineral at once becomes coated by the oil, the quartz particle is quite unaffected, it remains wet and protected from surface contact with the oil by the water. A particle consisting of part quartz, part copper pyrite, is likely to be taken up by the oil from the contact effected through its metallic portion. From this it follows that a degree of crushing which does not effectively free the mineral from the gangue, will lead to a lower grade of concentrate, owing to the inclusion of a middle product. Excessive agitation leads to the introduction of waste rock into the thick oil by mechanical force. In most cases it is possible to make a sufficiently clean mineral concentrate from the commercial point of view. An examination under the microscope of the largest particles will show these to be mostly a middle product—part mineral, part gangue. Certain gangues are more apt to enter the oil than others, but they are not those usually found in payable mineral occurrences.

THE SAMPLING AND ESTIMATION OF ORE IN A MINE.

BY T. A. RICKARD.

Introductory.—It is held by some that to publish the details of personal practice is unprofessional. Others are of the opinion that while it may be well for professional men to discuss with freedom, but among themselves, the methods they employ in their work, it is poor policy to take the public into their confidence. As regards the first, no defense should be necessary in the face of the recent growth of technical associations which are founded for the avowed purpose of disseminating the knowledge acquired by their members; while, as to the second objection, it suffices to say that the mining engineer suffers from the ignorance of the public no less than the public itself, and, therefore, every step which will promote a better understanding between them is bound to be to the interest of both.

Other considerations, equally strong, prompt the willing distribution of the little knowledge which any individual among us may happen to possess. To give is to receive. No man realizes the limitations of his knowledge until he begins to crystallize it into writing, and if he be moved by a fraternal spirit to give a few hints to those who are his juniors, he will find that the effort will teach him more perhaps than those he has set out to help. It was well said by a man of wide learning that the best way to find out all about a subject was to write a book upon it.

There was a time when the examination of a mine implied merely a perfunctory visit to the underground workings, the copying of maps and the tabulation of the. output. On this flimsy foundation it was considered proper to base an estimation of values. Other times, other methods. During later years the common sense of every-day business has been introduced into the industry of mining, and it has become the practice to investigate with a thoroughness quite unknown twenty years ago. That we owe this betterment to the Rand is likely, for, while those of us who have found an adequate field of activity elsewhere have improved our own methods without conscious suggestions from the outside, it is probable that the very atmosphere of thought breathed by the earnest men of the profession has been influenced by the great developments in the Transvaal and the consequent introduction of a degree of system previously rare in metal mining, so that there has been exerted an influence not less valuable because it may not be directly measurable.

The purpose of examining a mine is, usually, to enable the engineer to pass judgment upon the value of it, both present and prospective. Whatever data he uses as the basis of his opinion must be verified as far as possible. There are many items of information which, on account of the relations of time and place, he may not be able to test at first hand; all the more reason, therefore, that especial care be taken to get alongside of facts in those matters which are verifiable. Among these the three most important are the determination of the quantity of ore in the mine, the average value of it, and the cost of turning it into money.

In practice these three determinations are undertaken in the reverse order, it being obvious that the results of sampling will be meaningless unless it is known how valuable the ore must be in order to yield a profit, and it is likewise apparent that no estimate of reserves can be made without the safe basis of one's own sampling of the mine.

"Ore" may be defined as metal-bearing rock which can be exploited at a profit, and it should be unnecesasry to distinguish profit-yielding material as "pay-ore"; however, it is a common habit to include all vein-matter containing any value under the term "ore," it being left to sampling and assaying to differentiate. In the present discussion, whenever the word "ore" is employed, it will mean such material only as at the time of the examination can be profitably exploited, and if there be other lode-stuff which will yield a profit in the event of a further probable reduction of the expenses of mining and milling then such material will be designated as "low-grade ore"; any other vein-matter, of less value, will be included under the general term "waste."

Determination of Costs.—In arriving at the average costs incurred in the business of a mine, the engineer will encounter conditions which may vary between the extremes of a going concern, having detailed accounts covering a period sufficiently long to afford thoroughly reliable data, and that of an undeveloped mine in an entirely new region where no such data are available.

The first renders it possible to obtain the fullest information, and in such instances if true figures are not secured it is often due to mere carelessness. Sometimes the costs are not segregated on the account books, and it will require tactful insistence to get at the actual facts. The investigator may find that there is a tendency to eliminate outlays on improvements for the reason that they are to be regarded as extraordinary items of expenditure, and it is not infrequently found that, in the case of a new equipment, the heavy item of wear and tear is overlooked. Errors may arise from the adoption of figures which cover exceptional periods; for instance, at high altitudes the costs during the summer months are less than in winter on account of cheaper transport, better water supply, and other causes connected with the difference of seasons; similarly, incorrect data as to mining costs may be accepted through overlooking the fact that during the period in question the amount of dead work (exploratory) has been unusually small in comparison to that which is required to keep step with the stoping operations; furthermore, in milling it is not uncommonly found that the power used during a part of the year is derived from water, which is either free of cost or relatively cheap, and that during the remainder of the year coal or wood has to be consumed, to generate steam, at a much greater expense. These are some of the errors against which one has to be on guard. Speaking broadly, the safest way to avoid them is to quote costs covering a period long enough to include the vicissitudes of seasons and markets.

Mines are rarely in a stationary state of development; like man himself, they are either growing or declining. When an engineer examines a mine he obtains data which are representative of conditions liable to change on account of the probable expansion or contraction of the entire enterprise; therefore, the figures he gets are apt to represent a passing phase in the development of the particular undertaking, and he cannot arrive at the average costs for the future by simply dividing the expenditure for a given period by the tonnage mined during that period. If the property is a steady-going concern, which has been operated for many years under conditions which are likely to continue unchanged, then indeed he has an easy task, and, given correct figures, he has only to perform a plain sum in simple division. Such cases are rare. Mines are usually bought by capitalists because they think they can enlarge the scheme of operations so as to make the business more profitable than has been the case under the previous ownership. This often entails a sweeping change in the manner of carrying on the enterprise; the entire business is conducted on broader lines, and it is assumed that a larger scale of operation will result finally in a considerable diminution in the average cost per ton. Apart from the fundamental supposition of ore-reserves big enough to warrant this expansion, there arises the question whether the money to be spent in extra equipment, a better trained staff, more vigorous and extensive development of the mine, etc., will result in a reduction in costs to the extent estimated. Experience has shown that sanguine expectations in this regard are not always fulfilled, and that a single mine owner or a small local syndicate can often, in spite of imperfections of administration and equipment, work a mine at a cost per ton which will compare favorably with that of a big company having the large permanent expenditures inseparable from the very nature of its organization. In judging of this, experience is the only guide, no rules can be laid down, and each case must be considered apart and on its own merits.

In the case of an undeveloped mine, in a new district, reliable data concerning costs are not available. Under such circumstances it is well to supplement one's judgment by visiting the nearest mines which are being operated under like conditions. To those devoid of experience the situation is honeycombed with pitfalls. Western Australia afforded many lamentable examples of this during the years between 1895 and 1898. The majority of reports made at that time omitted to include any estimate of costs, all the available space being taken up by flamboyant statements of results obtained from rough sampling, together with wild prophecies concerning enrichment in depth based upon the presence of sulphides, tellurides, etc. It is a fact that many reports, which confessed to an average of 8 or 10 dwt. gold per ton of ore, advocated the purchase of mines situated in localities where, at that time, the costs could not possibly be less than 20 dwt. per ton. Again and again one found in examining a mine which had proved a failure or was about to collapse, that the earlier reports contained the results of assays upon, what obviously must have been, mere specimens of ore. Such reports had served as the foundation for financiering on a Napoleonic scale, and prospects had been highly commended on the basis of an average tenor low even under exceptionally favorable conditions, but quite unattainable in an uninhabited desert several hundred miles from any manufacturing center.

It may seem that the follies of a boom are hardly worth castigation, but they may recur, and, if haply they do not, then at least one lesson may be learned from them, namely, that it is quite as important to ascertain the average costs as it is to determine the average value of the ore in a mine. To ask a man who has had no experience in the business and management of mines, to appraise the value of a prospect situated in a new region, is to court disaster. He may be a chemist, geologist, mineralogist, mechanical engineer, but, however accomplished he may be, unless he has served an apprenticeship as a mining engineer he will be more helpless than helpful. In sizing up the situation it is necessary that a man should know what are likely to be the costs of stoping, timbering, road-making, erection of machinery, equipment, etc., and these things he can only know through actual underground experience and personal participation in the administration of mines. In a new district all the data obtainable will be those furnished by prospectors, diggers and local promoters, very few of whom have accurate knowledge on these points, and when they have it they do not feel called upon to donate it to the novice who happens along. This disregard of the inevitable high cost attendant upon the opening up of a new mining region under unfavorable conditions has been at the bottom of the blunders which have retarded the early development of many districts.

The Determination of the Average Value of the Ore.—The average value of the ore in the past can be ascertained from the records of a mine, but to find out the probable average value of the production in the future there is no method save that of testing the ore exposed in the workings. This is done by taking representative fragments and then subjecting them to assay. The method is termed "sampling." There are many ways of carrying out the operation; the best are the outcome of experience.

Sampling is expensive. It cost $7,000 to sample one well-known mine, and it cost $12,000 to do the same work in a neighboring property. This did not include the fee of the engineer in either instance. Therefore, an engineer will not commence an elaborate sampling of a large mine unless he has reason to believe that the circumstances warrant it. The cost mounts up into big figures, because of the large number of assistants necessary, the workmen employed in rigging up such timbering as is required to enable the sampling gang to get at the stope faces, the cost of assays, and other expenses. When a mine has very extensive workings the cost is much increased on account of the necessity for putting up special timbering, upon which to rig up a temporary platform or such other arrangement as will permit of convenient access to the faces of ore in the stopes. The figures already quoted indicate very plainly that a thorough sampling must not be lightly undertaken. It should always be preceded by a preliminary investigation. In going through the mine for the first time the engineer will observe that either the present value of it or, perhaps, its future prospects, hinge upon certain facts; it may be a question whether the lower workings exhibit a falling off in value, it may be important to ascertain whether particular ends of levels or particular stopes are really as good as represented. A few samples will throw light on these points, and, if these are satisfactory, then it will be well to test certain portions of the mine more thoroughly, and in this way finally get data which will determine whether a complete sampling of all the workings is justified.

In organizing the sampling gang it is necessary to adopt a system in order to avoid confusion. If it is a small mine, or if the conditions render it advisable to keep quite clear of any assistance from the management, then the engineer will employ only his personal assistants, and, whatever their number, he will divide them into pairs, one of whom will break the sample while the other holds the box to receive it as broken. If, on the other hand, the examination is being made for the owner of the mine, or the conditions otherwise warrant the engineer in accepting the good offices of the management, so that he can utilize the services of workmen on the property, then the task is easier and he can put each of his assistants to work with a miner, the latter doing the muscular work of breaking the ore while the assistant watches to see that the sample is fairly taken, and collects it as it falls into the box or other suitable receptacle made for this purpose.

Next, it is necessary to determine what interval to allow between samples. If the ore is fairly regular in width and value, an interval of 10 ft. will usually suffice; if it is very spotty in value and subject to sudden changes in width, a lesser interval will be required. I have been compelled to sample every 3 ft. in the case of a vein, the ore of which varied between 1 in. and 1 ft., with an assay content ranging between 10 oz. and 1,000 oz. silver. In such a case extreme care to sample accurately at very short intervals is absolutely imperative in order to get at any kind of idea regarding the average value of the ore. When a lode is built up of the common sulphides, such as pyrite or galena, the variations in value are apt to be small, and under such conditions 20 ft. may not be unsafe. Even though you may decide to take samples at much smaller intervals, it is best to start off with a large interval, say, of 20 ft., and when the assay returns are received you can cut this down by taking intermediate samples, if the circumstances warrant it. This will prevent useless labor over stretches of poor ground, and at the same time suggest the proper interval required wherever the workings are in good ore. Having settled this point, the next step is to take the first assistant and measure as regularly as possible along the workings, marking each successive place with colored chalk so that there can be no mistake as to the point where the sample is to be taken. Then one of the assistants or the engineer himself, at all events, a man who has had some training as a mine surveyor, is told off to make sketches of the workings as the sampling proceeds, noting the variations in the vein, the number of each sample and its position, and gathering other information, often extremely important, such as develops in the course of the work done by the sampling gang. Another man sees to the correct labeling of the samples, the sacking and sealing, and the removal of them to a safe place. All the data thus obtained should be set down upon a longitudinal section of the mine so that they can be generalized by the engineer later on.

The Work of Sampling.—The best sampling tool is a moil when struck by a 4-lb. hammer. Beware of the prospecting pick or the geologist's hammer, or even the larger type of each which the working miner uses; the former insensibly, but inevitably, seeks out the soft places and crevices in the vein, and does not therefore yield a true sample, while the hammer does the reverse and tends to break off the projecting points, which usually represent the harder portions of the ore. As a rule, the richest parts of the vein are not in the hard quartz, but, particularly near the surface, in the decomposed lode-stuff, so that the pick gives too high an average and the hammer one which is too low. By the right use of the moil and hammer this error of extremes can be avoided. Of course, the excellence of a tool depends upon the right use of it, and it is very easy to get misleading results with the moil as with the other implements already criticised, nevertheless, experience demonstrates that the former is more likely to give a closer approach to a perfect sample. The ideal method of sampling is the testing of a cheese by a cheese-tester, which removes a core of uniform size. In a mine the intention is to imitate this method as nearly as a material of very variable hardness and texture will allow, an effort being made to cut out a channeling or groove of uniform breadth and depth across the full width of the ore.

Either a moil or a gad is obviously best adapted for this purpose. If the ore is too hard for a moil and a single-hand hammer, get another striker and a double-hand hammer. Do not let the hardness of the ore lead you into the mistake of using dynamite, in the form of "pop shots," in order to loosen the ground. No ground that can be mined in the ordinary way, that is, by drilling holes and charging them with an explosive, is too tough for a moil struck by a double-hand hammer, when swung by a good man. The use of an explosive introduces an element of danger from "salting," as it is easy to charge the cartridges with powdery gold, which the dynamite will distribute very prettily amid the ore. Of course, one can avoid such tricks by using one's own dynamite, but engineers, as a rule, do not find it convenient to travel about with high-grade explosives. Apart from this, there is a commoner danger. Dynamite tends to break a conical cavity, with the drill-hole as the axis of a cone which tapers inward. The product of the drill-hole would not be a fair sample even if it could all be secured without loss or interference. Usually the explosion of the hole breaks a mass of rock, the cross-section of which tapers from the width of several feet to almost a point, so that as a sample the material obtained is misleading. To pick a sample out of a mass of ore thus broken, or to take it all, is a procedure likely to lead to serious errors.

An accurate sample represents a true cross-section of the ore; it depends, therefore, upon the uniformity of size of the groove or furrow, that is to say, an equal amount of ore must be broken across every part of the entire width of the lode. That is what makes sampling difficult, especially in gold-veins, the predominant matrix of which is quartz, in some form, varied by softer, more friable minerals, which cause marked contrasts in the ease of fracture. In one case, which came under my notice, it took six men (three of whom moiled while the other three held the boxes to receive the samples) the whole of one shift to take three samples across a vein 12 ft. in cross-section, and in accomplishing this they dulled 35 moils. This example was one of good, honest sampling work.

The Size of the Sample.—This question is an important one, and it is a matter to be decided by convenience, scientific principle and experience. Considering the least important first; large samples are more difficult to handle than small ones and require more assistance. In mountainous regions or in desert places, where facilities for crushing the ore are lacking, it will be found inconvenient to break samples so big that their reduction by hand consumes much time. Occasionally greater inconvenience than this will arise through the want of facilities for removing the ore from the mine without entrusting it to unsafe hands. The factor of time has been mentioned, that of cost must not be forgotten, for time and money are valuable alike to the engineer and to his client, so that the former will find it advisable to "cut the coat according to the cloth." Every engineer meets obstacles such as have been referred to, and these vary so much with each individual case that it is needless to attempt to specify them in greater detail.

The size of the sample will also depend upon the facility with which the ore can be broken, because the scientific principle underlying the act of sampling is the obtaining of a true cross-section of the lode. In the case of an ore having the consistency of cheese, which is by no means an impossible occurrence and is approached by certain lodes which are built up of crushed material, a perfect sample can be obtained by running a scraper over it so as to make a narrow furrow across the full width of it. This will result in a sample of minimum size. On the other hand, in order to obtain a true sample of a large lode made up of streaks of varying hardness and uneven fracture it will be found necessary to break a hundred pounds at the very least. In such a case it is impracticable to secure a sample of the hardest portions except in large irregular pieces, and this necessitates the breaking of a proportionate amount of material from those places where the ore is much softer or of easier fracture. In hard quartz-veins it will be found that a channeling from 4 to 6 in. in width, and from 0·5 to 1 in. deep, will be adapted to the securing of a true sample; in those instances where the ore has a fairly even grain, as with replacement deposits in igneous rocks of granular texture, it will be found that a groove 3 in. wide, and from 0·25 to 0·75 in. deep, will give a true sample. The minimum size of groove which will yield a correct result should be chosen because any unnecessarily large groove simply increases all the work of subsequent reduction and handling of the samples without a commensurate increase of accuracy in the final results. Furthermore, one has always to remember that two samples of 50 lb. each at 5 ft. apart are better than one sample of 100 lb. at an interval of 10 ft. The whole idea underlying the operation is that of securing an average, and it is obvious that the larger the number of data, the more likely one is to approximate the truth.

The next factor is more important than the two already considered. I refer to that invaluable guide, experience, without which all work of this kind is as dangerous as is mountaineering in the Alps to a thoughtless tenderfoot. To one who has done his own sampling and assaying there has often arisen the inevitable contrast between the dimensions of the sample and those of the gold button which represents its contents. Whatever the size of the original sample, the outcome is merely one button of minute size. Gold, as at present known to exist in workable lodes, occurs in a metallic form, and is usually disseminated through the ore in an extremely irregular and sporadic manner. As a consequence the final pulp taken for assay, and weighing, as a rule, about an ounce, if not less, is apt to contain a coarse speck of gold, the accidental presence of which vitiates the result. Whatever the weight of the original sample, whether 5 lb. or 500 lb., the particular particle of gold included within the final pulp will have the same effect of exaggeration, save in one respect, *viz.*, that, given the fact of its occurrence in the original sample, it is more likely to find its way into the assay pulp of a small sample, the latter being to the former in the proportion of 1 oz. to 5 lb., or, say, 1 to 80, than in a large sample the final pulp of which represents, say, one part in 8,000 parts of the original. When, however, the gold is not present in the usual condition, but occurs in that pulverulent state known as "mustard gold," characteristic of the metal when it is the product of decomposed tellurides, then the more even dissemination of the gold causes it to be so spread throughout the sample so as to make the size of the latter a factor of safety. Of course, usually, the particles of gold become flattened out during the process of crushing (on the buckboard) previous to the assay, so as to appear on the screen in the form of scales, termed "metallics," and the practice is to pick them up, weigh them, cupel them, and then determine their weight in relation to the weight of the sample, but this does not overcome the interference with accuracy because, although this determines the proportion in which such particles occurred in the particular sample, it does not give any clue as to the relative importance of such particles in the enrichment of the entire lode. Naturally, in small samples the interference is relatively greater and therefore more clearly recognizable. On the whole, therefore, one comes back to the conclusion that the best rule to follow is the taking of the smallest sample consistent with securing a true average of the lode at each cross-section. The larger the sample the more difficulty in handling it, the more persons required to help, and the greater the chances of poor work. Let me mention an example. Two engineers examine a mine, and, in carrying out their investigations, one gets large samples resulting from a wide groove, while the other takes small samples, the product of a smaller groove. Although both samples are equally good, in so far as they represent an approach to the true cross-section of the lode at each place sampled, nevertheless, the former, on account of the greater size of the samples, is, theoretically, the better of the two. However, the second engineer employed fewer assistants, and all those whom he employed in this capacity were men whose antecedents he knew and whose reliability he had previously tested, while the first engineer engaged his gang of samplers at the mine, most of them being vouched for by the management or by a fellow-engineer, yet the chances of error were increased by the number of men employed, the real ability of each to take true samples being merely assumed on the statement of some one else.

The Reduction of the Samples.—When the samples are broken they are put into sacks which are not marked upon the outside, but are, preferably, labeled by inserting a tag with the number upon it. This tag is often merely a piece of paper, detached from a notebook, but in this form it is apt to get torn or the number upon it obscured, especially when the ore is moist, therefore it is best to use a metal or wooden tag especially prepared for this purpose. The latter will be found convenient. Get a lot of small pieces of soft wood (0·125 in. thick, 1 in. wide and 1·5 in. long), and mark the numbers of the samples upon them by the use of a hard pencil; this will remain as a visible indentation even after the pencil trace has been rubbed off.

The samples are then removed to a safe place, either temporarily in the mine itself or to a building where they can be locked up. Then comes the work of reducing them in bulk by crushing and subdivision. If an assay office is conveniently at the engineer's disposal he will probably find a rock-breaker which he can use, otherwise a portable rock-breaker, worked by hand, will be found a useful machine to take with him when a large sampling job is to be done. In the absence of these conveniences the ore is broken by hand with a cobbing hammer, to the size of walnuts, and then subdivided. This is followed by further reduction in size and subsequent subdivision by quartering.

It is usual to place the crushed ore upon a square sheet of canvas, which is rolled backward and forward in opposite directions in such a manner as to mix the ore lying upon it, until finally a conical pile is left standing in the center. This is flattened to a frustrum previous to quartering, the two opposite quarters being taken and again mixed previous to a further mixing and quartering, until the bulk of the sample has been reduced to the size considered suitable for shipment to the assay office.

The foregoing method is open to criticism. In the first place, the rolling canvas is not nearly so good a way of mixing as it looks, the fines are apt to slide over the surface of the canvas instead of becoming thoroughly mingled with the coarser particles; moreover, the cone which is finally formed is deceptive in that the fines are likely to be collected not at the center of the base of the cone, as is supposed, but to one side so that, in quartering, any particular division may include an undue proportion of the fines, which usually form the richest part of the sample. Further, in flattening the cone into a frustrum, for convenience in quartering, it is difficult to distribute the ore evenly, and though great care be taken to draw the ore in a straight line outward, toward the circumference, the distribution is liable to be faulty and this part of the work may be so imperfectly done as to become a source of error.

An alternative, and better, method can be suggested. Get a few short boards, or cause some to be sawed to the required length, of about 6 ft., and put them together so that they will make a platform which can be kept firmly in place by being spread upon a couple of sills and wedged in with stones. Then, if the joints are not tight, put your sheet of canvas upon it, not to roll the samples within it, but merely to prevent any leakage of fines through the cracks between the boards. When the sample is crushed, gather it up, with a scoop or other handy implement, to the center, lifting the broken ore, shovelful by shovelful, and pouring it as nearly as possible at the same central point so as to aid the mixing of it. In doing this it will be found convenient to use the "cone," in vogue at many smelters, which consists of a sharp central cone, made of iron, with four thin radiating partitions which cause the ore, as it falls upon the center, to become quartered.

In order to do accurate work at this stage it is necessary that the particles of ore should not vary too much in size. The fines are apt to obscure the fact that there are a good many large lumps, and the unaided eye is likely to mislead in this respect. For this reason it is well, if convenient, to use a wire screen, say, 0·5 or 0·75 in. mesh, or perhaps two, one of 0·75 and the other of 0·25 in. mesh, to be employed at successive stages of the operation, so that the maximum size of the particles can be kept within defined limits. It is an easy matter to take a piece of wire cloth, say, 1 ft. square, and have a frame put around it when you reach the mine.

If it is necessary to send the samples to a distant assay office or to take them with you on your departure from the mine, then it becomes convenient to reduce them until they weigh only 3 or 4 oz. each. In doing this the engineer will anticipate the work of further reduction which is usually carried out by the assayer. The samples will be crushed smaller and passed through, say, a 10-mesh screen, and, instead of quartering, it will be well at this stage to use a gridiron sampling device, which consists of a series of metallic scoops separated by vacant spaces of equal width so that one-half of the ore falls through while the remainder is arrested. When this method has reduced the bulk of the samples to the desired dimensions they are put into small paper or canvas sacks, the latter preferably, especially if it is intended to ship them a long distance.

If genius be, as has been authoritatively stated, "an infinite capacity for taking pains," then it is safe to say that genius is exactly the mental quality needed for the humdrum work of sampling, for, to do it conscientiously and well, requires patience, strength and an amount of unwearied watchfulness sufficient to elevate this common task to the level of a fine achievement. It requires an obstinate persistence to get a true average across a hard and tough quartz vein; any relaxation of care or muscle will at once result in the spoiling of the sample and the consequent introduction of an error into the calculations of the engineer. It needs judgment to know how to treat a cavity (or vug) or an unusual inclusion of waste rock; it needs a nice sense of proportion to avoid cross-sections which are exceptional, to break an equal weight of ore along a line 10 or 12 ft. in length, and to get the true width of an irregular cutting. For these reasons it is best, when carrying out an arduous scheme of sampling, to divide the muscular from the mental work, allowing a miner to do the actual breaking under the direction of an intelligent trained assistant who holds the receptacle for the ore as it falls, and at the same time watches the movements of the miner. Further, it is well to make the hours of labor short, so as to avoid an excessive strain on the faculties, such as will cause relaxation of the intent watchfulness and care necessary to good sampling. In order to escape the risk of inferior work it is good practice to vary it, as, for instance, by putting the assistants to surveying or mapping for a day or so, at intervals. Otherwise your men are apt to get stale through weariness. How tiresome such work is those can testify who have done much of it; the dirt, the wet, the strained positions, the splinters that hit the face and hands, the obstinacy of rock and circumstance, the weary iteration of it; these require something better than mere mule-like persistence to overcome them, and the men who can do a difficult piece of sampling honestly and well, can be entrusted to do work for which much greater credit is usually given by those in authority.

Precautions in Sampling.—Although the greater thoroughness with which mines are investigated at the present time has made trickery scarce, instances of the latter do occur occasionally. They are rarely exposed because of the lack of evidence, and, therefore, the occurrence of them is obscured amid those failures and disappointments in mining which arise from other causes. The tampering with samples, called "salting," and the blocking up of workings which might give unfavorable testimony regarding the condition of a mine are two possibilities against which one must be continually on guard. To prevent "salting" it is imperative that the work be done by trustworthy assistants and in the case of a large mine where it becomes necessary to employ workmen whose antecedents are unknown, it is well to arrange that the work be done in pairs, the miner breaking the samples under the direction of an assistant who holds the box to catch the sample as it is broken. When the sampling is done it is well for the chief himself to take a certain number of samples, aided by his first assistant, these samples being taken not at haphazard but in such a way as to check the previous work. One of the best guards against any successful tampering with one's samples is to take an occasional sample of waste. If the samples are all salted the assay of the waste will disclose the fact. Occasionally it may be well to fill one or two sacks with material the exact assay contents of which have been previously determined. In any event it is better not to use sacks which are numbered or otherwise marked on the outside, because, should trickery be purposed, such marks make it easy to note from what parts of the mine the various samples come, and to salt them accordingly. It is well to assay the samples on the spot, if a suitable assay office is available, particularly when the engineer, or one of his assistants, is a good assayer, as is frequently the case. Of course, in using a strange assay plant it is necessary to guard against fraud, and to this end it is well to test the fluxes used, by assaying a charge without ore every time a batch of samples is put through the furnace.

During the interval which elapses between the time when the sample is first broken in the mine and its final assay, it is necessary that the sack containing it should be sealed. It is a good thing to use uncommon wax and an uncommon seal so as to render trickery more difficulty. It is well even to use a peculiar kind of string for tying up the sacks. "He is most free from danger who, even when safe, is on his guard." Any extra precaution should never be considered a nuisance; on the contrary, it ought to become a habit. Cases of salting have been known where the ore has been artificially enriched without breaking the seal and without puncturing the sack, and I know of an instance in which samples of copper ore. put into a carpet bag, were withdrawn and substituted with others by removing the bottom of the bag and sewing it up while the engineer was asleep. "Dead things will crawl." "Eternal vigilance is the price of safety."

Unfortunate consequences have sometimes ensued from the failure of an engineer to see all the workings of a mine. This may be due either to carelessness or oversight, but it may also be due to the rascality of the mine owner. Cross-cuts are sometimes blocked up with old timbers, drifts may be allowed to cave, shafts may be under water; in each of these cases the engineer must realize that he is under a responsibility, if he passes judgment on the mine without seeing for himself what these inaccessible workings have to tell. Their testimony may be unfavorable, it usually is in such cases, but on the other hand, there may be circumstances which influence the owners in desiring temporarily to depreciate their property.

An opportunity for splendid business was lost in the case of the great Broken Hill mine through an error of this kind. An engineer, and a good one, too, was engaged by a Melbourne financier to make an examination of the new discovery at Broken Hill with a view to the purchase of an interest. He duly reached the mine and found a gang of miners engaged in sinking a prospect shaft which at that time, in 1885, was about 70 ft. deep. Much to his annoyance he was refused permission to go underground, except by written order from the manager, who had left the day previous for Adelaide. Disappointed, but not without hope of getting information, he chatted with the men, more especially the foreman, and endeavored to pump the real facts out of them. Their talk indicated that no rich ore had been found, and that the prospects were poor. He examined the dump, took samples of it, and finally returned to Melbourne, via Adelaide. The samples from the dump gave 16 oz. of silver at the best. He advised his client to keep out. A few days afterwards it became known that a rich mine had been found at Broken Hill. He had been fooled, the discovery having been made just previous to his visit and covered up for a particular purpose. The mine has since produced over one hundred million ounces of silver.

This in one side of the question. It is rarely that a bonanza is kept out of sight. As a rule, the exclusion of an engineer from certain parts of a mine is intended to cover unfavorable testimony. It is therefore of the greatest importance, more especially in a small mine, the character of which has not been truly established, that an effort be made to personally investigate all the workings. Intentional deception is, I am glad to believe, rare, nevertheless, in passing upon the purchase of property, the engineer should write across his notebook, *"Caveat emptor."* One instance will suffice. Let the accompanying section, Fig. 1, represent the workings of a small mine, where the level *A D* is 200 ft. from surface and *F M* is 100 ft. deeper. Above *A D* there has been a line of stopes from *B* to *C*, a distance of 200 ft., all the ground being worked out, with results testified to by certified returns from mine and smelter. When the mine is sampled it is found that there is good ore in the floor of the level *A D*, and along the back of the lower one, *F M*, as indicated in the section; moreover, the raise at *H* is going up in good ore, and the drift (at *M*) is proceeding in ore of an average tenor; in short, the evidence proves that the ore-body is persisting downward with a pitch to the east, similar to its behavior in the upper workings. No winze has been sunk below *A D*. At *E* there is a hole, about 5 ft. deep, which, according to the statement of the superintendent, is being used as a sump to catch the drippings from the stopes and thus prevent the water running down the shaft. A small pump at *A* sends this water to surface.

All looks serene and straightforward, but the facts are as shown in Fig. 2. At

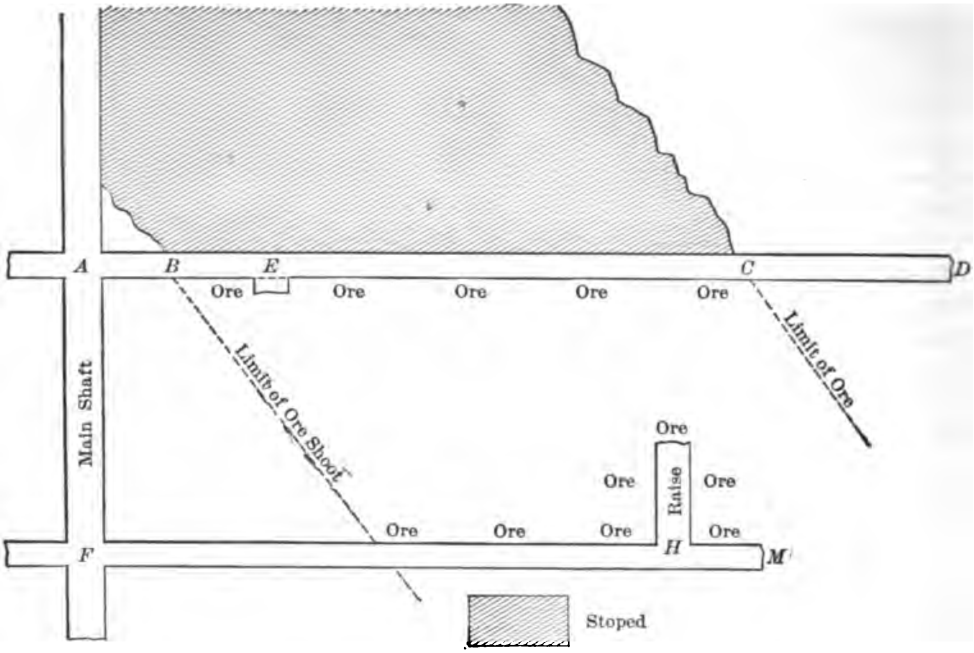

FIG. 1.—SECTION OF APPARENT WORKINGS OF A SMALL MINE.

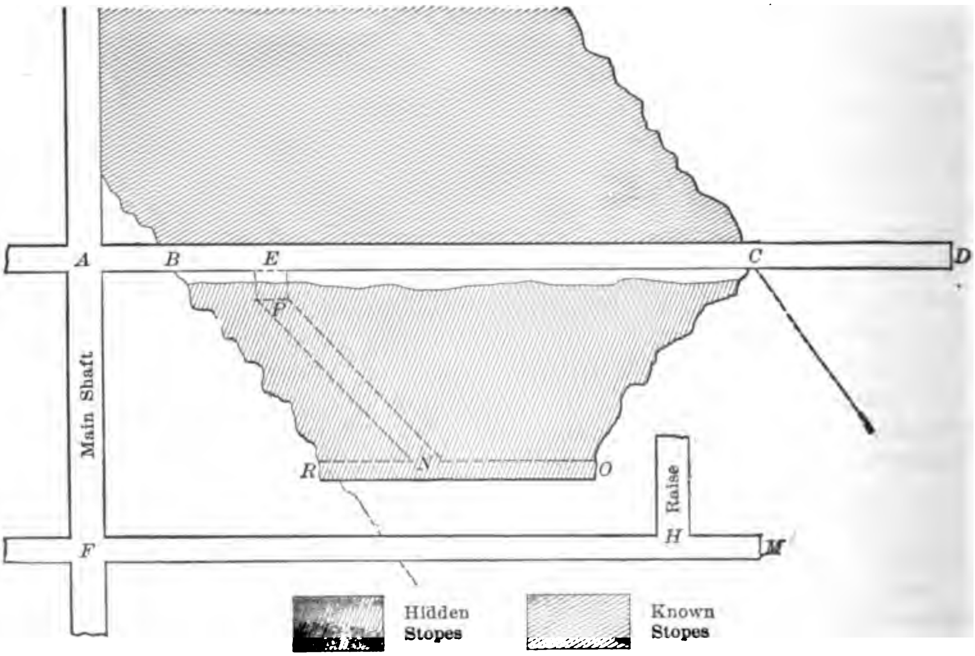

FIG. 2.—SECTION OF ACTUAL WORKINGS OF A SMALL MINE.

E there is a vertical winze which is deeper than 5 ft., and has been carefully filled up. From the bottom of this (at *P*) an incline has been run down to *N*, at *N* there is a drive *R O*, and all the ground above has been stoped out bodily, leaving a mere shell under the level between *B* and *C*. The raise *H* is situated so as to miss these secret workings. The heart of the ore-body has been taken out, and a clever piece of trickery has been attempted.

As a possible check against the perpetration of such practical jokes it is not out of place to ask the manager in charge of the mine to sign a statement which sets forth that he has informed the engineer of all the existing workings. and to this can be attached a map or a brief description of such workings as are inaccessible through caving or other causes. Such a paper will serve as a record to make clear the position of the engineer and fix the responsibility on the management of the mine should false statements have been made with the intent to deceive.

Wrong Methods of Sampling.—In the early days of Western Australia, and, indeed, one may say in the early days of most gold fields almost everywhere, it was a common practice for the gentlemen vaguely known to the press as "experts" to sample an incline shaft, on a vein, by having a few shots put into the ore, at intervals, and then collecting the material, thus thrown down to the bottom of the shaft, and having it hoisted to surface, where it formed one of those "large" samples, the tonnage of which was referred to with pride, in the reports as evincing an accurate testing of the value of the ore in the mine. Such work is the travesty of sampling. A bunch of specimen ore, a few inches in extent, was enough to vitiate the whole result. Such spots of free gold were commonly characteristic of the Western Australian reefs near the surface, and if this unintentional salting was not enough, the subsequent performance at the surface and the handling of the ore by a large number of men of unknown character,gave sufficient opportunity for further tampering with this supposititious sample. There is a lot of this sort of thing perpetrated during the windy days of mining booms, not in Western Australia alone.

In the case of wide lodes, that is, such as exceed the averaging stoping width, it is advisable to take sectional samples, dividing the lode into successive divisions, each of which is, say, 4 ft. across. The results thus obtained will be useful in indicating the distribution of values. Occasionally it will be discovered that a vein is being worked for a greater width than circumstances justify, while, quite as commonly, it may be found advisable to change the practice radically, and in the opposite way, that is, it may be proved by sectional sampling that while a mine cannot be profitably operated if only a narrow width of rich ore is mined, it will become remunerative if it is worked on a larger scale by adopting a bigger stoping width, so as to include parallel streaks, feeders and branch veins which will yield a much bigger tonnage of low-grade ore, unsuitable, it may be, for shipment but profitable in a mill, to be erected at the mine or near it.

In the sectional sampling of wide lodes particular care must be taken to get the true width. Measurements must be taken at right angles to the walls of the vein. In sampling, however, a horizontal line may be followed, if it is convenient; it will give a larger quantity of ore than a right-angle section, but if each sample is taken along a parallel line the proportion will be maintained and a true sample will be secured.

The importance of an accurate recognition of the slope of a vein and the pitch of an ore-shoot, when making estimates, cannot be emphasized too much. An example will be of service. Thus: In Fig. 3 *A B* and *D F* represent an ore-shoot traversed by the two levels, which are 100 ft. apart. The ore has been stoped out above the upper level, and a portion had been removed between the levels. The stopes—inaccessible—above *B C* and the stoping begun at the bottom of the left-hand raise are calculated to obscure the real condition of affairs. The engineer samples the raise *E B* and the back of the level between *E* and *F*, with results which cause him to assume a block of ore, *A E F C*. He has failed to recognize the pitch of the ore-shoot because the stoping above *B C* has obscured it. It will be said that if he had sampled the bottom of the level this mistake might not have occurred, but the sampling of bottoms is not always practicable, and is usually very unsatisfactory on account of water and other factors. It is not realized often enough that ground which has been stoped was not necessarily profitable. Stopes are frequently started with the hope of an improvement or with the purpose of testing a run of ground. For this reason the workings of a mine, both underground and on the map, are apt to suggest unwarranted deductions as to the distribution of ore, and many misleading inferences have been caused thereby. Thorough sampling will usually make the truth clear to an experienced man.

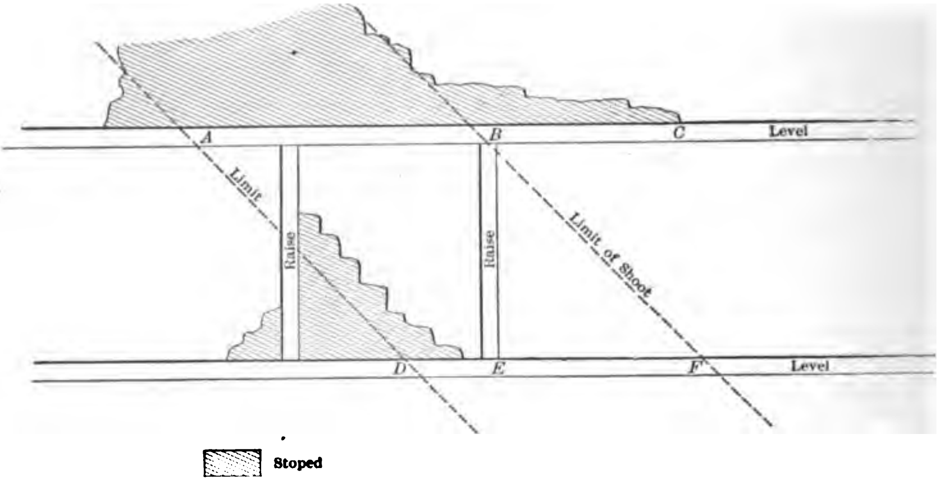

FIG. 3.—ORE SHOOT TRAVERSED BY TWO LEVELS.

Among the things to be avoided one must mention the so-called "grab" sample. This is the last resort of incapacity. A grab or haphazard handful of ore is taken indiscriminately from all over a pile of ore at the face of a level or in the stopes, and this is put into a small sack for subsequent assay. The idea of the grab sample is to shut your eye and be absolutely impartial, but the brutal fact is, that one usually gets a deceptive proportion of the fines and quite disregards the large pieces of waste or poor rock scattered through the heap. It is still the practice in many mines for the foreman to take samples in this manner while making his daily round of the workings. As a consequence, the record of the assay office is often an iridescent dream which may mislead the management and become the cause of a serious error in the estimates of ore. It takes more time to use a moil and a hammer, thereby obtaining a true average sample, than it does to pick up a grab sample and stick it into one's pocket or into a sack; for this reason the former procedure is objected to by many foremen. The fact is, the daily sampling of the faces of ore should be a task allotted to men who have the time and the training for such work; it should be no part of the duty of a foreman or a shift boss, both of whom are usually men of a type which confounds system with red tape, but it should be placed in the surveyor's department, so that the record of results can be incorporated with the maps of the mine. *"Chacun à son metier, et les vaches seront bien guardées."* It is a good saying. Let the important work of sampling be put into proper hands, separate from the particular supervision of the operations of the mine, the control of the men and other departments with which it has no kind of connection. The ordinary multifarious official has no time for a job which essentially requires time to do it properly. And before everything else, begin by prohibiting "grab samples" in any form!

Calculations after Sampling.—The calculations consequent upon sampling are based on the theory of averages. An arithmetical mean is the sum of all the numbers forming the series of figures under consideration divided by their number without reference to their weight or relative importance among themselves. This method has been applied to the results of sampling with most unhappy consequences. Thus, let the following series of figures represent the data obtained from sampling a length of 100 ft. of gold-bearing ore at intervals of 10 ft.

Width in Feet.	Assay. Oz. per Ton.
4·4	2·35
6·2	0·45
7·6	0·62
4·0	0·85
2·5	1·02
3·6	2·40
2·5	4·25
0·8	5·20
1·2	4·65
2·2	3·21
35·0	25·00

The arithmetic mean yields 3·5 ft. of ore averaging 2·5 oz. of gold per ton. This is woefully wrong. It disregards the fact, for instance, that the third sample yielded about 7·5 ft. of ore containing only 0·6 oz. of gold, while the richest ore, at the eighth sample, was less than 1 ft. wide.

The geometrical mean is the sum of such figures divided by their number with due allowance made for their weight. This is done in practice by what many call the "foot-ounce" method, which, applied to the foregoing example, works out thus:—

Width in Feet.	Assay. Oz. per Ton.	Foot-ounces.
4·4	2·35	10·34
6·2	0·45	2·79
7·6	0·62	4·71
4·0	0·85	3·40
2·5	1·02	2·55
3·6	2·40	8·64
2·5	4·25	10·62
0·8	5·20	4·16
1·2	4·65	5·58
2·2	3·21	7·06
35·0	25·00	59·85

The average assay per foot of width is 1·71 oz. per ton, instead of 2·5 oz. In matters of this kind, mathematical reasoning confirms the conclusions of rough common sense. The method just described is based upon the higher mathematics, as the following integrations, kindly suggested by Mr. Ross Hoffman, will demonstrate:—

Problem 1.—To determine the average value of the section of vein A between the samples whose widths are w_1 and w_2, and values v_1 and v_2, respectively, under the assumption that the values vary gradually over the area from v_1 to v_2 in the direction d, then at any distance x from w_1 the value (see Figs. 4 and 5)

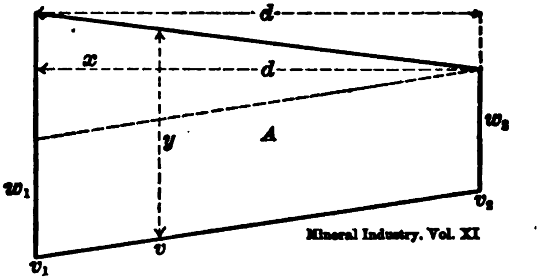

FIG. 4.—DIAGRAM ILLUSTRATING PROBLEM 1.

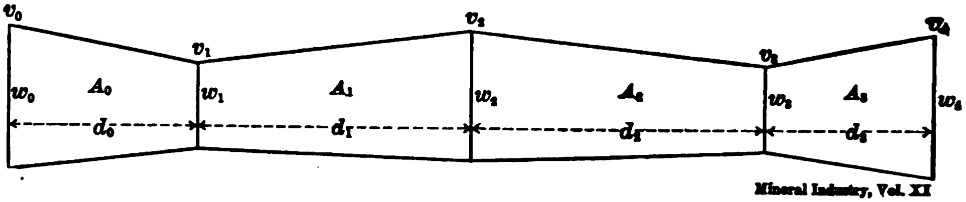

FIG. 5.—DIAGRAM ILLUSTRATING PROBLEM 2.

$$v = \frac{x}{d}(v_2 - v_1) + v_1 \qquad (1)$$

also

$$\frac{d}{w_1 - w_2} = \frac{d - x}{y - w_2} \text{ or } y = \frac{x(w_2 - w_1)}{d} + w_1 \qquad (2)$$

$$A = \frac{(w_1 + w_2)\,d}{2} \qquad (3)$$

$$\int_{x=0}^{x=d} v\,y\,dx \div A = \text{average value for the section A.}$$

From (1) and (2). $v\,y = \frac{x^2}{d^2}(w_1 v_1 + w_2 v_2) + \left(\frac{x}{d} - \frac{x^2}{d^2}\right)(w_2 v_1 + w_1 v_2) + \left(1 - \frac{2x}{d}\right) w_1 v_1$

$$\therefore \frac{2}{(w_1 + w_2)\,d}\int^{d} v\,y\,dx = \tfrac{2}{3}\,\frac{w_1 v_1 + w_2 v_2}{w_1 + w_2} + \tfrac{1}{3}\,\frac{w_2 v_1 + w_1 v_2}{w_1 + w_2}$$

$$= \frac{w_1 v_1 + w_2 v_2}{w_1 + w_2} + \tfrac{1}{3}\,\frac{(w_1 - w_2)(v_2 - v_1)}{w_1 + w_2}$$

The last term = 0 when $w_1 = w_2$ or $v_1 = v_2$.

Under normal conditions where ordinary sampling can be depended on to give fairly approximate averages this last term will be small enough to neglect. (See by substitution.) Hence

$\frac{w_1 v_1 + w_2 v_2}{w_1 + w_2}$ can be taken as the average value for section A.

Problem 2.—To find the average value from a number of samples taken as above, where w equals width of sample, v equals value, d equals distance between samples and A, the area of various sections of vein between samples:—

$$A_0 = (w_0 + w_1)\frac{d_0}{2} \text{ average value for } A_0 = \frac{w_0 v_0 + w_1 v_1}{w_0 + w_1}$$

$$A_1 = (w_1 + w_2)\frac{d_1}{2} \text{ average value for } A_1 = \frac{w_1 v_1 + w_2 v_2}{w_1 + w_2}$$

$$A_2 = (w_2 + w_3)\frac{d_2}{2} \text{ average value for } A_2 = \frac{w_2 v_2 + w_3 v_3}{w_2 + w_3}$$

$$A_3 = (w_3 + w_4)\frac{d_3}{2} \text{ average value for } A_3 = \frac{w_3 v_3 + w_4 v_4}{w_3 + w_4}$$

(See Prob. 1.)

$$\frac{\Sigma(A \times \text{average value for } A)}{\Sigma A} = \text{average value over the whole area sampled}$$

$$= \frac{(w_0 v_0 + w_1 v_1)\frac{d_0}{2} + (w_1 v_1 + w_2 v_2)\frac{d_1}{2} + (w_2 v_2 + w_3 v_3)\frac{d_2}{2} + (w_3 v_3 + w_4 v_4)\frac{d_3}{2}}{\frac{w_0 (d_0)}{2} + \frac{w_1 (d_0 + d_1)}{2} + \frac{w_2 (d_1 + d_2)}{2} + \frac{w_3 (d_2 + d_3)}{2} + \frac{w_4 (d_3)}{2}} =$$

$$\frac{v_0 \left\{\frac{w_0(d_0)}{2}\right\} + v_1 \left\{\frac{w_1(d_0 + d_1)}{2}\right\} + v_2 \left\{\frac{w_2(d_1 + d_2)}{2}\right\} + v_3 \left\{\frac{w_3(d_2 + d_3)}{2}\right\} + v_4 \left\{\frac{w_4(d_3)}{2}\right\}}{\left\{\frac{w_0(d_0)}{2}\right\} + \left\{\frac{w_1(d_0 + d_1)}{2}\right\} + \left\{\frac{w_2(d_1 + d_2)}{2}\right\} + \left\{\frac{w_3(d_2 + d_3)}{2}\right\} + \left\{\frac{w_4(d_3)}{2}\right\}}$$

The bracketed terms represent areas and may be considered the importance or weight factors with which the various sample values taken separately enter into the general average value for the whole area. It is equivalent to giving each sample value an importance (or weight) proportional to its sample width multiplied by half the sum of the distances to the two adjacent samples.

Averaging in this manner assumes as in Problem 1, that the values between various adjacent samples change gradually.

If the samples are taken equidistantly the above average becomes

$$\frac{v_0 \left(\frac{w_0}{2}\right) + v_1 w_1 + v_2 w_2 + v_3 w_3 + v_4 \left(\frac{w_4}{2}\right)}{\frac{w_0}{2} + w_1 + w_2 + w_3 + \frac{w_4}{2}}$$

which, with the exception of the two end samples, is simply giving each value an importance in the general average proportional to the width of its sample.

The two end sample values are shown to have half this importance, though in practice, with many samples in the average, it is customary to give the two end samples the full importance proportional to their respective widths.

In the calculations for tonnage the cubic feet of ore are converted into tons on the basis of a certain specific gravity; thus, quartz is usually taken at 15 cu. ft. per ton, while ores containing sulphides are rated at 8 to 12 cu. ft. It is not unusual to guess at this proportion because experience does enable an engineer to approximate the correct figure fairly well. But it is a dangerous practice. Approximations should never suffice where greater accuracy is possible. It is well to weigh a series of measured pieces of ore or to determine actually the specific gravity of a few pieces of average vein-stuff. Surface quartz, on account of its cellular structure, may require 20 cu. ft. to weigh a ton. Pyritic ores will vary to an extent hardly appreciable even to the experienced eye. Grevious errors in tonnage estimates have been caused by the assumption of an incorrect basis of calculation.

A minor source of error is sometimes created by the occurrence in the vein of numerous cavities, or "vugs," as the miners call them. In some cases they form a very appreciable proportion of the space occupied by the lode, so that they are apt to lessen the tonnage obtainable from a block of stoping ground.

The Question of High Assays.—In these calculations, whether they be mathematical or rough-and-ready, it is assumed that where two adjoining samples vary there is a gradation from one to the other. Generally the assumption is warrantable, but occasionally the difference between any two such adjoining samples is so marked, as to require further consideration. In the sampling of gold mines, especially where the metal occurs in a native condition and visible to the eye, there will be a few very high results which affect the average of a run of samples to an extent quite out of proportion to the importance of a single sample.

This question of high assays demands careful discussion. It can be viewed from two standpoints: the seller of a mine is apt to argue that if you are going to base an estimate of the ore-reserves upon the results of sampling and assay, you ought to take all the data without favor, just as they come, and that to eliminate high assays is no more fair than it would be to omit poor ones; to this the engineer, representing the interests of a possible purchaser, will reply that the occasional very high assays are largely accidental, that they affect the estimates to a degree out of proportion to their weight, and to an extent by no means comparable to the omission of an equal number of poor results; finally, he will murmur under his breath something about a factor of safety being necessary.

In the first place, it is incumbent upon the engineer to find out whether these occasional high results do, or do not, represent the average of the ore, not at the particular place sampled only, but over the whole space or interval which that sample is supposed to represent. Each sample, in the final calculation, speaks not for a spot but for a section of the vein, the length of which is the interval between samples and the height is the distance separating it from the next working overhead or underfoot; thus, when the distance between samples is 10 ft.

and the next series of samples is on a level 100 ft. distant, above or below, then the section represented by a single sample contains 10 by 100 ft. or 1,000 sq. ft., which, if the vein be, for example, 3 ft. wide, may contain over 200 tons of ore. In practice the responsibility of one series of such samples is shared by that of a corresponding series taken on the level above or below; nevertheless, it is obvious that a single sample represents something very different to the mere spot or point in a particular working. In order to answer the question whether an individual high assay is accidental or representative, the only thing to do is to re-sample at the same place; if the result is confirmatory then evidently that spot is as rich as the first sampling indicated. But this does not determine whether the high values gradate on either side toward the adjoining samples. Thus, if *A*, *B* and *C* in the diagram (Fig. 6) represent three points, 10 ft. apart, which have been sampled with the results shown, then, if *B* assayed 10·4 oz., and was re-sampled with 8·22 oz. as the assay return, the next question arising is whether the ore midway between *B* and *A*, or *B* and *C*, is correspondingly intermediate in value; for this is what the calculations assume. For this reason it is best to check the high assays by taking further samples at these intermediate places, thereby finally settling the query whether the high results are trustworthy factors in estimating the average value of the ore-bodies.

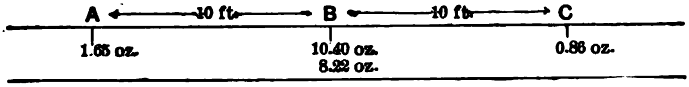

FIG. 6.—DIAGRAM OF VARIATION IN ASSAY VALUE.

The treatment of high assays has caused much discussion among engineers, especially when they are encountered in the course of a sampling, the results of which are to decide the price of a mine. The seller, or his representative, is apt to suggest that a re-sample of poor spots is also in keeping with the theory of the whole business, and to this I would say that where a barren or nearly barren result is obtained amid a series of samples indicating good ore it is correct to re-sample such a place or places. The occasional barren and the occasional high assay return, however, are not comparable in their effect upon the estimates. In the first place, the "nil" or "trace" indicates the entire absence of the metal and has not the accidental feature arising from the presence of a stray speck of gold, which may cause the abnormally high assay; further, one very high assay affects the calculations more than a number of poor ones, supposing both to be deviations from fact, as can be easily shown, thus: Take the following series of samples and assay returns:—

Width in Feet.	Assay. Oz. Gold.	Foot-ounces.	Width in Feet.	Assay. Oz. Gold.	Foot-ounces.
7	1·22	8·54	3·5	0·95	3·32
4	0·54	2·16	6	0·39	2·34
12	1·20	14·40	6	Trace.	....
8	2·20	17·60	7·2	Trace.	....
5·3	27·40	144·22			
7	1·60	11·20	66·0	33·50	203·78

The average of the ore, using these data, is slightly over 3 oz. per ton. If, however, the fifth sample, which is very high, is eliminated the average drops to less than 1 oz. per ton, while, on the other hand, if the high sample is retained and the last two poor places are omitted the result is affected to a much less degree, the average then being about 3·75 oz. per ton.

In re-sampling these apparently very rich spots, it will be found that three contingencies may occur; the result may be corroborated or it may be proved to be accidental, while, should every high assay be found incorrect then there is a third possibility to be considered, namely, whether the samples have been tampered with. If, out of a considerable number of high results, not one is confirmed, then it is time to look around. If some are confirmed by re-sampling, while others are not, then, obviously, the values in the ore are erratic and a correction must be made for each case; if most of the high results are approximately repeated by the second sample, then it is evident that the first sampling was correct and that the ore is very rich in spots; intermediate samples must be taken, and when this is done the data for calculations will be complete. It is wise to take intermediate samples, both when the high assays are wholly, and when they are only partially, confirmed.

It has been argued by certain engineers that the mill or smelter always fails to confirm the very high assays occasionally obtained in sampling and that, therefore, they should be omitted as a factor of safety. This is not a fact. Exceptions occur. In the case of the Argentine lode of the Tomboy Mining Co., at Telluride, Colo., a careful sampling of a block of ground, at intervals of 10 ft., yielded an average of $7 per ton, all rich spots carrying visible gold being avoided. This work was done by an inspecting engineer of recognized capacity; nevertheless, the actual mill returns were $28 per ton. Nor is this inexplicable when the nature of the ore is considered. I have seen a piece weighing 25 lb., yellow with finely disseminated gold, so that it contained $100 worth of the native metal, which came from the breast of a level on a certain day—and the very next day the foreman's sample from the face of the same drift, which had been advanced two or three feet in the interval, yielded only 0·02 oz. of gold per ton! The Pandora vein, in the neighboring Smuggler-Union mine, affords another exceptional case; the mill results are usually higher than the assays, and this is explained as being due partly to the greater hardness of the rich ore, but chiefly because the gold occurs almost entirely in coarse particles which, being readily visible, are apt to be carefully shunned by the conscientious sampler. These instances are corroborated by the thoroughly experienced managers of the properties quoted. It remains to add that while it is true of the veins specifically mentioned, that the assays are usually lower than the mill returns, such is not the case with the Tomboy lode, which is near the Argentine, nor is it true of the Smuggler lode, which is intersected by the Pandora in the Smuggler-Union mine. The above are, however, well authenticated exceptions, which serve effectually to undermine a generalization which is the last resort of a timid engineer. Not that the factor of safety is to be discarded, quite the contrary; in all engineering such a precautionary measure is imperative, but do not introduce it disguised, face the facts, state them, and then introduce a factor of safety without any circumlocution.

Why do sampling results differ from the mill returns? In the unusual instances, just mentioned, the difference was traceable to conditions which are relatively rare, but are always within the range of possibility. There is no doubt in my mind that the usual experience, of finding the mill-extraction below the estimates, based upon sampling and assay, is traceable to the fact that rich ore is ordinarily in the softer, more crumbly parts of a lode, or it is associated with sulphides which are not only easier to break than quartz, but they also make a shining mark which invites the blow of the moil and hammer. This aspect of the inquiry emphasizes the weak factor in sampling, it is not absolutely mechanical, a man and not a machine does the work, and the results partake of that liability to error which is essentially human.

It may be asked, in conclusion, what course should be adopted with high assays when it is not possible to re-sample. Frequently, the samples are not assayed near the mine, but are taken, or sent, by the engineer to a reliable assayer living in a distant locality. Time, an element in all business matters, may prevent the engineer from returning to the mine to take further samples. This is a dilemma not infrequent in current practice. Judgment and experience must decide. The relative frequency of high assays, the degree to which they affect the final estimates, the character of the ore, the results of sampling as compared to the actual recorded average of the mine, the character of the work done by the engineer and his assistants; these and similar factors will determine the decision. One cannot lay down rules to direct any man's judgment.

It may be permitted to say, that, if you are uncertain of your results—don't use them. Do not let yourself be hurried, either by your client or, as is more probable, by the vendor, to committing yourself to a decision based upon data, the accuracy of which, in your own mind, is in any doubt. It is better to be sure than sorry.

The Possible Discrepancies between Sampling and Mining.—In sampling the workings it is necessary that the engineer should have an eye to the manner in which the mine is being worked. It is useless, for instance, to sample 2 ft. of vein matter without any regard to the fact that in stoping it is the practice to remove a width of 4 ft. Unless judgment is exercised, the samples are apt to represent cleaner ore than the output of the mine, so that the estimates based upon them will be misleading. The material sent for treatment to mill or smelter may differ from the ore composing the lode as seen in the mine, in several respects. Thus:—

A. The lode may be smaller than the minimum width removed in stoping, so as to necessitate the mining of a certain portion of barren rock.

B. The lode may be as wide as the convenient size for stoping, but it may have a casing of soft rock, which breaks down with the ore and becomes mingled with it so as to increase the tonnage and diminish the average yield per ton.

C. The lode may be built of one or more streaks of rich ore irregularly distributed through it, so that in stoping it is necessary to break down a large and variable width.

In the preliminary trip through the mine the engineer will be able to find out by observation, together with the information obtainable from either the foreman or the manager, how the ground is being worked, and how the ore is being handled. If he does not secure these data at the preliminary examination, he will light upon them in the course of his investigations into costs, for without them the relative expenditures at mine and mill will be contradictory, if not unintelligible.

Concerning the conditions first mentioned, under the heading A, it is obvious that the width broken in stoping has a minimum, which in ordinary practice varies according to the method employed; that is, with hand labor a width of from 2 to 3 ft. will ordinarily suffice; while at least from 3 to 4 ft. is necessary when machine drills are used.[1] In both cases this minimum width will be exceeded if the rock is very hard or if it breaks along easy lines of fracture, which cause more rock to be taken down in blasting than is absolutely required for mere convenience in working. If the streak of ore is less than the width of the stope there will be, inevitably, an admixture of waste, except in the rare cases where it is practicable to strip the pay-streaks, that is, stope the country without removing the vein, which is subsequently taken down separately. This method, which is covered by the Cornish term "resue," is excellent when the vein of ore is narrow, but it depends for success upon the ore being closely attached or "frozen" to one of the vein walls, so that it will not be shaken down when the adjoining waste is shot away. In many mines in Colorado, Montana and Idaho, especially in the case of narrow streaks of very rich silver ore, it is not unusual to spread canvas or sacking along the floor of the stope and then break down the ore upon it, which in this way is kept free from admixture with waste, and can be sacked without any sorting. The canvas is covered for protection with 6×3×12-in. timbers. In such a mine as this the sampling of the vein itself would give data which closely approximate the actual returns from ore sent away to the smelter.

When it is not possible to mine the ore separately from the waste it is usual to pass it over the sorting tables, where the waste is picked out by hand. In the determination of the percentage thus eliminated lies the difficulty of getting the proper relation between the assays of the ore as sampled and the value of the material as sent to the reduction works. Unless this is determined, and the sampling is corrected in accordance, the figures of the engineer will not harmonize with the results of future operations. The most practical way to find out the percentage sorted out is to measure the ground stoped during a given period, and, knowing the tonnage extracted from such a particular block of ground, to determine the average width of clean ore actually obtained from that block. If the average width of the vein is fairly consistent one can, from these data, deduce the amount of waste which gets mingled with the pay-streak and then correct the assay returns, from sampling, accordingly.

However, gold-veins are rarely uniform in width, and, moreover, any given mine may contain several lodes, the output of which is not kept separate. In such localities as Kalgoorlie and Cripple Creek where the veins are rich, erratic, and so diffuse in their mineralization as to make it compulsory to break down a great deal of waste in extracting a small width of clean ore; where, also, the large

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[1] A small (2·25-in. cylinder) drill usually requires a stope of from 3·5 to 4 ft. in width, the large air drills (with 3·5-in. cylinder) take from 4·5 to 5 ft.

mines include within their boundaries two or three distinct lodes of variable width and richness, it becomes an extremely difficult task for an engineer to determine, within the short period of his inspection, to what degree the veinstuff is mixed up with waste. An example will emphasize the matter under discussion. Take a lode or series of lodes having an average width of 1 ft. of 4-oz. ore. Assume, as is usually the case, that a width of at least 4 ft. of rock is actually removed in mining, so that 1 ft. of ore is shot down with 3 ft. of waste. If the vein alone is sampled an average of 4 oz. of gold per ton is obtained; if the 4 ft. of stoping width, an average of 1 oz. per ton results, unless there happen to be one or more stringers of ore outside the main pay-streak, not rich enough to be worked on their own account, but near enough to the vein proper to be included within the ground which is removed. In this case the average may become slightly higher than the figure which is based on the supposition that the extra three feet is barren material. That is a detail. The point to be emphasized is that the product of the mine will be more than the tonnage based on 1 ft. of ore and considerably less than the tonnage based upon the stoping width; more is broken than 1 ft., because mining does not copy sampling methods, and less is shipped than 4 ft., by reason of the sorting which intervenes between stope and smelter. Similarly, as to average value, the production of the mine will average less than the 4 oz. in the clean ore, but more than the 1 oz. which is the assay value of the stoping width.

At Cripple Creek, and in other districts where the costs of transport and treatment are high, this 4 ft., or more, of ores is sent to the ore-house and is hand sorted. It may have been first culled underground, the large pieces of waste being retained on the stulls. This is the practice in most mines. In any event, a certain proportion of waste is thrown out, and it is only the remainder that is milled or marketed. What is that proportion which is taken out?

Here lies the difficulty which has been at the bottom of many an erroneous estimate. If the engineer is pressed for time, by reason of agreements made between the buyer and seller of the mine, he will not have the opportunity to conduct such tests as would give him the requisite data. The management is apt to have loose ideas on the subject, the ratio of waste eliminated to clean ore actually shipped will vary from week to week, just as the different stopes underground will change from time to time, so that it is rarely possible within the period of a brief examination to get, save at second-hand, at the percentage which so seriously affects all calculations. Under these conditions the only thing to do is to state the results just as they are obtained, explaining how they are obtained, and then make the correction which judgment dictates. If the vein has been sampled by itself then an addition for the unavoidable admixture with waste must be estimated, the amount being based upon the observation both above and underground. If the sampling has included the full stoping width then a similar correction must be made for the amount of material subsequently removed by sorting, otherwise the statement of sampling returns may prove unintelligible, it being not uncommon for the average value of the ore as stoped, before sorting, to be less than the total working costs.

However, except in the unpleasant circumstances of limited time due to the unavoidable exigencies of business, which unfortunately do often hamper, hinder and obstruct the engineer in his professional work, it is possible to arrive at the ratio of ore and waste, and, therefore, to formulate accurate estimates. It requires time and it needs money, but, in the examination of large mines nowadays it is appreciated by financiers and syndicates employing first-class engineers that they must make provision for plenty of time and money in order to get good men to do good work. This may seem a digression, but it vitally affects the consideration of this branch of the subject under discussion.

When, therefore, conditions do permit of every precaution, the engineer will cause the ore, as it comes to the surface, to be weighed, he will get the weight of the clean ore after sorting, and he will check this with the weight of the material which goes over the dump. He will also take samples of the dump to correct his estimate of the average values. The weighing and sampling will, of course, be done by his own men. He will also take careful note of any waste which is retained underground, as is usually the case in a well-managed mine. If this is done during the space of a month or so, which is the minimum period permissible for an important examination, he will have data enough to enable him to correct the results secured from the sampling of the mine. In the suppositious case, quoted above, the 1 ft. of 4-oz. ore would be mined (and sampled) with three times as much waste, one-half of the material thus broken would be sorted out at the surface and with it would go some of the fines, so that the net result might be about 2 ft. of ore assaying 1·75 oz. and 2 ft. of waste assaying about 0·25 oz. per ton.

These final estimates should be borne out by the future record of the mine. As a safeguard, however, the engineer ought to state in detail, in his report, how he arrived at his figures, lest, later on, an ignorant directorate or an unscrupulous manager should either work more than a proper width, in order to get an increase in tonnage, or mine only the richest portion of the lode with a view to a brief period of inflated returns. Such things have happened and honest men have been drawn into the blame which followed.

Coming to the consideration of the second point, specified under B, it is evident that here also there is room for error. In most lodes of gold-bearing quartz, where sorting is out of the question on account of the low grade of the ore and the uncertain dissemination of the gold, it is not possible to break the ore in the stopes as clean as it is broken in the course of sampling. Should the lode be free from an admixture of country it is nevertheless rarely practicable to stope it without bringing down some of the encasing rock. This is slight in some instances of very well-defined quartz veins, large enough to admit of a full-sized stope and so separated by selvages from the wall-rock as to come clear away. In most instances, however, the stoping will include a large proportion of waste, and when it happens, as is not infrequent, especially with big generous ore-deposits, that the lode throws out branch-veins or is enriched by feeders, then it will be found that there is a very considerable admixture of comparatively barren rock.

Circumstances such as these, overlooked or underestimated, have been at the root of the differences between the estimates of capable engineers and the subsequent record of the mines they have reported upon. Managers, as a rule, like to emphasize the clean-cut character of their operations, and are apt to accentuate the fact that the ore "breaks easy" and free from wall-rock. Moreover, in all mining, there is an element of the unexpected, which in this case takes the form of the breaking away of "slabs" of wall-rock, the admixture of large pieces of "casing," the occasional "horse" or intrusion of barren rock amid a width of ore, and other contingencies, all of which tend inevitably to an increase of tonnage and a diminution in the average value of the output. One must look for these features in a mine and obtain data sufficient to warrant an estimate of their perturbing influence upon the accuracy of those calculations which are at first based solely on the results of sampling.

The third subdivision, C, includes a large proportion of the big low-grade lodes from which so much of the metallic wealth of the world is derived. An examination of a mine is usually confined to those workings which are confessedly profitable or likely to become so. The non-payable workings are neglected. In actual mining, however, a level or a raise is apt to be carried forward through poor ground in the hope of encountering better ore, and it is not uncommon to remove blocks of unprofitable ground lying between good stopes because of practical convenience in working. In this way there is a tendency to vitiate the results of sampling, if not corrected in accordance with a recognition of such indubitable facts. Moreover, in the working of large deposits of low-grade ore, where the width to be removed is not determined by well-defined boundaries, but is left to the arbitrament of the assay, as a consequence of a diffused impregnation of ore, there is a tendency to increase the stoping width. The result of a steady diminution in working costs, due to better management, improved equipment and economic conditions, is to permit of the exploitation of poorer ores. This leads to the utilization of neglected stopes, previously considered unprofitable, and the enlargement of the stoping width so as to include more and more of the outer poorer edges of the lode. An increase in the capacity of the mill is usually followed by a drop in the average value of the output. On the Rand this tendency has become very marked, thus, for example, most of the original estimates of the life of particular mines were based on ore-reserves calculated upon the basis of a certain width of "banket," but since the substitution of rock-drills for hand labor it has been found advisable, consequent upon observation and experience, to increase the stoping width by as much as 50%. This increase has necessitated the breaking of a large amount of barren rock, but a compensatory factor has been found in the introduction of revolving circular tables which facilitate the picking out of the waste by natives.

These are considerations which the engineer must keep in mind. He is not expected to write next year's almanac, but if he is to be justified by the actual record of the mine, his report must be aided by some of that farsightedness and shrewdness which is necessary to a successful meteorological forecast.

Estimation of Ore Reserves.—It has been well said that "if you want to arrive at intelligent issues—not to say conclusions—in any discussion, begin by settling the meaning of the terms you are going to use." This is particularly necessary in discussing a subject which suffers from the want of definition. "Ore in sight" has become one of those nebulous phrases which are only noise and smoke. It is imperative that a clear conception be had of the fact signified by the technical terms employed when it is found that they are robbed of sense as soon as they are dissected. Therefore it is necessary to discard them and seek for better ones. "Ore in sight," as used to describe the ore-reserves of a mine, is, if taken literally, a contraction in terms and, if taken otherwise, it has an elasticity which has caused many to stretch it until it has become so indefinite as to include the ore which is beyond even the most imaginative vision.

In order to express the results of careful sampling and estimation by a phrase which will at once convey its meaning, even to the untechnical, I would suggest "ore in reserve and ready to be broken," or "ore ready for stoping."[2] This would cover those parts of a mine which have been so cut up by systematic workings as to permit of very close calculations. Next would come the blocks of ground incompletely developed, but known to carry ore, which, in character and persistence, is similar to the main portion of the mine. These could be covered by the term "probable ore reserves." Beyond this point a careful engineer will not go, avoiding "possible ore reserves," or any similar phrase, as a snare of the devil, because of the great likelihood that his client, or the shareholders who may follow, will disregard the qualifying adjective and commit him to a meaning which he did not intend to convey. When it comes to the chances of development, itself a most important part of the engineer's exercise of judgment, it will be best to include the consideration of this aspect of the inquiry under the paragraphs which deal with "the future prospects of the mine."

That is reserved which is stored for future use, therefore that which is to be used forthwith is not in reserve, from which it follows that by "ore-reserves" is meant such bodies of ore as are kept back for the present with a view to future use, when those are exhausted which are now being stoped. A mine which is being stoped at a rate so rapid in ratio to its development that it has, at any given time, only enough ore to keep the mill going for a few palpitating moments cannot be said to have any "ore-reserves." The idea of the latter includes a reservoir of supply not to be exhausted at short notice. As a consequence of these considerations it is obvious that the amount of ore which warrants being entitled "reserves" will depend upon the relative size of the reduction plant which is attached to the mine.

At the outset it is permissible to quote the famous dictum of President Cleveland, in referring to the tariff, "It is a condition which confronts us, not a theory."[3] Any attempt to establish uniformity of procedure in the estimation of ore reserves is bound to break down because it disregards the inevitable diversity of the conditions which obtain in mining. Mines differ, as men do. A safe presumption in one case is a hazardous guess in another. During a recent discussion of this subject it was suggested that it was desirable for mining engineers to agree upon certain general rules, as to the allowance to be made in estimating ore. You might as well sign an agreement upon the percentage of trust to be placed in human nature. There are mines, the ore bodies of which are of such a char-

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[2] This discussion of terms was written some time ago, before Mr. Argall brought forward the sensible suggestions which appeared in the *Engineering and Mining Journal*, Feb. 14, 1903.

[3] *Messages of the Presidents*. Richardson. Vol. VIII., p. 590.

acter that it is safe to predict their persistence for several hundred feet, there are others where the lode is so erratic that 10 ft. is a dangerous assumption.

Examples will serve to emphasize the range of variation. On the Rand a bedded vein of gold-bearing conglomerate extends for a great distance and over portions of its known length it maintains an average tenor so fairly constant that "the values of unworked portions may be closely calculated from the results achieved in adjoining developed mines."[4] In any given mine—to narrow the assumption—it is quite safe to calculate the average value of the ore in a block of ground, say, 300 ft. long and 150 ft. high, that is, after this block, 150×300 ft. has been sampled at intervals of, say, 10 ft., on every one of the four sides of the rectangle. This would be the ideal "ore in reserve," a thoroughly sampled block, not too big to vitiate the assumption of a certain uniformity in value per ton. In contrast to this I would quote such mines as, for example, the Seven-Thirty at Silver Plume, Colo., or the Yellow Pine, near Boulder, in the same State, both of them mines which have been at some time richly productive, but with a distribution of value, in silver chiefly, so varying, so spotty and uncertain, that careful sampling, at regular intervals of even less than 5 ft., around the four sides of a block only 50 ft. square would afford the basis for an estimate which at its best would be only a reasonable guess. Each mine must be judged on its merits; in each instance the conditions vary, and while there may be a general similarity of method in getting at the various facts, there never can be any cast iron uniformity in the nature of the inferences deducible from the facts. Experience, silvered with age, is the presiding judge, and will decide whether this or that piece of evidence is relevant or not. Nor is there any room for pessimism or for optimism, one is as much out of place as the other; indeed, it is not too much to say that while a sanguine temperament will lead sometimes to exaggerated expectations, it is equally true that an overcautious hesitancy is to be condemned. Occasionally, an engineer in his effort to avoid risking his own reputation is apt to lean toward a timid conservatism which sacrifices the interest of his client. He is engaged to determine the facts, in the first place, and then to apply his best judgment to them. If the facts are insufficient, let him say so; if they are sufficient to warrant a decided opinion, let him enunciate it clearly to the end that his client may get the maximum benefit of his investigations.

"The proof of the pudding is in the eating." The exact profit to be won from a certain block of ore-bearing ground is best known when it has been mined and milled; even the most uniform ore has its spots of greater and lesser richness, the best estimate is therefore only a close approximation based upon the doctrine of averages. Nevertheless, if such estimates are occasionally wide of the mark it is not merely because of *la malice des choses*, that essential contrariness of things which will balk even the best of engineers, but more frequently it arises from the disregard of the A, B, C of proper procedure and a judgment vitiated by financial participation in the undertaking itself. I am not of those who believe that the sampling of a mine is the one decisive factor in the diagnosis of it: on the contrary, I hold that as evidence, it is crucial or merely collateral, according to the circumstances of the case, which may depend upon the past record of the

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[4] *The Deep-Level Mines of the Rand.* G. A. Denny. P. 119.

mine, its future possibilities, the geological environment, economic conditions and other factors of primary importance.

Inferences from Sampling.—When the sampling has been thoroughly done the engineer is in possession of many important facts. If he is a novice he will have learned the assay value of the ore at each of the spots he has sampled and he will have learned little else.

Nothing illustrates so well the proverb that "a little knowledge is a dangerous thing," as the direct inferences from the results of sampling. To emphasize this statement, I will take an instance which is founded on fact. In Fig. 7 a longitudinal section of a small mine, which has been apparently well opened up, is illustrated. The shaft is vertical and does not follow the vein, which inclines to the west. The levels to the north have found nothing, those to the south (*A B* and *C D*) have cut through ore which is also explored by a raise (*K L*), and two winzes (*E F* and *G H*). At the lower levels, stopes have been started and the "backs" make an excellent showing, as the figures indicate. The latter are not expressed in any particular unit, but it is to be supposed that zero means barren,

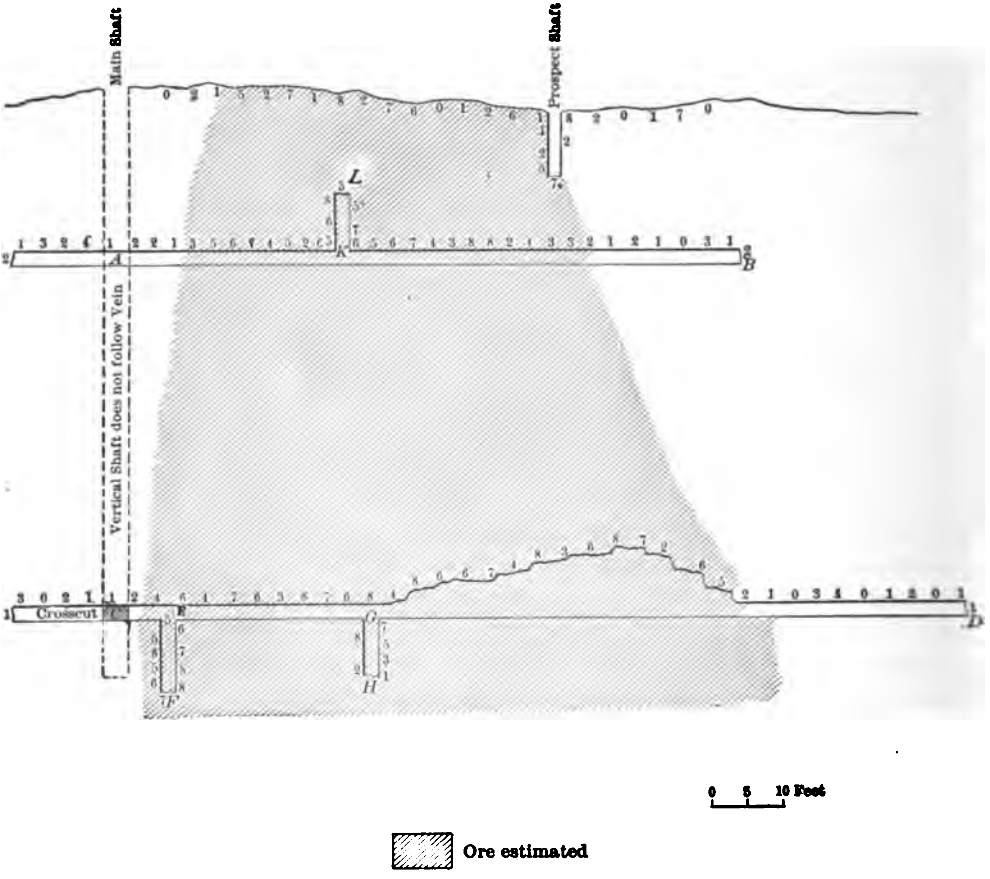

FIG. 7.—SECTION OF WORKINGS EXHIBITING THE RESULTS OF SAMPLING.

2·5 means pay-ore and so on, up to 8, which marks rich ore. The results are indicated on the section. The inference, as to the amount of ore in the mine, is exhibited by the cross-hatching.

In arriving at this estimate the novice is guided by his sampling alone; he has failed to take note of the geological features. It may happen that the superintendent of the mine, supposedly an old practical miner, has told him that the ore is fairly uniform within the limits of the shoot and that while the rock does indeed vary a little in places, this variation does not seem to affect the general distribution of values. Or, again, it may be, as happens often, that the man in charge of the mine is honest, but not honorable, and, instead of committing himself to such statements as the foregoing, he keeps discreetly silent, or, under cover of appearing to refrain from influencing our young engineer,[5] he absents himself while the sampling is in progress, and leaves his shift-boss or some other underling to do the talking. Perhaps, indeed, those in charge of the mine really do not appre-

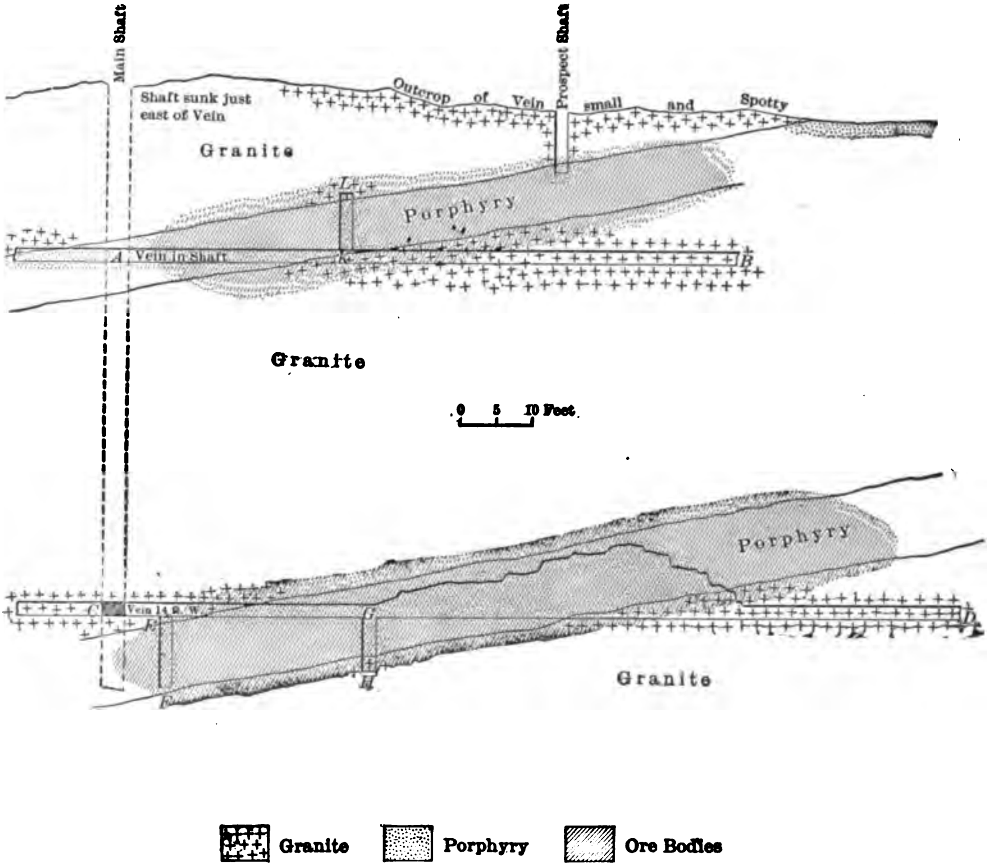

FIG. 8.—SECTION OF WORKINGS SHOWING THE GEOLOGICAL FEATURES.

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[5] I have supposed the blunder to be due to youthful inexperience, for this is the least blamable, but as a matter of fact, blunders of this kind are due to ignorance and are frequently made by older men of the kind described as "thoroughly practical" where the particular emphasis on "practical" is indicative of utter lack of training or such technical education as an engineer requires.

ciate the true condition of affairs, and the engineer is deceived by an oversight which will appear almost excusable. However, the mischief is done, the mine is taken over by a financial syndicate or a mining company. Before the business is actually consummated, another engineer, representing another financial interest, is sent out to make an examination. Suppose that this man is of greater experience than the last; he is, moreover, familiar with the geological structure of this particular district or of another similar to it. He proceeds to sample. The accuracy of the previous sampling is confirmed, but in the course of his investigation he has noticed that the country is not uniform, and that there are two different rocks exposed by the workings. One is obviously granite, the other he cannot label accurately without a microscopic section, but it is evidently an eruptive which has intruded into the granite; so, on account of its speckled appearance, he applies the term porphyry to it, and when the sampling is finished he spends a few days in carefully examining the workings with a view to getting an idea of the structural relations between these two rocks. The results are set down graphicallly and he obtains the information illustrated in Fig. 8. By examining this section, side by side with Fig. 7, it will be seen that his inferences are warranted. The consequences are surprising. He discovers that there is no continuous ore-shoot from the surface downward, but that there are two comparatively small lenticular ore-bodies which occur where the vein cuts through the porphyry sheets, and only in those portions of the porphyry where certain cross-veins have exercised an enriching effect. When the vein gets into granite it becomes poor, and, moreover, it pinches, a fact which the sampling did not sufficiently emphasize. The ore-reserves are cut down to a fraction of the previous estimate, and the future prospects of the mine are considered most uncertain, because the ore already found is due to local structural conditions which are unlikely to recur.

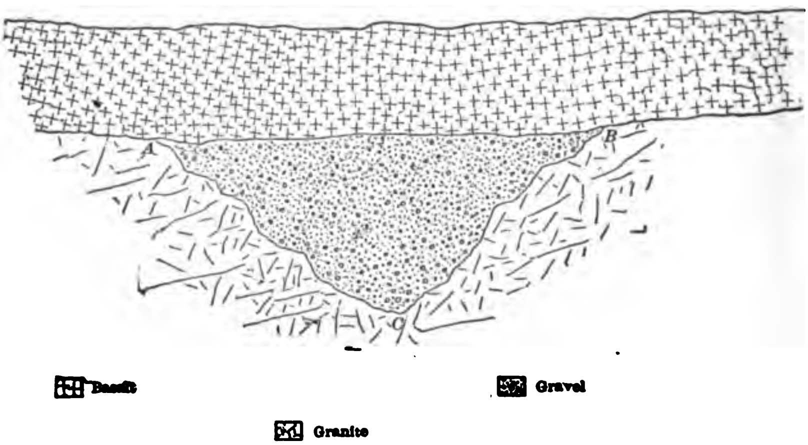

FIG. 9.—CROSS-SECTION OF A DEPOSIT OF TIN GRAVEL.

Another kind of error may be instanced. It is more frequent in placer mining than in the estimation of ore in lodes. Fig. 9 represents the cross-section of a deposit of tin gravel in an old river channel now capped with basalt. The deposit was sampled through shafts which cut right down to the gutter, 180 ft. deep, below the basalt. In this sampling the gravel was taken all the way down the shafts and mined together, so that each shaft yielded one large sample. From the weight of this and that of the resulting grains of tin, after panning down, the percentage was calculated. The estimate of quantity was based upon the length of channel, within the boundaries of the property, multiplied into an inverted triangle *A B C,* the base of which was the top width of the deposit and the apex the "gutter." The cubic yards, thus obtained, gave an approximately correct result as to quantity of material, but the estimated average content was all wrong, because the method of calculation disregarded the fact that the richest stuff was concentrated at the lowest end of the triangle, and actually formed a very small proportion, in weight, of the whole. Subsequently, the ground was re-sampled. The total depth of 180 ft. was, in the case of each shaft, subdivided into sections of 30 ft., except the last 30, which was further divided into two portions, one of 20 ft., and a lowest of all, only 10 ft. thick. The first 30 ft. was found to be almost barren, the next 30 ft. assayed 0·2% of tin, the next 30 ft. 0·28%, and so on, increasing gradually until the last 10 ft. was reached. This was very rich, 1·5%, on account of concentration in the gutter or bed of the channel. Each layer was calculated separately as to quantity and average contents, giving results which proved the bottom to be very profitable, but difficult to work on account of want of gradient for hydraulicking operations; while the uppermost portions of the deposit were found to be too poor for profit, but yet requiring handling in order to get at the lower-lying part of the gravel.

The method first described would have given a very much exaggerated idea of the cubic yardage and a false notion of a uniformity of value, besides ignoring the working difficulties to be encountered in the extraction of the tin from the successively deeper layers of the gravel. This is very much like the sampling of a vein in a prospect shaft where the samples are taken every 10 ft. and are allowed to fall to the bottom where they mingle confusedly and eventually form a "large sample," the weight of which is mistakenly supposed to give assurance of the accuracy of the average deduced from the subsequent assay.

It is not necessary to cite other instances of this kind. Happily, they are rare. The real work of good judgment usually commences in the estimation of future prospects. Mines are very rarely bought merely for the ore proved up by complete evidence; the attactive feature is, as a rule, a speculative enhancement of value likely to arise from further discovery. This is where the trouble begins.

The Future Prospects of a Mine.—There is room for the exercise of a wonderful lot of common sense in the judgment of a mine. Science, after all, is, as Huxley himself said, "organized common sense." If you have been walking along a road which has been straight and level for five miles you are unlikely to go wrong in supposing that it will continue straight and level for another half mile, even though the foliage prevents you from seeing more than a hundred yards ahead, but if you have proceeded along a road for a half mile or so only, it would be deemed foolish to predict that the road will maintain the same gradient and direction for five miles further. Thus, in estimating the persistence of an ore-body you may be justified in counting upon its continuity for another hundred feet if the ore has already persisted with some degree of uniformity for five or six hundred feet downward, and on the contrary, you will be playing with Providence if you assume the continuation for several hundred feet on the part of an ore-shoot which has as yet been traced for only 50 ft. from the surface. In this respect the mines of the Rand afford a striking contrast to most precious metal mines. The banket, in comparison with the ordinary type of gold-vein, has the persistence and uniformity of a coal-seam, and explorations on a large scale all over a very extensive region will warrant an engineer in making assumptions which would be ludicrous in California or Colorado. Yet, even under these exceptional conditions, such general evidence of continuity, when applied to an individual mine, must be amenable to the particular testimony obtainable in that particular mine or in the workings of its immediate neighbors. In most gold mining districts there is such an absence of uniformity in the structure and behavior of gold-bearing lodes that it becomes imperative to rely upon the particular testimony afforded by each mine. Such testimony, however, must be read in the broad light of experience. For this reason the estimates of ore likely to be opened up by further development will be more nearly correct on the Rand than similar calculations made by the same engineer elsewhere. Another distinction obtains; a precious metal mine in Colorado or California, by reason of mining laws which give the owner of the outcrop the right to follow the vein indefinitely in depth, has a future which is not confined to the narrow limits of mere acreage, such as is imposed in the Transvaal, in Australia, Mexico, etc. This renders the future of the American mine more speculative, while at the same time it lays upon the engineer the responsibility of appraising possibilities which are quite beyond the limits of ascertainable fact. It is no solution of the problem to say that such possibilities have no assessable value, for to adopt this attitude is to disregard the entire history of precious metal mining in the Great West, and the engineer who rests content with the evidence which is before his nose will prove but a disappointing, and often misleading, adviser to an enterprising client.

In arriving at general conclusions concerning the persistence of an ore-body in a mine, the engineer may have several guides, namely, the internal evidence afforded by the behavior of the ore-body in the ground which he has examined, the collateral suggestions afforded by the behavior of other ore-bodies in the same mine, the general evidence obtainable in other mines within the same region.

When the value of a mine centers upon one large ore-body, rather than several. there is no opportunity for inferences founded on similarities of behavior. The engineer is compelled to seek for internal evidence. If the sampling has been properly conducted and the results have been set down on the longitudinal section of the workings it will be found that the ore exhibits local variations from which certain deductions are possible. The relatively richer parts of the ore-body may be so distributed as to indicate mere absence of uniformity, and nothing more, but, as a rule, the indications will go further and suggest either that the ore-body is becoming richer with increasing depth, or poorer in the same direction, or that there are successive zones of richer or poorer. Again, the lode may be as rich as heretofore, but a change may be apparent either by way of a shortening of the ore-shoot, or of a narrowing of the pay-streak. For all these possibilities one has to search amid the tangled mass of evidence.

One or two instances will serve to illustrate such possibilities. In the San Juan region of Colorado the prevailing geological formation is a volcanic breccia, of Tertiary age, built up of fragments of andesite, which are arranged in nearly horizontal layers. The veins cut through this rock without, commonly, causing any very big dislocation. In these gold-bearing quartz veins there occur ore-shoots having a pitch which is usually not far from the vertical, and while such ore-shoots may be worked out in their entirety so as to exhibit an unbroken continuity in the stoping, nevertheless, to those who are observant of the variations in the grade of the ore, as recorded by daily assays or weekly mail returns, it is very clear that such variations coincide with the changes in the country, that is to say, the ore-body will be characterized by nearly horizontal bars of enrichment which are traceable to the effects produced upon the vein by the particular layer of breccia through which it is passing at a particular horizon. My observations lead me to suppose that the composition of certain layers of the fragmental volcanic rock is responsible for the effects noticed and that the layers which have the finest texture are those which are the most beneficial, for reasons outside of the present discussion. One example will suffice. In Fig. 10 it is seen that a series of adits penetrate a steep mountain which is entirely composed of andesite breccia. The lowermost adit goes through an average of 2·5 ft. to 6 dwt. of gold, which is, in the district where the mine is situated, rather low grade. The first portion of the level and the end of it pass through barren ground so that there is some evidence of the existence of an ore-shoot of this low-grade stuff. In the stopes there is no change to record until the next level overhead, No. 2, is approached. A raise connecting with this level passes through 8-dwt. ore. No. 2 adit makes a much better showing, and averages, fairly uniformly, 11 dwt. for an average width of 4 ft. Here also the level passes out of ore at a point nearly vertically over the corresponding impoverishment at No. 1. The stopes above No 2 give, at first, results as good as the drift, but in going upward they show a marked falling off, so as to average one-half the results given by the No. 2 level. At No. 3

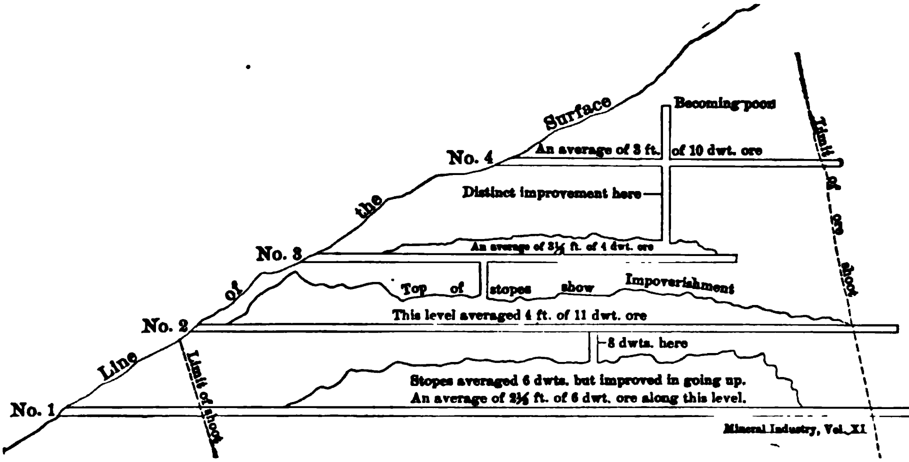

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FIG. 10.—SHOWING RESULTS OF SAMPLING.

the average of the level is only 3·5 ft. of 4-dwt. ore; this is doubtless the reason why the drift was not extended to the limit of the shoot. A raise put up from this level is in poor ground until within 50 ft. of No. 4; then marked improvement sets in. This is confirmed by the results from the No. 4 adit, which gives an average of 3 ft. of 10-dwt. ore. This good mill stuff, however, does not extend much above the level, as is proved by a raise, which gets into poor ground.

These data are perplexing and indicate an alternation of values which renders any estimate very hazardous. When, however, the geological structure is investigated, there is found to be a relation, between values and structure, which illuminates the entire problem. In Fig. 11 there is given a section, on the plane of the vein, which exhibits the position of the series of layers through which the vein cuts. This helps to explain the results shown in Fig. 10. The zones of enrichment penetrated by adits No. 1 and No. 4 coincide with two layers of close-textured tuff, or fine-grained breccia, laid down during the intermittent violence of volcanic eruption. The intermediate, overlying, and underlying beds of breccia are coarse, and, for some reason which does not concern the present inquiry, they are less favorable to ore-deposition than the occasional layers of tuff.

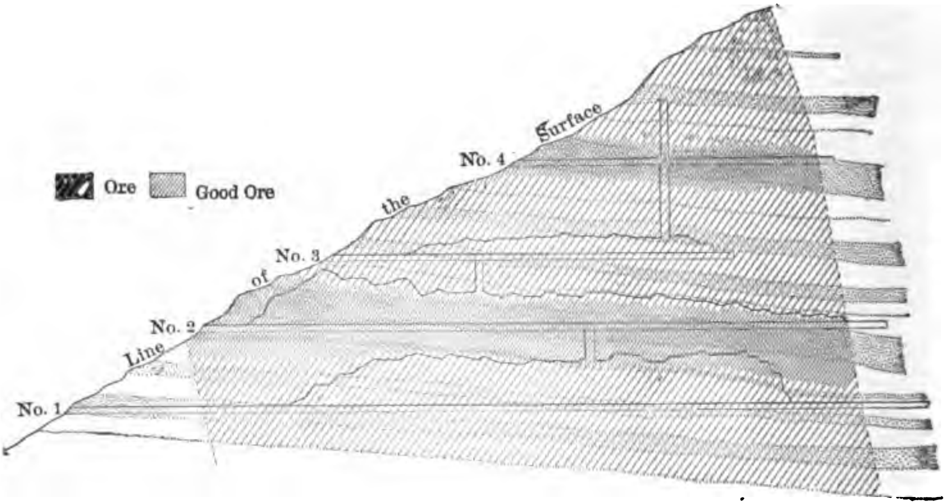

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FIG. 11.—SHOWING ROCK STRUCTURE.

In this instance the evidence was very clear; in other mines situated in the same region it is not practicable, on account of the decomposition of the enclosing country, to establish the relationship so clearly, but it is a matter of experience that notable variation in both the width and value of the lodes does occur in a similar nearly horizontal direction. The understanding of it is, therefore, a clue to many apparent vagaries in the distribution of rich ore.

In the case of a mine which contains several ore-bodies there are many useful suggestions to be obtained from a comparison of their characteristics. Careful investigation will lead sometimes to the detection of peculiarities applicable to the general occurrence of ore in that particular mine. The longitudinal section of the stopes warrants the close study given by a general to the map of the region which is to be the scene of his campaign. Stope-maps are not always correct; sometimes they are incorrect to a very misleading degree. A few measurements, at least, should be made to test this point, and occasionally, when the general accuracy of the surveys warrants a doubt, it is a good precaution to make one's own map of the mine, either personally, or by engaging the services of a reliable surveyor. The conditions are so diverse that it is impossible to give a typical illustration, but, by way of suggestion, I will append an example of inferences derived from a study of the old workings of a mine. It is a small mine; for, after all, the most perplexing of problems is a prospect, and it is found in practice that the greatest mistakes and the exercise of the keenest judgment are alike exhibited in the appraising of the uncertainties of an undeveloped mine; therefore, the size of the property chosen as an illustration scarcely requires apology.

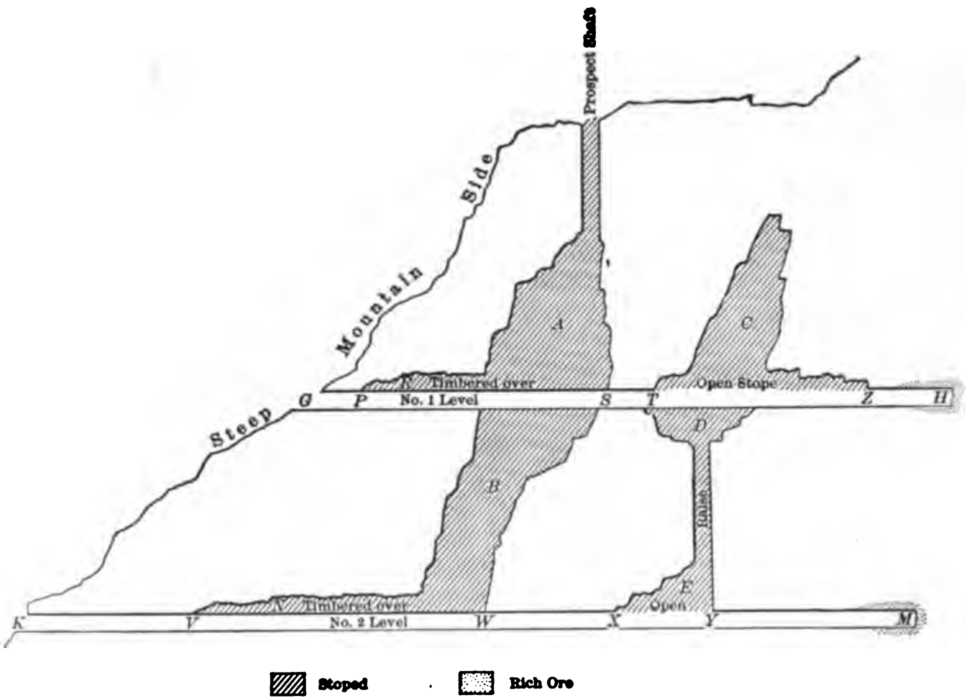
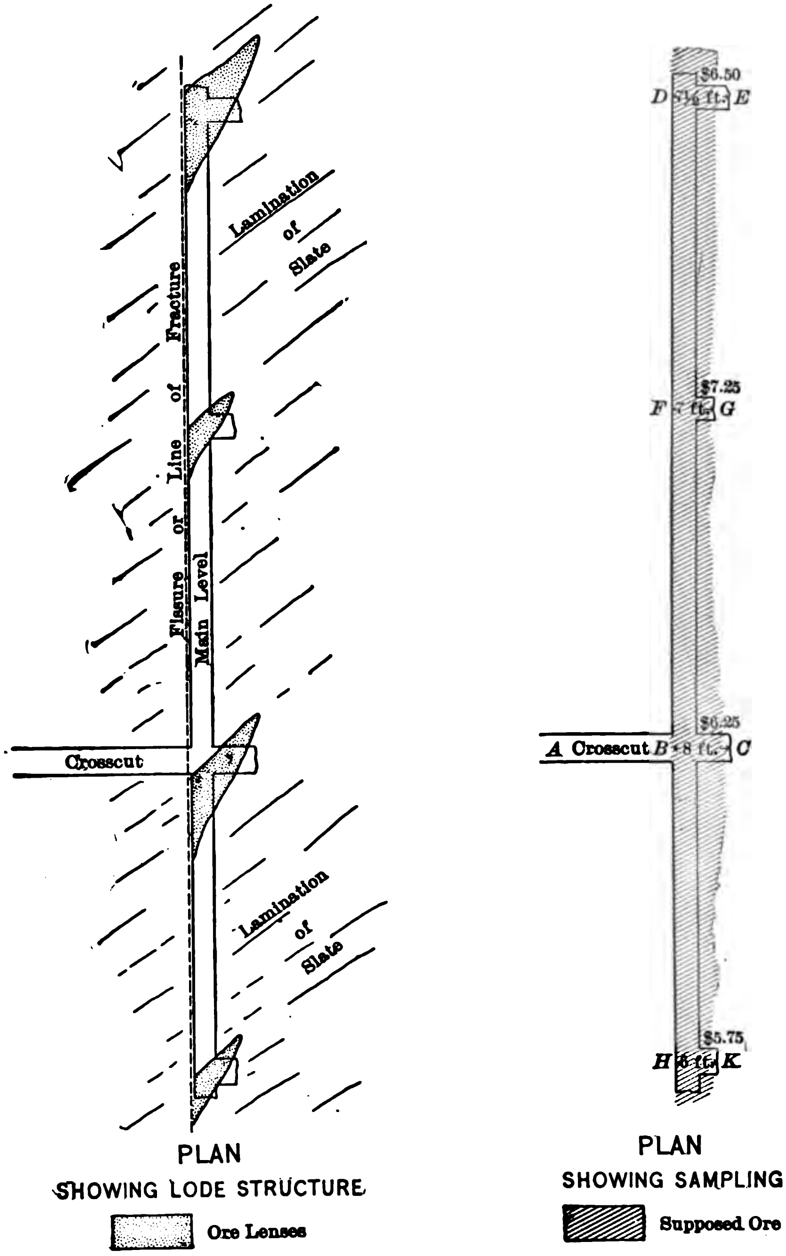


FIG. 12.—SECTION OF A MINE SHOWING ORE IN CHIMNEYS.

Fig. 12 represents a section of the workings. These consist of two adits, on the vein, together with a discovery shaft, which joins the upper level (*G H*), and a raise connecting the latter with the lower level (*K M*). The problem is to determine what weight should be given to the occurrence of a good width (say, 4 ft.) of very rich ore (say, 5 oz. gold per ton) in the ends (*H, M*) of the two levels. In such a case it is most important to investigate, with thoroughness, the mode of occurrence of the ore-bodies previously encountered in the mine. This is not always easy; old workings have been allowed to cave or the ground is heavy and they are carefully timbered so as to impede examination.

Sometimes this is intentional. In the case cited the upper level appears to carry one continuous body of ore from *P* to the breast at *H*, with a small comparatively barren interval *S T*. The timbering obscures the fact that the first half of the stope *P S* is only a cutting-out stope, which was worked for the purpose of testing a low-grade portion of the vein; the same applies to more than two-thirds of the stope *V W*, at the lower level. Similarly, while the timbering between *T* and *Z* indicates a good length of stope, as a matter of fact the innermost half of this is little more than a "cutting-out" stope in comparatively poor ground. The truth is, the ore-body *A B* did not go to surface, having been first cut by the discovery shaft at 70 ft. down; it is a very short body of ore, almost a chimney, and it diminishes in approaching the lower level; further, the ore-body *C D* is still less persistent; it is a narrow, short lens which does not hold out to the lower level, nor does it go up more than half way to surface, but it makes a sort of spurious connection, by means of the raise, with another patch of ore, *E*, on the second level. In practice, such workings as these are largely inaccessible, and usually dangerous; as a consequence, the statements of an inaccurate superintendent, who desires to serve his employer by putting things in the most favorable light, are apt to carry more weight than they should, so that, with the usual desire for quick decision on the part of both the vendor and the vendee, the engineer may be pushed to a conclusion which the actual facts do not warrant. It may seem to one who has missed the essential character of these ore-bodies, through the failure to examine the old workings, that the good width of rich ore at *H* and at *M* indicates the beginnings of a big body of ore which persists, at least, from one level to the other, but, to another man, who has carefully studied the old workings, it is evident that the probabilities point merely to another narrow lens of uncertain extent. The moral is, do not allow yourself to be hurried into an opinion by either party to the transaction, and beware of workings which are stated to be inaccessible, because such inaccessibility may have a purpose.

Another illustration will emphasize the warning conveyed in the last sentence. In Fig. 13 is represented the single level of a Californian mine which is reached by the western cross-cut shown to the left of the drawing. The level is 450 ft. long; owing to the fact that the country is a soft, black slate the ground is very heavy and the level is closely timbered throughout, permitting of only occasional glimpses of ore at the points where short cross-cuts have been run out eastward. At these places, *D E*, *F G*, *B C* and *H K*, the lode is plainly visible and exhibits from 6 to 8 ft. of fairly uniform quartz carrying an average of from 6 to 7 dwt. gold, in a district where working costs are about $3 per ton. After sampling these cross-cuts, examining the little there was to be seen, and finding that the ground really seemed heavy enough to justify the close timbering over the level, the engineer came to the conclusion that he was dealing with one of those persistent ore-bodies not uncommon in that part of California, and he estimated the ore to have the continuity exhibited by the cross-hatching in the drawing. However, he had wholly misunderstood the real character of the ore-occurrence, as Fig. 14 will indicate. The close timbering was not necessary in order to sustain the ground alone; it was an excuse for obscuring certain facts. The quartz exposed by the several cross-cuts belonged to a number of small lenses. These abutted against the "fissure," or main line of fracture, which constituted the supposed lode; the lenses were short-lived and lay with their longer axis parallel to the



PLAN
SHOWING LODE STRUCTURE

PLAN
SHOWING SAMPLING

FIGS. 13 AND 14.—SHOWING LODE STRUCTURE AND METHOD OF SAMPLING.

layers of slate; the body at *D E* only lasted as far as two sets of timber; that at *F G* died out at 60 ft., and that at *B C* "petered out" at 40 ft. above the level, while the last one, *H K*, went up as a narrow body for a distance of 160 ft. Compare Fig. 10 with Fig. 13 and quote Hamlet's comment on his own portrayal of his mother's successive husbands. This incident did not befall a tyro, but an old campaigner, who was caught by his own carelessness under circumstances from which only the greatest wariness could have saved him.

Misconceptions concerning the conditions contributory to the localization of ore shoots and the consequent mistaken ideas as to the future possibilities of a mine have often arisen from a misunderstanding of vein intersections. In the case of a well-known mine in southwestern Colorado, a length of 2,700 ft. of ore had been opened up by an upper level, and stopes, which had worked out most of the ore except at one end, had proved that it persisted to the surface, an average distance of 150 ft. above this upper level. In the meantime two winzes had demonstrated the apparent downward continuance of the ore-body. A longitudinal section of these workings is shown in Fig. 14. In the examination of the mine by several distinguished mining engineers, it was assumed that the winzes, one of which was 58 ft., and the other 143 ft. deep, proved the continuity of the ore-body to an extent sufficient to warrant a price for the property which was a good deal in excess of the net profits to be won from the ground as measured to the bottom of the winzes. In the sequel it was found, after the mine had been purchased and when deeper workings had explored the lower horizon, that the ore-body owed its existence, and certainly its shape and position, to the intersection with another lode. This made a "scissors crossing," the hinge of which was a line, dipping west at an angle of 7° 30′. The ore-body reached from this line to the surface, while downward it extended about a hundred feet or so. Other scattered smaller bodies of ore were, it is true, encountered, but the main ore-body of the mine, upon which its value was based, extended only about a hundred feet below the broken line shown across the longitudinal section in Fig. 15. Such an instance as this proves the need for deciphering the conditions which have affected the distribution of ore. The crossing referred to was visible in the stopes at the east end, but only to an inquiring observer who suspected some eccentricity of lode structure.

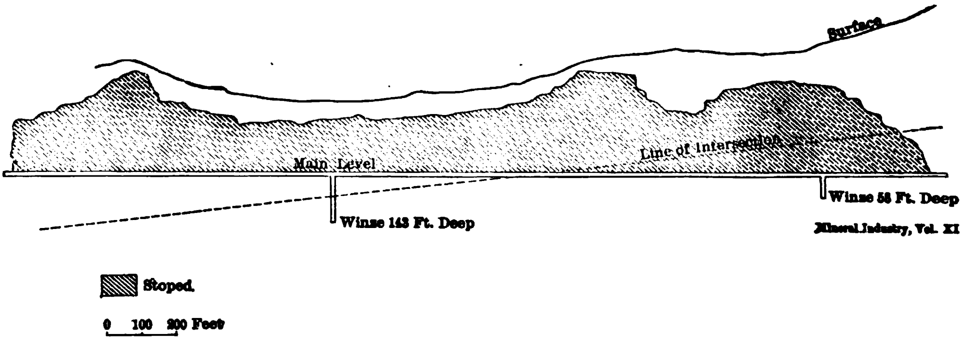


FIG. 15.—LONGITUDINAL SECTION.

Collateral Evidence.—Of all the collateral evidence likely to aid the engineer in a correct diagnosis of the condition of the mine he is examining, none is so useful as that derived from a study of the surrounding district. Mines situated in the same district are apt, on account of an identical geological environment, to exhibit similar symptoms and to suggest like possibilities. The general study of a region, therefore, is a useful preliminary to the investigation of a particular mine. Moreover, there is, I am glad to say, a certain spirit of *camaraderie* among professional men of the right sort which will enable a stranger to obtain many useful hints from resident engineers if he is properly made known to them.

The characteristics of ore-deposits within limited areas are often well marked; in one case persistence, without probabilities of bonanzas, is the rule, as on the Rand; in another case an irregular distribution of values is to be expected, as in most silver-lead deposits in limestone and also in many rich telluride veins where secondary enrichment has been at work; again, certain lines of faulting and well-defined contacts between sedimentary and eruptive rocks may be recognizable as factors in determining the place of rich bodies of ore, as is illustrated by the Aspen and Rico districts in Colorado.

Another very important factor, in influencing the relative richness of a lode in depth, is the position of the ground-water level. No engineer can afford to disregard it. Two opposite cases may be cited. In certain arid regions of the southwestern part of North America, which it would be invidious to specify further, the persistence of rich ores coincides roughly with the zone of oxidation. I recall a well-known mine which, at the time it was examined by several reputable engineers, exposed an ore-body nearly 1,800 ft. in length. This was the length of the ore traversed by the longest level, which was also the deepest. (See Fig. 15.) Both ends of this level were, however, still in ore. Three winzes proved the ore for a further depth of about 30 ft. The upper workings contained carbonates of lead and iron-stained quartz rich in the precious metals. At the third level there was evidence of the edge of the oxidized zone, for sulphides predominated. All of the winzes left off in sulphides, of average tenor as regards gold and silver, but exhibiting a noteworthy admixture of zinc blende amid the galena. One engineer who examined the mine allowed 50 ft. below the lowest level as ore to be considered in appraising the value of the property, but he allowed nothing beyond the ends of the level. This was adversely criticised. However, among the reasons prompting a conservative attitude was the recognition of the fact that many gold and silver veins in that region turned into poor zinc-bearing lodes at a short distance below the limit of visible oxidation. In the sequel he was proved to be right. When, later on, the mine underwent extensive development it was found that at 45 ft. below the lowest level the ore became poor in gold and silver, but heavily charged with zinc blende, while at the same time the lowest level ran out of the ore-body within a few feet at both ends. In this regard it is a curious fact how often good miners, especially if they are selling a mine, stop their explorations at the proper psychological moment.

The great copper region around Butte, Mont., exemplifies another aspect of the inquiry. Very extensive exploration, prompted by the extreme richness of the lodes, has permitted of the accumulation of evidence, which proves conclusively that the big ore-bodies are the result of a secondary enrichment brought about by the leaching of copper by the ground-water and its precipitation upon the sulphides of the deeper zone. The original vein stone consisted of iron pyrite, copper pyrite and, probably, enargite, while the bonanzas consist of the higher sulphides, bornite, covellite and chalcocite. Experiments have been made[6] in the laboratory which illustrate the formation of chalcocite (copper glance) on pyrite by precipitation from a solution containing copper sulphate, such as would be the product of oxidation through the agency of the ground-water. As a result of such reactions the outcrops are poor in copper and silver, because these have been leached out; the silver appears at a comparatively shallow depth (300 or 400 ft. below the surface) so as to form a zone of maximum enrichment in that metal, while the copper has been deposited deeper still, so as to form the magnificent masses of high-percentage ores which have made Butte so productive. Below these come the first-formed ores, chiefly pyrite with a little copper pyrite, without the higher copper sulphides which have enriched the overlying zone. While, therefore, the lower limit of the horizon of secondary enrichment has been passed through in some of the mines, it must be added that in others the rich sulphides extend to a depth of over 2,000 ft. from the surface, so that the effects of the ground-water circulation continue to a profundity quite exceptional in the experience of mining. This may be due to the intensity of the fracturing which followed the deposition of the earlier sulphides, and it may be partly a result from the open character of the lode channels which has permitted of the far-reaching penetration of the ground-water, but, whatever the cause, it renders the problem of ore-occurrence at Butte quite exceptional, particularly when compared to cases such as the one quoted in the preceding instance, in Fig. 15. A novice who has sampled the shallow workings of a young mine in a region such as Butte would be likely to be misled by the low percentage of copper, and therefore enunciate an unfavorable opinion, whereas one who recognized the effects of ground-water leaching and was guided possibly by a knowledge of the changes encountered at greater depth, in a neighboring mine, would make quite a different inference. Under other circumstances in another region the occurrence of the higher sulphides, such as covellite and chalcocite, would suggest secondary enrichment and warn the engineer against counting upon a persistence of conditions which are frequently quite local.

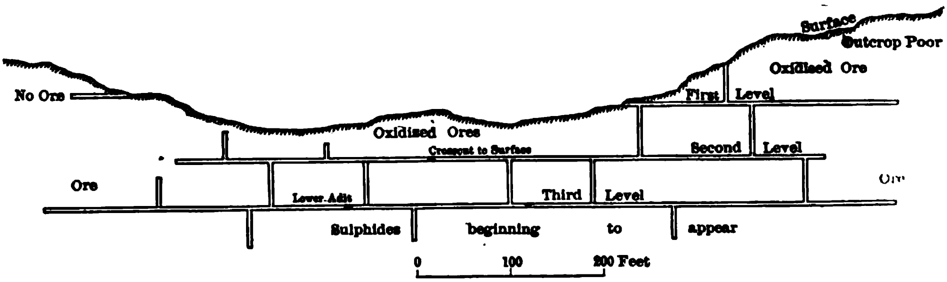


FIG. 16.—CROSS-SECTION OF MINE, SHOWING THE WORKINGS.

Considerations such as these suggest very forcibly that keen observation and

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[6] "The Synthesis of Chalcocite," by H. V. Winchell, *Engineering and Mining Journal*, May 23, 1908.

wide experience are required for the appraisement of the potentialities of a prospect.

Conclusion.—This discussion of the subject has emphasized one great factor in work of this kind, and that is—the personal equation. No two men set to work in exactly the same way, and no two men make exactly the same deductions from a complicated series of data. My views on the subject are those based upon my own experience—hence the inevitable limitations of my presentation of it. For this reason also I have omitted to refer to the literature which deals with sampling and estimates of ore because it would have extended this contribution to uncomfortable length had I taken up the other aspects of the inquiry as discussed by other men. Herein lies my excuse and my apology to the Institution of Mining and Metallurgy, to Messrs. J. D. Kendall, E. B. Kirby, A. G. Charleton, W. Wybergh, G. A. Denny, S. J. Truscott, D. W. Brunton, W. McDermott and other authoritative writers on the same subject.

The conclusion of the whole matter is sufficiently obvious—so obvious as to need but little further insistence. If the discussion of the methods to be applied in the sampling and estimation of ore has served to accentuate the difficulties to be encountered in the diagnosis of a mine, then it will have fulfilled one of the purposes of this contribution. *"Chi va piano, va sano."* Extreme care is necessary at every stage of the work—care and experience, the experience born of wide knowledge and practical work without which a man in a mine is no better than the proverbial bull in a china shop, with a strong suggestion of a coming smash!

The old hands—the engineers who have sampled mines from China to Peru—do not need my maxims to guide them. They have lost the cheerful confidence of their apprentice days and are saturated with the experience of difficulty and doubt which have been frankly faced on a hundred occasions. To the youngster, who still has to receive his first fall and to realize that few data are absolutely certain, also that data carelessly obtained are inevitably uncertain—to him this analysis of methods of work will, it is earnestly hoped, serve as a red flag of warning. To the general reader, who is usually more in sympathy with the pains of the unfortunate investor in mines than he is with the causes which may vitiate good advice from the expert, to him these *obiter dicta* will, I trust, suggest forcibly that good advice is hard to get and expensive—yet cheap, indeed, compared to the costly experience of entrusting onerous professional duties to the inefficient.

THE MINING STOCK EXCHANGES IN 1902.

THE tables on the following pages give a résumé of the business done during the past year on the leading exchanges of the United States and Europe, and the dividends paid and assessments levied by the principal mining companies. While the year was less eventful than 1901, the conditions on the whole were highly satisfactory for the mining, as well as the other industries.

THE BOSTON MINING STOCK MARKET IN 1902.

The copper mining shares show a remarkable shrinkage in value from the quotations of the preceding year, and there has been also a decided falling off in the distribution of dividends. Of the Lake Superior mines only three paid dividends during 1902, the aggregate distribution being $3,440,000 or less than one-half the amount paid in 1901 by six companies. The most noticeable decline on the exchange has been the Calumet & Hecla, which reached the low figure of $420 per share, as compared with the high price for the year of $650. Amalgamated Copper shares fluctuated from $78·87 to $52·12, Osceola from $88 to $47·50, and Tamarack from $276 to $140; Quincy sold down from $140 to $100, the lowest price in four years. Wolverine was an exception in that its shares showed an upward tendency and reached the highest quotations near the close of the year. This stock fluctuated from $61 to $42 per share. Mohawk shares rose from $27 to $49, but later declined to $40. Among the Canadian shares dealt in at Boston, those of the Dominion Coal Co. and the Dominion Coal & Iron Co. were most active. The former rose from $54 to $146, and the latter rose from $25 to $79·87; both declined heavily, however, toward the close of the year.

THE COLORADO SPRINGS MINING STOCK MARKET IN 1902.

The records show wide fluctuations in some of the leading stocks, such as Elkton, Portland, Jack Pot and Vindicator, and the general trend of prices was downward. Elkton fell from the high price of $1·40 to 30c., Portland from $2·90 to $1·80, Jack Pot from 39c. to 8c., and Vindicator from $1·26 to 93c.

FLUCTUATIONS IN MINING STOCKS AT BOSTON DURING 1902.

Name of Company.	Par Value.	January.		February.		March.		April.		May.		Ju	
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L	H.	L.
Copper:													
Adventure Con. (*b*)	$25	$23·50	$17·75	$25·00	$19·50	$23·50	$20·25	$24·25	$21·00	$24·25	$21·50	$24·50	$22·50
Allouez (*b*)	25	3·75	2·50	4·00	3·13	4·75	3·75	4·00	3·00	4·00	3·00	3·75	2·88
Amalgamated (*a*)	100	78·00	67·13	79·00	67·88	79·00	61·13	61·88	61·13	71·63	65·00	69·63	62·38
Anaconda (*a*)	25	35·00	30·75	36·00	30·13	33·60	30·50	27·50	27·88	29·50	27·50	28·63	26·50
Arcadian (*b*)	25	6·25	3·50	7·75	4·50	13·25	6·50	9·50	7·00	6·75	4·00	6·00	4·75
Arnold (*b*)	25	1·00	·50	1·00	·50	1·00	·75	·85	·50	·80	·50	·80	......
Ash Bed (*b*)	25	......	......	......	......	......	......	......	......	......	......	......	......
Atlantic (*b*)	25	28·00	22·00	33·00	22·00	31·50	27·63	33·50	28·00	37·00	28·00	32·00	29·00
Baltic (*b*)	25	40·50	34·00	49·50	38·00	48·00	43·50	63·00	54·00	......	......	......	......
Bingham (*h*)	10	25·00	20·50	28·00	22·00	27·63	23·50	39·75	25·00	38·50	34·25	36·50	31·00
British Columbia (*i*)	5	10·25	9·50	9·25	9·00	10·50	7·88	10·50	9·25	9·50	6·63	9·50	......
Calumet & Hecla (*b*)	25	680·00	570·00	650·00	600·00	610·00	575·00	600·00	533·00	570·00	530·00	595·00	560·00
Centennial (*b*)	25	14·75	11·00	18·50	11·75	28·00	15·75	21·75	19·13	20·75	17·50	20·00	17·25
Copper Range (*b*)	25	61·75	53·00	74·00	46·38	73·00	48·50	62·50	48·88	61·00	53·50	59·00	52·25
Elm River (*b*)	12	2·75	1·50	4·00	2·25	5·50	3·50	3·75	3·25	4·75	3·00	3·50	3·00
Franklin (*b*)	25	15·50	11·75	16·00	13·50	14·63	12·00	12·50	11·50	12·00	10·75	11·75	11·00
Isle Royale (*b*)	25	24·25	20·00	25·00	19·50	21·00	15·00	17·25	12·00	16·00	12·50	18·00	12·00
Mass Con. (*b*)	25	19·50	15·38	20·75	17·75	21·00	17·00	19·63	19·50	21·50	17·00	20·25	18·00
Mayflower (*b*)	25	2·50	2·00	3·00	2·00	3·63	2·50	3·00	2·88	3·00	2·50	2·50	2·00
Michigan (*b*)	25	12·00	9·25	12·00	11·00	13·25	10·50	12·50	10·25	13·50	9·25	12·50	11·50
Mohawk (*b*)	25	38·00	27·00	39·00	31·00	38·00	33·00	38·00	34·50	44·00	34·00	43·38	39·75
Montreal & Boston	5	4·25	3·00	4·00	3·00	4·75	4·00	4·00	2·63	4·75	2·63	3·00	2·00
National (*b*)	25	1·50	1·25	3·75	1·50	1·75	1·25	1·50	......	1·00	......	......	......
Old Colony (*b*)	25	3·50	2·50	4·00	3·00	4·50	3·50	4·00	3·50	3·50	2·50	3·00	2·25
Old Dominion (*c*)	25	24·50	21·00	28·75	21·00	30·00	18·25	23·75	17·50	23·00	17·50	23·25	19·50
Osceola (*b*)	25	88·00	77·50	89·75	75·00	75·75	58·50	64·00	60·00	63·50	59·50	68·00	59·50
Parrot (*a*)	10	33·25	28·00	35·00	30·50	32·75	28·00	29·00	24·75	31·00	24·75	31·00	25·50
Phœnix Con. (*b*)	25	4·50	4·00	4·25	3·50	4·00	3·50	4·00	3·50	5·00	3·50	4·75	4·00
Quincy (*b*)	25	140·00	135·00	147·00	140 00	141·00	130·00	130·00	125·00	135·00	125·00	135·00	130 00
Rhode Island (*b*)	25	3·00	2·00	3·00	2·50	3·25	1·88	2·88	2·25	2·50	2·00	2·25	1·50
Santa Fé (*j*)	10	4·00	2·50	4·00	2·50	4·00	2·75	3·50	2·75	3·00	1·00	2·88	1·88
Shannon (*a*)	10	......	......	......	......	......	......	......	......	......	......	......	......
Tamarack (*b*)	25	276·00	250·00	281·00	230·00	230·00	175·00	180·00	170·00	185·00	169·50	185·00	175·00
Tecumseh (*b*)	25	1·75	·50	2·00	1·50	2·00	1·50	2·00	1·50	1·75	1·25	3·50	1·50
Tennessee (*k*)	25	14·00	......	......	......	14·25	10·75	......	......	......	......	17·75	15·00
Tri-Mountain (*b*)	25	60·00	31·50	125·00	61·00	108·00	95·00	175·00	100·00	100·50	100·00	100·00	95·00
Trinity (*e*)	25	15·00	12·75	14·75	11·00	18·50	13·25	14·75	12·63	14·25	12·13	13·00	11·75
United (*a*)	100	......	......	......	......	......	......	......	......	......	......	......	......
Utah Con. (*h*)	5	26·50	21·25	27·25	23·88	25·00	21·25	25·00	22·00	23·00	21·00	22·75	20·00
Victoria (*b*)	25	5·75	4·38	6·50	5·00	6·75	5·25	6·00	4·75	4·88	4·13	6·38	4·00
Washington (*b*)	25	1·50	......	......	......	......	......	......	......	......	......	......	......
Winona (*b*)	25	2·00	1·00	4·50	1·50	2·00	1·25	2·50	1·50	3·88	1·75	5·75	2·50
Wolverine (*b*)	25	53·00	42·00	55·00	49·00	56·00	50·50	56·00	52·00	56·00	53·00	56·00	54·25
Wyandotte (*b*)	25	1·13	·75	1·25	·75	1·25	1·00	1·50	1·00	1·63	1·00	1·63	1·00
Gold:													
Cochiti (*j*)	10	2·00	·70	1·25	·45	·70	·45	·50	25	·50	·45	·60	·30
Cons. Mercur (*h*)	5	1·88	1·38	2·25	1·50	2·00	1·00	2·00	1·75	2·00	1·38	2·13	1·88
Daly-West (*h*)	20	30·00	25·00	29·00	15·50	41·00	18·00	49·00	40·00	46·50	34·75	50·00	44·50
Guanajuato (*l*)	5	5·75	4·00	4·75	3·25	4·50	3·75	4·25	3·50	4·25	3·25	3·75	3·50
Merced (*e*)	15	......	......	3·50	2·50	......	......	......	......	......	......	......	......
N. Amer. Dredging	5	......	......	2·00	1·75	3·75	1·50	3·88	2·38	3·00	......	......	......
North Star (*e*)	10	......	......	......	......	......	......	......	......	......	......	......	......
Santa Ysabel (*e*)	5	·50	......	·50	......	·50	......	·50	......	......	......	......	......
United States (*h*)	25	17·50	13·25	18·25	16·38	19·38	17·50	22·75	18·13	21·50	20·00	21·00	19·00
Zinc:													
Am. Z. L. & Sm. (*g*)	25	11·25	10·00	10·00	9·00	13·50	9·00	14·25	12·00	12·38	10·00	12·25	11·00
Continental (*g*) old	10	2·00	......	2·75	2·50	3·75	2·38	4·00	3·00	4·00	3·00	4·00	3·00
Continental (new)	25	......	......	......	......	......	......	......	......	......	......	......	......
Miscellaneous:													
Ætna (*e*)	5	......	......	......	......	......	......	......	......	......	......	......	......
Bonanza (*d*)	25	·90	·75	·90	·80	1·05	·75	·90	·80	·80	·75	·75	·70
Boston (*e*)	10	2·00	......	2·13	2·00	2·13	2·00	5·00	3·00	......	......	......	......
Breece (*d*)	25	......	......	......	......	......	......	......	......	......	......	......	......
Catalpa (*d*)	10	·50	......	......	......	......	......	......	......	......	......	......	......
Central Oil (*m*)	25	......	......	8·00	7·00	7·50	7·00	8·38	6·00	9·00	8·00	8·00	7·50
Dominion Coal (*f*)	100	64·75	52·50	88·50	63·38	123·00	87·00	146·00	122·25	141·50	130·00	142·00	132·00
Dominion Coal, pref. (*f*)	100	119·00	116·00	118·50	117·00	119·00	116·00	119·00	118·00	116·00	115·00	118·50	114·50
Dominion I. & S.	100	......	......	......	......	47·50	40·00	75·00	47·00	68·88	50·00	57 00	51·00
Mont. Coal & Coke (*a*)	25	4·00	3·50	......	......	4·50	2·75	4·00	......	4·50	4·00	4·00	......
New England Gas & Coke	100	5·25	5·00	6·75	4·50	7·63	5·00	7·50	3·00	4·13	3·25	4·00	2·25
New Idria (*e*)	5	......	......	......	......	8·00	......	7·50	......	7·50	......	8·00	7·00
United States Oil (*m*)	25	12·00	11·00	13·25	12·00	13·00	11·00	16·00	12·25	18·13	15·00	17·00	14·38
Total sales	...	......	......	......	......	......	......	......	......	......	......	......	......

FLUCTUATIONS IN MINING STOCKS AT BOSTON DURING 1902.—*Continued.*

Name of Company.	July.		August.		September.		October.		November.		December.		Sales. No. of Shares.
	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	
Copper:													
Adventure Con. (*b*)	$24·50	$22·00	$24·00	$22·50	$24·00	$19·25	$22·00	$18·25	$21·00	$14·75	$15·00	$12,25	59,995
Allouez (*b*)	3·00	2·50	2·50	2·00	3·00	2·00	2·75	2·13	2·88	2·25	2·63	2·00	24,990
Amalgamated (*a*)	68·75	61·88	70·25	65·00	71·38	63·38	67·25	62·00	65·75	53·13	59·63	52·00	758,757
Anaconda (*a*)	27·00	23·75	26·25	25·25	25·75	25·50	25·50	25·00	25·00	21·00	23·00	21·00	9,891
Arcadian (*b*)	5·63	4·50	5·38	4·50	5·00	4·50	5·00	4·50	4·75	4·00	4·50	3·50	116,613
Arnold (*b*)	·50	......	......	......	......	......	......	......	·75	·60	·50	·38	4,070
Ash Bed (*b*)	......	......	......	......	......	......	·20	......	·22	·20	......	......	150
Atlantic (*b*)	31·00	27·00	28·00	25·00	28·00	25·00	26·00	21·00	27·00	22·00	7·63	6·00	24,119
Baltic (*b*)	......	......	......	......	......	......	......	......	......	......	......	......	47,084
Bingham (*h*)	35·13	31·00	34·50	29·50	32·75	29·50	39·50	27·00	59·25	24·00	29·38	26·00	99,650
British Columbia (*i*)	......	......	7·88	6·00	6·00	5·50	......	......	7·00	5·00	6·00	......	8,425
Calumet & Hecla (*b*)	576·00	563·00	555·00	526·00	565·00	450·00	550·00	505·00	510·00	455·00	475·00	420·00	4,357
Centennial (*b*)	20·75	17·50	19·00	17·25	19·50	15·50	19·25	16·00	19·63	15·13	17·00	15·00	260,487
Copper Range (*b*)	60·38	52·75	59·88	56·00	60·75	54·50	60·50	54·50	65·25	50·00	57·75	57·25	539,165
Elm River (*b*)	4·13	2·75	3·50	2·63	3·13	2·50	3·00	2·50	3·00	2·00	2·13	1·75	87,317
Franklin (*b*)	15·25	10·50	12·00	10·00	11·00	10·00	10·50	9·63	10·00	7·50	9·00	7·50	18,344
Isle Royale (*b*)	15·75	12·00	15·00	11·63	15·25	13·00	14·00	13·00	14·00	9·00	12·00	9·00	43,083
Mass Con. (*b*)	18·88	17·75	17·88	17·00	18·25	15·25	16·38	14·25	15·00	13·50	14·13	12·50	112,645
Mayflower (*b*)	2·50	2·00	2·25	......	2·38	1·38	2·00	1·50	1·75	1·50	1·75	1·50	28,719
Michigan (*b*)	12·00	11·25	12·00	11·25	12·00	10·13	11·00	9·50	10·00	7·00	7·50	7·00	38,645
Mohawk (*b*)	45·50	40·75	47·50	43·00	49·00	45·00	47·38	45·00	47·00	37·50	39·00	36·00	120,238
Montreal & Boston (*i*)	2·50	2·00	3·88	2·38	3·63	2·63	3·75	2·38	3·00	2·38	3·50	2·38	342,584
National (*b*)	......	......	......	......	1·50	......	......	......	......	......	......	......	2,800
Old Colony (*b*)	3·00	2·25	3·00	2·50	3·50	2·00	2·50	2·00	2·00	1·13	1·25	1·35	17,101
Old Dominion (*c*)	20·00	18·00	19·50	17·00	19·25	16·00	18·00	16·00	17·00	14·75	16·50	14·25	68,864
Osceola (*b*)	62·75	58·00	60·00	55·00	62·00	56·00	59·00	56·00	59·00	47·50	54·00	50·00	98,979
Parrot (*a*)	30·00	26·75	28·50	26·00	28·50	25·00	26·50	25·00	26·00	21·00	26·00	22·00	26,392
Phœnix Con. (*b*)	5·00	4·25	5·00	4·00	5·00	4·50	4·88	4·00	4·75	3·75	4·00	3·25	16,820
Quincy (*b*)	137·00	130·00	130·00	125·00	135·00	125·00	130·00	125·00	200·00	105·00	109·00	100·00	5,119
Rhode Island (*b*)	3·00	1·75	3·00	2·50	3·00	2·50	2·50	1·75	2·38	1·25	3·00	1·50	20,318
Santa Fé (*j*)	2·50	1·75	2·38	1·75	2·00	1·50	2·00	1·50	1·88	1·50	1·63	1·50	69,484
Shannon (*a*)	13·50	12·50	12·50	9·00	11·50	9·00	10·00	9·00	9·75	8·00	......	......	33,486
Tamarack (*b*)	182·00	175·00	180·00	171·00	180·00	165·00	175·00	162·00	160·00	146·00	145·00	140·00	14,396
Tecumseh (*b*)	3·25	2·75	3·00	2·50	2·75	2·00	2·00	1·50	1·50	1·00	1·00	·50	7,292
Tennessee (*k*)	18·50	16·25	......	......	......	......	......	......	......	......	......	......	1,984
Tri-Mountain (*b*)	95·00	......	......	......	90·00	87·50	......	......	95·00	92·00	93·00	91·00	71,455
Trinity (*e*)	12·75	11·13	12·50	11·00	12·25	10·50	12·25	10·00	11·00	8·50	9·00	8·00	68,719
United (*a*)	35·00	34·35	35·00	34·75	22·38	·20·75	......	......	32·88	19·00	30·50	30·00	10,214
Utah Con. (*h*)	22·00	19·00	21·50	20·25	23·50	20·50	22·25	15·00	22·00	14·00	26·00	22·38	106,193
Victoria (*b*)	6·38	5·25	6·25	5·75	6·00	3·13	7·00	3·13	6·75	3·00	5·00	4·00	54,642
Washington (*b*)	·25	......	·50	·30	·25	......	......	......	......	......	·25	......	975
Winona (*b*)	5·25	4·00	6·00	4·25	5·50	4·00	4·25	3·75	4·00	3·00	4·75	3·00	57,987
Wolverine (*b*)	60·00	54·50	60·00	57·00	61·50	58·00	60·00	58·00	60·00	57·25	60·00	57·50	24,197
Wyandotte (*b*)	1·75	1·00	......	......	1·50	1·00	1·00	......	1·00	......	6·00	·75	15,342
Gold:													
Cochiti (*j*)	·35	......	1·00	·60	·60	·50	·60	·50	1·75	......	·30	......	57,099
Cons. Mercur (*h*)	2·25	2·00	2·50	2·00	2·93	1·96	2·50	1·64	2·00	1·75	1·88	1·75	176,890
Daly-West (*h*)	56·00	48·00	54·00	50·00	53·13	49·50	50·75	49·00	50·50	42·00	39·00	34·00	47,367
Guanajuato (*l*)	4·00	2·88	4·25	3·50	4·75	3·25	3·75	2·25	4·50	3·00	3·50	2·50	130,543
Merced (*e*)	......	......	......	......	......	......	......	......	......		......	......	50
N. Amer. Dredging	3·00	......	2·75	2·25	2·50	2·25	......	......	2·13	1·50	......	......	22,165
North Star (*e*)	......	......	......	......	8·00	6·00	9·00	7·00	......	......	......	......	1,070
Santa Ysabel (*e*)	......	......	......	......	......	......	......	......	......	......	......	......	3,570
United States (*h*)	22·00	19·00	21·25	20·25	22·88	20·75	......	......	21·75	13·25	22·75	20·13	339,990
Zinc:													
Am. Z. L. & Sm. (*g*)	16·00	11·00	14·50	12·75	12·09	12·00	12·00	11·00	12·00	10·00	7·00	......	32,985
Continental (*g*) (old)	......	......	......	......	......	......	......	......	......	......	......	......	3,283
Continental (new)	15·00	......	......	......	......	......	16·88	16·00	16·88	16·00	16·50	......	364
Miscellaneous:													
Ætna (*e*)	·80	·40	......	......	......	......	......	......	·60	......	......	......	3,250
Bonanza (*d*)	·80	·75	1·00	·65	·95	·75	·80	·60	·75	·66	·75	·53	22,931
Boston (*e*)	......	......	......	......	......	......	......	......	......	......	......	......	1,200
Breece (*d*)	......	......	·50	......	......	......	......	......	......	......	......	......	10
Ca alpa (*d*)	......	......	......	......	......	......	......	......	......	......	......	......	448
Central Oil (*m*)	8·00	......	8·00	7·50	7·50	7·25	......	......	......	......	7·00	6·25	6,291
Dominion Coal (*f*)	37·50	132·50	143·75	135·00	146·50	126·00	135·25	124·00	133·00	125·00	129·50	126·00	188,677
Dominion Coal, pref. (*f*)	15·00	114·50	116·50	115·00	117·00	116·50	117·00	115·00	117·00	115·00	119·50	117·50	10,939
Dominion I. & S (*f*)	68·00	52·00	79·88	61·00	78·00	60·00	71·50	50·00	61·50	52·50	59·00	53·00	574,411
Mont. Coal & Coke (*a*)	3·75	......	3·50	2·88	5·63	3·25	6·00	5·13	5·50	5·00	5·00	......	18,514
N. England Gas & Coke	4·75	3·00	6·00	4·50	5·50	4·00	9·50	......	8·50	......	......	......	84,638
New Idria (*e*)	8·75	8·50	9·75	9·00	9·75	9·00	......	......	......	......	9·00	......	1,910
United States Oil (*m*)	18·50	15·00	17·63	16·25	17·00	14·00	16·00	14·00	21·00	13·00	14·63	13·00	199,412
Total sales	......	......	......	......	......	......	......	......	......	......	......	......	5,266,094

(*a*) Montana; (*b*) Michigan; (*c*) Arizona; (*d*) Colorado; (*e*) California; (*f*) Nova Scotia; (*g*) Missouri; (*h*) Utah; (*i*) British Columbia; (*j*) New Mexico; (*k*) Tennessee; (*l*) Mexico; (*m*) West Virginia.

FLUCTUATIONS OF MINING STOCKS AT COLORADO SPRINGS, COLO., DURING 1902.

Name of Company.	Par Value	January.		February.		March.		April.		May.		June.	
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
Acacia	$1·00	·14	·11⅛	·12	·10¼	·11	·10	·10	·08	·11	·05	·10	·09
Alamo	1·00	·14	·12	·13¾	·10	·08	·03½	·05	·03	·03⅝	·03	·08⅝	·08
American Con	1·00	·04⅛	·03	·03	·02	·03	·02	·03⅛	·02	·02⅝	·01⅛	·02⅝	·02
Anaconda	5·00	·35	·20	·30	·27½	·25	·20	·21	·14	·19	·13	·20	·16½
Ben Hur	1·00	·06	·04	·06	·04	·06	·03½	·05½	·04	·04½	·03	·04½	·03
Black B·lle	1:00	·09	·07	·08	·06	·09	·04	·08½	·06	·07	·05	·07	·05
Blue Bell	1·00	·12	·07	·10	·08	·10	·07	·08½	·06	·09	·04	·09	·08
C. K. & N	1·00	·04	·02	·03⅝	·02⅞	·03⅞	·03⅝	·05¾	·03	·07	·05¾	·06⅞	·06
C. C. Con	1·00	·09	·12	·10	·08½	·09	·07½	·08	·06⅝	·07	·06	·07½	·06
Dante	1·00	·05⅛	·04	·05	·04	·04¼	·03½	·05⅝	·04½	·04⅛	·03¼	·04¼	·03
Dr. Jack Pot	1·00	·44	·40	·44½	·39	·50	·42½	·48	·33	·40	·19⅝	·19⅞	·17½
Elkton	1·00	1·19	1·12½	1·40½	1·27	1·31	1·15	1·10	·75	·74	·57	·65	·61
El Paso	1·00	·60	·55	·65	·56	·58	·53	·55	·43¼	·50	·45	·55	·53⅞
Fanny Rawlings	1·00	·11	·07	·15	·10	·12	·05	·10	·05	·07	·03	·06	·03½
Findley	1·00	·12	·09	·12	·11	·12	·09	·11	·10	·10½	·08	·09	·08
Gold Dollar	1·00	·09¾	·07	·07	·06	·07	·05	·05⅝	·03	·05	·02	·06⅛	·04
Golden Cycle	1·00	·68	·53	·70	·55	·71	·68	·70	·61	·65	·62	·66	·60
Golden Fleece	1·00	·60	·40	·60	·36	·50	·25	·50	·25	·45	·20	·25	·10
Gold Sovereign	1·00	·04	·03	·03¼	·03⅛	·04	·02¼	·03	·02⅝	·02⅞	·02½	·03	·02½
Ironclad	·50	·06	·02	·05	·04½	·05	·02	·03½	·02	·03½	·02½	·03⅛	·03
Isabella	1·00	·35	·27	·33	·27	·25⅞	·23	·27	·24¾	·34	·15	·31¼	·26
Jack Pot	1·00	·36	·30	·39	·29	·35	·29	·35	·28	·25½	·15	·17	·10
Last Dollar	1·00	·55	·45	·60	·45	·60	·40	·60	·40	·60	·40	·60	·45
Lexington	1·00	·06	·05½	·08	·07½	·06⅝	·05½	·08½	·05⅝	·06⅞	·06	·06	·05½
Little Puck	1·00	·06	·04	·07	·05	·06½	·05	·07	·05	·06	·05	·07	·05
Mollie Gibson	1·00	·20	·16	·20	·14	·14	·10	·14	·10	·15	·10¾	·20	·10
Moon-Anchor	1·00	·25	·19	·21	·18	·30	·15	·20	·13¼	·15	·10	·15	·10
Morning Star	1·00	·04	·03	·03⅞	·03⅛	·03⅝	·02½	·03⅛	·02	·02⅝	·01⅝	·02¾	·01½
National	1·00	·04	·02	·02¼	·02	·02⅝	·02¼	·03	·01⅞	·02	·01½	·02½	·01¼
Nellie V	1·00	·04⅝	·02	·04	·02⅝	·03	·02½	·02⅝	·01¾	·02⅝	·01½	·02⅝	·01
New Haven	1·00	·05	·03⅞	·04	·03¼	·04½	·02	·04	·03½	·03½	·02⅝	·04	·03½
Pappoose	1·00	·03	·02	·03	·01	·03	·01	·03½	·02	·02	·01	·02½	·01
Pharmacist	1·00	·06	·04⅞	·07	·04½	·04⅞	·03½	·04½	·04	·04½	·03	·04	·03¾
Pinnacle	1·00	·09	·07	·08	·06	·07	·05	·07	·05	·06½	·05	·07¾	·05½
Pointer	1·00	·04	·03	·03⅝	·03	·04	·03½	·03	·02⅞	·02¾	·02½	·03¼	·02
Portland	1·00	2·90	2·10	2·70	2·57	2·60	2·35	2·05	1·96	1·92	1·75	2·00	1·75
Prince Albert	1·00	·04	·03½	·04	·02⅞	·03½	·02	·03	·02½	·03⅝	·03	·02⅞	·02
Republic	1·00	·04	·03	·03½	·02	·03	·01	·03	·02	·02½	·01½	·03	·01½
Rose Maud	1·00	·07	·05	·05	·04¼	·04½	·03	·05	·03½	·03½	·01⅛	·02¾	·01
Sunset Eclipse	1·00	·10½	·07½	·12	·08	·13¾	·09	·10⅝	·07	·07⅝	·03	·08⅞	·02⅞
Uncle Sam	1·00	·02¼	·01⅛	·03	·01⅝	·02	·01	·02	·01	·03	·01	·02½	·01
Vindicator	1·00	1·26	1·19	1·22	1·14	1·20	1·18	1·14	1·01	1·00	·85	·95	·90
Work	1·00	·10	·08⅞	·09½	·06	·08½	·06	·07⅞	·06	·07½	·05	·07	·05¼
Total sales	......	......	......	......	......	......	......	......	......	......	......	......	......

THE NEW YORK STOCK MARKET IN 1902.

The year was notable for the general liquidation and depression of prices. The low metal market, especially for copper and silver, together with the financial stringency, reacted unfavorably upon mining shares, and the quotations were below the average for the preceding year. The total sales were 8,575,029 shares, as compared with 12,063,196 shares in 1901.

The copper shares attracted widespread attention. Amalgamated pursued a downward course under the influence of the numerous lawsuits in which the company is engaged, the unsettled copper market and professional manipulation. Moreover the cut in the original dividend rate of 8 to 2% per annum had a demoralizing effect. In February the stock brought $79, which, though the highest quotation of the year, was 51 points lower than the high mark in June, 1901, and in November the low price of $53 was recorded. Within 10 months

FLUCTUATIONS OF MINING STOCKS AT COLORADO SPRINGS, COLO., DURING 1902.—*Continued.*

Name of Company.	July.		August.		September.		October.		November.		December.		Sales. No. of Shares.
	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	
Acacia	·10	·06	·09	·05½	·11½	·09	·09¾	·07¼	·09½	·07⅝	·08½	·07	199,166
Alamo	·03⅝	·03	·03½	·02⅞	·04½	·03	·05	·03¾	·04½	·03	·04	·03¾	318,000
American Con	·02¾	·01⅞	·02	·01	·03½	·02	·03	·02¼	·03	·02	·02	·01	157,000
Anaconda	·20	·12	·20	·12½	·22½	·16	·21½	·14	·20	·15	·20	·16¾	100,800
Ben Hur	·04	·02½	·04	·01	·04½	·04	·04½	·03	·03¼	·02½	·02¾	·01½	184,500
Black Belle	·04	·01½	·03	·01	·09½	·05	·08	·04	·07½	·04	·07	·03	80,500
Blue Bell	·09	·05	·07½	·03	·10	·06	·09	·06	·07	·05	·04¾	·04	40,500
C. K. & N	·05⅞	·05	·06½	·05	·10¾	·07	·10	·08½	·10	·05	·12	·09	1,115,100
C. C. Con	·06½	·06	·06½	·05	·09½	·07	·07½	·06½	·07¼	·06	·06½	·05	805,500
Dante	·08½	·08	·08	·01½	·04¼	·03	·06⅝	·03	·03½	·03	·04	·02	207,000
Dr. Jack Pot	·14	·10	·10	·11½	·12¼	·10	·13¼	·13	·13½	·11	·11½	·08	1,089,790
Elkton	·59½	·55	·48	·33	·40	·35	·38⅝	·35	·36	·33	·36	·30	1,848,657
El Paso	·53	·51	·64	·60	·73	·63	·73	·69	·71	·66	·70	·60	1,028,584
Fanny Rawlings	·07	·05½	·05½	·04	·07	·04	·06	·05½	·05	·04	·09½	·03	85,325
Findley	·12	·09	·09	·01	·12	·08	·10	·08	·10	·07	·10	·08	346,000
Gold Dollar	·04½	·03	·04	·03	·05¼	·04½	·04⅝	·04	·05	·04⅝	·05	·04½	510,500
Golden Cycle	·62	·57	·70	·56	·70	·58	·75	·55	·63	·59	·62	·59	289,750
Golden Fleece	·18	·10	·18	·10	·25	·10	·25	·10	·25	·12	·12	·05	165,500
Gold Sovereign	·03½	·03	·03¾	·02	·06	·04¼	·04¼	·03	·03⅞	·02½	·05	·02½	222,500
Ironclad	·03½	·03	·03½	·03	·03½	·03	·03	·02½	·04	·02½	·04	·02½	31,000
Isabella	·29	·26½	·38	·25½	·37½	·32	·35½	·34	·35	·30⅝	·33	·30	1,620,750
Jack Pot	·12	·09⅞	·14	·10	·16	·10	·18	.12	·13	·11	·12	·08	420,900
Last Dollar	·75	·40	·80	·30	·77	·55	·75	·40	·65	·45	·65	.....	41,500
Lexington	·07⅝	·05	·05	·04	·06¾	·05	·07⅝	·05	·05½	·04	:06	·04½	419,900
Little Puck	·05⅞	·04	·05	·04	·06	·04	·05¾	·05	·05	·04	·04½	·03	205,900
Mollie Gibson	·14	·12	·12	·09	·06½	·06	·05½	·04	·08	·04½	·08	·04½	154,500
Moon-Anchor	·14	·10	·14	·12	·10½	·10	·10	·05	·10	·06	·06	·05	59,300
Morning Star	·02⅝	·02¼	·03	·02½	·04⅝	·04	·04⅜	·04	·07	·04½	·05	·04	229,500
National	·02	·01½	·02	·01	·02	·01½	·02	·01	·04	·01⅞	·01⅝	·01	135,100
Nellie V	·02	·01	·03	·02½	·04	·03	·02	·01¾	·02	·01	·02	·01	200,750
New Haven	·03½	·02¼	·03	·02½	·03½	·03	·03⅝	·02⅞	·03½	·01½	·02⅝	·02	132,200
Pappoose	·02	·01¾	·02	·01½	·03	·01	·02	·01⅝	·03	·01	·02	·01	24,600
Pharmacist	·04	·03	·03¾	·03	·06½	·05	·06	·04	·06	·05	·04⅞	·04	218,400
Pinnacle	·07¼	·05	·05½	·05	·07	·05	·07	·06	·06	·04	·06	·04	115,000
Pointer	·02	·01½	·02¾	·02	·03½	·03	·02¼	·02	·02½	·01¾	·02	·01½	241,400
Portland	1·90	1·76	1·90	1·75	2·00	1·95	2·06	1·80	2·00	1·85	1·92	1·80	186,411
Prince Albert	·02⅞	·02	·03	·01	·03	·02½	·03¼	·02⅞	·03½	·03	·03	·02	257,250
Republic	·03	·01	·03	·02	·04⅝	·01½	·04	·02½	·03	·01	·03½	·01½	184,000
Rose Maud	·02	·01	·03	·01⅝	·03⅞	·03	·04⅞	·03	·03¼	·02	·02½	·01	78,500
Sunset Eclipse	·03½	·02⅞	·03¼	·02½	·04½	·01⅞	·03⅝	·02	·03	·02	·02	·01	641,200
Uncle Sam	·02	·01	·02	·01	·02⅝	·02	·02½	·02	·02	·01	·03	·01	168,700
Vindicator	·95	·93	1·10	·90	1·05	·98	1·10	1·02	1·25	1·00	1·07	·98	86,000
Work	·07	·04⅝	·06½	·04⅞	·09½	·05⅞	·08¾	·07	·08	·06	·07	·05	196,500
Total sales	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18,749,888

the market showed a depreciation of over $40,000,000. Anaconda, which is under Amalgamated control, also reduced its dividend rate from 16 to 4% per annum, causing the shares to fall below par. The highest price for the year was $36·50 in February and the lowest price $20 in December, a shrinkage of over $19,000,000 in the market value of the shares. A prominent feature in the trade was the appearance early in May of the United Copper Co., representing a consolidation of the Heinze properties in Montana. The new company was incorporated with a capital of $80,000,000, of which $5,000,000 represented 6% preferred stock, and $75,000,000 common stock. Of the latter $30,000,000 were reserved in the treasury, and $45,000,000 were issued. The initial sales of United common shares were made at $36@$35·25, but the prices dropped subsequently to $27. A 3% dividend on the preferred shares was declared in November. Greene Consolidated brought $31·38 in May. but fell to $19·50 in July. On November 5 the company increased its capital stock from $6,000,000 to

FLUCTUATIONS OF MINING STOCKS AT NEW YORK DURING 1902.

Name and Location of Company	Par Value.	January.		February.		March.		April.		May.		June.	
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
Acacia, Colo	$1							·11		·11	·05	·11	
Adams, g., Colo	10	·28				·45							
Alamo, g., Colo	1	·15	·14	·14	·13			·05	·05	·05	·05		
Alice, g., Mont	25			·50	·48	·49	·48	·55				·56	·48
Amalgamated, c., Mont	100	$78·00	$67·63	$79·00	$62·50	70·50	61·00	$67·25	$63·50	$71·88	$65·00	$69·75	$62·25
Anaconda, c., Mont	25	35·50	29·25	36·50		33·50	28·00	120	110	119	111	117	·05
Anaconda, g., Colo	5	·26	·24	·30	·25	·22		·23	·20	·19	·18	·19	
Argentum-Jun., g.s.l., Colo	2	·15	·08	·08	·07	·05	·04	·05	·04	·05	·04		
Belcher, Nev	3	·14	·10	·07		·10	·08						
Best & Belcher, g.s., Nev	3	·15	·12	·31	·12	·29	·20	·28	·25	·30	·15	·20	·14
Breece, s., Colo	25	·75		·65								·70	
Brunswick, g., Cal	1	·15	·08	·11	·17	·10	·08	·21	·15	·15	·12	·10	·06
Catalpa, s.l., Colo	10	·14	·12					·10					
Chrysolite, s.l., Colo	50	·05	·04	·10	·05	·05	·04	·04		·06			
Comstock Tunnel, s.g., Nev	2	·07	·06	·06	·05	·06	·05	·06	·05	·07	·06	·06	·06
Comstock Tunnel Bonds	100	·07		·06	·06	·06	·06	·06	·05			·06	
Con. Cal. & Va., s.g., Nev	2½	1·80	1·15	1·55	1·20	1·40	1·15	1·70	1·25	1·65	1·30	1·50	1·25
Creede & Crip. Creek, g., Colo	1			·09	·08	·09	·09						
Crescent, s.l., Colo	10			·10		·10		·14					
Cripple Creek Con., g., Colo	1	·11	·07	·11	·09	·09	·08	·08	·08	·08	·07	·08	·07
Croesus, Colo	1					·10							
Crown Point, g.s., Nev	3	·12		·10		·09	·07	·13		·08			
Daly, g., Utah	20												
Deadwood-Terra, g., S. Dak	100			·65		·65		·75	·65				
Dunkin, s., Colo	1	·11	·10			·14	·13						
Elkton Con., g., Colo	1	1·33	1·12	1·30	1·20	1·28	1·13	1·00	·74	·72	·63	·68	·61
El Paso, Colo	1												
Gold Dollar, g., Colo	1	·09	·09										
Golden Fleece, g.s., Colo	1	·40		·45				·37	·30	·30	·27	·23	·21
Greene Con, c., Mex	10	26·75	25·00	29·25	21·13	25·00	19·50	23·50	19·75	31·88	23·25	29·13	27·00
Hale & Norcross, s.g., Nev	3	·34	·18			·33	·30	·25	·22	·24	·20	·42	·40
Hart, g.,Colo	1									·05			
Homestake, g., S. Dak	100			99·00									
Horn Silver, s.l., Utah	25	2·00	1·30	1·75	1·40	1·60		1·63	1·40	1·50	1·40	1·50	1·40
Iron Silver, s.l., Colo	20	·65	·61			·80	·78	·80				85	·80
Isabella, g., Colo	1	·38	·28	·30	·25	·28	·23	·28	·23	·37	·24	·32	·28
Jack Pot, g., Colo	1	·35	·34	·33	·30	·35	·33	·29	·27	·25		·16	·14
Justice, s., Nev	1			·15		·10	·07						
Kingston & Pembroke, l., Ont	10	·10		·12	·10	·12	·10					·13	
Lacrosse, g., Colo	10	·07											
Leadville Con., g.s., Colo	10	·06		·07	·06	·12	·06	·06					
Little Chief, s.l., Colo	1	·11	·10	·14	·11	·13	·12	·13	·12	·14	·13	·13	
Mexican, g.s., Nev	3	·45	·30	·50	·30	·54	·30	·60	·43	·65	·45	·53	·42
Mine Securities, U. S	100							8·00	7·00	7·50	6·50	7·25	6·50
Mollie Gibson, s., Colo	5	·18	·13	·16	·12	·13	·10	·12	·10	·11	·10	·18	·12
Moon-Anchor, g., Colo	5			·21		·22	·21			·18		·15	
Moulton, g., Mont	25	·27	·25			·20		·25					
Occidental, Nev	1												
Ontario, s.l., Utah	100	9·50	7·88	8·50	8·25	8·50	7·63	9·50	8·50	9·25	7·63	8·90	7·75
Ophir, g.s., Nev	3	·92	·80	1·25	·82	1·05	·95	1·60	·90	1.80	1·30	1·30	1.05
Pharmacist, g., Colo	1			·05		·05		·05				·05	
Phœnix Con., g., Ariz	1	·07	·06	·07	·06	·07		·08	·06	·06		·07	
Portland, g., Colo	10	2·75	2·50	2·50	2·45	2·65	2·25	3·25	1·85	3·85	1·75	1·90	1·70
Potosi, g.s., Nev	3	·18	·16					·23	·15	·38	·22	·35	·19
Quicksilver, q., Cal	100	4·13	3·75	3·75	3·12	4·25	2·85	3·50	2·85	4·00	3·13	3·75	3·25
Quicksilver, pref., Cal	100	10·50	9·75	10·00	8·50	11·18	9·75	11·00		10·25	10·00	10·38	9·88
Savage, s., Nev	2½	·09											
Sierra Nevada, s., Nev	3	·25	·19	·17	·14	·15				·30	·25		
Silver Hill, Nev	1			·66									
Small Hopes, s.l., Colo	20	·43	·40	·40	·30	·55	·45	·50	·45	·45	·40	·55	·50
Standard Con., g.s., Cal	10	3·85	3·40	3·55	2·50	3·65	3·45	3·60	3·25	3·50		3·45	3·25
Syndicate, g., Cal	10	·05											
Tennessee, Cop., Tenn	25	15·00	14·00	15·50	12·00	15·00	10·63	13·60	10·13	13·50	10·00	17·75	13·28
Union Con., s., Nev	2½			·21									
Union Copper, N. C	10	4·13	2·88	4·00	2·75	4·00	3·50	4·00	3·25	5·63	2·75	5·00	3·63
Union Gold, Colo	10												
Virginia Con., Colo	1												
White Knob, g.s., Ida	100	20·00	15·00	24·00	16·50	24·00	20·13	27·25	20·50	25·75	20·25	23·88	15·75
Work, g., Colo	1	·11	·09	·18	·06	·09	·07	·08	·08	·08	·07	·07	·07
Yellow Jacket, s., Nev	3					.20							
Total sales													

FLUCTUATIONS OF MINING STOCKS AT NEW YORK DURING 1902.—*Continued.*

Name and Location of Company.	July.		August.		Sept.		October.		November		December		Sales. No. of Shares.
	H.	L.	H.	L.	H.	L.	H.	L.	H	L	H	L.	
Acacia, Colo					·11		·08		·08	·07			8,500
Adams, g., Colo													278
Alamo, g., Colo	·04		·08	·08							04		29,000
Alice, g., Mont	·48	·35	·35	·33	·39	·25	·30		·35	·25	·25		7,990
Amalgamated, c., Mont	$68·75	$62·75	$68·63	$65·25	$71·50	64·25	67·25	62·00	65·50	53·00	59·63	54·00	6,844,924
Anaconda, c., Mont	108	*97	*106	*102	*111	*102	*105	*88	*97	*83	89·00	80·00	231,403
Anaconda, g., Colo	·15	·14	·15	·14	.20		·21	·16	·18		.20	·18	18,650
Argentum-Jun., g.s.l., Colo					·02		·02		·02		·02		32,200
Belcher, Nev									·14				2,800
Best & Belcher, g.s., Nev	·23	·15	·18	·08	·12	·10	·11		·70	·17	1·05	·50	21,950
Breece, s., Colo	·65	·60							·67	·60			570
Brunswick, g., Cal	·09	·06	·08	·06	*·30	·07	·09	·06	·06	·05			83,490
Catalpa, s.l., Colo													800
Crysolite, s.l., Colo	·07	·05	·06	·06	·08				·07	·04	·04		10,485
Comstock Tunnel, s.g., Nev	·06	·06	·06	·05	·06	·05	·05		·05		·05		173,500
Comstock Tunnel Bonds	·06	·06			·06	·05	·06	·05	·05		·05		71,500
Con. Cal. & Va., s.g., Nev	1·45	1·30	1·35	1·25	1·30	1·10	1·15	·88	1·15	·80	1·50	1·02	44,310
Creede & Crip. Creek, g., Colo.	·07	·05					·03		·03		·03		23,900
Crescent, s.l., Colo					·10		·08						1,400
Cripple Creek Con., g., Colo	·08	·07	·08	·07	·10	·08	·08	·07	·07	·06			65,500
Croesus, Colo													300
Crown Point, g.s., Nev	·09		·08		·07		·08						2,600
Daly, g., Utah	1 50				1·60								73
Deadwood-Terra. g., S. Dak													125
Dunkin, s., Colo	·08				·10				·09	·08	·07		5,200
Elkton Con., g., Colo	·57	·35	·45	·35	·52	·36	·40	·31	·36	·32	·30	·27	41.900
El Paso, Colo									·78				1,000
Gold Dollar, g., Colo					·06	·05	·06	·05	·06	·06			32,600
Golden Fleece, g.s., Colo	·20	·16	·18	·17	·28	·18	·18	·17	·20	·19	·10	·06	23,450
Greene Con., c., Mex	28·50	26·25	28·00	26·50	29·25	25·50	27·00	21·63	26·38	21·75	·26	·25	324,464
Hale & Norcross, s.g., Nev	·40	·31	·18	·17	·30	·24	·22	·12	·20		·30	·21	13,500
Hart, g., Colo													1,000
Homestake, g., S. Dak					78·00				67·00	65·00			280
Horn Silver, s.l., Utah	1·65		1·50										7,889
Iron Silver, s.l., Colo	·95	·81	·90	·81			·78		·85				9,330
Isabella, g., Colo	·29	·26	·33	·24	·41	·31	·34	·29	·32	·28	·30	·28	97,770
Jack Pot, g., Colo	·15				·15	·15	·29	·12	·12		·10		14,000
Justice, s., Nev	·08										·18	·12	2,200
Kingston & Pembroke, i., Ont.							·14				·16		3,850
Lacrosse, g., Colo							·05						600
Leadville Con., g.s., Colo							·03		·05		·03		8.050
Little Chief, s.l., Colo,	·13	·12	·15	·12	·34		·31	·12					13,400
Mexican, g.s., Nev	·60	·45	·51	·20	·35		·23	·18	·87	·60	·72	·53	7,500
Mine Securities, U. S	7·25	6·50	7·25	6·50	7·25	6·50							21,150
Mollie Gibson, s., Colo	·14	·10	·06		·08	·07	·09	·07	·10	·07	·08	·07	68,280
Moon-Anchor, g., Colo.			·10						·10	·08			11,000
Moulton, g.. Mont					·30								100
Occidental, Nev									·15				300
Ontario, s.l., Utah	8·75	8 25	9·00	8·75	9·00	6·50	9·00	8·50	8·00	7·50	6·22	5·50	12,004
Ophir, g.s., Nev	1·40	1·20	1·35	1·20	1·25	·95	·95	·85	1·20	·94	1·35	1·00	26,580
Pharmacist, g., Colo					·05		·05	·05	·06	·05	·06	·04	28,600
Phœnix Con., g., Ariz	·08	·07			·08	·04	·08		·08	·07	·07		10,600
Portland, g., Colo	1·75	1·60	1·85	1·70	1·97	1·25	2·00	1·75	2·00	1·95	1·90	1·75	18,060
Potosi, g.s., Nev	·25	·18	·21	·18	·24	·19	·10	·07	·21	·18	·26	·20	27,900
Quicksilver, q., Cal	3·75	3·60	2·75		3·25	3·00	3·50	2·00	2·25		2·25		8,535
Quicksilver, pref., Cal	9·75	9·50			9·00	8·50	8·00						8,175
Savage, s., Nev					·12		·12				·20	·13	1,800
Sierra Nevada, s., Nev	·24				·12	·10	·08		·20	·17	·46	·30	8,450
Silver Hill, Nev													300
Small Hopes, s.l., Colo	·55	·50	·43	·40	·36	·35	·45	·40					8,860
Standard Con., g.s., Cal	4·00	3·15	3·75		3·65	3·25	3·50	3·40	3·50				8,480
Syndicate, g., Cal					·04		·06	·04	·07				5,000
Tennessee, c.. Tenn	19·13	15·00	18·75	16·25	19·00	16·00	19·38	16·25	18·25	15·50	18·38	16·25	291,221
Union Con., s., Nev			·20				·13	·14			·55	·30	1,400
Union, c., N. C	4·00	3·50	4·00	2·50	3·50	2·88	3·13	2·75	3 38	2·63	3·13	2·25	109,268
Union, g., Colo									·30				800
Virginia Con., Colo					·04		·04	·02	·02				8,000
White Knob, g.s., Idaho	21·00	18·00	24·00	18·75	22·00	16·50	17·50	10·00	14·00	11·50	14·00	9·50	57,345
Work, g., Colo	·06	·05	·06	·05	·08								48,490
Yellow Jacket, s., Nev	·15		·15								·27		1,200
Total sales													8,575,029

* Per cent. † Assessment.

$7,200,000, the additional $1,200,000 being issued to pay its indebtedness. After the increase in capital the new shares sold at $24@$22·87. Tennessee Copper, which is closely held, was one of the few stocks that advanced near the close of the year. It rose from $10·12 in April, to $13·37 in October, and in December large sales were made around $18. These prices, however, are lower than in 1901. British Columbia was erratic, due to inside manipulation. In January the price opened at $10, dropping to $8·50 in February, and recovering to $10·50 in March, the highest price for the year. The stock closed at $5·50.

The gold and silver mining shares were generally unsteady, owing to the fluctuations in other stocks, and they responded more or less to bearish influences. A new concern—The Bamberger-De Lamar Gold Mines Co.—made its appearance in August. The company, which is capitalized at $5,000,000, is a consolidation of the properties owned by Capt. De Lamar in Lincoln County, Nev. The subscription price was $10 for 150,000 shares, but sales were made at $11@$9·50. Ontario Silver, of Utah, paying dividends of 30c. per share, fell to

PRICES OF INDUSTRIAL AND COAL STOCKS AT NEW YORK AND PHILADELPHIA DURING 1902.

Name of Company.	Par Value.	January.		February.		March.		April.		May.		June.	
	$	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
Allis-Chalmers	100	......	......	......	......	......	......	......	......	......	......	......	......
Allis-Chalmers, pf	100	......	......	......	......	......	......	......	......	......	......	......	......
Amer. Agri. Chem	100	$39·00	$30·00	$36·00	$21·00	$24·50	$21·00	$30·50	$22·00	$29·50	$25·00	$29·00	$25·00
Am. Ag. Chem., pref	100	89·00	82·50	89·00	81·00	99·00	82·50	87·50	82·00	91·00	82·00	91·25	85·00
American Cement	10	6·38	5·50	6·00	5·63	5·75	5·50	7·38	5·75	7·25	7·00	7·75	7·13
Amer. Sm. & Ref	100	49·13	44·75	48·25	45·75	47·50	46·00	48·25	43·50	49·63	43·50	49·25	47·00
Am. Sm. & Ref,. pref	100	98·00	96·00	99·00	97·13	99·50	96·13	98·00	95·00	98·00	95·00	100·13	85·00
Cambria Iron	50	48·25	47·75	48·00	37·88	48·80	46·88	48·00	46·88	48·00	47·50	47·75	47·50
Cambria Steel	50	28·00	23·75	24·13	23·75	24·00	23·13	28·00	23·75	24·88	23·00	24·63	23·13
Colo. Fuel & Iron	100	88·25	84·00	88·00	84·25	109·00	86·50	110·50	95·50	108·88	95·75	100·50	85·00
Colo. H. C. & Iron	100	17·13	14·38	18·50	15·50	22·25	16·50	23·75	19·88	20·25	17·75	17·50	16·00
Curcible Steel	100	......	......	......	......	......	......	......	......	......	......	22·38	21·50
Crucible Steel pref	100	86⅝	......	......	......	......	......	......	......	......	......	87·75	85·38
International Pump	100	52·00	46·75	53·25	50·50	57·25	50·00	55·88	52·50	56·00	53·00	55·00	51·00
International Pump, pref	100	90·00	85·00	91·00	85·00	94·00	89·50	94·00	88·00	94·00	87·00	94·00	85·00
Monongahela R. Con. C. & C.	100	13·75	12·88	14·50	13·25	13·88	13·00	13·50	13·00	13·00	12·88	12·88	12·38
Mong. R. Coal, pref	100	44·00	43·25	44·00	42·50	44·00	42·00	43·63	43·00	42·88	41·00	42·50	41·50
National Lead	100	19·63	15·38	19·00	17·13	20·88	16·88	20·86	17·88	23·50	18·13	23·00	21·00
National Lead, pref	100	86·00	78·00	87·00	80 00	86·25	81·00	89·88	85·00	91·00	87·00	89·00	88·25
Pennsylvania Steel, pref	100	......	......	......	......	......	......	......	......	......	......	......	......
Philadelphia Natural Gas	100	......	......	......	......	......	......	......	......	......	......	......	......
Phila. Natural Gas, pref	100	......	......	......	......	......	......	......	......	......	......	......	......
Pittsburg Coal	100	28·00	25·00	26·00	25·13	25·25	25·00	25·63	24·50	25·00	23·25	27·25	24·00
Pittsburg Coal, pref	100	92·75	90·00	91·00	90·00	92·50	90·00	92·00	89·00	90·00	85·63	90·50	88·88
Republic I. & Steel	100	17·50	15·63	17·25	16·13	18·50	16·13	20·00	17·00	19·50	16·63	18·25	17·00
Republic I. & Steel, pref	100	70·00	68·00	70·50	69·00	75·25	71·38	76·00	72·50	75·25	72·25	75·63	72·75
Sloss-Sheffield St. & Iron	100	31·00	29·00	33·00	29·50	35·00	32·00	34·00	32·00	33·00	29·00	34·00	30·00
Sloss-Sheffield St. & Iron, pref.	100	83·00	80·00	83·50	81·00	84·50	82·00	83·50	79·00	82·50	78·00	88·00	80·00
Standard Oil	100	700·00	630·00	665·00	635·00	650·00	630·00	650·00	612·00	645·00	625·00	657·00	620·00
Susq. Iron & Steel	10	2·00	1·63	2·00	1·43	2·25	2·00	2·25	2·00	2·25	2·06	3·00	2·25
Tenn. Coal, I. & R.R.	100	67·25	61·50	71·25	68·00	72·63	67·50	74·63	67·25	71·25	61·50	65·00	61·50
United Gas Improvement	50	126·00	115·00	122·00	116·00	123·00	120·00	123·00	120·00	122·00	*101·50	108·50	108·00
U. S. Cast Iron Pipe	100	......	......	......	......	......	......	......	......	......	......	......	......
U. S. C. I. P., pref	100	......	......	......	......	......	......	......	......	......	......	......	......
U. S. Red & Ref	100	......	......	42·00	38·50	44·50	40·00	44·00	39·50	43·50	39·00	41·00	30·00
U. S. Red & Ref., pref	100	......	......	66·50	63·75	67·38	64·50	65·75	63·00	65·25	63·00	66·00	51·50
U. S. Steel Corporation	100	46·75	41·63	44·75	43·00	43·50	41·75	43·88	40·88	42·13	38·25	40·25	36·75
U. S. Steel, pref	100	97·75	92·38	95·50	93·00	95·75	93·38	94·75	92·50	92·88	88·75	90·38	87·50
Virginia-Car. Chem.	100	68·00	59·00	63·00	60·00	69·88	62·25	76·38	68·63	75·25	70·00	70·88	69·50
Virginia-Car. Chem., pref.	100	123·50	120·00	128·00	120·00	133·00	121·00	132·63	130·00	134·00	131·25	132·50	131·00
Westinghouse E. & M.	50	177·50	173·50	179·50	173·50	......	......	......	......	......	......	212·00	209·00
Westinghouse E. & M , pref.	50	187·00	180·00	180·00	175·00	......	......	......	......	......	......	......	......
Total sales	...	......	......	......	......	......	......	......	......	......	......	......	......

$5·50, the lowest price in years. Horn Silver fluctuated from $2 to $1·30, selling generally around $1·50. Homestake, of South Dakota, suffered a decline from $99 in February, to $65 in November, owing to the reduction of the dividend rate to 3% per annum. On May 15, the capital stock was increased $1,000,000 to $22,000,000 to pay for improvements and new property. This company absorbed the Deadwood-Terra mines with a capitalization of $5,000,000. The Cripple Creek stocks were influenced unfavorably by difficulties with water, and in some cases by depleted ore reserves. Portland passed two quarterly dividends and reduced the rate in October by one-half; its shares fell from $3·85 to $1·25. The dividend of 9c. per share in 1902 is the smallest in six years. Elkton Consolidated fell from $1·33 in January, to 31c. in October, discontinuing its dividends in April. Breece, of Leadville, receded from 75c. to 30c., and Mollie Gibson fell from 18c. to 6c. The latter closed down in August, owing to the exhaustion of ore reserves.

PRICES OF INDUSTRIAL AND COAL STOCKS AT NEW YORK AND PHILADELPHIA DURING 1902.—*Continued.*

Name of Company.	July.		August.		September.		October.		November.		December.		Sales. No. of Shares.
	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	
Allis-Chalmers	......	......	......	......	......	......	......	......	$21·00	......	$19 00	$17·00	2,137
Allis-Chalmers, pref.	......	......	......	......	......	......	......	......	·83	$82·00	81·88	80·63	1,383
American Agri. Chem.	$31·00	$25·00	$30·50	$25·00	$31·00	$22·50	$25·50	$20·00	25·50	20·00	25·50	18·00	16,086
Am. Ag. Chem., pref.	91·00	86·50	90·25	88·00	90·00	83·50	90·00	78·00	90·00	78·00	90·00	76·00	3,468
American Cement	7·75	7·00	7·75	7·00	7·75	7·38	7·75	7·50	9·13	8·25	8·88	8·25	58,496
Amer. Sm. & Ref.	47·50	46·00	48·75	46·00	48·38	44·00	48·63	43·00	46·00	36·88	40·75	37·00	656.982
Am. Sm. & Ref., pref.	98·00	91·50	98·00	97·00	97·63	94·75	96·50	94·00	95·50	87·50	92·00	90·00	145,235
Cambria Iron	48·00	47·50	49·50	49·00	49·00	48·00	49·00	48·00	47·88	46·88	47·00	46·50	8,115
Cambria Steel	27·63	24·50	28·25	26·25	29·13	27·50	29·00	27·00	28·50	26·38	27·13	23·00	382,240
Colo. Fuel & Iron	102·25	88·25	93·00	73·75	83·75	76·50	92·50	81·00	90·50	77·00	89·00	75·00	3,221,870
Colo. H. C. & Iron	18·00	16·00	22·00	17·50	24·75	19·00	24·88	21·00	22·00	18·50	22·00	16·38	185,033
Crucible Steel	21·63	21·00	22·63	21·25	24·00	22·00	22·38	20·63	21·38	18·13	19·50	16·00	96,232
Crucible Steel, pref.	86·75	85·50	87·00	85·88	88·88	85·00	86·25	85·00	86·00	81·13	85·00	82·50	60,920
International Pump	54·50	52·00	55·00	51·00	54·00	48·00	54·00	49·00	51·00	47·00	50·00	40·00	45.898
Internat'l Pump, pref.	93·00	90·00	93·00	90·00	95·00	91·50	95·00	87·00	93·00	85·00	90·00	82·90	11,035
Mononga. R. C. C. & C.	12·63	12·38	12·63	12·00	13·00	12·13	12·50	11·00	11·50	9·25	10·50	9·50	109,458
Mong. R. Coal, pref.	40·63	39·50	40·88	39·50	47·50	40·25	40·63	39·00	40·75	39·00	40·50	39·13	49,531
National Lead	22·25	21·00	26·00	21·25	31·00	23·25	30·50	26·50	29·00	24·13	28·00	24·00	415,217
National Lead, pref.	89·00	87·75	95·00	90·00	94·25	90·63	96·00	92·00	94·00	90·00	92·00	91·00	33,175
Pennsylvania Steel, pf.	100·00	92·00	103·00	96·00	103·00	100·00	102·00	100·00	101·00	99·00	99·00	95·00	20,449
Phila. Natural Gas	49·25	48·50	50·13	48·75	50·00	48·00	49·63	47·00	48·00	46·25	49·25	43·63	15,510
Phila. Natural Gas, pf.	50·00	48·88	50·50	40·88	50·00	49·50	49·75	48·00	50·00	49·00	49·50	43·63	3,715
Pittsburg Coal	28·63	25·25	30·00	26·50	32·00	28·13	31·00	29·00	30·75	27·50	30·38	28·13	180,509
Pittsburg Coal, pref.	92·00	89·88	91·00	90·00	92·00	91·38	88·50	76·25	88·88	87·00	88·50	87·00	80,617
Republic I. & Steel	19·25	17·00	21·50	18·50	24·75	19·88	23·50	19·63	22·00	18·00	21·00	17·00	703,860
Republic I. & Steel, pf.	77·00	72·75	78·88	75·75	83·38	77·25	38·50	76·25	79·00	74·00	78·00	74·25	256,616
Sloss-Sheffield St. & I.	39·00	32·50	65·00	38·50	83·00	65·00	78·00	50·00	67·00	60·00	61·00	54·50	124,485
Sloss-Sheffield S.&I., pf.	83·00	81·00	91·50	82·25	96·00	91·50	93·00	88·00	94·00	88·00	94·50	87.00	15,755
Standard Oil	695·00	653·00	688·00	655·00	690·00	657·00	685·00	645·00	683·00	660·00	676·00	665·00	144,228
Susq. Iron & Steel	3·00	2·00	2·75	2·63	2·75	......	2·75	2·63	2·75	2·50	2·75	2·25	56,180
Tenn. Coal, I. & R.R.	69·50	62·00	71·38	67·00	71·88	63·50	69·25	60·13	66·00	54·38	58·13	49·50	1,355,975
United Gas Improvem't	109·88	107·00	114·88	108·63	115·00	111·00	114·50	111·50	114·38	110·00	111·50	105·00	170,782
U. S. Cast Iron Pipe	12·25	11·00	12·50	11·50	16·88	12·50	17·00	15·50	15·75	12·50	14·00	11·13	97,045
U. S. Cast Iron Pipe, pf.	47·00	43·38	46·75	30·00	59·00	46·00	58·00	53·00	56·00	45·00	54·00	45·00	49,306
U. S. Red & Ref.	39·00	35·50	45·75	30·00	37·50	30·00	36·00	32·00	25·00	......	26·00	......	40,213
U. S. Red & Ref., pref.	63·00	60·50	61·00	50·00	60·00	56·00	57·00	54·00	......	......	......	......	41,727
U. S. Steel Corporat'n.	41·00	37·13	41·63	39·38	42·63	38·75	41·63	38·63	40·25	35·38	37·13	30·00	5,378,233
U. S. Steel, pref.	92·13	88·75	90·75	89·25	92·00	87·50	91·63	87·13	88·25	82·63	84·50	79·00	3,530,643
Va. Car. Chem.	70·88	67·75	69·25	66·13	72·75	66·50	68·75	64·50	67·25	60·50	63·00	64·00	418,822
Va. Car. Chem., pref.	133·00	129·00	130·00	128·00	134·88	129·00	130·50	125·00	128·00	123 00	123·00	120·00	31,674
Westinghouse E. & M.	210·00	206·00	230·00	211·00	232·00	215·00	220·00	209·00	212·00	190·00	206·00	178·00	22,657
West. E. & M., pref.	218·00	213·00	230·00	216·00	230·25	222·00	220·00	215·00	208·00	200·50	208·00	200·00	2,850
Total sales	......	......	......	......	......	......	......	......	......	......	......	......	18,243,354

REVIEW OF ENGLISH MINING COMPANIES AT LONDON (*a*) DURING 1902.

Name of Company.	Location.	Authorized Capital.	Par Value.	Total Divid'nds Paid During 1902.	Fluctuations of Quotations, 1902.	
					Highest.	Lowest.
		£	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Alaska-Treadwell, g.	Alaska	1,000,000	5 0 0	6 0	5 2 6	3 17 6
Camp Bird, g.	Colorado	1,100,000	1 0 0	1 3	1 8 9	15 0
El Oro, g.	Mexico	1,150,000	1 0 0	4 6	1 18 9	1 2 6
Le Roi, g.	British Col.	1,000,000	5 0 0	....	4 7 6	18 9
Le Roi No. 2, g. s. c.	British Col.	600,000	5 0 0	5 0	5 17 6	11 3
Montana, g. s.	Montana	660,000	1 0 0	....	5 3	2 3
Mountain Copper, 6% Deb., c.	California	1,000,000	4 0 0	4 0	5 5 0	4 12 6
Stratton's Independence, g.	Colorado	1,100,000	1 0 0	6 0	15 0	4 0
Copiapo, c.	Chile	250,000	2 0 0	....	2 12 6	17 6
Frontino & Bolivia, g.	Colombia	140,000	1 0 0	....	1 11 3	11 3
Ouro Preto of Brazil, g.	Brazil	140,000	1 0 0	6	7 9	3 6
Rossland Kootenay, g. s. c.	British Col.	150,000	1 0 0	....	8 9	5 0
Snowshoe, g. c.	British Col.	250.000	1 0 0	....	1 0 0	17 6
Tomboy, g.	Colorado	300,000	1 0 0	1 0	2 9 6	1 9 6
St. John del Rey, g.	Brazil	600,000	1 0 0	1 0	1 0 0	14 6
Ymir, g.	British Col.	200,000	1 0 0	1 0	2 6 3	2 6
Linares, l.	Spain	45,000	3 0 0	9 0	5 7 6	2 0 0
Mason & Barry, c.sul.	Portugal	210,000	1 0 0	13 0	4 5 0	3 2 6
Rio Tinto, c.	Spain	1,625,000	5 0 0	3 0	47 7 6	38 7 6
Rio Tinto, Pref., c.	Spain	1,625.000	5 0 0	5 0	6 5 0	6 0 0
Tharsis, c.	Spain	1,250,000	2 0 0	8 0	7 12 6	3 12 6
Broken Hill Prop., s.	N. S. Wales	384,000	8 0	2 0	1 17 6	1 1 6
Golden Horseshoe, g.	W. Australia	1,500,000	5 0 0	18 0	11 15 0	7 0 0
Great Boulder Perseverance (old) g.	W. Australia	175,000	1 0 0	2 0 0	18 11 3	8 8 9
Great Boulder Prop.	W. Australia	175,000	2 0	2 6	1 1 6	17 9
Great Fingall, g.	W. Australia	125,000	10 0	11 6	9 3 9	5 8 9
Ivanhoe Gold Corp., g.	W. Australia	1,000,000	5 0 0	18 0	8 5 0	6 15 0
Kalgurlie, g.	W. Australia	120,000	1 0 0	2 6	4 5 0	2 16 3
Lake View Consols, g.	W. Australia	850,000	1 0 0	....	6 15 0	1 18 9
Mt. Lyell M. & R., l.c.	Tasmania	900,000	3 0 0	7 6	4 10 0	2 0 0
Mt. Morgan, g.	Queensland	1,000.000	1 0 0	3 3	4 12 6	3 10 0
Oroya Brownhill, g.	W. Australia	450,000	1 0 0	2 0	2 10 0	2 1 3
Waihi, g.	New Zealand	500,000	1 0 0	10 0	6 2 6	4 18 9
Champion Reef, g.	Colar Fields	236.500	10 0	10 0	7 0 0	5 7 6
Mysore, g.	Colar Fields	290,000	10 0	13 0	7 12 6	5 16 3
Nundydroog, g.	Colar Fields	242,000	10 0	3 9	2 6 3	1 12 6
Ooregum, g.	Colar Fields	171,500	10 0	3 9	2 17 6	1 10 0
Ooregum, Pref., g.	Colar Fields	120,000	10 0	4 9	3 0 0	1 17 6
British S. Af. Chartered	South Africa	5,000.000	1 0 0	....	4 10 0	2 16 3
Cape Copper, c.	South Africa	300,000	2 0 0	8 0	5 0 0	2 0 0
Cape Copper, Pref., c.	South Africa	150,000	2 0 0	10 3	4 15 0	2 18 9
City & Suburban, g.	Transvaal	1,360,000	4 0 0	....	7 15 0	5 17 6
Crown Reef, g.	Transvaal	120,000	1 0 0	1 5 0	18 10 0	16 5 0
De Beers, Def., d.	Cape Colony	2,500,000	2 10 0	12 6	26 2 6	21 0 0
Ferreira, g.	Transvaal	90,000	1 0 0	....	26 0 0	22 0 0
Geldenhuis Est., g.	Transvaal	200,000	1 0 0	5 0	7 15 0	6 2 6
Henry Nourse, g.	Transvaal	125,000	1 0 0	....	10 5 0	8 7 6
Jagersfontein, d.	OrangeRiv.Col.	1,000,000	5 0 0	....	30 0 0	24 0 0
Johannesburg Con. Invest.	South Africa	2,750,000	1 0 0	....	4 3 9	2 12 6
Jubilee, g.	Transvaal	50,000	1 0 0	....	7 10 0	4 15 0
Langlaagte Est., g.	Transvaal	470,000	1 0 0	....	5 1 3	3 7 6
May Con., g.	Transvaal	290,000	1 0 0	6 0	5 8 9	4 5 0
Meyer & Charlton, g.	Transvaal	100,000	1 0 0	6 0	6 10 0	5 7 6
Namaqua, c.	Cape Colony	200,000	2 0 0	2 0	4 7 6	2 2 6
Primrose (new), g.	Transvaal	325,000	1 0 0	....	5 8 9	3 10 0
Rand Mines, g.	Transvaal	490,000	5 0	4 0	13 3 9	10 5 0
Robinson, g.	Transvaal	2,750,000	5 0 0	12 6	12 0 0	10 5 0
Sheba, g.	Transvaal	1,250,000	1 0 0	....	13 9	1 2 6
Simmer & Jack Prop., g.	Transvaal	3,000,000	1 0 0	....	2 12 6	1 18 9
Wolhuter, g.	Transvaal	860,000	4 0 0	....	6 10 0	4 2 6

(*a*) Specially prepared for THE MINERAL INDUSTRY by Fred. C. Mathieson & Sons, London. *c.*, copper; *d.*, diamonds; *g.*, gold; *l.*, lead; *s.*, silver.

Prices of the Comstock stocks were forced down by the continued assessment policy. Consolidated California and Virginia paid a dividend in 1901, but it was compelled to levy another assessment in 1902, and the shares fell from $1·80 in January, to 80c. in November, recovering to $1·35 in December. Ophir, Best & Belcher, and Mexican also levied assessments.

The United States Reduction & Refining Co., the mill combination of Cripple Creek, was listed on the New York Stock Exchange. The 6% preferred stock, of which there is $4,000,000, opened at $63·75@$64·62, and the common with an authorized issue of $6,000,000, was quoted at $38·50@$40. The first quarterly dividend of 1·5% on the preferred was paid on January 1, and 1% on the common on April 1. At the close of the year the common shares were quoted at $32·50 and the preferred at $50.

The American Smelting & Refining Co., known as the "Smelter Trust," paying 7% on its preferred stock, but nothing on the common, reached the high point in June, when the preferred was quoted at $100. The common stock brought $49·62 in May and sold down to $36·87 in November.

The St. Joseph and Doe Run companies of Missouri increased their capital in December to pay for the enlargement of their plants. The capital of the former company has been doubled to $6,000,000, of which $2,250,000 remains in the treasury, while Doe Run has added $500,000 to its former capital of $1,000,000. St. Joe has returned an aggregate of $3,309,500 in dividends, considerably more than its original capital.

London Stock Market during 1902.

The market for South Africans was dull throughout most of the year. In the early months shares were bought quite freely in anticipation of a possible rise when peace was established, but the reaction did not materialize. It is now generally conceded that a long time must elapse before the country and the mining industry can recuperate from the effects of the war and that there is practically no chance of any rise in prices or shares within the immediate future. This view is justified by the reports that have been received regarding the difficulty of securing natives to work in the mines, the high cost of living owing to the land having been denuded, and also by the uncertainty as to the burden of taxation to be borne by the mines. The death of Cecil Rhodes was not a disturbing factor in the market, as it was not altogether unexpected, but it served to revive a rumor of the absorption of the Chartered Company by the Imperial Government. This is a matter that cannot be undertaken, however, in the near future, as the re-settlement of the Transvaal and the Orange River colonies fully occupies the attention of the home authorities. In contrast to the dulness of the Rand Mines, the Rhodesia market was very little affected by the war. Several new companies have been organized to work gold mines in Rhodesia, and to interest the public in the shares of other properties. During the year a large amount of money was spent in the equipment of new gold properties and in developing and prospecting for copper propositions. It is to be noted that no high-grade gold mine has yet been opened in Rhodesia, the veins so far developed being comparatively low-grade and requiring large capital to operate.

The Indian mines received a great deal of attention, and the shares of the established concerns were very strong. One of the most important events of the year has been the inauguration of the Cauvery Falls electrical and installation works. The power is supplied to the Kolar fields from the Falls, a distance of 92 miles. The saving in cost under the new system must be considerable, as fuel is expensive and labor poor. During the year, the lease of the mines from the

Mysore Government was renewed for a further period of 30 years, dating from 1910.

The Western Australian market was generally free from any disturbing elements such as have characterized previous years. Lake View Consols and other mines have passed out of the hands of the Whittaker-Wright group, and the management has been given over to the firm of Bewick, Moreing & Co. In a report by this company, additional capital for working the Lake View Consols mine was recommended, and it is now expected that the mine will again become a dividend payer, although on a considerably less scale than formerly. The Great Fingall mine in the Murchison district was prominent during the year both as producer and in the speculative markets.

The Le Roi mine has furnished many disappointments, and many contradictory reports have been issued at various times during the year as to estimated and realized profits. Shareholders agree that the dividing line between profit and loss depends on several things; any one of which may effect the position seriously. Very little interest is now manifested in the shares, and the same may be said of Le Roi No. 2. The prospect of the two mines is not very promising, although under the new management better results may be obtained in the future. The other British Columbia mines operated from London have proved a disappointment. The Ymir has been compelled to raise additional capital for a new plant and further development. The Velvet has also been reconstructed, while the Hall mine is unable to make a profit.

Of the mines in the United States, Stratton's Independence commanded the largest share of public attention. Shareholders have been dissatisfied with the management of the company, and the contradictory reports of the various experts have formed the subject of acrimonious discussions. The somewhat uncertain tone of Mr. Hammond's reports have made it impossible for shareholders to judge the actual position. The unsatisfactory administration of this mine has deterred capitalists from becoming interested in the Camp Bird mines, although no very great efforts have been made by the underwriters of this company to dispose of their shares.

The Etruscan Copper Estates, a company formed two years ago to acquire gold mines in Italy, received much notice. The properties owned by the company were examined by competent engineers, who found that the veins were poor, although of considerable extent, and that the ore could not be treated satisfactorily owing to the amount of zinc present. In spite of the verdict of these experts, however, the directors and shareholders have decided to work the mines. Another new company is the Dunderland Iron Ore Co., which was publicly floated during the year with a large capital to acquire and work a low-grade iron ore deposit in Norway. It is planned to use the Edison magnetic process for concentrating the ore. The company received general support, as the mine will afford a new supply of iron ore for English furnaces. There is still some doubt, however, as to the cost of concentrating and briquetting and as to the quality of the material from a metallurgical standpoint.

The Nickel Corporation working properties in New Caledonia was taken over last year by people connected with the London metal trade, and arrangements have been made to place it under the control of the International Nickel Corporation. The last-named company is to take up the shares of the concern in exchange for its stock. A company known as the Spanish Tin Mining Co. has been floated to acquire mining deposits in Orense, Spain. Extravagant claims have been put forward regarding the richness of the properties, and the prospectuses have been adversely criticized. The Sapphire Corundum Co. was formed during the year to acquire corundum deposits in Canada. Unfortunately, the company was floated with a very large capital stock, and financial difficulties have been encountered. It is planned to reduce the capital and to work the properties on more business-like lines.

Strenuous efforts have been made by the shareholders of the Siberian Goldfields Co. toward the reconstruction of that concern, and its title has been changed to the Nerchinsk Gold Co. This reconstruction was made necessary by the fact that the Russian Government would not grant the concessions to the former directors. Mine experts who have examined the properties have reported rather unfavorably.

The Smelting Co. of Australia has been reconstructed under the title of the Smelting & Refining Co. of Australia; the former company became insolvent through bad business methods, but it has now been placed on a sounder footing.

Among the English properties the Cornish mines suffered severely from the decline in the tin market, and the Dolcoath was obliged to devote its year's profits to further expenditures on capital account. The St. David's mine is the only gold producer now operating in Wales. Considerable attention was given to the Elmore oil concentration process; several plants have been erected in Norway to treat copper ores, and the process is being worked on a practical scale in North Wales. A company has also been formed to work this process in Canada.

DIVIDENDS PAID BY AMERICAN MINES AND INDUSTRIAL COMPANIES, $1=$1,000; TOTAL, FULL AMOUNT.

Name of Company.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Total Paid.
Aberdeen, c., N. M.								$32		$32,17
Acacia, g., Colo.							$43			43,170
Adams, s.l., Colo.		$6					8	15	$23	738.500
Ætna Con., q., Cal.	$30	20	$40	$40	$40	$60	15			225,000
Ala. Con. Coal & I., pf., Ala.						44	175	175	185	568,750
Alamo, g, Utah						3				2,500
Alaska Goldfields, Alaska						125		135		260,000
Alaska-Mexican, g., Alaska	120	90	80	90	72	72	72			465,381
Alaska-Tread. g., Alaska	375	400	350	300	300	300	300	300	300	5,120,000
Alliance, g., Colo.						32				31.500
Allis-Chalmers, pf.								569	1,128	1.706,250
Alpha Oil, Cal.								1		1,250
Altoona Coal & Coke, Pa.								75		75,000
Amalgamated, c., Mont.						1,500	6,000	8,304	3,847	19,656,667
Amanda, g., Colo.							10			10,000
Amazon, g., Colo.							102			121,882
American, g.s.l., Colo.				36	54	60				446,000
American Agric. Chem., pref.						510	1,020	1,025	1,028	3,582,600
American Cement, Pa.						60	80	160	160	380,000
American Coal, Md.	98	105	120	120	135	150	255	150	150	1,282,500
American Fuel Oil, Cal.						3	12	1		16,000
Am. Iron & Steel, com.							34	19	10	256,100
Am. Iron & Steel, pref.						50	150	150	150	450,000
Am. Sm. & Ref., pref.						1,137	1,545	2,709	3,500	8,891,553
American Steel & Wire, com.							2,625	1,500		4,125,000
American Steel & Wire, pref.						2,800	2,800	1,400		7,000,000
American Steel Hoop, pref.						245	980	490		1,715,000
American Sheet Steel, pf.								858		857,500

DIVIDENDS PAID BY AMERICAN MINES AND INDUSTRIAL COMPANIES.—*Continued.*

Name of Company.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Total Paid.
Am. Zinc-Lead Sm., Mo.						$120	$60			$180,000
Amistad y Concordia, Mex.								$17	$63	79,080
Anaconda, c., Mont.					$3,000	3,900	4,800	3,900	1,200	22,050,000
Anchoria-Leland, g., Colo.			$30	$72	72	36				198,000
Anderson, g., Colo.							15			15,000
Anglo-Mexican, g., Mexico		$361	271	90	180	180				1,825,048
Annie Laurie, g.s., Utah									60	60,000
Apollo Con., g., Alaska				100		40	70			110,000
April Fool, g., Nev						16				16,000
Argentum-Juniata, s., Colo.		156				42				198,000
Argonaut, g., Cal.					180	240	70			490,000
Arizona, c.s., Ariz.					405	722	576	866	1,115	3,445,468
Arizona Western Oil, Cal							6			6,000
Arrow, g., Colo								50		50,000
Associated, g., Colo					50	12				12,000
Atlantic, c., Mich				40	40		80	80		940,000
Aztec Oil, Cal								12	16	16,450
Bald Butte, g., Mont	$172	127	88	88	98	150	38	180	160	1,297,148
Bankers, g., Colo								188		187,500
Bartolome de Medina, Mex									20	63,488
Bethlehem Steel, Pa						300	600	425		1,325,000
Big Four, g., Colo							15			15,000
Blue Bird Extension, Utah								1		834
Bonanza Dev., g., N. Mex						1,050				1,050,000
Boston, q., Cal						20				20,000
Boston & Colo. Sm., Colo						56	34	45	45	402,350
Boston-Aurora, z., Mo., pref						29	37			66,160
Boston-California, g., Cal						72				72,000
Boston-Duenweg, z., Mo						32	24			56,000
Boston Get There, z., Mo						11	9			20,250
Boston Gold-Cop. Sm., Colo							50	100		150,000
Boston-Little Circle, z., Mo						75	13	25		112,500
Boston & Montana, c.s., Mont	275	1,050	1,500	1,800	1,950	5,375	6,450	5,250	900	27,125,000
Boston-Phila., z.l., Kas							2			2,000
Boston-Providence, z., Mo						11	6			17,242
Boston-S. Dak., g., S. Dak							10			10,000
Boston-Springfield, z., Mo							15			15,000
Boston-Sunflower, z. Mo						5				4,500
Bosun, s.l., B. C.								18		12,500
Breece, i.s., Colo					10	40	80	70	20	190,000
Buckeye, g., Colo							160			160,000
Buckhorn Oil, Cal							4	4		8,800
Buffalo Hump, g., Idaho							275	25		300,000
Bull Hill, Con., g., Colo							15	88		37,500
Bull'n-Beck & Cham., g.s., Utah	425	325	290	170	90	120	60			2,498,400
Bunker Hill & Sull., s.l., Idaho				102	228	201	252	252	156	1,442,000
Burlington Oil, Cal							8			8,600
Butte & Boston, c.s.l., Mont							1,000	600		1,600,000
Butterfly-Terrible, g., Colo								31		31,250
California, g., Cal								43		43,200
California Oil & Gas, Cal								540		540,000
Calumet & Hecla, c., Mich	1,500	2,000	2,500	5,000	5,000	10,000	7,000	4,500	2,500	79,850,000
Cambria Iron, Pa						339	339	339		1,015,980
Cambria Steel, Pa						660	940	2,150	1,350	5,100,000
Camp Bird, g., Colo									221	221 400
Cariboo-McKinney, g., B. C		49	76	48	67	72	86		19	496,387
Carisa, g.s.c., Utah								30		30,000
Cent'l-Eureka, s.g.l., Utah	195	510	390	98	15	120	268	200	50	2,667,700
Center Creek, l.z., Mo						10	30	20	10	70,000
Center Star, g., B. C							35	175		210,000
Central, l., Mo				28	54	60	65	60	60	325,000
Central C. & Coke, com., Mo									198	248,750
Central C. & Coke., pf., Mo									84	708,124
Central Eureka, Cal								16	8	23,718
Central Oil, Cal							73	25	24	160,247
Central Oil, W. Va							23	68	75	142,500
Central Point Con. Oil, Cal							4	38		45,600
Champion, g., Cal	41	27		51	26	35				321,700
Charleston, phos., S. C					30	20				50,000
C. K. & N., g.s., Colo									14	14,819
Cherry Hill, g., Cal								33	30	62,500
Chicago Oil, Cal									10	10,000
Chippewa Con., g.s.l., Colo									3	2,500
Cinco Sonores, Mex								9	57	656,105
Cloverdale, z., Mo						40	40			80,000
Colonial, l., Mo						10				10,000
Colo. City Mg. & Leas., Colo									65	65,000
Colorado Fuel & Iron, com								682	805	1,642,500
Colo. Fuel & Iron, Colo., pref	160		160	80			800	160	160	1,480,000
Columbia, l., Mo							12			12,125
Commodore, g., Colo				20	20	48				432,000
Commonwealth, z., Mo., pref						20	30			50,000
Consolidated, g., Colo						10	110	182	76	378,000
Consolidated, z.l., Mo., pref							8			8,000

DIVIDENDS PAID BY AMERICAN MINES AND INDUSTRIAL COMPANIES.—*Continued.*

Name of Company.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Total Paid.
Consolidation Coal, Md	$205	$205	$205	$205	$205	$205	$205	$205	$205	$5,523,000
Con. Mercur, g., Utah	200	200	200	250	355	100	225			1,591,000
Con. Mercur, g. (new), Utah							110	375	395	880,000
Continental, z., Mo									18	17,600
Continental Oil, Cal								10		10,400
Copiapo, c., Chile								108		2,826,000
Cordell, z l., Mo						3	27			30,000
Cripple Creek, g., pf., Colo									5	45,000
Cripple Creek Con., g., Colo							160			160,000
Crœsus, g., Cal					29	19	103	76		227,800
Crowned King, g.s.l., Ariz					96	121				242,760
Crucible Steel, pref., U. S							427	1.740	2,187	3,937,500
Cummings Cement, N. Y			27	27	27	27	27	27	27	189,000
Dalton & Lark., g.s.l., Utah								263		850,000
Daly-West, s.l.g.c., Utah						120	487	600	864	2,259,000
Deer Trail Con., g., Wash						55				55,000
De Lamar, s.g., Idaho	500	450	500		48	48	48	192	122	2,708,094
Delta, l.z., Mo						3	4			7,680
Denver & Cripple C'k, g., Colo							11			10,625
Desloge Con., l., Mo					20	30	20			70,000
Dewey Con., Utah							2	3		5,850
Diamond Star Oil, Cal							6			6,000
Diamond State St., com., Del							100	64		184,000
Dixie, g., Nev							10	158		167,500
Doctor Jack-Pot, g., Colo								282		282,000
Doe Run, l., Mo				30	30	60	60	60	60	537,072
Dominion Coal, N. S								240	120	2,040,000
Dominion I. & St., pf., N. S								175	350	525,000
Ducktown Sul., C. & I., Tenn					29	86				175,000
Eldorado, g., Cal						10				10,000
Elkton Con., g., Colo	60		90	260	220	68	259	325	100	1,404,461
El Oro, g.s., Mex								900	705	1,886,100
El Paso, g., Colo								24		35,045
Empire Con., q., Cal									15	15,600
Empire State, g.s.l., Idaho					67	256	355	586	304	1,562,838
Empire Steel & Iron, pref						71	107	71	71	319,850
Esperanza, s.g., Mex								171	159	1,070,079
Eureka, g., Cal								10		10,000
Eureka Oil, Cal								2		2,000
Fanny Rawlings, g., Colo						20				20,000
Favorite, g., Colo							48			48,000
Feather River Expl., g., Cal								20		20,000
Federal Chem., pf., Ky									90	90,000
Federal Steel, com							1,748	2,324		4,067,376
Federal Steel, pref						1,598	5,060	2,397		9,089,654
Ferris-Haggerty, c., Wyo						5		10		15,000
Figaro, g., Colo								10		10,000
Finance Con., g., Colo									2	2,000
Flat-Top C. Land Ass'n, com							111	74		352,840
Flat-Top C. Land Ass'n, pref							149	149		2,098,450
Florence, s., Mont		35	54	54	44	44	20			223,780
Four Metals, Colo								25		25,000
Four Oil, Cal								8	19	27,181
Free Coinage, g., Colo								140	20	160,000
Frisco Con., l.s., Ida	15	10	50			165				920,000
Frontino & Bolivia, c., Colom								108		1,211,708
Fullerton Oil, Cal								1		750
Garfield Con., g., Colo						84		125		159,000
Guadalupe Mill, Mex								157	123	3,484,950
Gemini, g., Utah							50		150	850,000
General Chem., com						129	285	287	296	930 021
General Chem., pref						396	494	506	565	1,975,178
Globe Oil, Cal								3		3,000
Gold Belt Con., g., Colo							113			112,500
Gold Deposit, g., Colo							10			10,000
Gold Coin of Victor, Colo				120	120	210	240	360	260	1,220,000
Gold Hill Bonanza, Colo									15	15,000
Golden Cycle, g., Colo				60	60	105	120	80		408,500
Golden Cycle (new), g., Colo									56	56,250
Golden Eagle, g., Colo			10			10	5	10		98,916
Golden M. & Ext., g., Ont						10				10,000
Golden Star, g., Ont						46				45,500
Gold King, g., Colo			11	25		66	112	56		412,219
Goodenough, s.l., B. C									7	13,188
Grafton, g., Colo						10				10,000
Grand Central, g.s., Mex							120			840,000
Grand Central, g., Utah					219	348	25			691,250
Grand Gulch, c., Ariz							10			9,600
Grass Valley Expl., g., Cal						23	7			30,000
Gray Eagle Oil, Cal							50	97		217,000
Greater Gold Belt, g., Colo							76			76,000
Great Western Oil, Cal							10			10,000
Green Mountain Oil, Cal								5		5,000
Greene Con., c., Mex								220		220,000
Gwin, g., Cal				16	85	85	66	120	165	486,500

DIVIDENDS PAID BY AMERICAN MINES AND INDUSTRIAL COMPANIES.—*Continued.*

Name of Company.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Total Paid.
Hanford Oil, Cal								$6	$7	$13,000
Hecla, l.s., Idaho							$100			100,000
Hecla Con., s.l., Mont	$120	$90	$45	$80		$15	50	30		2,250,000
Helena, g., Oregon							45	72		116,500
Helena & Liv., S. & R., Mont							90			90,000
Heywood Oil, Tex							32			32,000
Hidden Treasure, g., Cal							29			457,452
Higgins Oil, Tex									97	96,850
Holy Terror, g., So. Dak				86	$81	50	5			172,000
Home, g., Colo							100	187		287,500
Home Oil, Cal							200	61	90	350,000
Homestake, g., So. Dak	256	344	375	375	636	963	1,260	1,260	1,058	11,712,150
Homestake Oil, Cal							23	12	1	33,009
Horn Silver, g.s.l.z.c., Utah	150	50	50		80	20	20	72		5,842,000
Horseshoe, g., So. Dak									420	420,000
Houston Oil, pf., Tex								224	448	672,875
Idaho, g., B. C						28				292,000
Idaho, g., Idaho							8			8,188
Imperial Oil, Cal								20	24	260,000
Independence Con., g., Colo							100	181		281,875
Ingham Con., g., Colo								34		33,981
Int'l Ach. Graph., pf., N. Y									35	70,000
Iowa, g.s.l., Colo			50	25	10		89	67	67	270,501
Iron Silver, s.l., Colo							50			2,550,000
Isabella, g., Colo		23	180	68		270	158	23		742,500
Jack Pot, g., Colo						175				175,000
Jackson, g., Cal		2					6			6,000
Jamison, g., Cal						12		12		62,400
Jeff. & Clearf. Coal, Pa., com							30	30	75	105,000
Jeff. & Clearf. Coal, Pa., pref					75	75	75	75	75	525,000
Katinka, g., Colo								10		10,000
Kend. & Gelder Sm., Colo								20		20,000
Kennedy, g., Cal								10		1,801,000
Kentucky I. & Coal, Ky						11				164,041
Kern Oil, Cal							375	25	20	370,000
Kern River Oil, Cal							10			10,000
La Fortuna, g., Ariz				188	238	238	238	150	100	1,166,000
Lake City, g., Colo							4			3,875
Lake Superior, I., Mich		84			252	84				2,132,000
Last Chance, g., B. C					20	25				45,000
Last Dollar, g., Colo						30	90	60		180,000
Lawrence, g., Colo							10			10,000
Lehigh Coal & Nav., Pa	574	574	574	574	574	574	789	861	717	20,095,120
Le Roi, g., B. C						240				1,305,000
Le Roi No. 2, g., B. C								144	144	288,000
Liberty Bell, g.s., Colo									18	18,035
Lightner, g., Cal							10	18	5	33,230
Lillie, g., Colo					50	136	45			349,183
Los Angeles Oil & Trans., Cal								3		2,500
Madison, g., Colo							35			35,000
Magnolia, g., Colo							187		11	198,000
Mammoth, g.s.c., Utah			100		200	260	200	100		1,840,000
Marion Con., g., Colo						5				300,000
Maryland Coal, Md., pref	66	85	94	75	85	94	94	104	141	885,544
Mary McKinney, g., Colo						30	150	150	120	450,000
May Day, Utah								18	12	30,000
Mesquital, Mex								36		36,458
Midget, g., Colo							25	15	30	195,000
Mo. Zinc Fields, Mo., pref						21	11			31,885
Modoc, g., Colo				10	90	45	60	35	25	250,000
Monarch, g., Colo							120			120,000
Monongahela R.C. & C., Pa., pref							700	694		1,888,600
Montana Coal & Coke, Mont							120			120,000
Montana, g.s., Mont		205			36	99				453,700
Montana Ore Purchas., Mont		160	320	160	160	560	240	722	324	2,646,000
Monument, g., Colo					13	6		8		21,124
Morning Star, g., Cal					82	63	7			854,400
Morse, g., Colo						15				215,650
Mountain, c., Cal				31	62	1,080	1,200	720	540	3,633,750
Mount Diablo, s., Nev							5			260,271
Mount Rosa, g., Colo			5	10	20	40				75,000
Mount Shasta, g., Cal						6				6,000
Napa Con., q., Cal	50	80	70	80	80	110	40	40	40	1,180,000
National Lead, com	447	149			149	149	149		298	1,341,486
National Lead, pref	1,490	1,192	1,043	1,043	1,043	1,043	1,043	1,043	1,043	12,926,563
National Salt, com							245	420		615,000
National Salt, pref						175	350	350		875,000
National Steel, pref						1,418	1,891	945		4,253,500
National Tube, com							1,196	1,196		2,391,624
National Tube, pref						700	2,800	2,800		6,299,410
Natividad, s.g., Mex								24	48	164,626
New Central Coal, Md	50				20	40	40			510,000
New Idria, q., Cal				10	70	110	60	70	80	400,000
N. J. & Mo., z., Mo							11			11,000
N. J. Zinc				600	600	600	1,000	400	700	3,900,000

DIVIDENDS PAID BY AMERICAN MINES AND INDUSTRIAL COMPANIES.—*Continued.*

Name of Company.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901	1902.	Total Paid.
N. Leadville Home, g., Colo							$100	$137	$25	$265,500
N. Y. & Hond. Ros., s.g., C.A				$165	$165	$130	255	240	180	1,850,000
New Zealand Con., g., Colo								46	32	76,950
Nighth'k & Nig't'gale, g., Colo							180			180,000
North Star, g., B. C							39		78	117,000
North Star, g., Cal						50			47	581,356
Nova Scotia St. & C. com									124	123,600
Nova Scotia St. & C. pf									20	61,800
Nugget, g., Colo								30		84,730
Oceanic Oil, Cal							2			2,000
Ohio & Ind. Nat. Gas, U. S							760	360	360	1,080,000
Oil City Petroleum, Cal								15		15,000
Old Colony, Z. & Sm., Mo							68	70		138,184
Olive, g., Ont						12				12,000
Omega, g., Colo							18			18,188
Ontario, s., Utah			$180	230		15	90	90	180	14,917,000
Original-Empire, g., Cal						100				580,000
Osceola, c., Mich		$100	125	191	277	558	558	575		4,245,800
Pacific Coast Borax, Cal						100	240	209	228	1,217,500
Park Oil, Cal							5			4,897
Parrot, c.s., Mont,	$67				483	1,242	1,084	1,264	115	5,788,000
Payne, g., B. C						50		78		1,488,000
Peerless Oil, Cal									47	46,920
Pennsylvania Coal, Pa	1,000	800	1,500	800	800	800	800	2,160		21,860,000
Pennsylvania Con., g., Cal					28	68	26			161,325
Penn. Salt Mfg., Pa					150	150	300	300	300	13,150,000
Pennsylvania Steel (of N. J.), Pa								1,151	1,177	2,828,250
Penoles, s.l., Mex								693	1,128	1,978,289
Petro, s., Utah						15				33,000
Petroleum Dev., Cal									25	25,000
Phila., Nat. Gas, com., Pa								848	905	2,491,207
Philadelphia, Natural Gas, pref							100	200	400	799,836
Pioneer, g., Cal					50	13				62,500
Pioneer of Nome, Alaska									300	300,000
Pittsburg Coal, Pa							2,240	2,079	2,240	6,898,168
Plumas-Eureka, g., Cal	51	51	25	25			84	34		2,881,294
Pointer, g., Colo								25		25,000
Portland, g., Colo	67	556	240	330	570	720	750	720	270	4,297,080
Potomac Oil, Cal									8	8,178
Pride of the West, g., Ariz									15	15,000
Producers & Cons. Oil, Cal							53	4		56,500
Providencia, Mex								16	60	160,500
Providence, g., Colo								5		5,000
Queen Bess Propr., g., B. C						25				25,000
Quicksilver, q., Cal						22	22	22	21	1,909,411
Quincy, c., Mich	400	600	1,000	800	650	950	900	900	700	18,570,000
Quincy, Utah								725	234	959,875
Rambler-Cariboo Con., g., B. C						31	34	25	188	220,000
Raven, g., Colo					20	50	50	25		130,000
Reco, s.l., B. C							10			287,500
Reed Oil, Cal								50	50	100,000
Republic Con., g., Wash					120	158	105			382,500
Republic I. & St., pref						355	1,421	1,421	1,423	4,621,570
Retsof Salt, N. Y									144	576,000
Reward, g., Cal						20				20,000
Rex Oil, Cal							21			21,250
Richmoud, g.s.l., Nev							13			4,458,797
Rob Roy, z., Mo									1	366
Rocco-Homestake-Nev., s.g.l							9	45		54,000
Rocky Gulch, g., Oregon							25		2	90,000
Russell Irwin, z., Mo						15				15,000
Sacramento, g.s.l., Utah			15	15	60	50		15		188,000
Saint Joseph, l., Mo	150	150		144	150	150	150	150	150	3,609,500
San Carlos, Mex								212	22	234,329
San Diego de Char., Mex								32		61,100
San Francisco Mill, Mex								87	61	287,160
San Joaquin Oil, Cal								25	35	60,000
San Rafael, Mex								136	54	1,774,068
Santa Rita, g., Colo							4			4,000
Senator Oil, Cal								5		5,429
Shawmut Oil, W. Va								100	50	150,000
Shelby Iron, Ala						180	120		160	690,000
Silver King, g.s.l., Utah		263	375	450	450	625	1,000	1,800	1,800	6,050,000
Silver Hill, g.s., Nev									5	5,400
Silver Shield, g.s.l., Utah							2	3		4,500
Six Points, g., Colo							120			120,000
Soledad, Mex									25	222,241
Sloss-Sheff. I. & St., pref							456	467	469	1,276,750
Small Hopes, s., Colo					25	25				3,325,000
Smuggler, s.l.z., Colo	50		110		120	275	360	360	20	2,175,000
Sorpressa, Mex								27		185,653
Southern Boy, g., Colo							18			17,500
Southern Cal. Oil & Fuel, Cal							8	33		39,000
South Godiva, g.s., Utah								2		2,000
South Swansea, g.s.l., Utah			20	50	38	53		8		167,500

DIVIDENDS PAID BY AMERICAN MINES AND INDUSTRIAL COMPANIES.—*Concluded.*

Name of Company.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Total Paid.
South Winnie, g.s., Colo								$15		$15,000
Spearfish, pf., So. Dak									$18	17,640
Specie Payment, g., Colo								27	14	40,500
Specimen, g., Colo							$158			158,347
Squaw Mountain, g., Colo						$10				10,000
Sta. Gertrudis, Mex								81	88	2,647,344
Sta. Maria de Guad, Mex								133	85	377,918
Sta. Maria de la Paz, Mex									104	1,839,633
Standard, s.l., Idaho							320	300	150	2,720,000
Standard Con., g., Cal	$40	$20		$40	$27	60	71	71	71	4,106,814
Standard Oil of N. J.						26,325	47,800	46,660	48,650	164,085,000
St. Eugene Con., s., B. C.						2		210		210,000
St. John del Rey, g., Braz								102	142	14,005,995
Stratton's Independ., g., Colo						976	1,789	788	240	3,770,860
Strong, g., Colo				250	300	300	300	800	375	2,275,000
Sunday Lake Iron, Mich								40		40,000
Sunset, s.l., B. C.									6	6,000
Susquehanna I. & St., Pa						180	118	68	90	672,500
Swansea, s.l., Utah			$20	50	65	65	75	29		330,500
Syndicate, g., Cal									2	82,000
Tamarack, c., Mich	400	400	500	360	440	600	1,020	1,200		8,490,000
Temonj, g., Colo		10					250			250,000
Temple Iron, Pa									7	7,200
Tenn. C., I. & R. R., com							451			1,102,144
Tenn. C., I. & R. R., pref							189	20	20	282,880
Texas & Pacific Coal, Tex						140	120	120	120	2,040,000
Thirty-three Oil, Cal									120	120 000
Thomas Iron, Pa									200	200,000
Tomboy, g., Colo		300	800		50	152	144	216	72	1,244,000
Touraine, g., Colo							86	9		96,119
Town Topics, g.c., Colo								15	20	35,000
Uncle Sam Con., g.s., Utah								45		45,000
Union, g., Colo		27	18	23			818	25	25	445,244
Union, z.l., Kas							9	7		16,000
Union Mill, Mex								81	26	878,270
Union Oil, Cal								118	179	297,595
United, c., pf., Mont									150	150,000
United, g., Colo									280	279,842
United, z.l., Mo						3	28	30	47	107,259
United Petroleum, Cal									34	33,750
United States Crude Oil, Cal							3	24		27,220
U. S. Crude Oil, Cal							3	24		27,220
U. S. Marble, Wash								20		20,000
U. S. Oil, W. Va						300	275			575,000
U. S. Red. & Ref., com									177	177,326
U. S. Red. & Ref., pf									236	236,073
U. S. Steel Corp., com								15,228	20,833	35,560,502
U. S. Steel Corp., pf								26,753	35,720	62,473,072
United Verde, c., Ariz						3,000	4,499			
Utah, g., Utah		17	22	4		2	2	14	12	207,000
Utah Con., c., Utah								732		732,000
Vindicator, g., Colo					138	178	189	170	253	917,000
Va.-Car. Chem., com			10	40	40	270	360	480	1,329	2,979,000
Va.-Car. Chem., pref						800	800	920	960	6,060,000
Ventura Con. Oil, Cal									5	5,000
Vic. C. & Coke, com., W. Va								15		15,000
Vic. C. & Coke, pf., W. Va								9	6	15,000
War Eagle, g., B. C.					177	315	58			540,250
Warner Oil, Cal								10		10,000
Warwick Iron & Steel, Pa						64	132	84		279,324
Wasp No. 2, g., So. Dak								4	9	218,410
Weatherly-Bonanza, g., Wash						2				2,000
West Lake Oil, Cal							50			50,000
West Shore Oil, Cal								20	25	45,000
Westmoreland Coal						750	750	750	750	7,500,000
What Cheer, z., Mo						2	9			11,250
White Rock, g., Nev									2	2,000
Whittier Con. Oil, Cal							6			5,600
Wolverine, c., Mich					60	210	240	240	240	990,000
Wythe, l.z., Va							76			76,000
Yankee Con., g.s.l., Utah									75	75,000
Yellow Aster, g., Cal				40	131	145	150		80	489,000
Ymir, g., B. C.						30		192	48	288,000
Yreka, g., Cal							50	8		58,000
Yukon Oil, Cal						3	18			21,000
Zoe, g., Colo							8			7,500

c., copper; g., gold; i., iron; l., lead; q., quicksilver; s., silver; z., zinc.

ASSESSMENTS LEVIED BY MINING COMPANIES.

Name of Company.	1894.	1895.	1896.	1897.	1898.	1889.	1900.	1901.	1902.	Total Levied.
Acacia Oil, Cal								$6,000		$6,000
Acme Oil, Cal								10,000		10,000
Acorn, g.s.l., Utah						$365	$760			1,125
Addie, g.s.l., Utah									$2,500	5,000
Admiral, g., Utah									2,500	2,500
Ætna, g.s.l., Idaho							5,000			5,000
Ætna, g.s.l., Utah					$2,500	500				3,000
Ætna Oil, Cal								50,000		50,000
Ajax, g.s.l., Utah								15	30,000	45,000
Alaska, g., Cal								20,000		20,000
Alaska, g.s.l., Utah,						34,000	20,000	12,000	28,000	94,000
Albian, g., Utah								20,000	24,000	44,000
Alexandria, g.s.l., S. Dak						500	500			1,000
Alhambra, s., Nev					100,000					100,000
Allah, g., Utah									2,500	2,500
Alliance Explor. & Mg., g., Cal							5,000	2,000		7,000
Alliance, g, Utah		$50,000				15,000	10,000			225,000
Allison-Rauch-Ford, g., Cal						5,000	10,000			15,000
Allouez, c., Mich	$16,000				80,000			240,000		1,760,930
Alma, g., Cal									10,000	10,000
Alpha, s., Nev	6,000	15,750	$15,750	$8,400	8,400	3,150	3,150	3,150	6,300	331,800
Alta, s., Nev	50,400	20,160	32,400	16,200	16,200	16,200	16,200	10,800	10,800	3,718,910
Alta, g., Utah						938				938
Amelia, g., Cal							2,500			2,500
Am. Oil & Ref., Cal							5,000	10,000		15,000
American, g.s.l., Utah									2,000	18,000
American Mines, Utah									5,000	5,000
Andes, s., Nev	25,000	15,000	15,000	20,000	10,000	15,000	15,000	10,000	15,000	1,250,000
Annandale, g., Utah									5,000	5,000
Annie, g. s., Utah							5,000			5,000
Apex, c., Utah									5,000	5,000
Apollo, Alaska								10,000		10,000
App Con., g., Cal									50,000	50,000
April Fool, g.s.l., Nev									50,000	50,000
Argentum-Juniata, g., Colo									104,000	104,000
Argonaut Oil, Cal							12,000	12,000		24,000
Arnold, c., Mich					180,000					180,000
Arrastraville, g., Cal					20,000	20,000	10.000			50,000
Aurora, g.s.l., Utah									500	500
Bachelor's Oil, Cal								6,000		6,000
Badger, g.. Oregon							10,000	10,000		20,000
Badger Hill & Cherokee, g., Cal						60,000				60,000
Baker Divide, g.. Cal									12,000	12,000
Baliol, g., Cal				25,000	30,000					55,000
Bay City Oil, Cal								5,000		5,000
Bear Flag Oil, Cal								6,761		6,761
Belcher, s., Nev	50,200	50,200	50,200	57,000	20,800	36,400	52,000	52,000	26,000	3,681,200
Belle, g., Cal							2,000			2,000
Bellefontaine, g.s., Cal					10,000	10,000	10,000	10,000		40,000
Ben Butler, g.s., Utah						11,250	6,250	2,500	10,000	30,000
Ben Franklin, g., Cal									15,000	15,000
Benton Con., g.s., Nev							20,000			20,000
Berkeley Crude Oil, Cal									4,500	4,500
Best & Belcher, s., Nev	50,400	50,400	25,200	75,600	30,240	40,320	60,480	30,240	50,400	2,772,523
Big Chief Oil, Cal								5,000		5,000
Biesinger & Beck, s.l.g., Utah							756			756,000
Bingham Placer, g., Utah						27.500	27,500		27,500	82,500
Blue Bird, g., Utah						500				500
Blue Eagle, g., Utah								10,000	5,000	15,000
Blue Extension, g., Utah								5.500	2,500	7,500
Blue Goose, Cal								10,000		10,000
Blue Gravel, g., Cal							10,000			10,000
Bogan, s., Utah								12,500		39,375
Boss Tweed, g., Utah									10,000	18,000
Boston & Cripple C'k, g., Colo					20,000					20,000
Boulder, g., Cal					10,000	3,000	3,000	3,000		19,000
Bountiful, g.s., Utah							5,000		15,000	20,000
Brown, g., Utah									5,000	5,000
Brunswick Con., g.s., Cal	10,000	20,000	15,000	30.000		15,000	50,000	40,000	45,000	310,000
Buchanan, g., Cal					25,000					25,000
Buckeye, g., Utah			3,750	6,250	6,250					16,250
Buckhorn, g., Utah								1,000		1,000
Buffalo Hump Dev., g., Wash							200			200
Bullion, s., Nev	30,000	40,000	20,000	20,000	15,000	10,000	5,000	6.000	3,000	3,144,000
Bunker Hill, g.s., Utah						5,000	6,250			11,250
Butler, g., Utah								3,000		3,000
Butte Basin, g., Cal								2,500		2,500
Cadmus, g., Cal							10,000		8,000	18,000
Caledonia, s., Nev	50,000		5,000				30,000	15,000	30,000	3,815,000
California, g., Cal		4,500		1,000		2,000		2,000	4,500	26,000
California, g.s.l., Utah									30,000	30,000
California Borax, Cal							9,500			18,000
California Dredging, Cal								30,000		30,000
California Mutual Oil, Cal								12,500		12,500
California Oil, Cal								20,000		20,000

ASSESSMENTS LEVIED BY MINING COMPANIES.—*Continued.*

Name of Company.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Total Levied.
Canadian King, Wash								$1,000		$1,000
Canton Placer, g., Cal										25,000
Carb. & Rattler, g.s.l., Utah									$24,000	24,000
Carbon Oil, Cal										8,000
Caribou Oil, Cal							$8,000	16,000		24,000
Carmelita Oil, Cal								10,000	10,000	50,000
Cassa Oil, Cal								2,000		2,000
Cedar Creek, g., Cal					$2,000					2,000
Centennial, c., Mich				120,000	300,000		270,000	180,000		910,000
Central Eureka, g., Cal				20,000			12,000			32,000
Central Mammoth, g., Utah							500			500
Century, g., Utah									10,000	10,000
Century Oil, Cal								8,600	5,500	22,200
Cerulean, g., Cal								5,000		5,000
Challenge Con., s., Nev	$50,000	$5,000	$7,500	50,00	1,000	$12,500	22,500	5,000	5,000	474,500
Champion, g., Cal									17,000	107,508
Channel Bend, g., Cal					2,000					2,000
Chicago, g.s.l., Utah									2,500	2,500
Chicago & Mercur, g.s., Utah						1,000		1,000		2,000
Chloride Queen, Idaho								1,000		1,000
Chollar, s., Nev	56,000	56,000	28,000	44 800	50,400	28,000	39,200	22,400	22,400	2,159,600
Christmas, g.s., Utah						1,500	3,000			4,500
Church, g., Cal					3,000					3,000
Cinnabar King, g., Cal					1,000					1,000
Clarissa, g.s., Utah						5,000	5,000			10,000
Cleveland, g., Utah					2,000	1,000				3,000
Clyde Oil, Cal								5,000		5,000
Coe, g., Cal									25,000	25,000
Columbia, g.s., Utah					750					750
Columbus Con., g.s., Cal							2,000		3,000	5,000
Commonwealth, g., Utah									2,500	2,500
Comstock, g. s. l., Utah								20,000	30,000	50,000
Confidence, s., Nev	6,240	14,976	7,488	14,976	13,728	8,736	9,984	99,984		568,880
Conglomerate, g.s., Utah							6,250			6,250
Con. Cal. & Va., s., Nev	108,000	54,000	118,800	108,000	108,000	108,000	97,200		54,000	987,200
Con. Gold G. & Sulp., Cal									45,000	45,000
Con. Golden Trout, g., Cal									25,000	25,000
Con. Imperial, s., Nev		5,000	500	10,000	10,000	10,000	20,000	10,000	10,000	2,250,000
Con. New York, s., Nev	5,000	10,000	5,000	60,000	30,000	3,000				136,500
Con. St. Gothard, g., Cal					35,000	15,000		10,000		60,000
Constellation, g., Utah							2,250	2,250		63,000
Contra Costa Coal, Cal								30,000		30,000
Contra Costa Oil, Cal								5,000		5,000
Copper Queen, Utah									4,000	4,000
Corona Oil, Cal								6,000		6,000
Crown Point, s., Nev	65,000	25,000	70,000		25,000	20,000	15,000	15,000	20,000	3,040,000
Crusader Con., g.s.l., Utah							5,000		2,500	7,500
Dalton, g.s.l., Utah	5,000	5,000	5,000	2,500	7,500	5,000		5,000	7,500	71,250
Daylight, g., Utah								2,000	5,000	7,000
Del Monte Oil, Cal								20,000		20,000
Devil's Den Oil, Cal								2,000		2,000
Dewey Gravel, g.s.l., Cal							10.000			10,000
Dexter, g.s., Nev					30,000					38,000
Diamond Con. g.s.l., Utah						8,000		8,000		16,000
Diamond Creek, g., Cal									20,000	20,000
Dreisam, g., Cal						51,000	15,000			66,000
Dublin, g., Cal								10,000	5,000	15,000
Dudley, g., Cal									20,000	260,000
Dutch, g., Cal						22,500	52,500			75,000
Eagle, g., Oregon					3,000					3,000
East Honorine, g s.l., Utah									5,000	5,000
East Valeo, g., Utah								5,000		5,000
Eldorado Oil, Cal									10,000	10,000
Ella Eldon, g., S. Dak								500		500
El Rey, g., Utah							8,000			8,000
Elsie, g.s.l., Utah									10,000	10,000
Ely, g., Utah						2,000	3,000		2,000	7,000
Emerald, g.s., Utah					3,000			1,500	10,750	15,250
Empire Oil, Cal								14,000		14,000
Equality Oil, Cal									10,000	10,000
Eureka Con., s., Nev		12,500			10,000	5,000				519,000
Eureka Con. Drift, g., Cal				75,000	5,000	15,000	17,500	10,000	5,000	228,000
Eureka-Swansea Ext., g.s., Utah							5,000			5,000
Eutonia, s.l.g., Utah							9,000	2,000	6,000	17,000
Excelsior Drift, g.s., Cal					667	5,000	2,000			7,667
Exchange, g.s., Utah							1,000	1,500		2,500
Exchequer, s., Nev	10,000	5,000	5,000	5,000			3,000			738,000
Fall Creek, g., Cal								10,000		10,000
Fall River, g.s., Cal						2,500				2,500
Father de Smet, g.s., S. Dak							25,000			225,000
Fifteen-Three Oil, Cal									10,000	10,000
Fish Springs, g., Utah							1,500			1,500
Florence, g.s., Utah						1,000				1,000
Forlorn Hope, g., Cal					20,000					20,000

ASSESSMENTS LEVIED BY MINING COMPANIES.—*Continued.*

Name of Company.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Total Levied.
Four Aces, g.s., Utah				$2,500	$2,500	$2,500	$17,500	$5,000		$27,500
Free Coinage, g., Utah								5,000		5,000
Fremont, g.s., Utah							2,500			2,500
Fremont Con., g., Cal									$10,000	10,000
Fresno & S. Benito Oil, Cal.									4,000	4,000
Frisco, g.s., Utah						2,000	2,000			32,000
Fullerton & Sunset Oil, Cal								3,000		3,000
Galata, g., Cal					10,000					10.000
Galena, g., Utah					10,000			5,000	6,000	21,000
Galena Treasure, g.s., S. Dak						200	200			400
Garden City, g.s., S. Dak							563			7,105
Garibaldi, g.s., Cal						4,000	4,000		3,000	11,000
Genevieve, g.s., Utah						5,000				5,000
Gerrymander, g.s., Cal						10,000	5,000		5,000	20,000
Geyser, s.l., Colo					50,000	200,000				1,275.000
Geyser-Marion, g.s., Utah							9,000			9,000
Giant Oil, Cal								24,107		24,107
Gibraltar Con., g., Cal								5,000		5,000
Golconda, g.s., Nev								750		750
Gold Coin (Gilpin Co.), Colo.						10,000				10,000
Golden Channel, g., Cal						3,000	2,500			5,500
Golden Eagle, g.s., Nev						4,000			1,820	5,820
Golden Jubilee, g., Cal									5,000	5,000
Golden King g., Cal					3,500					3,500
Golden Star, g.s., Cal						2,000	1,500	2,500	4,000	10,000
Gold Hill, g.s., Cal							25,000	25,000	25,000	75,000
Gold Hill, g.s., Utah							1,000	500	500	2,000
Gold Leaf, g.s., Wash						100				100
Gold & Silver Carb., g.s., Utah						2,500				2,500
Goleta, Con., g., C.							63,000	30,000		93,000
Gonyon, g.s., Utah							2,500	3,750		6.250
Good Hope, g., Utah								2,000		2,000
Good Title, g., Cal					20,000					20,000
Gould Central Oil, Cal								5,000		5,000
Gould Oil, Cal								25,000		25,000
Gould & Curry, s., Nev	$32,400	$48,600	$48,600	59,400	37,800	49,400	54,800	43,200	32,400	4,818,850
Grand Prize Oil, Cal								20,000		20,000
Granite Hill, g.s., Cal						3,000				3,000
Grape Vine Canyon, g.s., Cal						10,000	14,000	10,000		34,000
Great Bonanza, g.s., Utah							5,000			5,000
Great Eastern, g.s., Utah					1,500	1,500	1,500			4,500
Great Western, q., Cal					5,000	20,000				75,520
Grizzly, g.s., Cal					1,500		5,000		10,000	16,500
Hale & Norcross, s., Nev						39,200	22,400	11,200	44,800	5,795,880
Hanford-Fresno Oil, Cal								24,140		24,140
Hanford-Sanger Oil, Cal								6,000		6,000
Hawk-McHenry, g.s.l., Utah									15,000	15,000
Head Center Con., g.s.c., Ariz						25,125				25,125
Hercules, g.s., Utah							20,000			20,000
Hester A., g.s., S. Dak							500			3,000
Highland, g.s., Utah							8,000			8,000
Highland(Leadville), g.s., Colo							125,000			125,000
Hilda Gravel, g.s., Cal					2,000		2,000			4,000
Hillside, g.s., Utah						1,500				1,500
Himalaya, g.s., Utah						5,000				5,000
Home, g.s., Cal					3,000		10,000			13,000
Homestake, g.s., Utah					4,000	4,000			10,000	60,000
Horn Silver Tunnel, g.s., Utah						500	500			1,000
Horsefly, g., Cal					8,000			10,000		18,000
Horseshoe Bar Con., g.s., Cal					6,000	3,000	1,200	600		87,600
Humboldt, g.s., Cal						2,000				2,000
Imperial, Cal								2,000	3,000	5,000
Imperial Oil, Cal								2,000		2,000
Imyo Marble, Cal								5,000	5,000	175,000
Independence, g.s., Utah						6,000	9,000			15,000
Independent, g., Cal								10,000		10.000
Ingot, g.s.l., Utah								10,000		10,000
International, g.s., Utah						1,500			5,000	6,500
Jefferson, g.c., Utah							1,500	1,750		3,250
Jennie Lind, g.s., Cal						2,000	2,000	8.000	9.000	21.000
Joe Bowers, g.s.. Utah							14,000	21,000	10,500	45.500
Joe Bowers Ext.. g.s., Utah							15,000			40.500
Jubilee, g., Cal									10,000	10,000
Julia Con., s., Nev		5,500	5,500	5,500		3,300	3,300		6.600	1,508.400
Jumbo, g.s., Utah					500				1,200	1,700
Junction, g.s., Cal					10,500	6,000				16.500
Junction Oil, Cal								25,000		25,000
Jupiter Gravel, g., Cal				40,000	40.000					80,000
Justice, s., Nev					10,500	21,000	15,750	21,000	17.750	3,723,250
Karan, g., Cal					2,500					2,500
Karl Brown Oil, Cal								15,000		15,000
Kate Hayes, g.s., Cal					10,000	10,000				70,000
Kentuck, g., Utah					30,000					30,000
Kentuck Con., s., Nev	26,250	10,500	5,250	10,500	5,250		3,150			128,450
Kern River Oil, Cal								40,000	20,000	60.000

ASSESSMENTS LEVIED BY MINING COMPANIES.—*Continued.*

Name of Company.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Total Levied.
Kern Sunset Oil, Cal								$2,000		$2,000
Keystone, g., Cal									$3,000	3,000
Kings County Oil, Cal								6,000		6,000
Lady Washington, s., Nev			$5,400			$5,400			8,640	171,840
La Grange, g.s., Cal						15,000				15,000
Laird, g., Cal					$10,000					10,000
La Reine, g.s.l., Utah									5,000	5,000
Larkin, g.s., Cal					2,000	2,000	$4,000	10,000	12,000	40,000
La Suerte, g.s., Cal					7,500	7,500	7,500	5,000	4,750	32,250
Laurel, g., Cal									2,500	2,500
Leo, g., Mont								2,500		2,500
Leon, g., Cal					1,500					1,500
Linda Vista Oil, Cal								11,460	3,000	14,460
Lion Con., g.s., Utah						500	500			1,000
Little Bell, g., Utah								37,500		37,500
Little Chief, g.s., Utah						8,000	12,000	16,000	16,000	52,000
Little Jimmie, g.s.l., Utah									1,875	1,875
Little Pittsburg, g.s., Utah		$4,000	6,000	$4,000	4,000	5,000				23,000
Little Standard Oil, Cal									10,000	30,000
Live Oak Con., g.s., Cal					20,000	10,000	10,000		8,000	48,000
Live Yankee, g.s., Cal					5,000	2,000				7,050
Lombard, g.c., Utah								1,250		1,250
Los Angeles Oil, Cal									5,000	5,000
Louis, S., g., Utah								10,000		10,000
Lower Mammoth, g.s., Utah					12,500	15,000	15,000			42,500
Lucky Bill, g.s., Utah			7,200	6,600	1,800	2,500	2,400	12,000		73,000
Lulah Con., g.s., Utah						1,500				1,500
Madeleine, g.s.l., Utah									10,000	10,000
Madsen, g., Utah								1,250	2,500	3,750
Mammoth, g.s., Nev									2,000	2,000
Manhattan, g., Utah								2,500	7,500	10,000
Mammoth Garfield, g.s., Cal							17,500			17,500
Maple, g.s., Utah								3,000	6,000	9,000
Maple Creek, g., Cal								10,000		10,000
Marguerite, g.s., Cal				20,000	15,000	15,000				35,000
Marina Marsicano, g.s., Cal				16,360	19,000	19,000	7,000	1,000	24,000	86,360
Mariposa Com'l&M'g,g.s.,Cal							50,000	50,000		210,000
Marmaduke, g.s., S. Dak							500			500
Martha Washington, g.s. Utah					3,000	6,000	6,000	9,000	15,000	39,000
Martin White, s., Nev	$25,000					120,000				1,200,000
Maxfield, g.s., Utah					6,000	9,000	9,000			24,000
Mayday, g.s., Cal					5,000	10,000	5,000	2,500	1,500	24,000
Mayday, g.s., Utah					2,000	2,000				4,000
Mayflower, g.s., Utah							2,000	5,000	5,000	12,000
Mayflower Gravel, g.s., Cal					6,000		7,500	6,000		19,500
Mazeppa, g.s., Cal							5,000		2,000	7,000
McKinley, g., Utah								1,250		1,250
McKittrick, Con., Oil, Cal							18,000	18,000		30,500
McKittrick Oil, Cal								15,000	6,000	21,000
Melcher, g.s., Utah							1,000	625	1,375	3,000
Menlo, g., Cal									6,000	6,000
Mercantile Crude Oil, Cal									5,000	5,000
Merrimac, g., Cal					20,000					20,000
Meteor, g.s., Utah					3,734	4,999	2,997	1,960		13,690
Mexican, s., Nev	75,600	75,600	40,320	20,000	40,320	25,200	45,360	50,400	30,240	2,440,160
Midland, g.s., Utah							3,000			3,000
Midnight Bowers, g.s., Utah						1,000	1,000			2,000
Minnehaha Oil, Cal								10,000		10,000
Minnie, g., Utah									1,000	4,000
Mistletoe, g., Cal									10,000	10,000
Mohican g., Cal								10,000	5,000	15,000
Molly Bawn, g.s., Utah						1,000				1,000
Montecito, g., Cal					10,000					10,000
Monte Cristo, g.s., Utah									2,500	2,500
Montreal, g.s., Utah		375		375		25,000				30,625
Mooney Con., g.s., Cal							20,000			20,000
Morgan, g., Cal					10,000					10,000
Morning Glory, g., Wash									3,000	3,000
Mountaineer, g.s., Cal					15,000		25,000			40,000
Mountain Lake, g.s.l., Utah									5,000	5,000
Mountain View, g., Cal								15,000		15,000
Mt. Blanc Con., g., Cal								1,250		1,250
Mt. Diablo Oil, Cal								10,000	5,000	65,000
Nancy Hanks, g., Cal					5,000					5,000
Nashville, g., Cal					2,000					2,000
National Con., g.s., Cal					15,000	45,000	15,000	10,000	5,000	83,685
Navajo, g.s., Utah								2,500		2,500
Nevada, s., Nev							10,000			10,000
Nevada, c., Utah									5,000	5,000
New Century Oil, Cal								15,000		15,000
New Erie, g.s., Utah						2,000	500	7,500	500	10,500
New Imperial, g.s., Utah						1,000				1,000
New Klondike, g.s., Utah						2,961	235			3,196
New La Plata, g.s., S. Dak							300			1,700
New Mercur, g.s., Utah[1]									4,200	4,200

ASSESSMENTS LEVIED BY MINING COMPANIES.—*Continued.*

Name of Company.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Total Levied.
New Montezuma, g., Cal									$10,492	$15,675
New Redwing, g.s.l., Utah									15,000	15,000
New Southern Cross, g., Mont								$5,000		5,000
New State, g.c., Utah							$1,500			4,500
Niagara M. & S., Utah									97,500	97,500
Nineteen Oil, Cal								6,000		6.000
North Bloomfield, g., Cal					$25,000					25,000
North Bonanza, s., Nev							15,000			255,000
North Gould & Curry, s., Nev	$20,000		$10,000		20,000					375,000
North Mercur, g., Utah					10,000					10,000
North Rapidan, s., Nev							8,000			8,000
Northern Light, g.s., Utah					8,000		8,000	18,000	16,000	50,000
Northern Spy, g.s., Utah					10,000	$10,000				20,000
Nugget Placer, g., Cal								10,000		10.000
Occidental Con., s., Nev	30,000	$30,000	65,000	$30,000	20,000	20,000	5,000	10,000	15,000	549,119
Okanogan, g., Wash							10,566			10,566
Olcorose, Cal									3,000	3,000
Old Bonanza, g.s., Cal						2,500				2,500
Old Bullion, g.s., Utah									4,000	4,000
Old Colony & Eureka, g.s., Utah							2,500		2,500	5,000
Old Evergreen, g.s., Utah									6,000	6,000
Old Home, g.s., Cal					5,000	3,500	3,500	1,000		13,000
Old Home Con., g.s., Cal							3,500	1,000	2,000	15,000
Old Indian, g.s., Utah									2,000	4,000
Old Susan, g.s., Utah							7,500	500		8.000
Olinda Oil, Cal									10,000	10,000
Omaha, g.s., Utah							6,000			6.000
Omaha Con., g.s., Cal					10,000	25,000	100,000		50,000	185,000
Ophir, s., Nev	100,000	100,000	25,200	25,200	43,200	50,400	60,480	45,360	45,360	4,794,168
Ophir (Cen. Dist.), g., Nev									6,000	15,000
Opohonga, g.s., Utah					1,500	1,000				2,500
Orient, g.s., Cal						50,000	75,000	35,000		160 000
Orient, g., Utah								2.500	2,000	4.500
Orleans, g.s., Cal					15,000	12,000		5,000		32,000
Oro Quartz, g.s., Cal						4,500				4.500
Osceola Con., g.s., Cal					1,000	1,000	2,000	2,000		15,810
Overman, s., Nev	34,560	23,040	34,560	17,280	17,280	11,520	17,268	23,040	23,040	4,204,470
Pacific, g.s., Utah						500	750		600	1,850
Paria, c., Utah									2.500	7.500
Park City & Mid. Sun, Utah							10,000			10,000
Patterson Creek, Cal									10,000	10,000
Peabody, g.s., Cal							10.000			10.000
Petroleum Center Oil, Cal							20,500	61,500	20,500	102.500
Petrolia Oil, Cal								10.000		10,000
Phœnix, g.s., Utah				1,000			1,000			2.000
Picnic, g.s., Utah							1,000			1.000
Pilot, g., Cal									10,000	10,000
Pioneer, g.s.l., Utah									1,000	1.000
Planet, g., Cal									10,000	10.000
Potosi, s., Nev	112,000	56,000	28,000	50,400	50.400	39.200	39,200	28,000	22,400	2,286,000
Powning, g.s., Cal						2,500			2,500	5.000
Princess Maud, g.s.l., Wash									3,000	3,000
Prior Hill, g.s., S. Dak							200			1.000
Prospect M't'n Tunnel, Nev									10,000	10,000
Prosperity Oil, Cal								25,000		25.000
Providence, g., Cal								20,000		20,000
Provident Oil, Cal								7,500		7,500
Purjue Sur., g.s.l., Utah									1,000	2,000
Queen Esther Oil, Cal								5,000		5,000
Quincy, g., Cal						10,000	20,000			30,000
Raven Oil, Cal								10,500		10.500
Raymond, g., Utah								12.500		12,500
Reamer Con., Cal									10,000	10.000
Red Bank Oil, Cal								6,000		6,000
Red Cap, g., Cal					90,000					90.000
Reddick, g.s., Cal					5,000	5,000			3.000	13,000
Red Jacket, s., Nev						2,000				2.000
Red Wing, g.s.l., Utah									1,000	1,000
Red Wing Ext., g.s.l., Utah									500	1,000
R. G. W., g.s., Utah						2,000	1,000	2,500	1,500	7,000
Rescue Gold, Nev				3,000	2,000	500				5,500
Revenue, g.s., Utah						4,500				4,500
Reward, g.s., Cal				7,040	3.840	3,200	9.920	14,500	6,000	97,500
Rich Bar Gravel, g.s., Cal							6,000			6,000
Richmond, g., Cal					10,000					10,000
Ridge & Valley, g.s., Utah							5.000	10,000		15.000
Roberts Oil, Cal								3,000		3.000
Rockland, g., Cal					3,000					3.000
Rose Creek, g.s., Cal					5,000	5,000				10.000
Ruby Hill, g.s., Utah							600	1,000	1,000	2,600
Rusby, g., Cal									14,000	14,000
Sacramento, g.s., Utah						600		2,500		3,100
Sailor Con., g.s., Cal						11,000	6,000	3.000	1,000	21.000
Salmon River, s., Nev						1,425				11,970
Salt Lake & Nev., g.s., Utah					1,000			2.500		3,500

ASSESSMENTS LEVIED BY MINING COMPANIES.—*Continued.*

Name of Company.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Total Levied.
Sam Houston, g.s., Cal									$4,000	$4,000
Sampson, g.s.l., Utah									10,000	10,000
San Pablo Oil, Cal									5,000	5,000
Santa Rosalia, q., Mex							$5,000			5,000
Savage, s., Nev	100,805	$67,200	$67,200	$67,200	$44,800	$22,400	33,600	$22,400		7,366,000
Scorpion, s., Nev	5,000			5,000			3,000			448,000
Sea Breeze Oil, Cal								20,000		20,000
Sea Swan, g., Utah								2,500		2,500
Seg. Belch. & Mides, s., Nev	20,000	30,000	10,000	10,000	8,000	10,000	6,000	6,000	3,000	393,000
Sharp, g., Utah								5,000		5,000
Shasta Oil, Cal								20,000		20,000
Sheba, g.s., Cal							10,000			10,000
Sheep Rock, g.s., Utah				5,250			52,500			57,750
Shenandoah Con., g., Cal								4,000		4,000
ShoebridgeBonanza,g.s.,Utah							8,200	4,000		13,600
Shower Con., g.s., Utah						8,000	2,000	24,000	12,000	46,000
Sierra Nevada, s., Nev	50,000	50,000	50,000	40,000	20,000	50,000	45,000	50,000	30,000	6,881,910
Sierra Union W'r & Mg., Cal									75,000	75,000
Silver Bell, s., Mont					5,000					5,000
Silver Bow, g.s., Utah							5,000	7,500	5,000	17,500
Silver Cloud, g.s., Utah						5,000		2,500		7,500
Silver Hill, s., Nev	5,400			5,400	5,400					2,220,200
Silver King, g.s., Ariz	100,000		75,000	50,000	50,000	50,000	25,000	25,000	15,000	530,000
Silver Park, g.s., Utah							9,000			9,000
Silver Queen, g.s., Utah							1,000			1,000
Silver Shield, g., Utah								1,000	2,000	3,000
Silver State, g.s., Utah				1,000			500		2,500	4,000
Siskiyou Con., g.s., Cal	14,000	4,000	2,000		3,000	3,000	6,000			55,000
Skagit Cumb. Coal, Wash							7,500	22,500		29,500
Skylark, c., Utah								5,000	7,500	12,500
Snow Flake, g.s., Utah					2,000	5,000	2,000	7,000	10,000	38,500
Snowstorm, g.s., Utah								2,500		2,500
Sonora, g., Cal							5,000	4,000	8,000	17,000
Sonora Quartz, g.s., Mex							5,000		10,000	5,000
South Bingham, g.s., Utah						2,500	2,500			5,000
South Eureka, g.s., Cal						6,000			3,000	9,000
South Fork Con., g.s., Utah					5,000					5,000
So. Queen, g.s.l., Utah									1,250	1,250
South Paloma, g.s., Cal							1,200			1,200
South Lily, g.s.l., Utah									500	2,000
South Sliger, g., Cal								10,000		10,000
Spanish Bar, g.s., Cal					2,000	5,000	11,000	5,000		23,000
Spence Mineral, Cal									6,000	6,000
Springfield, g.s.l., Utah									5,000	5,000
Star, g.s., Utah					5,000	30,000	25,000		7,500	67,500
Sterling, g., Cal					15,000					15,000
Stockton, g.s.l., Utah									5,000	5,000
Success, g.s., Utah						9,750	3,000			12,750
Sumdum, g., Alaska									25,000	25,000
Sumdum Chief, g., Alaska									25,090	25,000
Sunbeam Con., g s., Utah				11,250	5,000	50,000	55,000			131,385
Sunrise, g.s.l., Utah									750	750
Sunset District Oil, Cal								7,500		7,500
Superior Oil, Cal								4,600		4,600
Sweet Vengeance, g.s., Cal							10,000			130,000
Tanama, g.s., Cal						10,000		30,000	10,000	50,000
Tesora, g.s., Utah							2,750	30,000		102,000
Tetro, g.s., Utah					18,000	15,000	15,000	27,000	12,000	90,500
Texas, g.s., Cal						15,000	30,000	10,000		55,000
Thorpo, g s., Cal					5,000	5,000				10,000
Tintic, g.s., Utah						4,375				4,375
Tintic Copper King, Utah									2,500	2,500
Tomboy, g., Utah							5,000		2,500	7,500
Tracy, g.s., Cal						5,000				5,000
Trent, g., So. Dak								1,500		7,500
Troy, g.s., Alaska				2,000	6,250	6,250				16,750
Tule Belle, g., Cal								10,000		10,000
Tuscarora Chief, g.s., Utah						2,000				2,000
Twentieth Cen., g.s.l., Utah									1,250	2,500
Ukiah Oil, Cal								10,000		10,000
Ultimo, g., Cal									30,000	30,000
Uncle Sam, g.s.l., Utah									6,000	6,000
Union Con., s., Nev	35,000	20,000	40,000	20,000	30 000	18,000	30,000	25,000	30,000	2,745,000
United Sunbeam, g., Utah								30,000	20,000	50,000
U. S. Grant, g.s., S. Dak							1,000			4,500
Usona Oil, Cal									1,000	1,000
Utah Con., s., Nev	5,000	5,000	10,000	30,000	20,000	15,000	15,000	20,000	20,000	540,000
Utah-Wyoming Oil, Utah									2,500	2,500
Uyak Bay, g., Alaska									3,000	3,000
Valeo, g.s., Utah						10,000	10,000			20,000
Vallejo, q., Cal					2,000	2,000				4,000
Valley View Oil, Cal								17,500		17,500
Vernon Oil, Cal								25,000		25,000
Victor, g.s., Utah			875				15,000	5,000	15,000	35,875
Victoria, g.s., Utah							4,000			4,000

ASSESSMENTS LEVIED BY MINING COMPANIES.—*Concluded.*

Name of Company.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Total Levied.
Victory, g.s., S. Dak	....	....	....	....	....	....	$300	....	....	$2,835
Virginia Con., g., Cal	....	....	....	....	....	....	....	....	$10,000	120,000
Vulcan Sm. & Ref., Cal	....	....	....	....	....	....	....	....	5,000	5,000
Wandering Jew, g.s.l., Utah	....	....	....	....	....	....	....	....	500	3,500
Wasatch, Utah	....	....	....	....	....	....	....	$6,000	....	6,000
Washington Con., g.s., Wash	....	....	....	....	....	....	200	....	....	2,000
Washington Oil, Cal	....	....	....	....	....	....	....	7,000	....	7,000
Watt Blue Gravel, g.s., Cal	....	....	....	....	....	$3,000	....	....	....	58,000
Wedge Exten., g.s.l., Utah	....	....	....	....	....	....	....	....	500	500
Wellington Oil, Cal	....	....	....	....	....	....	....	7,000	7,500	14,500
West Argent, Utah	....	....	....	....	....	....	....	10,000	....	10,000
West Century, g.s.l., Utah	....	....	....	....	....	....	....	....	5,000	5,000
Western Union Oil, Cal	....	....	....	....	....	....	....	....	1,000	3,000
West Lake Oil, Cal	....	....	....	....	....	....	....	10,000	....	10,000
West Morn'g Glory, g.s., Utah	....	....	....	....	....	....	1,250	1,250	13,750	21,000
West M't'n Placer, g.s., Utah	....	....	....	....	....	....	8,000	3,750	....	11,750
Willietta, g., Cal	....	....	....	....	....	....	....	10,000	20,000	30,000
Wilson & Barrett, g.s.l., Utah	....	....	....	....	....	....	....	....	30,000	30,000
Wisconsin Oil, Cal	....	....	....	....	....	....	....	25,000	....	25,000
Yankee Con., g.s., Utah	....	....	....	....	....	2,500	5,000	10,000	....	17,500
Yankee Girl, g.s., Utah	....	....	....	....	....	5,000	....	....	....	5,000
Ybarra, g., Cal	....	....	....	....	....	....	....	....	10,000	10,000
Yellow Jacket, s., Nev	$90,000	$90,000	$30,000	....	$24,000	36,000	42,000	36,000	36,000	5,94,0000
Young America, g.s., Utah	....	....	....	....	....	....	8,000	....	....	8,000
Yuba Con., g., Cal	....	....	....	....	2,500	....	....	45,000	6,000	53,500
Zacca Lake Oil, Cal	....	....	....	....	....	....	....	1,875	....	1,875
Zuba, g., Cal	....	....	....	....	5,000	....	....	....	....	5,000

c., copper; g., gold; i., iron; l., lead; q., quicksilver; s., silver; z., zinc.

GENERAL SUMMARY OF THE IMPORT DUTIES OF THE PRINCIPAL COUNTRIES IN THE WORLD. REVISED TO 1903.

Substance.	Austria Hungary. 100 kg. or ad. val.	Canada Ad. val. Tons. and lb.	Chile. Ad. val.	China. 133⅓ lb.	France. 100 kg.	Germany. 100 kg.	Italy. 100 kg.	Japan. 133⅓ lb. ad. val. Tons.	Mexico. Kg.	Russia. 36·112 lb (33)	Spain. 100 kg.	Sweden 100 kg.	United States. Ad. val. Tons and lb.
	$	$	$	$	$	$	$	$	$ Mex.	$	Pesetas	$	$
Alum........	0·609	Free.	30%	0·0815	0·965	0·714	0·193	0·099	0·25	0·23	1·80	0·335	0·005 lb.
Aluminum, crude....	Free.	Free.	30%	....	38·60	Free.	0·97	Free.	0·25	2·58	2·00	Free.	0·08 lb.
M'f'res.....	....	(1)25%	25%	....	38·60	14·28	19·30	....	0·25	2·393	48·75	....	45%
Antim'ny ore	Free.	Free.	Free.	....	Free.	Free.	Free.	Free.	Free.	0·15	0·80	Free.	Free.
Metal....	Free.	Free.	30%	....	1·158	....	1·16	5%	0·25	0·23	2·00	Free.	0·0075 lb
Arsenic......	0·203	Free.	30%	0·315	Free.	....	0·193	....	0·25	0·41	12·00	Free.	Free.
Arsenious acid......	0·203	Free.	30%	0·315	....	....	....	....	....	0·41	....	....	Free.
Asbestos, crude	Free.	Free.	30%	....	....	Free.	....	....	0·01	0·10	....	Free.	Free.
M'f'res.....	(2)	25%	5%	....	....	(3)	....	10%	....	1·30	....	Free.	25%
Asphalt......	Free.	Free.	30%	....	Free.	Free.	0·10	....	0·04	(4)0·0.7	0·60	Free.	3·00 t.
Barytes	....	....	30%	....	....	Free.	0·39	....	....	....	....	....	0·75 t.
Borax, crude	....	Free.	30%	....	Free.	Free.	0·10	0·619	....	0·62	12·00	....	0·05 lb.
Refined....	1·218	Free.	30%	....	1·93	Free.	0·10	0·619	....	1·35	12·00	....	0·05 lb.
Cement......	1·218	(a) 0·125	Free.	5%	(5)0·096	0·119	0·10	....	(b)0·50	0·10	....	0·161	(a)0·08
Coal..........	Free.	(6)Free.	Free.	0·126	....	Free.	Free.	0·44 t.	Free.	0·03	3·00	....	(6)Free
Coke..........	Free.	....	25%	0·105	0·023	Free.	Free.	0·395 t.	Free.	0·05	3·00	....	20%
Copper, pigs, ingots ...	Free.	Free.	Free.	0·70	Free.	Free.	0·77	5%	0·10	1·338	(7)	Free.	Free.
Bars, sheets	(8)3·25	Free.	25%	1·35	2·509	2·856	2·70	1·54	(9)0·12	2·39	(7)	1·34	0·25
Wire.......	(8)3·25	15%	25%	....	2·509	2·856	3·86	3·75	0·20	3·78	48·00	2·68	45%
Copper sulphate....	Free.	Free.	(10)15%	....	0·772	0·476	0·39	....	....	0·772	1·20	10%	0·005 lb.
Copperas	....	Free.	Free.	0·07	0·193	Free.	0·39	....	....	0·17	1·80	10%	0 0025 lb
Fluorspar....	Free.	....	Free.	....	....	Free.	Free.	....	....	....	....	....	....
Graphite, crude	Free.	10%	Free.	....	Free.	....	Free.	....	0·08	....	....	Free.	Free.
M'f'res.....	0·406	25%	25%	....	....	0·95	....	....	....	....	....	....	Free.
Hydrochloric acid......	0·203	20%	30%	....	0·071	Free.	0·193	....	....	0·348	2·60	Free.	25%
Iron, pig.....	0·325	2·50 t.	Free.	0·05	0·386	(11)0·238	0·58	0·042	0·01	0·27	2·40	Free.	4·00 t.
Bars.......	1·117	7·00 t.	Free.	0·087	0·965	0·595	(12)1·16	(13)0·178	....	0·464	11·40	0·67	0·006 lb.
Sheets and plates....	(14)1·624	....	Free.	0·067	(14)1·447	0·714	1·74	0·197	0·04	0·65	(15)15·60	(16)1·07	....
Steel, ingots	1·116	2·00	Free.	0·175	0·965	0·595	0·58	0·042	(b)0·50	0·417	6·00	0·54	(7)
Rails.....	1·116	30%	Free.	0·175	1·351	0·595	1·16	0·149	Free.	0·463	7·20	Free.	0·0035 lb
Tin plates	1·624	Free.	25%	0·28	(18)2·89	1·19	(19)2·70	0·346	(20)0·01	1·687	24·00	Free.	0 015 lb.
Lead in pigs.	0·812	15%	Free.	0·175	(21)0·77	Free.	0·10	0·184	0·05	0·077	3·00	Free.	0·02⅛ lb
Sheets, pipes wire......	2·030	35%	Free.	0·335	1·35	0·714	0·58	9·38	0·05	0·348	2·00	Free.	0·025 lb.
Mangan. ore.	Free.	Free.	Free.	....	Free.	Free.	Free.	....	....	0·054	0·80	Free.	(22)Free
Nickel, crude	Free.	(23)10%	25%	....	Free.	Free.	Free.	1·765	0·25	2·58	2·00	....	0·06 lb.
Bars, sheets	....	Free.	25%	5%	2·509	2·74	1·93	1·765	....	2·393	2·00	....	0·06 lb.
Petroleum, crude....	1·42	(c)0·025	Free.	Free.	(d)1·737	1·428	1·54	....	0·02	0·154	25·00	Free.	Free.
Refined....	2·03	(c)0·05	25%	Free.	(d)1 93	1·428	9·26	(c)0·008	0·01	0·772	40 00	Free.	Free.
Pyrites	Free.	....	Free.	....	Free.	Free.	Free.	....	....	0·008	....	Free.	Free.
Quicksilver..	Free.	Free.	30%	1·40	Free.	Free.	1·93	2·34	Free.	1·853	2·00	Free.	0·07 lb.
Salt	(24)0·34	(25)0·075	(26) 25%	Prohib.	(27)0·46	0·19	Prohib.	....	0·02	....	3·90	Free.	(28)0·12
Slate, roofing	0·41	25%	Free.	Free.	0·266	(30)0·30	....	....	0·01	0·077	....	....	20%
Soda.........	0·325	Free.	30%	....	(29)0·44	(29)0·21	0·10	....	0·03	(30)0·70	4·55	Free.	0·002 lb.
Nitrate	....	Free.	Free.	....	Free.	Free.	(29)Free	0·24	0·01	1·35	1·20	....	Free.
Sulphur	Free.	Free.	25%	(24)	(30)Free	Free.	Free.	....	0 01	0·015	1·50	Free.	(30)Free
Sulph'ric acid	0·304	25%	30%	....	Free.	....	0·10	....	....	0·17	2·60	0·14	(31)Free
Tin in blocks or pigs...	Free.	Free.	25%	0·875	Free.	Free.	Free.	0·996	0·12	0·348	15·00	Free.	Free.
Bars, plates, sheets....	2·03	Free.	25%	....	1·158	1·428	2·90	....	0·25	0·772	....	....	....
Zinc, blocks, pigs......	0·406	Free.	Free.	0·175	Free.	Free.	Free.	5%	0·01	0·386	6·00	Free.	0·015 lb
Sheets and plates....	1·218	Free.	25%	....	0·772	0·714	0·76	10%	0·07	0·772	18·00	Free.	0·02 lb.
M'f'res.....	2·03	25%	35%	....	2·316	(30)1·43	2·32	....	0·25	0·772	33·80	....	....
Zinc white...	1·218	5%	30%	....	5%	0·476	0·97	0·615	....	0·463	....	....	0·01 lb.

NOTE.—The United Kingdom exacts no import duties on the above substances.

(*a*) Per 100 lb. (*b*) Per 100 kg. (c) Per gallon. (*d*) Per hectoliter. (1) Hollow-ware, 30%. (2) Paper, unformed, $2·03 per 100 kg.; paper, formed, $4·872 per 100 kg. (3) Yarn, string and cordage, $5·712 per 100 kg.; tissue, $9·52 per 100 kg.; other articles, $14·28 per 100 kg. (4) Crude only. Ground asphalt, $0·1108. (5) Portland cement, $0·1447. (6) Anthracite only. Bituminous coal, $0·53 per ton in Canada and $0·67 per long ton in the United States. (7) Copper of first fusion, 15·00 pes.; in bars and ingots, 27·00 pes.; in sheets and rails, 42·00 pes. per 100 kg. (8) Plates, sheets and wires less than 5 mm. in section, $4·06 per 100 kg. (9) Bars only. Copper sheets and plates, $0·15 per kg. (10) Unrefined. (11) Iron for purpose of being wrought, $0·595 per 100 kg. (12) Rods, plates and bars more than 7 mm. in section. Material 5-7 mm. in section, $1·35; less than 5 mm., $1·74. (13) Bars and rods more than 0·25 in. in section. Bars and rods 0·25 in. or less in section, $0·333. (14) Sheets more than 1 mm. thick. (15) Plates more than 3 mm. thick, 12 85 pes. (16) Plates more than 3 mm. thick, $0·804. (17) Duty varies from $0·003 to $0·047 per lb. (18) Plates less than 6 mm. thick. (19) Plates more than 1·5 mm thick. (20) Plates more than 55 cm. in length or 40 cm. in breadth, $0·07. (2) Containing less than 25 g. silver per 100 kg. (22) Less than 50% Mn, $0·40 per ton. (23) Nickel anodes. (24) Can be imported only by special permission. (25) Duty per 100 lb. in package. Salt in bulk pays $0·05 per 100 lb. (26) Duty per kg. of refined salt. (27) Crude salt. Refined salt pays $0·5848 per 100 kg. (28) Per 100 lb. salt in package. Salt in bulk pays $0·08 per 100 lb. (29) ide soda. (30) Unrefined. (31) Not exceeding 1·38 sp. gr. (32) Coarse wares. (33) Coast shipments; land shipment du are higher.

AUSTRALASIA.

THE most important articles of mineral production in the seven colonies of Australasia are gold, silver, lead, copper, tin, iron and coal. These industries are referred to specifically under the respective captions elsewhere in this volume. The statistics of production, imports and exports as reported in the official statistics are summarized in the following tables:

MINERAL PRODUCTION OF NEW SOUTH WALES. (*a*) (*c*) (IN METRIC TONS AND DOLLARS; £1—$5.)

Year.	Alunite.		Antimony and Ore.		Bismuth.		Chrome Ore		Clay. (Fire.)		Coal.		Cobalt Ore.		Coke.	
														$		
1897....	736	$10,960	172	$18,060	3	$4,000	3,433	$51,845	....	......	4,453,729	$6,150,205	...	.....	65,229	$326,960
1898....	2,988	44,115	84	4,580	30	23,075	2,145	31,505	15	$160	4,781,551	6,859,163	119	2,800	83,538	394,674
1899....	935	13,815	332	13,470	16	16,775	5,327	87,080	27	330	4,670,580	6,628,995	193	4,495	98,074	385,650
1900....	1,946	23,725	252	12,145	11	28,200	3,338	59,185	29	545	5,595,879	8,344,555	145	7,950	128,238	548,100
1901....	3,196	47,190	90	5,915	21	33,825	2,523	38,870	17	175	6,065,914	10,894,645	112	5,255	108,764	528,825

Year.	Copper Ingot.		Copper Ore and Regulus.		Gold—Kg.		Iron. (*b*)		Iron Oxide		Lead, Argentiferous.		
											Metal	Ore.	Value.
1897....	6,864	$1,499,145	169	$4,255	9,088·9	$5,442,065	3,291	$109,810	234	$2,680	18,395	275,249	$8,407,640
1898....	5,744	1,400,240	181	4,195	10,590·4	6,223,649	5,283	211,250	398	4,160	10,270	394,676	8,223,845
1899....	4,715	1,650,600	1,358	848,470	15,433·8	8,759,075	6,604	277,500	402	4,230	20,614	431,126	9,968,720
1900....	5,712	1,975,515	1,494	164,665	10,801·6	5,972,605	7,863	475,000	318	3,430	19,400	426,480	12,569,870
1901....	5,781	1,915,490	1,132	151,020	8,345·7	4,606,410	10,594	618,750	181	1,145	17,206	406,691	9,272,815

Year.	Lead, Pig.		Manganese Ore.		Opal—Kg.		Platinum. Kg.		Shale, Oil.		Silver—Kg.		Stone.	
													Limestone Flux	
1897....	32	$1,990	..	....	2400·4	$475,000	61·2	$14,745	34,635	$303,060	4,666	$83,555	68,671	$308,990
1898....	1,745	96,410	1	$25	......	400,000	38·9	10,310	30,164	159,170	16,580	296,390	9,401	28,915
1899....	(*d*) 4,896	498,945	*Nil*	.....	......	675,000	19·8	5,350	37,307	204,115	21,525	384,565	1,016	2,750
1900....	(*d*) 6,807	695,730	18	230	......	400,000	15·6	6,035	23,229	103,260	24,080	451,215	17,278	19,810
1901....	(*d*) 8,394	502,505	12	120	......	600,000	12·2	3,895	55,669	207,445	14,016	252,420	27,804	28,970

Year.	Tin, Ingot.		Tin Ore.		Zinc Ore.		Sundry Minerals
1897....	1,159	$350,640	14	$2,800	29,303	$118,440	$37,160
1898....	908	302,825	1	175	39,564	144,705	10,105
1899....	835	490,690	5	1,450	50,677	246,035	24,850
1900....	915	600,160	15	4,500	20,594	290,930	25,780
1901....	677	384,265	11	2,320	642	20,285	10,145

(*a*) From the Annual Report of the Department of Mines and Agriculture, New South Wales. (*b*) Manufactured from old iron. (*c*) In addition to the above there is a small output of diamonds, which amounted to 56,352 carats ($156,965) for the ten years preceding 1898. (*d*) Includes carbonate and chloride.

MINERAL IMPORTS OF NEW SOUTH WALES. (*a*) (IN METRIC TONS AND DOLLARS; £1—$5.)

Year.	Brass. (Yellow Metal.)	Cement—*Barrels*.		Chrome Ore.		Coal.		Coke.		Copper.	
										In Matte and Regulus.	
1897....	$69,290	184,831	$408,210	2,731	$49,240	1,755	$6,065	33,970	$511,980	42	$3,680
1898....	102,250	183,851	418,560	4,780	82,770	666	2,965	4,064	61,735	.....	....
1899....	142,945	247,393	622,245	4,009	63,380	2,453	6,520	433	8,020	91	16,755
1900....	194,500	177,076	455,455	279	4,125	2,743	20,205	516	10,750	22	1,275
1901....	200,350	230,365	559,160	388	5,450	6,149	34,600	439	9,090	59	3,880

Year.	Copper—*Continued.*					Gold.		Iron and Steel.					
	Ingot.		Ore.		Rod, Sheet, and Wire.	Coin.	Bullion and Ores.	Pig.		Ore.		Manufactures. (*c*)	
1897....	6	$1,585	1,401	$92,440	$96,445	$5,749,095	$10,898,540	16,256	$969,470	1,293	$8,095	71,469	$3,904,105
1898....	8	1,000	1,018	40,245	61,685	18,823,980	9,779,270	12,081	189,885	2,698	8,525	65,140	3,621,285
1899....	43	11,560	9,209	346,500	185,370	8,510,800	12,908,555	9,153	168,895	4,205	14,615	89,957	5,294,515
1900....	85	12,400	7,076	366,470	289,605	7,212,835	15,857,095	18,280	883,130	6,350	20,545	86,886	6,203,885
1901....	4	1,670	3,577	164,820	347,690	6,328,900	18,372,410	9,649	186,040	4,252	2,290	96,816	5,704,390

Year.	Lead.				Nickel Ore.		Petroleum, Refined. *Liters.*		Potassium Salts. Nitrate.		Quicksilver. *Flasks.*	
	Pig.		Pipe, Sheet and Old.									
1897....	5,281	$289,590	308	$20,235	208	$5,000	11,027,291	$492,275	176	$18,455	470	$12,255
1898....	2,379	135,330	49	3,685	788	7,575	13,723,963	563,690	181	17,170	469	17,005
1899....	1,963	125,580	75	6,145	(*b*)	....	17,335,661	883,255	114	11,115	398	17,010
1900....	5,787	444,560	23	3,705	508	10,800	16,897,928	907,900	122	13,565	228	10,425
1901....	2,781	165,190	67	6,385	(*b*)	....	30,844,110	138,383	186	13,795	290	12,525

Year.	Salt.				Silver.							Slate.	
	Rock.		Brine. *Bags.*		Coin.	Ingot—Kg.		In Matte—Kg.		Ore.		Roofing—*Number*	
1897....	4,654	$34,110	36,722	$261,230	$181,630	288	$5,060	1,928	$35,500	1,288	$38,680	1,908,475	$78,990
1898....	8,647	59,220	30,991	217,115	286,010	267	4,980	....	....	964	37,625	1,893,871	90,240
1899....	7,987	46,480	34,587	231,740	354,185	299	5,975	1,045	18,715	3,070	95,045	2,825,687	113,690
1900....	3,662	23,120	28,305	210,790	810,480	342	6,955	132	2,370	1,880	83,445	2,350,980	96,025
1901....	5,758	35,930	29,782	231,160	494,600	87	1,645	438	8,800	1,648	121,670	2,062,790	77,315

Year.	Slate—*Cont'd.*		Sodium Salts.								Stone, Excepting Marble.
	Slabs. *Number.*		Bicarbonate.		Carbonate. (Crude.)		Carbonate. (Crystals.)		Hydrate. (Caustic.)		
1897....	2,605	$8,575	788	$31,395	1,452	$50,583	495	$7,940	1,213	$66,900	$27,065
1898....	3,482	12,430	953	36,495	1,469	38,905	468	13,440	1,241	68,225	30,235
1899....	5,807	13,135	1,200	39,080	1,716	42,525	566	19,875	1,209	61,680	31,065
1900....	10,176	20,230	979	32,475	1,341	39,755	185	5,180	1,492	81,765	46,590
1901....	8,258	9,565	845	27,165	1.957	65.885	116	3,800	1,426	88,065	41,935

Year.	Sulphur.		Tin.					Zinc.			
			Ingot.		Ore.		Plates.	Slabs.		Sheet and Manufactures.	
1897....	2,287	$33,955	693	$205,135	662	$104,510	$200,350	1,341	$122,815	561	$58,010
1898....	1,845	26,960	478	161,245	554	92,665	373,060	1,220	122,825	377	43,905
1899....	1,575	23,575	681	396,095	868	262,455	258,085	724	90,720	225	35,005
1900....	2,208	56,510	299	195,205	741	254,710	643,940	1,084	122,825	514	73,000
1901....	859	24,910	166	100,415	876	297,815	498,780	1,175	111,445	414	52,925

(*a*) From the *New South Wales Statistical Register.* (*b*) Not stated in the reports. (*c*) In addition there were imports of manufactures for which no weights are stated; in 1897, $68,495; 1898, $186,640; 1899, $86,690; in 1900, $96,205; and in 1901, $79,060.

MINERAL EXPORTS OF NEW SOUTH WALES. (*a*) (*e*) (IN METRIC TONS AND DOLLARS; £1 = $5.)

Year.	Antimony.						Bismuth Ore.		Cement. *Barrels.*		Chrome Ore.		Coal.		Cobalt Ore.	
	Ore.		Auriferous.		Metal.											
1897..	49	$2,510	21	$1,500	102	$14,050	23·3	$4,150	15,272	$39,185	5,959	$101,320	2,739,769	$4,760,270	73	$2,500
1898..	57	2,150	13	795	18	1,570	31·5	23,775	16,801	45,420	6,924	122,775	2,836,465	4,813,340	184	4,450
1899..	314	11,820	18	1,650	1	20	15·8	16,775	12,297	36,030	9,795	167,930	2,843,810	5,028,970	347	11,095
1900..	258	12,680	(*c*)	....	1	175	7·3	9,785	9,987	26,680	3,618	63,635	3,424,366	6,365,170	148	8,000
1901..	88	5,725	(*c*)	....	2	405	15·1	18,140	4,742	13,485	2,907	45,770	3,526,521	8,409,120	112	5,255

Year.	Coke.		Copper.							Gold.	
			Ingot.		In Matte.		Ore.		Rod, Sheet, Wire.	Ore.	Coin.
1897....	32,221	$135,225	4,126	$964,880	2,778	$549,440	169	$4,255	$5,770	292,040	$21,783,235
1898....	31,284	125,330	5,285	1 285,715	460	114,765	181	4,195	12,950	227,410	32,645,300
1899....	48,706	181,980	5,532	1,936,700	1,163	397,660	482	17,710	21,245	13,970	17,446,430
1900....	75,598	302,755	6,771	2,341,085	626	129,195	867	35,470	13,885	19,705	26,949,110
1901....	79,382	208,905	6.275	2,079,810	477	124,775	656	26,265	13,615	16,075	20,317,990

Year.	Gold—*Continued.*		Iron and Steel.				Lead.						Nickel Ore.	
	Bullion—Kg.		Pig Iron.		Manufactures. (*b*)		Pig.		Pipe and Sheet.		Argentiferous.			
1897....	3,295	$2,048,690	1,183	$22,495	19,515	$1,297,820	2,100	$119,395	1,043	$77,725	18,395	$3,227,885	208	$4,900
1898....	3,326	2,022,925	1,294	31,060	15,454	1,021,015	3,367	191,210	707	57,945	10,271	1,605,680	785	9,800
1899....	7,209	4,614,635	639	12,785	16,550	1,176,695	4,865	283,235	1,839	125,160	20,582	2,023,640	71	840
1900....	3,930	2,302,390	835	22,125	18,269	1,415,415	7,362	573,415	1,420	136,525	18,277	1,794,320	(*c*)	....
1901....	2,115	1,272,520	279	6,650	14,045	1,149,930	1,695	114,650	1,358	107,030	17,192	1,561,710	(*c*)	....

Year.	Potassium Salts. Nitrate.		Salt.				Silver.					Sodium Salts.	
			Rock.		Brine—*Bags.*		Coin.	In Matte—Kg.		Ore.		Bicarbonate.	
1897....	6	$5,730	330	$3,065	4,752	$58,880	$99,545	2,454	$41,860	276,807	$5,205,525	61	$2,795
1898....	42	4,365	438	3,685	5,166	60,445	149,360	8,794	152,655	396,057	6,684,955	124	5,580
1899....	37	1,840	315	2,520	5,491	59,985	312,475	17,588	312,665	498,520	7,901,180	105	3,915
1900....	20	2,300	392	3,600	2,904	30,595	308,590	27,887	519,500	428,615	10,816,160	117	4,215
1901....	28	3,100	165	1,705	1,235	14,270	182,640	17,327	314,490	406,560	7,458,235	78	2,780

Year.	Sodium Salts—*Continued.*				Stone.	Sulphur.		Sulphuric Acid.		Tin.				
	Carbonate. (Crude.)		Hydrate. (Caustic.)							Ingot.		Ore.		Plate.
1897....	117	$4,010	90	$4,660	$3,545	32	$1,300	52	$3,495	1,837	$556,345	143	$2,800	$78,205
1898....	285	9,595	182	6,530	3,505	38	1,565	24	1,390	1,384	481,925	1	175	55,040
1899....	139	4,145	297	12,725	5,575	102	4,175	43	2,460	1,876	1,108,735	7	2,225	141,560
1900....	217	6,640	191	11,490	7,040	99	4,215	53	3,750	1,777	1,159,085	15	4,500	122,770
1901....	63	2,295	298	18,495	6,655	80	3,415	21	1,770	1,389	774,230	21	6,220	97,145

(*a*) From the *New South Wales Statistical Register.* (*b*) Values including those of manufactures for which no quantity is stated, as follows: In 1897, $9,125; 1898, $14,445; 1899, $18,150; in 1900, $9,810; and in 1901, $6,820. (*c*) Not stated in the reports. (*d*) Probably bismuth metal. (*e*) There was also exported from N. S. W. in 1897, iron oxide: 246 metric tons, $2,830, and iron ore, 5 metric tons, $35.

MINERAL PRODUCTION OF NEW ZEALAND. (*a*) (*b*) (IN METRIC TONS AND DOLLARS; £1 — $5.)

Year.	Antimony Ore.		Coal.		Coke.		Gold—Kg.		Manganese Ore.	
1897............	10	$785	854,164	$2,259,575	14	....	7,827	$4,901,020	183	$2,705
1898............	*Nil.*	....	921,546	2,378,655	9	....	8,714	5,403,445	220	3,515
1899............	*Nil.*	....	990,838	2,488,085	18	$45	12,117	7,565,865	137	2,035
1900............	8	505	1,111,860	2,943,890	*Nil.*	....	11,775	7,198,010	166	2,940
1901............	30	680	1,247,280	3,330,870	*Nil.*	....	14,168	8,768,915	208	3,070

MINERAL PRODUCTION—*Continued.* ‖ MINERAL IMPORTS. (*c*) (IN METRIC TONS; £1—$5.)

Year.	Mixed Ores. Unspecified.		Silver—Kg.		Coal.		Machinery.	Railway Materials.	Tools and Implements.
1897............	1,586	$29,460	5,716	$104,360	112,681	$490,695	$3,005,265	$682,855	$450,905
1898............	1,857	23,960	9,140	165,535	117,274	526,115	2,349,315	499,985	555,755
1899............	1,330	32,945	10,866	204,190	101,259	464,075	2,267,075	636,820	465,100
1900............	2,126	63,755	10,202	194,395	126,059	602,030	2,936,830	1,007,960	645,385
1901............	707	33,875	17,762	326,290	152,160	756,670	3,244,950	3,814,275	701,015

(*a*) From *New Zealand Mines Statements*, by the Hon. A. J. Cadman, Minister of Mines, Wellington. (*b*) The exports are stated to be identical with the production, except in the case of coal, of which substance the exports were as follows: In 1897, 77,280 tons, value, $347,975; in 1898, 57,333 tons value, $251,905 ; in 1899, 90,912 tons, value, $415,425; in 1900, 116,216 tons, value, $497,870. (*c*) From *British Statistical Abstracts.*

MINERAL PRODUCTION OF QUEENSLAND. (*a*) (IN METRIC TONS AND DOLLARS; £1 —$5.)

Year.	Antimony Ore.		Bismuth Ore.		Coal.		Copper Ore.		Gems.	Gold—Kg.		Lead.		Manganese Ore.	
1898.....	(*c*)	....	8	$3,500	414,461	$752,465	63	$10,830	(*c*)	28,616	$13,751.745	252	$12,400	68	$1,255
1899.....	(*c*)	....	2	2,470	501,913	878,575	164	47,490	(*c*)	29,451	14,190,595	57	3,650	747	14,155
1900.....	41	$1,000	8	9,325	505,252	868,525	386	115,20	$4,500	30,099	14,358,545	207	16,795	77	1,025
1901.....	(*c*)	....	20	18,420	548,104	949,385	3,110	971,130	30,000	18,610	12,709,460	570	34,965	221	3,975
1902.....	(*c*)	....	1	615	509,555	861,430	3,845	946,000	25,000	19,920	13,603,195	271	13,530	4,674	84,945

Year.	Opal.	Silver Ore.		Silver—Kg.		Stone. Building. (b)		Tin Ore.		Tungsten Or	
							$				
1898..........	$33,225	3	$52,925	3,235	$52,925	(c)	....	1,041	$182,510	79	$12,700
1899..........	45,000	5	78,855	4,581	78,855	164,939	112,390	1,322	336,510	263	50,300
1900..........	37,500	4	63,560	3,514	63,560	152,484	107,585	1,133	370,205	193	33,095
1901..........	37,000	18	311,205	17,777	311,205	(c)	....	1,688	466,615	73	5,725
1902..........	35,000	(c)	....	21,818	350,725	(c)	....	2,118	580,855	56	5,835

MINERAL IMPORTS OF QUEENSLAND. (d) (IN METRIC TONS AND DOLLARS; £1 — $5.)

Year.	Cement and Plaster of Paris—*Barrels.*		Coal.		Coke.		Glass and Glassware.	Gold Bullion—Kg.	
1897..........	65,230	$159,375	21,624	$98,370	81	$505	$106,060	176·9	$91,490
1898..........	56,441	143,425	23,281	99,125	199	1,290	217,015	198·0	115,625
1899..........	86,986	233,735	33,863	135,825	*Nil.*	....	164,395	306·4	172,260
1900..........	70,217	188,595	31,592	150,315	57	250	295,470	81·0	49,645
1901..........	44,097	112,515	26,155	120,630	5,857	24,355	251,685	85·2	47,110

Year.	Gold Specie.	Iron and Steel.		Petroleum—*Gallons.*		Silver Bullion. Kg.		Silver Specie.
		Rails, Track Material.	All other.					
1897..........	$59,350	$121,950	$1,586,605	1,369,178	$278,070	11·1	$265	$113,145
1898	1,330,500	440,590	1,761,220	1,928,311	329,955	26·8	375	54,840
1899..........	818,000	335,360	2,660,860	1,867,755	357,485	8·6	175	152,655
1900..........	1,660,225	1,219,815	2,453,350	1,584,217	347,410	8·8	95	141,325
1901..........	1,094,000	646,475	1,961,735	1,961,921	419,825	9·4	240	42,780

MINERAL EXPORTS OF QUEENSLAND. (a) (IN METRIC TONS AND DOLLARS; £1 — $5.)

Year.	Antimony Ore.		Bismuth Ore.		Copper.								Gold—Kg.		Gold Ore.	
					Ore.		Ingot.		Matte.		Regulus.					
1897..	25	$2,500	39	$40,150	241	$15,425	196	$34,515	150	$21,925	148	$35,075	25,293	$12,843,510	220	$19,236
1898..	9	300	6	1,710	375	28,845	(c)	....	5	1,825	2	1,980	29,390	14,278,905	748	75,790
1899..	15	2,110	2	1,755	737	54,620	4	1,070	104	22,405	137	34,660	31,656	14,574,950	513	47,455
1900..	11	1,575	5	5,135	1,970	176,150	(c)	....	57	14,245	77	32,000	29,307	14,000,365	762	97,110
1901..	20	1,000	37	18,200	2,028	259,050	(c)	....	3,021	642,005	32	1,450	26,607	12,724,800	867	127,210
1902..	......	....	...	....	2,968	256,270	59	14,640	4,486	761,020	1	200	27,546	13,521,800	705	97,430

Year.	Precious Stones	Silver.						Tin Ore.		Tin.		Tungsten Ore.	
		Ore.		Silver-Lead Bullion.		Doré Bullion.—Kg.							
1897..........................	$5,700	259	$35,080	301	$37,850	1,823	$210,565	636	$115,750	161	$675	(c)	....
1898..........................	7,735	207	39,370	(c)	....	1,951	206,065	535	103,455	150	55,900	2	$120
1899..........................	11,950	332	54,686	4	875	1,930	173,945	709	221,615	358	198,180	371	131,090
1900..........................	660	61	9,260	15	3,050	1,047	159,780	596	209,075	283	190,715	232	69,765
1901..........................	1,765	506	48,255	......	2,160	1,488	207,305	808	267,275	485	308,330	76	8,760
1902..........................	2,745	81	6,630	......	2,195	2,078	429,045	774	258,115	677	399,375	125	19,385

(a) From *Annual Reports of the Under Secretary of Mines*, Queensland, when not otherwise stated. (b) From *Mineral Statistics of the United Kingdom.* (c) Not reported. (d) From *Statistical Abstracts for the Several Colonial and other Possessions of the United Kingdom.*

MINERAL IMPORTS OF SOUTH AUSTRALIA. (a) (IN METRIC TONS AND DOLLARS; £1—$5.)

Year	Coal.		Coke.		Gold and Silver Bullion and Specie.	Iron.				Silver-Lead.			
						Bar, Sheet, Hoop, and Rod.		Galvanized, Plain, and Corrugated.		Metal.		Ore.	
1897..	378,495	$1,012,140	75,205	$402,620	$78,840	6,505	$229,970	6,486	$454,750	17,466	$2,989,810	301,990	$5,221,195
1898..	420,001	1,121,795	82,796	428,705	47,685	10,076	287,500	6,627	501,245	3,455	621,885	415,861	6,856,645
1899..	444,539	1,223,595	54,166	318,145	963,920	6,023	216,605	6,863	523,475	208	59,750	480,104	8,331,495
1900..	508,769	1,520,605	72,247	458,675	424,120	5,726	270,705	7,555	732,150	(c)	....	571,598	11,499,005
1901..	483,811	1,425,290	64,254	383,880	595,278	5,471	221,690	5,577	460,080	(c)	....	341,774	7,758,660

(a) From *British Statistical Abstracts.* (c) Not reported.

MINERAL EXPORTS OF SOUTH AUSTRALIA. (*a*) (IN METRIC TONS AND DOLLARS; £1—$5.)

Year.	Coal.		Copper.		Copper Ore.		Gold Bullion—Kg.		Lead.		Lead. Argentiferous.	
1897......	39,480	$121,210	4,784	$1,192,835	554	$23,200	556·5	$345,670	21,283	$1,099,020	16,474	$2,548,515
1898......	39,399	124,680	*b*4,857	1,227,020	545	19,960	593·2	373,450	22,250	1,298,650	27,106	2,944,635
1899......	47,568	154,440	*b*5,597	2,034,250	3,356	150,100	501·5	315,955	25,639	2,202,680	21,298	2,832,835
1900......	78,945	269,515	*b*4,892	1,861,250	2,406	112,630	533·5	340,980	41,900	3,371,880	12,673	1,870,605
1901......	44,458	145,625	*b*6,847	2,348,935	1,899	115,065	381·4	238,775	41,230	2,488,980	13,135	1,244,600

Year.	Lead Ore. Argentiferous.		Manganese Ore.		Matte.		Mica.	Salt.		Slate, Roofing.
1897.......	180,870	$5,394,000	(*c*)	....	2,324	$342,235	$5,690	*d*29,374	$174,805	$18,865
1898.......	139,567	4,779,410	5	$50	867	128,300	500	31,471	192,725	3,510
1899.......	188,916	5,869,280	102	590	1,298	174,110	(*c*)	35,628	220,570	5,280
1900.......	168,015	5,254,205	(*c*)	....	(*c*)	....	(*c*)	33,976	186,285	(*c*)
1901.......	157,899	5,088,060	144	2,050	163	40,000	(*c*)	41,681	266,685	*f*560

Year.	Tin Ore.		Zinc.		Various Ores.	
1897........	(*e*)	....	11	$590	53	$2,095
1898........	5	$25	18	1,290	30,981	516,765
1899........	1	75	27	2,215	844	38,010
1900........	(*c*)	....	(*c*)	....	(*c*)	....
1901........	8	1,985	17	1,050	1,418	27,745

(*a*) From the ***Mineral Statistics of the United Kingdom***, except the figures for 1897, which are from ***British Statistical Abstracts***. (*b*) Includes yellow metal. (*c*) Not reported. (*d*) Exported in 1897, rock salt, 2 metric tons ($30). (*e*) No tin ore exported in 1897; but tin, block and sheet, 2 metric tons ($825). (*f*) Slates, wrought and unwrought.

MINERAL PRODUCTION OF TASMANIA. (*a*) (IN METRIC TONS AND DOLLARS; £1—$5.)

Year.	Coal.		Copper Ore.		Gold—Kg.		Iron Ore.		Lead-Silver Ore.		Stone. Limestone. *Tons*	Stone. Limestone. Total Value.
1897................	48,210	$84,640	113,261	$1,618,250	2,399	$1,446,205	999	$370	17,806	$966,125	1,702	$6,200
1898................	49,902	97,271	(*b*)	....	2,309	1,407,425	1,296	1,910	196,707	3,281,066	45,824	53,195
1899................	43,808	85,040	*c*60,985	2,792,860	2,612	1,637,725	6,726	16,400	424,552	8,168,690	71,747	202,699
1900................	51,549	108,550	*d* 4,221	817,945	2,525	1,581,100	5,141	25,800	453,579	7,917,020	47,671	65,245
1901................	49,963	99,215	*d*11,401	652,060	*e*12,161	1,475,880	1,422	9,000	804,463	8,068,185	26,545	39,350

Year.	Stone.—*Continued.* Freestone, Flagstones and Building Stones. *Cubic Feet.*	Stone.—*Continued.* Freestone, Flagstones and Building Stones. Total Value.	Stone.—*Continued.* Rubble or Metal. *Cubic Feet.*	Stone.—*Continued.* Rubble or Metal. *Tons.*	Stone.—*Continued.* Rubble or Metal. Total Value.	Tin Ore. Quantity. Alluvial.	Tin Ore. Quantity. Lode.	Tin Ore. Quantity. Total.	Tin Ore. Value. Alluvial.	Tin Ore. Value. Lode.	Tin Ore. Value. Total.
1897......	82,197	$5,805	95,202	18,274	$11,010	3,281	1	3,282	$545,545	$85	$545,630
1898......	19,560	4,025	525,258	70,701	89,235	2,882	......	2,882	578,810	....	578,810
1899......	14,400	3,079	88,425	12,060	18,151	3,333	......	3,333	1,354,320	....	1,354,320
1900......	51,509	56,010	13,562	4,291	19,915	2,492	201	2,693	814,035	69,975	884,010
1901......	37,579	10,940	240,867	244,721	329,515	2,229	287	2,516	636,410	91,235	727,645

(*a*) From *Statistics of the Colony of Tasmania*, Part V., Production. There was also mined in 1898, 6 tons of nickel ore, valued at $2,000. (*b*) Included with silver-lead ore. (*c*) In addition there were produced 8,496 tons of copper bullion, valued at $3,349,800. (*d*) In addition there were produced in 1900, 9,843 tons of copper blister, valued at $4,190,355; in 1901, 10,141 tons of copper blister, valued at $3,986,875. (*e*) Fine gold.

MINERAL IMPORTS OF TASMANIA. (*a*) (IN METRIC TONS AND DOLLARS; £1—$5.)

Year.	Cement and Whiting.		Coal and Coke.		Copper and Lead.	Glass, Sheet, Crown, and Plate.	Glassware Including Earthenware.	Gold Specie.	Iron. Railway Material	Iron and Tin Plate.	Jewelry and Plate.	Silver Specie and Bullion.
1897....	1,607	$16,895	41,436	$105,475	$4,950	$15,795	$84,845	$250,000	$89,190	$254,500	$44,740	$3,135
1898....	2,465	31,985	47,371	115,271	10,740	18,072	78,020	10,045	239,617	280,862	50,175	58,580
1899....	1,708	21,342	75,708	212,665	17,700	17,025	109,225	96,000	218,504	353,454	54,704	48,115
1900....	3,033	43,785	87,376	252,140	23,000	27,965	139,740	130,000	348,180	513,095	68,530	78,255
1901....	2,688	32,360	67,139	218,510	21,850	17,745	136,330	60,000	193,610	93,565	61,525	29,750

(*a*) From *Statistics of the Colony of Tasmania.* (*b*) Not reported.

MINERAL EXPORTS OF TASMANIA. (a) (IN METRIC TONS AND DOLLARS; £1—$5.)

Year.	Bismuth Ore.		Coal and Coke.		Copper Ore.		Copper. Blister.		Glassware Including Earthenware.	Gold. Ore.		Gold. Bullion—Kg.		Gold. Coin.
1897...	(b)	....	2,271	3,095	58	$4,560	4,585	$1,825,585	$360	421·6	$19,970	1,829	$1,181,440	(b)
1898...	4	$550	2,605	3,269	407	30,660	5,092	1,861,165	(b)	1,074·9	18,065	1,521	924,325	$325,000
1899...	6	4,500	2,740	6,005	1,735	119,125	8,476	3,690,275	(b)	547·6	23,505	1,647	1,006,175	(b)
1900...	(b)	....	2,782	5,150	4,289	317,945	9,348	4,190,355	(b)	80·5	1,600	1,729	1,022,720	(b)
1901..	(b)	....	20	85	10,189	740,580	9,886	4,398,160	350	298·9	26,245	1,727	1,020,820	(b)

Year.	Iron. Old Metal.		Iron. Rails.		Iron Oxide.		Lead.		Silver. Ore.		Silver. Bullion.		Tin. Ore.	
1897....	198	$1,450	57	$50	(b)	....	19·3	$725	19,828	$1,084,465	(b)	....	5	$2,960
1898....	117	1,295	(b)	....	20	$110	(b)	....	14,168	888,090	(b)	....	6	835
1899....	96	745	(b)	....	6	30	5	290	18,618	812,090	1,453	$232,255	58	18,120
1900....	(b)	......	(b)	....	(b)	....	5·5	415	12,387	860,890	2,337	399,570	13	3,195
1901....	288	2,970	(b)	....	1	50	5·6	315	15,984	944,645	4,164	682,030	80	18,220

Year.	Tin.—*Continued.* Metal.		Zinc.	
1897....	2,462	$749,970	42	$1,890
1898....	2,006	705,810	6	265
1899....	2,278	1,391,615	8	680
1900....	2,062	1,349,165	27	1,585
1901....	1,818	1,062,710	2	50

(a) From *Statistics of the Colony of Tasmania.* Additional exports in 1897: Jewelry and plate, $6,105; silver coin, $12,875; unclassified ore, 30 metric tons, $1,450; mineral sand, ½ metric ton, $5; copper metal, 1½ tons, $40; iron ore, 904 tons, $4,015; manganese ore, 2 tons, $30; mineral oxide, 5 tons, $45; in 1898: Jewelry and plate, $3,895; iron ore, 1,735 tons, $8,540; in 1899: Asbestic, 208 tons, $1,815; tin plates, $2,150; iron ore, 3,635 tons, $17,350, in 1901, asbestic, 47 tons, $225; iron ore, 622 tons, $2,585. (b) Not stated in the reports.

MINERAL PRODUCTION OF VICTORIA. (a) (IN METRIC TONS AND DOLLARS; £1—$5.)

Year.	Antimony Ore.		Coal.		Lignite.		Copper Ore		Gold—Kg. (b)		Lead Ore. Argentif.		Slate and Flagging.		Tin Ore.	
1897..	5	$100	240,057	$543,200	4,394	$6,885	(d)	....	25,280	$16,255,320	(d)	......	(d)	e$125,000	48	$8,250
1898..	118	2,550	246,845	515,495	2,915	3,835	(d)	....	26,041	16,745,140	20	$1,200	(d)	100,000	87	19,565
1899..	(d)	....	266,578	567,610	(d)	....	(d)	....	26,578	17,090,000	(d)	......	(d)	....	158	56,000
1900..	(d)	....	215,052	507,995	(d)	......	(d)	....	25,231	16,148,440	(d)	......	(d)	175,000	71	25,105
1901..	(d)	....	212,678	735,955	152	185	(d)	....	24,558	15,518,765	(d)	......	(d)	225,000	78	20,905

MINERAL IMPORTS OF VICTORIA. (c)

Year.	Coal.		Iron and Steel.	
1897..	585,812	$1,143,235	56,832	$2,294,645
1898..	571,326	1,288,440	....	2,074,705
1899..	541,199	1,380,685	....	3,507,105
1900..	701,616	2,018,615	....	3,762,965
1901..	722,298	2,230,290	....	3,570,060

MINERAL EXPORTS OF VICTORIA. (c)

Year.	Coal.		Coke and Charcoal.		Gold. Bullion.	Gold. Specie.	Silver. (Specie)
1897..	283	$1,980	1,212	$15,690	$969,055	$31,392,535	$11,605
1898..	411	1,775	567	7,033	1,355,240	28,253,685	122,300
1899..	445	1,695	430	8,810	988,210	20,821,110	144,500
1900..	78,929	186,535	279	2,760	433,000	20,227,305	114,875
1901..	11,814	43,285	305	6,560	481,485	21,011,605	30,500

(a) From *Annual Reports of the Secretary for Mines of the Colony*; additional products in 1897: Bricks, estimated value, $11,250; pottery, estimated value, $8,900; in 1898; Brick, $12,500; pottery, $10,000; infusorial earth, 142 tons, $1,400; in 1899: Infusorial earth, $1,250; brick, $15,000; pottery, $12,500; building brick, $100,000; in 1901; infusorial earth, 305 metric tons, $7,500. (b) The values are not separately stated in the report, and are estimated at $20 per oz.=$643·02 per kg. (c) From *British Statistical Abstracts*. (d) Not stated in the reports. (e) Represents estimated value of building stones, basalt, sandstone, granite, slate, flagging, etc.

MINERAL PRODUCTION OF WESTERN AUSTRALIA. (a) (IN METRIC TONS AND DOLLARS; £1—$5.)

Year.	Coal.		Copper Ore.		Gold.—Kg.		Iron Ore.	
1898......................	330	$20,500	6,263	....	28,986	$19,792,525	....	....
1899......................	55,208	129,755	3,012	$179,690	44,541	30,414,495	13,058	$44,695
1900......................	120,305	274,175	6,282	218,365	42,124	28,764,425	12,448	46,290
1901......................	119,721	342,805	10,319	376,230	51,914	35,448,840	20,898	66,990
1902......................	143,188	480,940	2,298	40,450	56,586	38,639,650	4,877	10,200

Year.	Lead Ore.		Limestone.		Precious Stones.		Silver.—Kg.		Tin Ore.	
1898.........	15	....	....	....	....	....	....	....	84	$1,165
1899.........	84	$4,560	17,875	$14,190	....	....	....	....	340	126,350
1900.........	272	2,665	16,183	17,970	(b)	$120	894	$17,970	886	283,510
1901.........	(c)21	760	18,501	21,740	(b)	5,000	1,893	38,045	746	200,000
1902.........	(c)36	1,335	5,161	6,700	(b)	120	....	....	680	198,915

(a) From the *Report of the Department of Mines of Western Australia*, and the *Blue Books for Western Australia.* (b) Weight not stated. (c) Silver-lead ore.

MINERAL IMPORTS OF WESTERN AUSTRALIA. (*a*) **(IN METRIC TONS AND DOLLARS; £1 — $5.)**

Year.	Brassware.	Cement. *No. of Barrels.*		Clay.			Coal.		Coke and Patent Fuel. *No. of Sacks.*		Copper.
				Bricks.	Earthen and Chinaware.	Tiles.					Ingot.
1897......	$23,935	47,457	$81,305	$12,120	$101,320	$16,365	139,369	$474,690	(c)	$10,825	$1,695
1898......	22,885	52,077	96,890	14,350	66,305	10,630	134,315	421,230	7,936	5,340	2,110
1899......	12,320	40,741	90,320	8,945	63,445	4,640	129,512	475,720	*d* 1,456	9,840	2,805
1900......	16,135	33,586	71,925	7,785	85,565	9,115	159,438	558,495	*d* 9,141	76,295	1,800
1901......	12,080	31,061	84,185	8,765	107,550	1,785	212,169	792,355	*d* 14,378	187,710	5,670

Year.	Copper.—*Continued.*	Copper Sulphate.	Glass and Glassware	Gold Coin.	Gold and Silver Leaf.	Iron.				
	Rod, Sheet, and Wire.					Pig.		Galvanized. (Corrugated Sheet.)		Other Manufactures.
1897......	$12,295	$625	$137,815	$225,000	$2,505	953	$14,095	11,689	$897,035	$661,630
1898......	18,095	885	86,740	675,000	4,265	1,431	20,620	8,997	685,575	681,145
1899......	15,515	(*c*)	105,890	25,000	1,905	1,379	25,345	4,280	841,770	649,785
1900......	23,455	2,800	85,835	(*c*)	2,445	2,565	47,950	9,455	745,570	893,225
1901......	24,690	4,110	145,450	(*c*)	(*c*)	(*c*)	....	7,139	557,695	557,890

Year.	Iron and Steel Wire.	Steel.	Lead—Sheet, Pig and Pipe.		Paraffine Wax.	Petroleum and Turpentine. *No. of Gallons.*		Plaster of Paris.		Quicksilver. *No. of Flasks.*	
1897......	$62,545	$80,340	537	$37,115	$3,750	1,058,022	$168,735	496	$6,225	623	$22,705
1898......	97,580	64,195	469	27,245	8,510	1,165,375	195,635	246	2,725	691	25,280
1899......	83,735	1,007,825	146	8,420	9,095	1,241,159	191,180	62	970	(*c*)	37,900
1900......	99,470	1,533,000	1,646	81,050	9,555	1,501,664	243,920	86	570	(*c*)	28,695
1901......	129,290	1,209,730	(*c*)	244,140	14,345	2,431,421	461,390	157	1,755	(*c*)	31,675

Year.	Salt.				Silver Coin.	Sodium Salts.				Stone.		
	Rock. *No of Sacks*		Other Kinds.			Carbonate. (Crystals.)		Hydrate.	Other Salts inc. Potash.	Grindstones. *Number.*		Marble and other kinds
1897......	(*c*)	$410	1,211	$11,568	$103,000	143	$2,730	$3,955	$4,940	(*c*)	$2,445	$20,190
1898......	332	275	1,346	12,665	1,050	137	2,390	5,510	6,505	1,206	1,140	19,190
1899......	(*c*)	205	1,567	14,290	5	(*c*)	....	(*c*)	(*c*)	(*c*)	1,085	18,250
1900......	(*c*)	850	1,596	15,965	17,390	(*c*)	....	(*c*)	(*c*)	(*c*)	770	11,230
1901......	(*c*)	185	1,794	15,915	123,250	22	595	11,755	14,160	(*c*)	1,790	17,130

Year.	Sulphur. *No. of Casks.*		Tin.		Whiting.	Zinc, Sheet and Ingot.
			Ingot.	Block, Foil, Plate, and Wares.		
1897......	(*c*)	$600	$6,360	$24,835	$1,530	$7,565
1898......	283	970	6,490	19,150	1,625	7,710
1899......	(*c*)	1,295	13,235	*e*4,900	1,530	16,530
1900......	(*c*)	3,940	13,165	23,410	1,755	8,860
1901......	(*c*)	970	2,835	21,800	1,415	12,570

(*a*) From the *Blue Books for Western Australia.* (*c*) Not stated in the reports. (*d*) Metric tons. (*e*) Foil and plate only.

MINERAL EXPORTS OF WESTERN AUSTRALIA. (*a*) **(IN METRIC TONS AND DOLLARS; £1 — $5.)**

Year.	Coal.		Copper Ore.		Gold.			Iron and Steel.	Lead Ore.		Mica.	Tin Ore.	
					Bullion—Kg.		Coin.						
1897......	23,756	$129,010	86	$5,165	20,994	$12,824 885	$3,130,400	4,165	(*b*)	$20	$1,045	96	$16,370
1898......	26,240	149,185	361	21,330	32,633	19,953,490	75,000	41,090	7	165	(*b*)	69	13,805
1899......	45,283	226,415	2,023	207,260	44,619	27,256,840	398,460	88,790	16	480	250	313	115,816
1900......	79,706	417,105	859	82,300	31,096	18,995,620	8,753,815	33,270	27	1,210	15	478	190,895
1901......	121,287	829,440	2,703	274,515	31,697	19,617,865	14,089,205	18,070	(*b*)	.....	(*b*)	515	197,475

(*a*) From the *Blue Books for Western Australia,* (*b*) Not stated in the reports.

AUSTRIA-HUNGARY.

THE latest official statistics of the mineral production, imports, and exports of Austria-Hungary are summarized in the following tables:

MINERAL PRODUCTION OF AUSTRIA. (*a*) (IN METRIC TONS AND DOLLARS; 5 CROWNS—$1.)

Year.	Alum.		Alum and Pyritous Shale.		Antimony.		Antimony Ore.		Asphaltic Rock.		Bismuth Ore.		Coal.	
1897	851	$22,164	21,585	$7,178	425	$45,292	864	$29,379	300	$3,547	1	......	10,492,771	$15,361,946
1898	1,037	29,126	28,914	8,547	343	46,694	679	22,867	648	6,242	*Nil.*	......	10,347,522	21,895,044
1899	604	16,718	19,879	6,711	271	33,692	410	15,244	2,635	15,184	0·3	$380	11,455,189	22,910,277
1900	620	18,426	3,004	3,608	153	14,844	201	7,065	887	9,603	4·0	2,558	10,992,545	19,118,184
1901	442	12,906	2,551	3,916	114	10,433	126	7,557	541	7,742	16·0	4,000	11,738,840	21,931,321

Year.	Coal, Lignite.		Copper.		Copperas.		Copper Ore.		Copper Sulphate.		Gold—Kg.		Gold Ore.	
1897	20,458,093	$16,033,769	1,083	$245,874	125	$1,254	7,405	$111,757	276	$23,204	67·6	$37,470	647	$13,175
1898	21,083,361	17,397,116	1,041	251,124	360	4,526	6,791	101,399	209	18,864	71·5	40,800	448	21,950
1899	21,751,794	19,033,493	1,123	368,417	475	3,907	6,731	96,601	235	20,295	75·7	37,746	387	12,408
1900	21,539,917	22,526,715	881	307,093	474	4,401	5,825	95,699	234	25,299	70·9	34,107	227	8,566
1901	22,478,510	25,087,512	770	254,347	472	4,438	7,406	119,241	256	26,727	46·6	20,007	143	6,363

Year.	Graphite.		Iron Ore.		Iron, Pig.		Lead.		Lead Ore.		Litharge.	
1897	38,504	$541,058	1,613,876	$1,506,419	762,685	$10,650,493	9,680	$630,484	14,145	$464,760	1,696	$106,268
1898	33,062	349,426	1,733,649	1,691,075	837,767	11,805,345	10,340	715,805	14,368	492,156	1,520	112,280
1899	31,819	395,280	1,725,143	1,968,261	872,352	13,342,588	9,736	748,978	12,820	509,732	1,526	117,132
1900	33,663	418,126	1,894,458	2,218,599	879,132	14,194,344	10,650	944,431	14,314	607,887	1,288	116,687
1901	29,992	363,702	1,963,246	2,310,428	884,844	13,374,003	10,161	727,085	16,688	548,810	1,317	109,038

Year.	Manganese Ore.		Mineral Paint.		Nickel and Cobalt Products(*b*)		Petroleum.		Quicksilver		Quicksilver Ore		Salt.	
1897	6,012	$19,184	3,653	$33,620	37·6	$10,022	275,204	$2,850,677	532	$476,048	88,238	$335,624	331,084	$10,224,576
1898	6,132	19,118	3,213	29,757	58·8	10,809	323,142	3,284,776	491	459,415	88,519	320,430	341,959	10,607,799
1899	5,411	18,239	2,055	24,567	38·1	8,572	309,590	3,185,541	536	492,021	92,323	354,946	342,059	10,124,760
1900	8,804	27,390	2,828	31,547	31·2	6,834	347,213	4,222,715	510	499,052	94,727	371,723	330,277	9,957,173
1901	7,796	25,466	1,701	26,743	20·5	2,998	404,662	4,602,118	525	547,513	97,360	392,705	333,238	9,888,281

Year.	Silver—Kg.		Silver Ore.		Sulphuric Acid.		Sulphur, Crude Rock		Tin.		Tin Ore.		Tungsten Ore.	
1897	40,026	$780,965	20,628	$748,720	8,515	$80,422	530	$1,935	48	$16,806	16	$769	31	$7,699
1898	40,304	754,022	20,886	705,038	7,003	63,769	496	1,661	48	18,849	13	758	36	13,333
1899	39,564	761,978	21,554	742,922	7,814	63,045	555	1,526	41	24,659	54	551	50	22,259
1900	39,572	781,519	21,641	759,299	7,067	46,970	862	2,256	40	27,651	51	1,266	50	14,010
1901	40,205	781,045	21,363	731,487	7,073	45,453	4,911	12,107	49	30,264	42	1,505	45	10,749

Year.	Uranium Ore.		Uranium Salts.		Zinc.		Zinc Ore.	
1897......	44	$18,004	4·4	$17,009	6,236	$486,344	27,463	$212,056
1898......	51	20,687	4·3	15,831	7,302	708,597	27,395	319,716
1899......	49	21,421	7·6	27,318	7,192	808,254	37,100	542,788
1900......	52	32,269	11·3	48,484	6,742	632,892	38,248	456,052
1901......	48	37,654	18·4	60,346	7,558	718,870	36,072	347,151

(*a*) From *Statistisches Jahrbuch des K. K. Ackerbau Ministeriums; Der Bergwerksbetrieb Oesterreiche.* Iron, common, cast, second fusion. (*b*) In 1897 and 1898 the figures represent nickel speiss, nickel sulphate and cobalt sludge.

MINERAL AND METALLURGICAL PRODUCTION OF HUNGARY. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Alum Ore.		Antimony.				Asphaltum.		Bismuth.		Carbon Bisulphide.		Coal.	
			Ore. (*b*)		Crude and Regulus.								Briquettes.	
1897..	*d* 60	$243	1,800	$34,563	528	$63,360	3,057	$65,001	4·7	$5,880	432	$7,132	27,022	$87,605
1898..	*Nil.*	....	2,201	20,219	855	109,681	3,125	66,422	3·1	5,880	771	56,393	31,781	102,840
1899..	*Nil.*	....	1,965	34,205	940	139,502	3,060	65,467	3·0	3,300	1,120	81,896	31,187	101,388
1900..	*Nil.*	....	2,373	37,720	846	123,070	2,900	60,997	2·0	6,397	1,250	90,000	69,358	231,554
1901..	*Nil.*	....	1,691	19,500	705	82,916	2,878	60,408	1·6	3,205	2,087	125,220	40,188	131,947

Year.	Coal—*Continued.*				Coke.		Copper.		Copperas.		Copper Sulphate.	
	Coal.		Lignite.									
1897......	1,118,024	$1,819,409	3,870,580	$4,118,139	(*c*)	....	213	$46,091	592	$1.199	6·5	$625
1898......	1,239,498	2,667,095	4,516,581	5,698,094	(*c*)	....	153	30,917	745	1,807	*Nil.*	....
1899......	1,238,855	2,640,015	4,292,584	5,948,062	10,336	$38,814	165	48,587	771	2,497	*Nil.*	....
1900......	1,367,190	2,897,369	5,128,277	6,868,197	12,973	56,174	181	52,109	700	2,240	*Nil.*	....
1901......	1,315,916	2,821,829	5,178,256	6,828,260	10,975	48,707	160	47,313	805	2,580	*Nil.*	....

Year.	Gold—Kg.		Iron Ore.		Iron, Pig.		Lead.		Lead Ore.	
1897......	3,068·00	$2,038,224	1,421,130	$1,530,967	402,508	$5,866,552	2,527	$149,302	525	$21,435
1898......	2,768·00	1,842,651	1,666,837	1,838,124	448,621	6,899,138	2,305	137,817	771	22,026
1899......	3,069·00	2,042,159	1,567,860	1,999,002	451,647	6,929,527	2,166	150,402	526	20,086
1900......	3,270·12	2,152,915	1,666,363	2,009,602	432,817	6,371,657	2,090	167,329	612	26,960
1901......	3,294·80	2,160,809	1,557,300	1,692,620	430,686	6,592,028	2,029	115,027	668	18,060

Year.	Litharge.		Manganese Ore.		Mineral Paints.		Nickel and Cobalt.				Petroleum.		Pyrites.	
							Ore.		Products.					
1897......	155	$13,888	4,030	$4,710	460	$2,976	32	$1,269	7·9	$957	2,299	$22,939	44,454	$71,500
1898......	188	15,854	3,087	3,776	247	893	*Nil.*	....	*Nil.*	....	2,471	24,746	58,079	93,522
1899......	213	18,351	5,073	5,765	394	507	*Nil.*	....	*Nil.*	....	2,125	21,822	79,519	129,879
1900......	201	18,859	5,746	6,479	370	2,320	*Nil.*	....	*Nil.*	....	2,199	22,378	87,000	133,482
1901......	338	17,250	4,281	6,080	305	518	*Nil.*	....	*Nil.*	....	3,296	33,067	98,907	150,480

Year.	Quicksilver—Kg.		Salt.		Silver—Kg.		Sulphur.		Sulphuric Acid.		Zinc Ore.	
1897......	700	$374	171,711	$5,375,788	26,790·0	$622,634	112	$3,317	3,397	$26,258	80	*Nil.*
1898......	6,800	5,562	178,551	5,679,534	18,799·0	448,427	93	2,883	1,818	13,906	30	$3,634
1899......	27,000	22,025	182,593	5,479,782	21,018·0	492,808	116	3,654	1,463	3,578	1,197	5,628
1900	31,800	25,466	189,363	5,456,600	20,202·0	461,234	123	3,818	1,371	3,290	326	1,427
1901......	33,300	33,292	184,083	5,668,200	22,636·0	541,972	137	3,847	1,464	2,807	693	2,466

(*a*) From *Magyar Statisztikai Evkönyv.* (*b*) This does not include the ore consumed in smelting the product of antimony. (*c*) Not stated in the report. (*d*) Represents refined alum.

MINERAL IMPORTS OF AUSTRIA-HUNGARY. (a) (IN METRIC TONS AND DOLLARS.)

Year.	Alum.		Aluminum and Alloys.		Aluminum Sulphate and Chloride.		Ammoniacal Liquor.		Ammonium. Chloride and Sulphate.		Ammonium. Hydrate.		Antimony. Ore.		Antimony. Regulus. Kg.	
1897......	346	$12,463	67	$50,096	1,351	$27,039	565	$2,710	339	$42,430	128	$6,677	8	$672	600	$78
1898......	334	12,018	101	62,143	1,822	29,146	230	1,105	430	42,288	80	4,150	12	1,088	28,200	4,004
1899......	332	11.938	120	58,015	1,299	20,789	72	363	358	37,957	46	2,587	10	840	30,400	5,107
1900......	430	15,476	154	68,420	1,435	22.954	176	879	574	64,265	65	3,488	46	3,822	23,000	3,450
1901......	418	14,800	152	87,000	1,882	37,600	293	1,400	620	64,000	44	2,800	27	2,200	1,500	250

Year.	Arsenic, Arsenious Acid, and Sulphide.		Asbestos. Crude.		Asbestos. Manufactures.		Asphalt. Crude Rock.		Asphalt. Mastic and Bitumen.		Barytes (Including M'f'd Product).	
1897......	259	$24,021	625	$33,041	134	$48,774	5,824	$38,894	1,309	$28,805	4,947	$52,128
1898......	287	34,080	609	33,316	136	54,200	5,973	40,621	1,117	24,574	5,012	52,776
1899	284	32,390	865	44,698	135	55,146	7,301	69,471	1,546	28,594	5,443	45,608
1900......	319	39,197	1,085	94,384	124	33,298	8.301	77,416	1,564	32,762	5,945	73,591
1901......	351	38,600	1,678	149,600	103	26,600	5,702	53,400	1,106	22,200	6,835	77,400

Year.	Borax. Crude, and Boric Acid.		Borax. Refined.		Brass, German Silver and Tombac. Crude, Old, and Remnants.		Brass, German Silver and Tombac. Bars, Sheets, Wire, etc.		Brass, German Silver and Tombac. Wares.		Cement.	
1897......	1,206	$68,772	63	$5,135	2,660	$489.052	152	$50,639	549	$658,920	32,479	$208,756
1898......	784	44,871	185	14,832	3,232	630,147	182	51,577	607	765,824	30,745	197,479
1899......	2,212	125,507	130	10,432	2,609	651,771	168	61,012	588	764,010	21,410	129,694
1900......	3,056	172,996	93	7,778	2,654	658,681	54	22,111	579	752,960	25,747	154,400
1901......	1,686	91,000	233	16,200	3,771	871,000	104	39,408	577	749,800	23,559	141,400

Year.	Chloride of Lime.		Chrome Ore.		Clay Products. Kaolin and Feldspar.		Clay Products. Manufactures.		Clay Products. Potters' and Other Clays.		Coal.	
1897......	1,820	$58,256	1,109	$22,188	6,913	$75,376	186,297	$1,233,200	28,925	$104 655	5,121,475	$10,552,887
1898......	2,851	85,542	2,206	39,701	7,991	88.160	183,822	1,230,400	31,905	114,859	5,396,760	12,524,317
1899......	3,749	113,045	1,874	35,990	8,152	94,016	177,119	1,110,000	30,799	110,876	5,296,700	14,072,800
1900......	3,326	106,422	2,823	59,287	6,847	80,981	179,748	1,116,400	30,418	91,256	6,242,939	19,068,689
1901......	2,326	65,200	860	18,000	7,687	84,600	190,663	1,119,400	36,448	131.200	5,827,332	18,024,800

Year.	Coal, Lignite.		Coke.		Copper. Ore.		Copper. Crude and Old.		Copper. Bars, Sheets, Wire, etc.		Copper Sulphate.	
1897......	19,609	$43,088	533,463	$2,279,648	81	$4,588	15,926	$3,981,080	94	$30,981	6,822	$577,990
1898......	19,393	42,446	606,783	2.876,321	64	1,272	17,443	4,706,135	159	55,142	5,271	453,398
1899......	20,879	46,850	564,005	2,652,153	*Nil.*	......	16,185	5,969,925	156	71,048	2,345	274,262
1900......	67,740	163,172	620,776	3,204,670	16	1,310	18,970	7,108,185	120	54,908	3,516	404,551
1901......	22,253	58,800	612,209	3,449,800	112	4,600	17,504	6,395,600	83	35,600	2,822	294,400

Year.	Copper and Iron Sulphates, Mixed.		Copperas.		Cryolite.		Fertilizers, Mineral		Fluorspar.		Glass. Crude and Ground.		Glass. Remnants.	
1897......	153	$5,512	401	$2.408	211	$44,194	7,583	$91.001	4,201	$41,344	270	$43,152	4,651	$32,558
1898......	93	3,352	466	2.330	275	58,676	8.482	101,784	4,169	41,809	299	47,840	6,860	48,021
1899......	28	994	408	1,920	342	73,822	8,120	64.964	4,958	41,947	341	54,600	8,574	60.017
1900......	45	1,602	343	1,715	342	68,550	5,757	46,200	5,649	48,615	360	57,632	6,618	46,400
1901......	...	.. ..	269	1,200	428	75,600	6,772	54,200	6,575	68,200	375	60,000	6,564	45,600

Year.	Glass.—*Continued.* Manufactures.		Gold.						Graphite.	
			Bullion—Kg.		Coin—Kg.		Old and Dross. Kg.			
1897.......	3,782	$874,800	33,668	$20,130,770	32,752	$17,895.693	5,572	$23,120	948	$15,322
1898.......	4,008	903,600	487	55,562	15,917	8,722,516	7,920	11,520	1,109	18,159
1899.......	4,081	873.400	719	425,887	13,850	7,549,419	9,401	6,802	815	13,491
1900.......	3,594	782,400	1,858	1,095,441	13.012	7,123.515	633	8,880	303	5,837
1901.......	4,225	699,600	22,800	18,660,200	37,000	20,052,800	3,000	14,600	318	6,000

Year.	Gypsum.				Hydrochloric Acid.		Iron.					
	Burned.		Crude.				Ore.		Pig and Old.		Manufactures.	
1897......	12,101	$106,487	960	$4,812	721	$5,765	134,778	$719,365	164,433	$2,390,800	28,876	$4,582,400
1898......	13,300	117,040	991	4,360	766	6,128	178,507	685 008	173,919	2,450,000	23,688	4,627,200
1899......	13,441	107,351	1,336	5,878	850	2,834	212,412	872,189	126,371	2,575.200	23,220	4,434,400
1900......	15,462	123,697	1,348	5,055	577	5,076	233,156	999,239	93,530	2,363,323	21,504	4,568,000
1901......	15,830	126,600	1,405	3,600	576	5.000	218,476	978,400	88,353	1,929,200	24,495	4,526,400

Year.	Iron and Steel. Bars, Sheets, Wire, etc.		Lead.									
			Alloys, Crude.		Bars.		Litharge.		Ore.		Red and Yellow.	
1897......	18,625	$698,000	5,887	$336,714	148	$11,240	234	$16,128	441	$14,124	543	$41,108
1898......	26,421	1,008,200	9,746	623,744	153	12,208	280	22,440	459	16,582	555	46,824
1899......	12,367	604,600	8,836	636,199	235	20,645	224	18,000	465	20,447	465	39,102
1900......	12,486	659,400	7,916	696,573	175	18,593	141	12,654	501	20,020	354	30,478
1901......	13,748	638,600	10,722	697,000	311	24,000	189	15,200	1,270	30,400	433	33,800

Year.	Lead.—*Con.*		Magnesite Calcined.		Magnesium Chloride.		Manganese Ore.		Millstones.		Mineral Paints.	
	White.											
1897......	111	$9,692	(*c*)	....	1,530	$32,953	8,018	$121,874	1,275	$71,394	4,553	$61,698
1898	115	10,589	(*c*)	....	2,196	31,442	5,396	69,070	1,429	80,018	4,979	68,912
1899	80	7,397	(*c*)	....	2,048	32,685	5,855	79,632	1,457	81,620	5,106	71,088
1900......	106	9,739	(*c*)	....	2,100	33,595	7,016	102,434	1,672	93,604	4.958	67,568
1901......	135	11,400	291	$2,400	2,528	32,800	6,367	84,000	1,595	89,400	5,109	97,400

Year.	Nickel.				Nickel and Cobalt Ores.		Nitric Acid.		Oxide. (Potash.)		Ozokerite.		Peat and Peat Coke.	
	Crude and Old.		Sheet, Wire, etc.											
1897......	267	$100,995	7	$7,282	55	$6,588	23	$1,271	333	$25,104	2·4	$288	2,189	$6,392
1898......	187	88,776	9	9,172	510	65,267	22	1,260	300	19,720	2·5	350	1,511	4,412
1899.....	119	78,342	11	11,152	198	26,110	39	2,181	526	37,100	0·5	70	2,075	6,000
1900......	258	172,798	8	8,716	406	56,896	36	2,005	1,029	84,398	0·2	36	2,664	7,991
1901......	277	190,800	10	10,000	788	126,200	22	1,200	1,441	100,800	5·0	800	2,896	9,200

Year.	Petroleum.				Phosphorus and Phosphoric Acid.		Potassium Salts.				Pyrites.	
	Crude.		Refined.				Chloride.		Chromate.			
1897......	70,573	$908,515	21,249	$592,782	209	$99,354	2,206	$79,382	34	$5,814	49,462	$237,417
1898......	58,580	725,788	22,299	684,381	209	97,984	2,258	81,281	3	408	52,282	209,128
1899.	75,885	1,131,905	21,823	707,800	221	108,589	3,264	228,478	1	154	54,844	285,187
1900......	20,812	178,787	22,962	860,783	204	95,855	3,633	210,737	11	1,680	60,817	337,776
1901......	22,545	189,400	18,067	539,000	221	69,200	4,356	252,600	21	3,400	54,202	303,600

Year.	Quicksilver. Kg.		Salt.		Silica, Quartz and Sand.		Silver.					
							Bullion—Kg.		Old and Dross—Kg.		Coin—Kg.	
1897......	1,000	$772	46,057	$184,260	61,532	$195,158	99,900	$1,814,184	1,000	$2,608	3,670	$75,944
1898......	6,300	5,090	41,870	167,520	70,296	219,200	15,400	274,131	3,000	1,380	5,470	108,424
1899......	2,600	2,423	37,833	151,583	71,279	282,020	28,930	527,338	600	1,420	5,060	110,300
1900......	1,300	1,365	39,822	159,263	87,980	306,714	29,300	550,661	2,700	2,510	8,630	196,208
1901......	2,600	3,250	39,625	158,600	83,401	466,200	41,800	788,600	1,700	1,400	8,900	204,600

Year.	Slag and Slag Wool.		Slate, Roofing and Other.		Sodium Salts.							
					Bi-Sulphate.		Carbonate.		Carbonate. (Calcined.)		Hydrate.	
1897......	4,717	$8,868	16,758	$406,080	91	$1,826	45	$1,068	2,787	$66,888	1,450	$49,518
1898......	9,655	19,319	16,026	399,200	89	1,784	58	642	2,408	45,451	1,498	51,868
1899......	5,665	11,830	15,562	379,550	85	1,698	68	748	1,128	28,591	1,669	57,521
1900......	4,679	9,858	13,047	319,646	73	1,464	104	1,252	1,141	28,528	1,836	62,000
1901......	3,068	6,200	11,555	284,200	98	2,000	77	1,000	911	21,800	1,293	54,000

Year.	Sodium Salts.—*Continued.*				Stone.							
	Nitrate.		Sulphate.		Lithographic Stone.		Marble.		Paving.		Not Elsewhere Specified.	
1897......	39,600	$1,584,016	2,879	$20,158	524	$20,739	2,333	$27,995	16,961	$67,843	118,848	$368,860
1898......	41,773	1,670,928	4,476	31,136	786	31,146	2,769	33,294	11,234	44,936	99,198	344,505
1899......	47,301	1,892,060	5,394	35,060	610	24,176	2,850	39,901	27,067	108,270	82,878	304,332
1900......	54,559	2,182,376	5,110	30,659	640	25,336	3,133	43,860	5,780	23,123	81,347	264,387
1901......	63,283	2,658,000	4,452	26,800	616	24,200	2,908	51,000	11,299	45,200	77,695	236,800

Year.	Sulphur.		Sulphuric Acid.		Tin.				Whetstones.		Zinc.	
					Ingot, Crude, Old, etc.		Salts.				Metal.	
1897......	21,406	$359,942	5,877	$58,967	3,467	$1,060,933	22·8	$4,995	4,151	$107,929	16,599	$1,394,299
1898......	20,655	358,316	9,724	97.389	3,769	1,318,016	20·9	5,518	3,490	90,750	17,471	1,712,168
1899......	23,504	387,938	10,245	102,692	3,004	1,742,610	30·2	10,570	3,717	96,645	15,225	1,887,863
1900......	27,795	444,228	10,643	106,717	3,439	2,214,652	23·9	9,082	3,643	94,721	17,843	1,820,080
1901......	25,300	379,200	11,712	117,400	3,671	2,144,000	24·9	6,800	3,445	75,800	16,921	1,421,400

Year	Zinc.—*Continued.*						Metal Wares Other than Iron and Precious Metals.		Ore and Minerals Unspecified.	
	Bars, Sheets, Wire, etc.		Calamine and Other Ores.		White.					
1897......	356	$37,214	7,868	$113,222	(*b*) 577	$55,790	2,056	$1,618,600	155,741	$1,731,515
1898......	453	52,461	14,112	259,659	(*b*) 697	59,783	2,121	1,754,800	158,997	1,674,265
1899......	481	70,996	12,730	254,596	(*b*) 750	74,580	2,292	1,971,600	174,249	1,831,760
1900......	667	93,651	14,181	340,332	(*b*) 875	83,971	2,091	1,755,800	181,052	1,926,710
1901......	579	74,200	18,408	331,200	423	89,000	2,089	1,720,000	183,089	1,692,200

(*a*) From *Statistik des Auswärtigen Handels Oesterreichisch Ungarischen Zollgebiets.* (*b*) Includes zinc sulphide. (*c*) Not reported separately.

MINERAL EXPORTS OF AUSTRIA-HUNGARY. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Alum.		Aluminum, Sulphate and Chloride.		Ammonium.				Ammoniacal Liquor.	
					Chloride and Sulphate.		Hydrate.			
1897....................	70	$2,307	210	$4,624	4,188	$193,295	39	$2,330	592	$3,553
1898....................	83	2,729	253	5,557	4,886	229,034	23	1,627	734	4,344
1899....................	54	1,822	233	5,319	7,576	381,887	41	3,046	734	4,406
1900....................	44	1,506	164	3,434	7,004	371,798	82	5,761	942	5,654
1901....................	55	1,800	211	5,000	8,863	468,600	118	8,400	705	4,200

Year.	Antimony.				Arsenic, Arsenious Acid, and Orpiment.		Asbestos.				Asphalt.			
	Ore.		Regulus.				Crude.		Manufactured.		Rock and Earth.		Mastic and Bitumen	
1897......	289	$25,467	359	$45,209	16	$1,629	56	$1,644	19	$12,000	102	$778	2,593	$25,980
1898......	266	23,417	679	89,694	29	3,276	150	3,567	28	22,149	183	1,418	2,126	21,264
1899......	562	49,447	240	38,384	47	6,729	71	2,136	60	33,202	1,143	9,984	2,619	41,800
1900......	247	21,727	276	39,758	65	6,833	47	2,570	167	56,420	1,218	8,589	2,177	34,826
1901......	179	13,600	385	49,200	80	9,600	86	2,800	165	55,200	298	2,800	1,909	30,600

Year.	Barytes, Including Manufactured Product.		Brass, German Silver and Tombac.				Cement.		Chloride of Lime.	
			Crude, Old and Remnants.		Bars, Sheets, Wires, Etc.					
1897.......	70	$2,928	1,699	$284,197	680	$269,856	19,786	$112,586	111	$3,552
1898.......	111	3,620	1,879	339,764	889	351,178	23,989	135,861	113	3,606
1899.......	65	1,161	1,824	421,087	910	378,314	38,193	198,606	208	6,490
1900.......	23	429	1,811	422,033	1,256	601,749	46,761	243,156	192	6,128
1901.......	55	1,000	2,006	466,800	1,054	521,800	44,728	232,600	738	20,600

Year.	Chrome Ore.		Clay Products.						Coal.	
			Manufactures.		Kaolin and Feldspar.		Potters' and Other Clays.			
1897.................	153	$3,663	55,895	$2,280,000	68,609	$918,756	46,968	$187,872	701,919	$2,133,251
1898.................	121	2,653	66,005	3,404,400	74,008	991,808	52,851	211,408	824,730	2,687,796
1899.................	53	1,052	72,104	3,524,200	78,537	1,055,430	61,898	247,594	879,236	2,823.766
1900.................	22	460	75,672	3,835,400	108,178	1,009,855	66,869	168,138	815,097	2,902.527
1901.................	63	1,200	62,916	3,946,000	97,087	947,400	57,571	146,400	748,802	2,760,000

Year.	Coal, Lignite.		Coke.		Copper.						Copper Sulphate.	
					Ore.		Crude and Old.		Bars, Sheets, Plates, etc.			
1897.....	8,108,975	$10,742,872	145,056	$790,594	0·1	$3	159	$38,232	180	$58,991	14	$1.305
1898.....	8,351,955	11,749,110	194,289	1,095,885	12	476	178	44,928	266	91,469	29	2,655
1899.....	8,662,788	12.879,387	252,971	1,481,120	74	3,690	584	190,938	298	183,547	66	7,960
1900.....	7,864,409	13,911,987	262,798	1,707,563	801	41,626	471	169,560	200	92,152	57	7,081
1901.....	8,076,575	16,249,000	303,651	2,142,400	1,042	61,400	435	148,000	384	139,800	23	2,600

Year.	Copperas.		Cryolite.		Fertilizers, Mineral.		Fluorspar.		Glass.			
									Manufactures.		Remnants.	
1897......	648	$6,870	10	$2,044	4,493	$44,979	27	$385	50,083	$8,948,000	2,086	$14,599
1898......	539	4,744	23	4,662	4,267	42,673	22	227	50,304	8,689,600	1,904	13,326
1899......	808	6,384	101	22,086	3,419	27,850	335	3,087	55,539	9,978,800	2,772	19,408
1900......	748	5,986	237	34,964	3,661	29,284	52	451	57,190	10,532,000	5,583	39,016
1901......	548	5,000	231	33,200	5,278	42,200	30	400	55,358	9,833,000	2,024	14,200

Year.	Gold.								Graphite.		Gypsum.	
	Ore.		Bullion—Kg.		Old, Remnants, and Dross—Kg		Coin—Kg.				Crude.	
1897......	37	$2,214	289	$110,896	119,336	$352,510	33,316	$18,324,070	14,229	$228,598	662	$2,914
1898......	13	810	27	12,528	187,478	371,760	42,620	23,428.432	17,109	252,235	718	3,160
1899......	67	6,336	38	17,632	163,160	308,800	22,770	12,523.500	19,451	283,771	633	2,787
1900......	1	96	298	119,200	182,690	312,220	20.628	11,411.409	18,996	296,643	502	1,506
1901......	0·2	......	100	41,800	149,800	347,200	12,800	6,779,200	14,900	238,600	461	1,200

Year.	Gypsum.—*Con.*		Hydrochloric Acid.		Iron.						Iron and Steel. Bars, Sheets, Wire, etc.	
	Calcined.				Ore.		Pig, Old, etc.		Manufactures.			
1897......	1,804	$15,875	1,439	$12,089	247,856	$941,852	12,084	$243,600	21,064	$4,362,400	17,387	$1,296.800
1898......	2,163	19,039	1,614	13,884	302,317	1,269,730	15,808	261,200	22,724	4,958,000	23,231	1,601,200
1899......	1,539	12,310	1,495	12,706	326,951	1,503.976	27,738	508.400	35,299	5,241,200	45,720	2,373,800
1900......	1,723	13,787	1,659	17,090	263,421	1,211,788	53,426	1,141,000	48,368	6.087,200	56,995	3,958,800
1901......	1,206	9,600	1,632	16,400	229,624	1,056,200	23,630	441,800	46,619	5,845,200	31,404	1,840,800

Year.	Lead.												Lime. (Hydraulic and Caustic.)	
	Ash.		Litharge.		Metal and Alloys.		Ore.		Red and Yellow		White.			
1897......	114	$3,181	355	$28,376	241	$15,868	2,438	$78,022	24	$2,008	47	$6,317	88,110	$379,166
1898......	100	3,209	188	16,579	545	56,300	2,253	81,122	45	4,132	55	7,796	89,067	407,569
1899......	99	3,859	188	16,600	258	21,058	2,502	110,070	45	4,108	40	5,711	85,570	359,486
1900......	66	2,244	242	22,245	398	35,096	2,628	99,860	21	1,955	34	4,910	86,273	379,599
1901......	112	2,600	179	14,200	68	4,800	4,143	111,800	32	2,800	22	2,600	82,398	362,400

Year.	Magnesite Calcined.		Manganese Ore.		Millstones.		Mineral Paints.		Nickel, Bars, Sheets, Wires, Etc.		Nickel and Cobalt Ores.	
1897......	(b)	....	622	$8,214	1,778	$106,886	1,621	$24,398	170	$145,184	117	$11,068
1898......	(b)	....	1,961	23,531	2,109	126,546	2,158	32,580	76	66,316	121	4,808
1899......	(b)	....	1,127	14,426	1,904	106,613	2,061	31,533	38	35,903	75	6,266
1900......	(b)	....	468	6,014	1,871	97,281	1,905	25,440	115	102,720	114	9,787
1901......	40,236	$321,800	398	5,000	1,971	102,400	1,947	31,200	89	78,800	120	10,600

Year.	Nitric Acid.		Oxide. (Potash.)		Ozokerite.		Peat and Peat Coke.		Petroleum.			
									Crude.		Refined.	
1897......	310	$20,902	5,997	$381,395	5,158	$762,570	1,655	$4,832	1,600	$15,364	13,082	$213,700
1898......	294	19,384	7,252	465,479	4,462	696,066	3,400	9,929	1,076	10,330	3,062	46,838
1899......	420	27,813	10,118	760,568	5,441	859,600	4,010	11,710	1,823	21,872	7,778	147,784
1900......	519	33,521	7,792	641,258	5,162	1,082,320	5,607	16,822	2,313	35,622	21,070	446,324
1901......	632	39,200	4,234	305,600	2,717	554,400	4,558	14,600	2,100	29.400	9,448	208,600

Year.	Potassium Salt Chloride.		Pyrites.		Quicksilver.		Salt.		Silica. (Quartz and Quartz Sand.)		Silver.	
											Bullion—Kg.	
1897......	1,005	$36,166	255	$1,379	529	$408,697	182	$1,091	31,347	$94,727	4,120	$66,250
1898......	994	35,798	3,039	16,418	468	378,548	240	1,439	39,033	117,806	4,870	78,310
1899......	974	35,078	5,201	29,123	490	456,680	117	705	68,412	210,142	48,240	849,024
1900......	879	31,633	17,162	102,969	492	517,020	1,915	11,490	69,434	212,744	54,000	961,200
1901......	909	31,000	16,491	99,000	540	546,800	3,616	21,600	29,580	97,000	21,900	298,400

Year.	Silver.—*Continued.*						Slag and Slag Wool.		Slate, Roofing and Other.	
	Coin—Kg.		Old and Dross. Kg.		Ore.					
1897......	114,560	$1,681,500	116,700	$68,648	(b)	....	65.966	$131,931	4,581	$102,461
1898......	26,130	378,376	121,400	71,280	1	$56	75,018	180,043	4,972	110,862
1899......	15,240	221,732	84,800	180.490	12	468	109,180	393.048	5,535	124,080
1900......	17,441	271,729	97,800	25,000	69	4,397	125,113	450,405	5,205	116,551
1901......	43,100	597,800	104,500	23,400	0·3	....	108,944	374,200	4,001	99,600

Year.	Sodium.										Stone.	
	Carbonate.		Carbonate, Calcined.		Nitrate, Crude.		Salts, Potassium Nitrates, Refined.		Sulphate. (c)		Lithographic.	
1897......	599	$7,782	3,372	$86,074	61	$2,562	120	$9,728	6,910	$55,281	22	$1,115
1898......	952	18,140	2,895	60,384	33	1,344	180	2,931	7,248	58,208	8	405
1899......	1,894	25,377	1,502	31,534	88	3,593	188	12,565	5,716	45,853	11	565
1900......	2,226	32,057	548	14,250	35	1,505	117	7,839	7,320	58,802	7	351
1901......	1,737	26,600	452	10,000	25	1.200	126	8,600	7,960	57,600	2	200

Year.	Stone.—*Continued.*								Sulphur.		Sulphuric Acid.	
	Limestone.		Marble.		Paving.		Not Elsewhere Specified.					
1897......	11,378	$22,747	2,994	$35,982	38,256	$221,886	223 321	$528,538	947	$18,950	7,903	$94,153
1898......	25,117	50,233	2,954	35,452	54,953	318,727	252,229	624,070	923	18,464	9,880	97,911
1899......	11,052	22,105	4,096	65,542	67,212	389,828	239,819	576,265	885	17,694	12,422	144,730
1900......	13,678	20,818	3,811	60,981	58,121	232,481	197,932	452,164	1,285	25,694	12,693	149,785
1901......	23,909	31,000	4,394	70,200	51,618	206.400	200,461	378,600	1,225	24,600	10,378	121,800

Year.	Tin.						Whetstones.		Zinc.			
	Ingot and Old.		Bars, Plates, Sheets, etc.		Ash.				Ash.		Metal.	
1897......	87	$20,880	75	$25,534	306	$66,009	2,323	$73,748	197	$14,198	770	$48,182
1898......	96	21,628	72	26,353	324	81,598	2,316	68,730	298	16,677	1,184	87,231
1899......	167	77,339	77	40,380	273	95,410	2,215	75,303	73	4,659	1,614	54,973
1900......	153	79,352	112	73,590	208	85,444	2,270	77,180	149	9,516	1,088	187,032
1901......	162	72,400	109	65,400	257	102,600	2,196	74,600	167	16,600	1,374	77,000

Year.	Zinc.—*Continued.*						Metal Wares Other than Iron and Precious Metals.		Ores and Minerals Unspecified.	
	Ores.		Sheets, etc.		White.					
1897.......	12,914	$247,950	993	$106,232	1,673	$140,532	4,486	$3,130,800	47,833	$680,364
1898.......	14,065	337,563	757	96,141	1,240	114,089	4,841	3,234,400	67,531	914,184
1899.......	20,461	613,818	1,313	211,468	1,096	100,823	5,250	4,078,400	82,865	1,081,906
1900.......	20,379	570,615	619	96,384	1,719	158,166	5,828	4,428,600	101,207	1,129,400
1901.......	23,150	463,000	813	119,000	2,720	232,800	5,187	3,954,200	55,581	610,200

(*a*) From *Statistik des Auswärtigen Handels des Oesterreichisch Ungarischen Zollgebiets.* (*b*) Not reported. (*c*) Includes magnesium chloride, etc.

MINERAL PRODUCTION OF BOSNIA AND HERZEGOVINA. (*a*) (METRIC TONS AND DOLLARS.)

Year.	Chrome Ore.		Copper.		Copper Ore.	Iron, Pig.		Iron Ore.	Lignite.		Manganese Ore.		Quicksilver.	Salt.	
1897	396	......	185	....	3,847	15,606	....	37,095	229,643	....	5,344	$33,772	(*b*)	13,919	$339,729
1898	458	......	156	....	3,760	15,263	....	57,985	270,752	....	5,320	....	4·0	14,496	....
1899	200	$3,136	180	$57,000	3,980	13,730	$181,465	67,080	308,000	$260,010	5,270	35,800	3·3	15,030	465,190
1900	100	1,400	141	47,472	3,008	38,960	531,359	133,454	394,516	312,447	7,939	45,000	6·7	15,791	430,557
1901	505	7,170	199	43,309	3,696	39,296	526,011	122,569	445,007	332,413	6,346	50,242	9·3	16,865	531,674

(*a*) From *Osterr. Zeits., für Berg-, Hütten und Salinenwesen*, except the figures for 1897 and 1898, which were furnished by the "Bosnisches Bureau des K. und K. gemeinsamen Ministeriums." Besides the substances specified in the table there was also produced: In 1897, fahlore, 40 tons; in 1898, 452 tons; in 1899, 620 tons; in 1900, 606 tons, and in 1901, 1,041 tons. Iron pyrites; in 1898, 3,670 tons; in 1900, 1,700 tons; and in 1901, 4,570 tons. (*b*) Not reported.

BELGIUM.

The most important articles of mineral production in Belgium are coal, iron, lead, zinc, manganese ore and phosphate of lime. Developments in these industries are described specifically under the respective captions elsewhere in this volume. The official statistics of production, imports and exports are summarized in the following tables:

MINERAL PRODUCTION OF BELGIUM. (*a*) (IN METRIC TONS AND DOLLARS; 5 f.—$1.)

Year.	Iron Ore.		Lead Ore.		Manganese Ore.		Pyrites.		Zinc Ore. Blende.		Zinc Ore. Calamine.		Totals.
1897........	240,774	$252,902	108	$3,230	28,372	$68,540	1,828	$3,990	6,804	$74,340	4,150	$41,270	$444,272
1898........	217,370	211,644	183	4,301	16,440	42,300	147	177	7,350	98,262	4,125	51,250	407,984
1899........	201,445	214,620	187	6,540	12,120	31,160	283	380	5,736	90,160	3,730	40,920	423,780
1900........	247,890	264,020	230	12,656	10,820	26,070	400	228	5,715	67,886	3,000	48,430	414,240
1901........	218,780	222,580	220	8,413	8,510	22,160	560	392	4,445	38,535	2,200	16,130	308,210

PRODUCTION OF MINERAL FUEL IN BELGIUM.

Year.	Coal. Quantity. Metric Tons.	Coal. Value. Total.	Coal. Value. Per Ton	Coal. Profit. Total.	Coal. Profit. Per Ton	Coal. Number of Workmen.	Coal. Average Annual Wages.	Coke. Ovens, Active.	Coke. Number of Workmen.	Coke. Consumption of Coal. Metric Tons
1897	21,492,446	$44,134,420	$2·05	3,911,350	$·182	120,382	$205	3,845	2,566	2,968,690
1898........	22,088,335	48,578,780	2·20	4,654,921	·210	122,846	219	4,028	2,519	2,944,096
1899........	22,072,068	54,888,780	2·49	7,568,600	·343	125,258	234	(*d*)	2,894	(*d*)
1900........	23,462,817	81,698,960	3·48	12,453,600	·531	132,749	283	(*d*)	2,928	(*d*)
1901........	22,213,410	67,654,818	3·05	10,362,146	·466	134,092	249	4,967	2,821	2,486,390

Year.	Coke—*Continued*. Quantity. Metric Tons.	Coke—*Continued*. Value. Total.	Coke—*Continued*. Value. Per Ton	Briquettes from Coal. Number of Works, Active.	Briquettes from Coal. Number of Workmen.	Briquettes from Coal. Consumption of Coal. Metric Tons	Briquettes from Coal. Quantity. Metric Tons.	Briquettes from Coal. Value. Total.	Briquettes from Coal. Value. Per Ton
1897........	2,207,840	$7,572,891	$3·43	37	(*b*)	1,129,791	1,245,114	$3,112,785	$2·50
1898........	2,161,162	8,104,357	3·75	37	1,191	1,227,720	1,351,884	3,623,049	2·68
1899........	2,304,607	9,448,889	4·10	(*d*)	1,234	(*d*)	1,276,050	4,096,120	3·21
1900........	2,484,678	13,098,567	5·38	40	1,233	(*d*)	1,395,910	6,574,736	4·71
1901........	1,847,780	8,222,621	4·45	(*d*)	1,486	1,449,080	1,587,800	6,136,350	3·86

METALLURGICAL PRODUCTION OF BELGIUM. (*a*) (IN METRIC TONS AND DOLLARS; 5 f. — $1.)

Year.	Iron, Crude.								
	Forge Pig.			Foundry Pig.			Bessemer Pig.		
	Quantity.	Value.		Quantity.	Value.		Quantity.	Value.	
		Total.	Per Ton		Total.	Per Ton		Total.	Per Ton
1897	426,332	$4,658,486	$10·91	78,410	$912,300	$11·63	183,701	$2,377,210	$12·94
1898	308,875	3,329,775	10·78	93,645	1,000,720	10·69	173,085	2,243,380	12·96
1899	317,029	4,071,540	12·84	84,165	1,122,600	13·34	169,664	2,417,210	14·24
1900	305,344	4,839,754	15·85	88,335	1,480,230	16·75	176,557	3,381,420	19·15
1901	178,250	1,863,084	10·45	86,170	930,680	10·80	166,820	2,275,470	13·64

Year.	Iron, Crude—*Continued.*						Iron, Manufactures of.			
	Thomas Pig.			Total Pig.			Bar, Crude.		Rails.	
	Quantity.	Value.		Quantity.	Value.					
		Total.	Per Ton		Total.	Per Ton				
1897	333,958	$4,001,380	$11·98	1,065,087	$12,144,076	$11·78	108,608	$2,801,200	1,443	$40,400
1898	397,801	4,898,140	12·31	979,755	11,580,970	11·82	123,998	3,216,770	887	23,850
1899	453,718	7,271,640	16·03	1,024,576	14,880,790	14·52	(*d*)	....	(*d*)	....
1900	447,271	8,584,636	19·19	1,018,561	18,309,200	17·97	(*d*)	....	(*d*)	....
1901	332,940	4,381,586	13·16	764,180	9,450,820	12·58	249,380	6,914,020	(*d*)	....

Year.	Iron, Manufactures of—*Continued.*						Lead, Crude.		Silver—Kg.	
	Sheet and Plate.		Wrought.		Other Manufactures.					
1897	100,262	$3,148,800	873	$47,800	263,644	$6,834,000	17,023	$1,101,760	30,073	$631,422
1898	91,686	2,831,800	993	61,440	267,521	7,061,280	19,830	1,252,420	116,085	2,477,170
1899	(*d*)	....	(*d*)	....	(*d*)	....	15,727	1,186,200	134,854	3,076,200
1900	73,572	3,154,126	(*d*)	....	284,591	10,846,042	16,365	1,395,600	146,548	3,076,200
1901	65,760	2,193,026	550	30,500	64,900	1,897,680	18,760	1,172,000	169,450	3,947,060

Year.	Steel.									
	Ingots, Cast and Blooms.		Rails.		Tires.		Sheet.		Forge.	
1897	616,541	$11,104,800	136,911	$3,295,800	10,870	$427,200	272,839	$6,743,400	23,104	$586,400
1898	653,523	11,877,040	117,751	2,868,960	10,953	408,920	314,150	7,981,610	17,902	516,700
1899	731,249	15,304,200	(*d*)	....	(*d*)	....	(*d*)	....	(*d*)	....
1900	655,199	17,110,000	(*d*)	....	(*d*)	....	(*d*)	....	(*d*)	.. ..
1901	529,840	10,802,530	132,260	3,400,010	12,380	542,770	(*d*)	....	3,310	178,650

Year.	Steel—*Continued.*						Zinc.			
	Plates.		Wire.		Total.		Crude.		Sheet.	
1897	64,366	$2,354,000	19,567	$558,400	527,617	$13,965,600	116,067	$9,936,090	37,011	$3,450,710
1898	87,219	2,978,590	19,753	567,620	567,728	15,322,000	119,671	11,881,660	35,587	3,841,190
1899	(*d*)	....	(*d*)	....	633,950	19,230,860	122,848	14,925,770	34,289	4,616,950
1900	(*d*)	....	(*d*)	....	568,539	20,934,944	119,317	11,926,230	33,825	4,543,800
1901	84,730	3,050,076	(*d*)	....	489,640	14,874,082	127,170	10,675,630	37,380	3,730,380

QUARRY PRODUCTION OF BELGIUM. (*a*) (VALUES IN DOLLARS; 5 f. — $1.)

Year.	Barytes. Metric Tons.		Chalk, Marl. Cubic Meters.		Clay. Metric Tons.		Feldspar. Cubic Meters.		Flint for Earthenware. Cubic Meters		Flint and Gravel for Ballast. Cubic Meters.		Mineral Paints.	
													Ochers. Cu. Met.	
1897	23,000	$32,200	204,600	$90,680	270,715	$359,952	1,100	$1,940	23,050	$17,720	235,495	$110,819	350	$1,450
1898	21,700	30,380	287,805	136,220	287,805	416,240	1,000	1,980	22,150	17,700	360,960	177,700	290	1,180
1899	25,900	36,260	351,800	115,540	291,125	398,968	1,525	3,350	25,185	20,690	238,835	121,838	300	1,200
1900	33,800	55,100	377,550	88,980	318,205	435,540	1,960	3,100	25,700	21,440	263,850	124,798	300	1,200
1901	22,800	31,920	449,000	106,610	298,340	374,360	(*b*)	......	17,700	14,720	7,860	8,556	*c*2,100	8,400

Year.	Phosphate of Lime. Cubic Meters.		Sand. Cubic Meters.		Slate.			Building Stone—Cubic Meters.					
					Pieces.	Cubic Meters	Total Value.	Conglomerate.		Dolomite.		Flagstones. Square Meters.	
1897.	350,056	$436,762	559,141	$237,196	41,422,000	1,445	$335,780	220	$5,500	52,720	$13,908	107,572	$71,646
1898.	156,920	303,230	287,805	186,220	42,311,000	210	350,660	180	4,680	37,100	13,068	170,672	157,650
1899.	190,090	342,180	627,770	241,698	44,167,000	200	358,112	200	5,400	56,400	19,888	144,330	127,355
1900.	215,670	367,164	653,780	250,996	43,941,000	1,410	333,210	380	7,900	45,000	13,050	153,217	143,343
1901.	c222,590	361,398	636,090	240,068	39,080,000	....	283,900	(b)	....	31,500	11,808	106,470	120,494

Year.	Stone.											
	Freestone. Cubic Meters.		Limestone. Cubic Meters.		Limestone for Flux. Cubic Meters.		Marble. Cubic Meters.		Paving Stones. *Pieces.*		Whetstones and Hones—*Pieces.*	
1897	181,746	$3,076,924	3,010,877	$2,730,730	225,300	$89,085	17,797	$471,954	95,542,700	$1,739,875	43,150	$16,740
1898	215,417	3,177,534	2,968,997	2,580,695	212,685	74,740	16,610	547,100	108,025,000	2,016,314	89,150	22,590
1899	139,294	3,249,146	3,238,875	2,735,025	195,505	77,956	17,740	601,170	114,108,900	2,236,411	82,100	14,160
1900	157,294	3,200,248	3,228,205	3,020,602	229,250	89,112	15,990	536,140	107,294,000	2.192,852	105,000	15,160
1901	167,310	2,834,304	3,751,880	3,124,892	193,370	68,280	15,390	513,910	110,930,000	2,273,980	160,150	20,150

(*a*) From *Statistique des Mines, Minières, Carrières, et Usines Métallurgiques*, by Emil Harzé, except the figures for 1901, which are from *Statistique des Industries Extractives et Métallurgiques*. Belgium also produced, in 1896, manganese pig-iron, 11,391 tons, $154,160; kaolin, 130,960 cu. m., $213,560; in 1897, manganese pig-iron, 12,636 tons, $199,700; and in 1901, kaolin, 2,640 tons $5,680. (*b*) Not stated in the report. (*c*) Metric tons. (*d*) Statistics not yet available.

MINERAL IMPORTS OF BELGIUM. (*a*) (IN METRIC TONS AND DOLLARS; 5 f. = $1.)

Year.	Ashes.		Cement.		Chemical Products.			Clay Products. (*b*)			
					Soda Salts.		Not Specified.	Terra Cotta.		Common Pottery.	
1896........	6,747	$26,968	30,565	$183,392	194,202	$11,989,011	$5,488,285	85,486	$629,221	2,065	$103,231
1897........	10,870	43,481	17,681	113,160	181,676	7,419,315	6,048,423	86,498	549,631	2,115	105,756
1898........	8,199	32,796	34,069	231,471	152,164	5,033,089	6,896,420	92,149	610,058	2,007	104,436
1899........	15,818	63,271	18,649	128,675	249.756	7,996,717	6,481,947	99,156	633,955	2,856	102,098
1900........	15,428	61,711	12,778	86,858	222,941	7,822,966	7,157,219	90,852	585,216	4,281	127,254

Year.	Clay Products—*Con.*		Coal.		Coal Briquettes.		Coke.		Copper and Nickel.	
	Earthenware.	Porcelain							Crude.	
1896........	c$272,894	d$177,207	1,698,376	$5,249,466	1,561	$5,151	260,273	976,024	15,506	$3,597,266
1897........	c298,535	d188,484	2,017,844	6,455,501	632	2,212	269,606	1,159,306	14,821	3,556,943
1898........	179,866	345,067	2,202,517	7,268,306	1,756	6,585	180,590	784,590	14,947	5,082,274
1899........	488,072	233,394	2,844,274	10.523,814	10,722	43,960	296,508	1,482,540	8,327	3,380,798
1900........	430,685	263,241	3,288,510	13,976,167	21,813	121,062	289,678	1,767,005	13,768	5,507,109

Year.	Copper and Nickel.—*Con.*			Glass and Glassware.			Gold (Including Platinum).			
	Hammered, Drawn or Rolled.		Wrought.	Common (Bottles, Broken Glass, etc.)		All Other Kinds.	Ore—Kg.		Unwrought—Kg.	
1896........	1.109	$321,718	$188,931	6,980	$213,380	$541,225	98	$614	4,928	$3,390,962
1897........	1,418	405.576	193,242	4,699	143,130	664,176	....	....	3,824	2,633,971
1898........	1,821	765,000	205,705	4,247	99,608	635,021	8,390	55,874	1,282	883,041
1899........	2,174	999,985	226,853	3,757	90,473	651,208	51	337	1,136	782,477
1900........	2,087	960,164	251,765	5,671	134,352	663,386	1,250	8,250	1,728	1,190,246

Year.	Gold.—*Continued.*		Guano.		Iron and Steel Filings.		Iron.			
	Coin.	Jewelry, etc.					Ore.		Pig.	
1896........	599,540	$757,507	25,946	$1,037,846	11·1	$ 93	2,069,676	$3,982,885	324,889	$3,897,069
1897........	1,726,700	701,535	5,162	185,825	26·4	227	2,544,377	4,884,316	302,198	3,815,918
1898........	372,000	840,593	10.657	383,664	18·0	158	2,252,553	4,279,850	317,829	3,782,157
1899........	744,000	965,170	16,111	579,991	184·0	1,748	2,621,152	5,242,304	362,458	5,665,163
1900........	459,420	921,624	15,832	569,964	3·0	30	2,528,615	5,310,022	309,674	5,521,417

Year.	Iron.—*Continued.*						Lead.			Lime.	
	Old.		Hammered, Drawn or Rolled.		Wrought.		Pig.		Manufactures.		
1896	53,802	$688,668	22,812	$646,150	6,118	$469,061	35,221	$1,987,173	$17,281	11,522	$22,699
1897	51,985	670,608	26,054	792,873	6,336	491,296	43,840	2,680,429	91,580	13,184	26,286
1898	52,298	690,320	25,470	781,167	14,918	879,347	54,867	3,489,549	50,728	12,674	25,349
1899	61,510	922,647	34,960	1,127,656	6,984	559,899	60,649	4,184,756	191,508	12,811	28,184
1900	62,053	992,841	32,783	1,188,576	7.933	726,074	58,141	4,767,579	148,040	11,448	25,757

Year.	Petroleum.				Resins and Bitumens, Not Specified.		Salt.			
	Crude.		Refined.				Crude.		Refined.	
1896	95	$1,336	158,979	$5,405,275	216,278	$10,813,881	92,408	$554,449	38,785	$387,852
1897	988	13,831	149,501	4,848,844	237,570	11,878,487	96,805	580,827	39,198	391,926
1898	382	7,446	161,281	5,419,070	269,914	13,495,710	92,300	553,804	50,186	501,864
1899	2,479	49,590	166,404	5,990,562	264,718	13,235,887	81,294	487,945	50,647	506,475
1900	1,751	36,773	156,064	5,848,881	253,788	12,689.402	97,812	586,871	59,875	598,748

Year.	Silver.						Steel.					
	Ore—Kg.		Bullion—Kg.		Coin.	Jewelry, etc.	Ingot.		Bars, Sheets, and Wire.		Wrought.	
1896	1,476,582	$177,190	8,980	$233,480	$6,461,840	$415,967	23,485	$561,744	15,263	$479,341	986	$233,924
1897	2,533,237	253,324	467,851	9,357,020	*e* 3,083,040	460,244	25,370	518,271	25,869	834,766	1,147	286,415
1898	461,914	46,191	299,369	5,987,990	7,655,200	449,244	25,142	596,442	24,761	805,918	1,013	256,925
1899	2,522,950	252,295	105,723	2,114,460	14,272,080	580,070	11,666	256,737	33,552	1,066,468	1,070	275,521
1900	921,500	92,150	11,366	234,140	7,834,560	513,767	19,705	486,587	42,580	1,594,780	1,295	336,088

Year.	Stone.									Sulphur.	
	Roofing Slate. *1,000 Pieces.*		Building Stone, Including Marble and Alabaster.		Cut, Polished, etc.	Paving.		All Other Kinds.			
1896	38,209	$152,834	40,511	$891,237	$61,769	6,163	$22,187	81,360	$394,964	14,399	$408,177
1897	38,754	162,765	47,929	1,054,433	111,313	13,197	47,509	182,950	1,097,417	13,261	371,307
1898	33,216	198,724	45,544	1,093,052	63,665	8,926	37,489	289,281	1,312,764	13,322	378,067
1899	35,888	186,616	49,498	1,484,940	88,872	7,885	37,608	216,231	1,405,892	8,449	236,567
1900	34,331	216,284	60,057	1,801,398	145,736	3,761	18,053	135,245	1,022,984	17,516	525,482

Year.	Tin.			Tin Plate.			Zinc.			Ores, Crude Not Elsewhere Specified.
	Ingot.		Manufactures.	Unwrought.		Wrought.	Ingot.		Manufactures.	
1896	4,617	$1,662,044	$2,845	3,203	$343,408	$27,425	20,182	$1,614,588	$11,280	$10,227,349
1897	1,609	547,118	2,634	3,875	294,533	22,972	16,820	1,387,218	10,661	13,048,392
1898	1,208	628,084	2,545	3,848	256,180	29,990	17,441	1,757,108	11,575	13,497,359
1899	1,113	667,504	4,378	3,900	306,564	46,437	11,058	1,150,063	11,436	17,728,858
1900	1,653	1,090,720	5,540	5,036	433,060	50,829	11,478	1,147,817	12,054	15,451,788

(*a*) From *Statistique de la Belgique; Tableau General du Commerce avec les Pays, Etrangers, Brussels.* (*b*) There was imported in 1897 also slabs of pottery for paving, building, etc., 7,755 metric tons, $172,795. (*c*) Corresponding in 1896 to 3,668 metric tons, and in 1897 to 3,713 metric tons. (*d*) Corresponding in 1896 to 824 metric tons, and in 1897 to 815 metric tons. (*e*) Corresponding to 52,076 kg.

MINERAL EXPORTS OF BELGIUM. (*a*) (IN METRIC TONS AND DOLLARS; 5 f. — $1.)

Year.	Ashes.		Cement.		Chemical Products.			Clay Products.			
					Soda Salts.		Not Specified.	Terra Cotta. *No. of Pieces.*		Common Pottery.	
1896	1,044	$4,338	277,615	$1,665,690	42,857	$2,298,608	$6,819,396	302,596	$1,918,054	2,628	$181,394
1897	2,675	10,701	322,024	2,060,951	59,054	2,202,874	7,236,116	294,615	1,778,837	3,197	159,867
1898	615	2,459	419,132	2,850,092	106,252	2,718,179	7,300,805	247,970	1,497,988	3,186	81,066
1899	400	1,598	445,602	3,074,655	109,253	2,790,617	6,431,947	328,733	1,974,565	3,216	96,158
1900	2,148	8,590	408,284	2,776,181	75,492	2,272,801	6,592,217	269,759	1,742,812	5,915	127,254

Year.	Clay Products.—*Continued.*				Coal.		Coal Briquettes.		Coke.	
	Earthenware.		Porcelain.							
1896........	4,692	$513,950	586	$54,332	4,649,799	$14,414,377	459,974	$1,517,914	863,067	$3,236,501
1897........	4,905	584,532	264	45,395	4,448,544	14,236,341	615,074	2,152,759	909,486	3,910,789
1898........	10,981	640,025	218	35,878	4,579,955	15,118,851	666,265	2,498,498	878,435	3,865,114
1899........	4,417	483,133	264	39,759	4,568,938	16,905,071	525,625	2,155,062	1,008,740	5,043,700
1900........	5,010	525,671	261	37,248	5,260,991	22,359,212	604,864	3,356,995	1,078,318	6,547,209

Year.	Copper and Nickel.					Glass and Glassware.				
	Crude.		Hammered, Drawn or Rolled.		Wrought.	Common (Bottles, Broken Glass, etc.).		Plate.	All Other Kinds.	
1896........	11,700	$2,714,477	2,078	$601,277	$168,594	3,647	$26,574	$3,468,668	178,611	$12,194,434
1897........	9,994	2,398,659	1,996	570,761	198,665	3,546	26,468	3,761,219	174,232	11,448,839
1898........	8,511	2,893,856	1,770	743,802	161,726	2,747	37,480	3,007,865	25,226	3,088,385
1899........	4,665	1,866,089	2,111	970,882	261,060	3,850	88,283	4,942,298	196,842	12,553,516
1900........	8,411	3,364,241	2,097	964,639	276,613	3,998	78,004	4,412,987	159,557	10,896,089

Year.	Gold (Including Platinum).				Guano.		Iron and Steel Filings.		Iron.	
	Unwrought—Kg.		Coin.	Jewelry, etc.					Ore.	
1896........	3,718	2,557,514	$2,666,620	$75,570	14,633	$585,308	7,025	$59,007	389,235	$739,546
1897........	2,547	1,754,374	605,120	126,385	14,044	505,585	584	4,595	410,817	780,552
1898........	1,231	817,213	578,120	118,897	21,626	778,542	407	3,581	384,047	729,683
1899........	504	347,753	998,200	118,916	18,213	655,669	239	2,270	318,415	636,830
1900........	549	378,151	613,180	161,155	14,204	511,329	121	1,210	420,179	882,376

Year.	Iron.—*Continued.*								Lead.	
	Pig.		Old.		Hammered, Drawn or Rolled.		Manufactures.		Pig.	
1896........	38,465	$1,182,480	18,416	$235,725	343,072	$9,072,611	44,952	$3,497,287	31,366	$1,725,144
1897........	42,554	1,325,352	17,590	226,911	356,835	10,097,254	43,114	3,389,400	35,988	2,159,298
1898........	16,789	223,453	23,326	309,676	234,562	4,155,448	51,820	4,151,200	40,302	2,563,246
1899........	43,304	1,418,941	32,504	487,557	385,878	10,955,330	59,054	4,879,090	41,618	2,871,662
1900........	35,318	1,317,952	43,736	699,773	270,524	9,158,530	65,279	6,122,112	46,566	3,818,425

Year.	Lead.—*Con.*	Lime.		Petroleum.				Resins and Bitumens, not Specified.	
	Wrought.			Crude.		Refined.			
1896........	$36,821	477,213	$940,110	2	$23	29,321	$996,913	86,906	$4,345,315
1897........	33,286	520,588	1,035,969	1	15	18,068	586,067	92,591	4,629,538
1898........	16,450	546,199	1,092,399	782	13,256	19.556	657,067	107.806	5,390,353
1899........	37,022	537,357	1,182,186	2,146	42,924	25,970	934,937	112,392	5,019,622
1900........	8,952	617,666	1,389,749	1,759	36,938	21,812	807,036	97,970	4,898,475

Year.	Salt.				Silver.						
	Crude.		Refined.		Ore—Kg.		Bullion—Kg.		Coin—Kg.		Jewelry, etc.
1896........	1,434	$8,604	129	$1,287	19,400	$2,328	40,118	$1,043,068	16,696	$667,840	$137,137
1897........	493	2,959	231	2,309	423,160	42,316	57,933	1,158,660	521	20,851,320	189,959
1898........	298	1,789	386	3,864	595	59	107,335	2,125,700	327	13,083,640	127,194
1899........	506	3,037	885	8,850	116	12	54,358	1,087,160	337,079	13,483,160	214,175
1900........	2,345	14,070	799	7,989	....	....	38,331	789,619	32,621	1,304,840	103,121

Year.	Steel.						Stone.				
	Ingot.		Bars, Sheets and Wire.		Manufactures.		Roofing Slate. *1,000 Pieces.*		Building Stone, Including Marble and Alabaster.		Cut, Polished, etc.
1896........	1,145	$23,272	179,878	$4,597,877	38,306	$7,848,777	15,435	$111,130	161,298	$1,290,987	$922,147
1897........	1,201	22,302	183,386	4,842,221	37,353	7,764,848	17,304	138,428	187,180	1,591,033	934,286
1898........	1,018	19,397	175,249	4,856,964	33,652	6,464,909	16,948	152,534	178,249	1,742,491	861,015
1899........	1,259	26,036	155,815	4,603,643	31,194	6,151,759	15,316	137,843	164,952	2,144,381	948,090
1900........	974	22,793	146,121	4,854,049	28,877	5,170,862	12,836	100,118	171,126	2,224,636	872,381

Year.	Stone —*Continued.*				Sulphur.		Tin.		
	Paving.		All Other Kinds.				Ingot.		Manufactures.
1896........	154,737	$1,197,835	796,231	$3,184,926	5,335	$149,871	1,055	$379,732	$678
1897........	153,504	1,339,421	778,531	3,248,832	6,041	169,157	347	118,069	889
1898........	159,455	1,449,530	917,654	4,221,212	6,355	177,960	508	263,962	2,394
1899........	150,998	22,798	834,528	4,172,641	6,769	189,533	659	395,479	1,511
1900........	178,057	1,709,351	1,022,780	5,118,904	7,363	220,880	495	396,479	2,902

Year.	Tin Plate.			Zinc.			Ores Not Specified.
	Unwrought.		Wrought.	Ingot.		Manufactures.	
1896........	3,952	$309,625	$11,750	100,369	$8,029,501	$56,349	$4,236,708
1897........	1,191	90,545	15,216	100,226	8,519,330	90,749	6,216,589
1898........	973	74,903	10,562	108,507	10,807,318	102,583	7,080,013
1899........	1,436	112,831	19,566	101,244	10,529,376	109,762	5,720,528
1900........	941	80,889	10,221	99,233	9,923,302	98,302	6,690,189

(a) From *Statistique de la Belgique: Tableau General du Commerce avec les Pays Etrangers.*

CANADA.

THE mineral statistics of the Dominion of Canada as collected by the Geological Survey and the Bureaus of Mines of the various provinces, are summarized in the following tables:

MINERAL PRODUCTION OF THE DOMINION OF CANADA. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Arsenic.		Asbestos and Asbestic.		Barytes.		Cement—*Barrels.*				Chromite.	
							Natural Rock.		Portland.			
1898....	*Nil.*	....	21,577	$486,227	971	$5,258	87,125	$73,412	163,084	$324,168	1,833	$24,252
1899....	52	$4,872	22,988	483,299	653	4,408	141,387	119,508	255,366	513,983	1,796	23,760
1900....	275	22,725	27,797	763,431	1,207	7,575	125,428	99,994	292,124	545,826	2,118	27,000
1901 ...	630	41,676	36,475	1,259,759	592	8,842	188,828	94,415	317,066	565,615	1,159	16,744
1902....	726	48,000	36,668	1,203,452	909	3,957	124,400	91,870	594,594	1,028,618	816	12,400

Year.	Clay.					Coal.		Coke. (*e*)		Copper (In Ore, etc.). (*f*)	
	Fire Clay.		Pottery	Terra-Cotta.	Tile and Sewer Pipe. (*d*)						
1898....	*b*1,969	$5,000	$185,000	$167,902	$166,421	3,785,408	$8,227,958	65,721	$219,200	8,146	$2,159,556
1899....	543	1,295	200,000	220,258	161,546	4,142,242	10,283,497	91,463	350,022	6,840	2,655,319
1900....	1,129	4,130	200,000	259,450	231,525	5,088,148	13,290,429	142,555	640,140	8,582	3,065,922
1901....	3,610	5,920	200,000	278,671	250,000	5,649,417	12,005,565	339,043	1,228,225	17,158	6,096,581
1902....	2,487	4,288	200,000	348,597	294,465	6,930,287	15,538,611	459,463	1,538,920	17,766	4,553,695

Year.	Feldspar.		Gold—Kg. (*h*)		Graphite.		Grindstones.		Gypsum.		Iron Ore.	
1898....	2,268	$6,250	20,613	$13,700,000	(*q*)	$11,098	(*q*)	$39,465	198,908	$230,440	52,763	$152,510
1899....	2,722	6,000	31,673	21,049,730	1,105	24,179	4,092	43,265	221,869	257,329	62,997	248,372
1900....	288	1,112	42,008	27,916,752	1,744	31,040	5,034	53,450	228,614	259,009	*j* 82,103	583,158
1901....	4,854	14,548	36,808	24,462,222	2,005	38,780	4,156	45,690	266,605	340,148	75,408	1,212,113
1902....	6,873	11,375	....	20,741,245	993	28,500	5,587	48,400	301,229	356,317	*s*389,115	1,065,019

Year.	Lead (In Ore, etc.). (*k*)		Lime—*Bushels.*		Manganese Ore.		Mica.	Mineral Paints. (Ochers.)		Mineral Waters.
1898....	14,477	$1,206,399	(*q*)	$650,000	45	$1,600	$117,598	2,124	$18,600	$155,000
1899....	9,917	977,250	(*q*)	800,000	279	3,960	163,000	3,555	19,900	100,000
1900....	28,654	2,760,521	(*q*)	800,000	(*q*)	....	166,000	1,783	15,898	75,000
1901....	23,542	2,249,387	(*q*)	830,000	399	4,820	160,000	2,026	16,735	100,000
1902....	10,433	985,870	....	....	76	2,774	400,000	4,495	30,495	100,000

Year.	Natural Gas.	Nickel (In Ore, etc.). Kg. (*r*)		Petroleum, Crude. *Barrels.* (*m*)		Phosphate (Apatite).		Platinum.	Pyrites.	
1898	$320,000	2,502,808	$1,820,838	700,790	$981,106	665	3,665	(*q*)	29,228	$128,87
1899............	387,271	2,605,461	2,067,840	808,570	1,202,020	2,722	18,000	$625	25,117	110,74
1900............	417,094	3,212,497	3,327,707	710,498	1,151,007	1,284	7,105	(*q*)	36,316	155,164
1901............	339,476	4,168,124	4,594,523	622,392	1,008,275	937	6,280	457	31,989	1[illegible]0,544
1902............	195,992	4,850,499	5,025,903	521,485	934,740	777	4,953	....	32,311	138,939

Year.	Sand and Gravel (Exports).		Sand. (Moulding.)		Salt.		Silver (In Ore, etc.)—Kg. (n)		Slate.	Soapstone.	
1898............	(q)	....	9,591	$21,098	51,839	$248,639	$137,911	$2,583,298	$40,791	(q)	....
1899............	(q)	....	12,450	27,430	51,796	234,520	95,762	1,834,871	33,406	408	$1,960
1900............	(q)	....	(q)	....	56,296	279,458	138,801	2,740,598	12,100	381	1,365
1901............	179,040	$117,465	13,267	29,410	58,927	262,328	172,287	3,265,354	9,960	235	842
1902............	144,961	119,120	12,113	27,651	57,243	288,581	136,014	2,280,957	19,200	......	....

Year.	Stone.							Various Products. (p)
	Brick, Stone, etc. (c)	Flagstones. *Sq. Ft.*		Granite.		Limestone for Flux.		
1898....................................	$3,600,000	(q)	$4,250	(q)	$73,573	30,766	$31,158	$491,660
1899....................................	4,250,000	(q)	7,600	(q)	90,542	48,265	45,662	487,271
1900....................................	4,850,000	(q)	5,250	(q)	80,000	48,050	39,333	....
1901....................................	4,820,000	(q)	4,575	(q)	155,000	153,719	183,162	303,126
1902....................................	5,500,000	....	......	(q)	170,000	265,906	218,809	1,159,214

(*a*) From *Reports Compiled by the Geological Survey of Canada.* (*b*) Estimated. (*c*) Includes brick, building stone, lime, sands, gravels, tiles, etc. (*d*) In 1898, 1899 and 1902, sewer pipe is alone reported. (*e*) Oven coke, all the production of Nova Scotia and British Columbia. (*f*) Copper contents of ore, matte, etc., at the following values per lb.: 1898, 12$\frac{1}{16}$c.; 1899, 17·61c.; 1900, 16·19c.; 1901, 16·12c.; 1902, 11·63c. (*h*) Fine kilograms calculated at $664·60 per kg. (*j*) Amount of pig iron produced from native ore; the total amount of pig iron smelted was 96,575 short tons, valued at $1,501,698. (*k*) Lead contents of ores, etc., at the following values per lb.: 1898, 3·78c.; 1899, 4·47c.; 1900, 4·37c.; 1901, 4·34c.; 1902, 4·07c. (*m*) Calculated from inspection returns at 100 gals. crude to 42 gals. refined. The value of the crude per bbl. of 35 imp. gals. was, in 1898, $1·40; in 1899, $1·48¼, and in 1900 and 1901 when the ratio was 100 gal. to 54 refined, $1.62 per bbl. (*n*) Silver contents of ores, values for production and exports per oz.: 1898, $0·583; 1899, $0·5958; 1900, $0·6141; 1901, $0·5895; 1902, $0·5216. (*p*) In 1898, includes tripolite, 922 metric tons ($16,660); in 1900, tripolite, 305 metric tons, $1,950; in 1901 sundry minerals estimated in part and including actinolite, 482 metric tons, $3,126; in 1902, includes pig iron from Canadian ore, 71,665 short tons, $1,043,011; actinolite, 550 tons, $4,400; zinc, 83 tons, $3,068; peat, 475 tons, $1,663; corundum, 768 tons, $84,468; talc, 689 tons, $1,804; and tripolite, 900 tons, $15.800. (*q*) Not reported. (*r*) Nickel contents of ore, matte, etc., in 1899, at 36c. per lb.; in 1900, at 47c. per lb.; in 1901, at 50c. per lb.; in 1902, at 47c. per lb. (*s*) Exports.

MINERAL IMPORTS OF THE DOMINION OF CANADA. (*a*) (IN METRIC TONS AND DOLLARS.)

Year. (*h*)	Aluminum.	Asphalt.		Brass. (*f*)	Buhrstones. *Number.*		Cement.	Chalk.	Chloride of Lime.		Cryolite.	
1898..	$7,102	6,006	$55,164	$560,014	889	$1,818	$376,315	$14,362	1,765	$55,987	17	$2,315
1899..	9,275	8,196	95,800	747,557	1,116	1,759	480,414	14,544	1,857	50,801	50	2,120
1900..	12,543	2,825	68,748	853,599	1,250	1,546	520,598	12,212	1,967	65,224	18	2,721
1901..	16,202	2,849	67,587	985,776	3,641	5,762	675,768	16,690	1,605	54,186	18	2,158
1902..	30,496	3,426	102,317	1,017,294	1,854	2,559	861,751	20,088	1,806	57,082	67	8,842

Year. (*h*)	Clay Products.			Coal.				Coal Tar. *Barrels.*		Coke.	
	Bricks and Tiles.	Clays.	Earthenware & China.	Anthracite. (*b*)		Bituminous. (*b*)					
1898..	$168,012	$72,795	$674,874	1,325,139	$5,847,685	1,785,838	$3,225,151	26,702	$35,194	122,527	$347,040
1899..	255,237	88,517	916,727	1,583,471	6,490,509	2,220,725	3,786,663	39,206	54,447	128,172	362,826
1900..	499,128	122,965	966,254	1,500,863	6,602,912	2,512,871	4,409,318	50,484	73,874	170,471	506,839
1901..	551,746	141,251	1,139,058	1,933,283	7,923,950	3,097,691	5,556,253	54,928	88,093	308,786	680,138
1902..	501,858	140,521	1,227,986	1,499,090	7,021,939	3,393,006	6,285,899	55,376	98,551	242,416	842,815

Year. (*h*)	Copper. (*f*)	Copper Sulphate.		Emery (Wheels and Ground).	Explosives.	Flint and Stones.		Fuller's Earth.	Glass.	Gold and Silver.	
										Coin and Bullion.	Manufactures.
1898..	$867,452	788	$57.497	$15,478	$141,781	389	$5.344	$3.330	$1.024.706	$4,390,844	$297.242
1899..	798,326	726	61,749	22,348	212,968	243	2,977	3.418	1,348,058	4,705,134	342.390
1900..	1,271,270	752	87,847	44,882	247,511	280	4.342	2,661	1.658,694	8,297,438	899.145
1901..	1,142.771	678	73,190	39,116	306,067	222	3.626	3,147	1.584,922	3.537.294	367,857
1902..	1,357,068	711	67,710	23,946	423,982	186	3,647	3,909	1,932,539	6,311.405	352,224

Year. (h)	Gravel and Sand.		Iron and Steel. (f)	Kainite.		Lead. (f)	Lead Pigments and Zinc White.		Lime. No. of Bbls.		Litharge.	
1898..	29,164	$48,287	$16,487,644	49	$1,098	$885,278	5,738	$463,059	12,850	$9,008	539	$32,394
1899..	27,477	42,380	19,703,735	30	...	385,450	6,324	514,542	15,730	11,124	428	32,518
1900..	32,380	41,280	27,428,910	143	2,330	322,446	6,654	601,492	12,565	11,211	415	28,176
1901..	25,744	42,591	25,082,974	95	1,292	312,530	4,657	482,353	13,657	14,586	565	55,944
1902..	42,985	56,985	[illegible]	85	2,650	283,480	7,484	608,621	34,842	17,386	580	47,021

Year. (h)	Litho-graphic Stones.	Mineral Oils. Gallons.		Mineral Paints. (Ocher.)		Ores of Metals.		Phos-phorus.		Potassium Salts. Except Saltpeter.		Potassium Salts. Saltpeter.	
1898..	$7,791	8,175,005	$683,364	448	$9,426	68,768	$155,548	5	$4,618	344	$22,502	627	$51,236
1899..	6,228	9,704,149	692,447	502	10,482	61,254	153,958	1	775	472	32,177	980	65,186
1900..	6,294	8,923,094	730,286	496	10,050	61,540	282,191	1	862	733	64,534	802	52,285
1901..	9,384	10,667,756	872,096	365	7,849	54,155	594,916	5	3,438	476	59,746	561	46,804
1902..	12,272	11,811,088	930,791	444	8,982	369,072	727,080	2	320	771	77,046	692	61,559

Year. (h)	Precious Stones and Jewelry.	Pumice Stone.	Quicksilver.		Sal Ammonia.		Salt.		Silex.		Slate.
1898............	$743,607	$3,829	27	$36,425	38	$3,721	96,965	$326,208	141	$2,773	$94,907
1899............	928,867	5,978	47	51,695	58	5,082	88,373	300,359	180	2,595	88,100
1900............	782,675	5,604	39	51,987	60	6,987	92,797	325,438	182	2,676	68,707
1901............	1,279,617	5,516	64	94,564	76	9,459	98,127	339,887	165	2,106	72,164
1902............	1,497,221	7,254	44	56,615	78	9,460	114,442	424,708	199	3,858	72,698

Year. (h)	Sodium Salts, Except Chloride.		Stone and Marble. (f)	Sulphur.		Tin. (f)	Whiting.	Zinc. (f)
1898..................................	16,026	$446,799	$189,386	17,248	$373,786	$1,548,346	25,761	$136,849
1899..................................	20,742	476,706	237,543	11,121	265,799	1,370,239	34,310	154,440
1900..................................	16,748	458,738	250,084	9,584	215,433	2,415,686	34,575	167,642
1901..................................	18,631	509,278	255,550	10,827	270,608	2,834,668	60,878	173,899
1902..................................	17,133	466,698	342,571	11,180	325,307	2,343,494	42,136	146,297

MINERAL EXPORTS OF DOMESTIC PRODUCE FROM THE DOMINION OF CANADA. (a) (IN METRIC TONS AND DOLLARS.)

Year. (h)	Antimony Ore.		Asbestos.		Barytes	Clay Products. Brick. Thousands.		Clay Products. Clay, M'f's of.	Cement.	Cinders.	Coal.		Coin and Bullion. (g)
1898..	1,118	$15,295	16,714	$510,368	(i)	276	$1,553	$343	$609	(i)	961,696	$3,273,415	$1,045,923
1899..	(i)	....	18,172	453,176	(i)	93	707	339	2,789	$50	1,034,963	3,562,794	1,101,245
1900..	6	200	16,478	490,909	(i)	842	2,814	215	2,274	66	1,581,422	4,771,441	1,670,068
1901..	219	5,074	26,715	864,573	3,820	728	5,807	761	3,554	10	1,888,538	5,307,060	1,978,489
1902..	13	2,170	30,011	1,131,202	(i)	669	5,581	414	1,359	75	1,648,852	4,867,068	1,669,420

Year. (h)	Coke.		Copper. (c)		Explo-sives.		Fertil-izers.	Glass and Glass-ware.	Graphite.		Grind-stones	Gypsum. Crude.		Gypsum. Ground	Iron and Steel, M'f's of
1898..	8,275	$7,341	4,208	$832,546	92	$74,305	$46,864	$7,494	348	$6,428	$18,785	163,612	$193,515	2,587	$606,068
1899..	4,024	15,684	3,812	917,429	151	115,065	51,224	11,788	662	12,749	18,619	148,525	166,222	7,611	706,411
1900..	12,558	38,770	6,272	1,387,218	212	155,764	51,410	11,016	1,742	30,054	22,196	211,734	236,084	2,622	1,425,113
1901..	60,129	192,910	11,938	2,655,467	434	240,535	37,706	13,574	1,246	40,099	38,304	172,010	195,208	25,472	1,432,951
1902..	52,873	184,499	18,790	2,990,094	331	248,434	61,881	11,587	783	25,789	21,878	243,890	273,335	10,150	2,460,781

Year. (h)	Lime.	M'f'es of Metals Not Iron and Steel.	Mica. Crude and Cut.		Mica. Ground.	Mineral Oils. *Gallons.*		Nickel in Ore, Matte, etc.		Ores. Gold Quartz, etc.	Ores. Iron.		Ores. Lead. (e)	
	$	$		$			$		$	$		$		$
1898	48,307	53,317	231	69,518	(i)	9,530	2,061	6,696	970,531	3,587,953	236	402	19,939	1,008,147
1899	64,112	34,583	538	148,239	(i)	4,268	1,194	6,545	994,537	3,272,702	1,677	4,968	15,443	895,349
1900	77,395	68,610	487	136,332	20	17,984	2,660	6,120	1,040,498	14,148,548	3,925	7,689	8,995	678,859
1901	83,489	186,877	406	146.848	$2,740	19,942	2,008	4,327	958,365	24,445,156	58,401	150,657	29,747	2,512,061
1902	111,910	361,428	452	242,290	20	2,748	881	1,762	834,518	19,668,015	477,078	1,308,901	18,886	889,310

Year. (h)	Ores.—*Continued.* Manganese.		Ores.—*Continued.* Silver. (d)		Phosphate of Lime.		Pyrites.		Salt. *Bushels.*		Sand and Gravel.		Stone and Marble.	Tin M'f's
1898..........	7	$1,371	211	$3,519,786	232	$1,090	18,752	$ 221,564	5,559	$1,189	150,270	$80,952	$61,080	$5.578
1899..........	24	862	187	2,690,281	781	9,290	11,707	27,377	5,209	1,518	162,509	93,492	66,516	3.159
1900..........	57	2,521	71	1,354,053	135	2,285	13,507	32,499	15,151	3,458	227,942	102,151	240,104	3,472
1901..........	36	1,945	152	2,420,750	6	120	22,146	54,357	56,461	11,238	197,065	108,509	128,039	14,481
1902..........	500	6,112	139	2,055,428	64	1,880	24,088	57,623	21,778	4,965	153,982	119,421	187,160	26,524

(*a*) From the tables of the *Trade and Navigation of the Dominion of Canada*. The imports figures are for home consumption only. The exports are those of domestic produce. (*b*) Including coal dust. (*c*) Represents fine copper contained in ore, matte, regulus, etc. (*d*) Silver contents of ores. (*e*) Represents lead contained in ore. (*f*) Includes manufactures. (*g*) Of foreign production. (*h*) Fiscal years ending June 30. (*i*) Not reported.

MINERAL PRODUCTION OF BRITISH COLUMBIA. (*a*) (IN METRIC TONS.)

Year.	Coal.		Coke.		Copper.		Gold—Kg. Lode.		Gold—Kg. Placer.		Lead. (*b*)		Silver—Kg.	
								$				$		$
1898	1,154,039	3,407,595	35,560	175,000	3,298	$874,781	3,423	2,201,217	1,600	$648,346	14,376	1,077,581	133,200	2,375,841
1899	1,314,838	3,882,396	34,799	171,255	3,503	1,351,453	4,802	2,857,573	2,092	1,344,900	9,917	878,870	91,425	1,663,708
1900	1,462,629	4,318,785	86,511	425,745	4,535	1,615,289	5,199	3,453,381	1,989	1,278,724	28,739	2,691,887	123,112	2,309,200
1901	1,488.693	4,380,998	129,120	635,405	12,521	4,446,963	6,543	4,348,608	1.509	970,100	23,898	2,002,733	160,223	2,884,745
1902	1,419,752	4,192,182	130,138	640,075	13,484	3,446,673	7,856	4,888,269	1,669	1,073,140	10,222	824,832	70,095	1,941,328

(*a*) From the *Annual Reports of the Minister of Mines.* (*b*) Attention should be called to the discrepancy between certain of these figures and those of the Canadian Geological Survey; practically the total production of lead in the Dominion is from British Columbian ore.

MINERAL PRODUCTION OF NOVA SCOTIA. (*a*) (*d*) (IN METRIC TONS.)

Year. (*c*)	Barytes.	Coal.	Coke.	Gold. Kg.	Grindstones.	Gypsum. (*b*)	Iron. Ore.	Iron. Pig.	Manganese Ore.	Stone, Limestone.	Tripoli and Silica.
1898......	....	2,317,957	42,672	967	38,000	133,096	31,547	....	76	24,384	....
1899......	308	2,683,373	56,372	864	50,000	142,240	16,428	....	102	32,512	310
1900......	721	3,290,057	62,992	945	56,500	124,237	15.755	....	8	50,800	998
1901......	544	3,683,373	121,920	949	286	137,352	380,629	81,678	10	97,359	813
1902......	684	4,432,675	412,650	879	4,064	184,768	*e*444,281	187,057	152	227,184	....

(*a*) From the *Annual Reports of the Department of Mines of Nova Scotia.* (*b*) Amount exported. (*c*) For the fiscal year ending September 30. (*d*) There was also produced in 1899, 400 net tons of copper ore; in 1900, 600 net tons copper ore; in 1902, 1,390 net tons of moulding sand. (*e*) Including 474,517 net tons of imported ore.

MINERAL PRODUCTION OF ONTARIO. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Arsenic.		Clay Products. Brick, Common. *Number.*		Clay Products. Brick, Paving and Terra Cotta. *Number.*		Clay Products. Pottery.	Clay Products. Tiles, Drain. *Thousands.*	
1898..............................	*Nil.*	......	170,000,000	$914,000	7,754,868	$87,894	$155,000	22.668	$225,000
1899..............................	52	$4,842	233,989,000	1,318.750	10.808,000	105,000	101,000	21,027	240,246
1900..............................	275	22,725	240.480,000	1,379,590	14.271.600	141,369	157,449	19.544	209,788
1901..............................	630	41,677	259,265,000	1,530,460	16,535.000	141,394	198 950	21,592	231,874
1902..............................	....	48,000	....	1,411,000	....	186,171	171,315	.....	199,000

Year.	Cement—*No. of Barrels.*				Copper.		Gold. Metal.		Graphite.		Gypsum, Crude and Calcined.	
	Natural Rock.		Portland.				Kg.	Value.				
1898	91,528	$74,222	153,348	$302,096	3,798	$268,080	505·8	$375,078	272	$6,000	2,722	$4,000
1899	139,487	117,039	222,550	444,227	2,571	176,237	1,164·8	419,328	1,107	16,179	1,089	16,512
1900	125,428	99,994	306,726	598,021	3,052	319,681	588·7	297,861	1,685	27,080	993	18,050
1901	138,628	107,625	350,660	563,255	4,117	589,080	446·6	244,443	907	20,000	1,410	13,400
1902	....	50,795	....	916,221	.....	686,043	....	229,828	....	17,868	.. ..	19,149

Year.	Iron.				Lime—*Bushels.*		Mica.		Natural Gas.	Nickel.		Petroleum. Crude. *Imperial Gallons.* (*h*)	
	Ore.		Pig.										
1898	24,865	$48,875	43,775	$530,789	2,620,000	$308,000	81	$7,500	$301,600	2,071	$514,220	26,978,977	(*g*)
1899	15,842	30,951	58,740	808,157	4,342,500	535,000	241	38,000	440,904	2,605	526,104	23,615,967	(*g*)
1900	81,221	111,805	56,596	936,066	3,893,000	544,000	552	81,550	392 823	3,211	756,626	23,331,783	$1,359,045
1901	247,308	174,428	105,599	1,701,703	4,100,000	550,000	337	37,219	336,183	4,080	1,859,970	21,438,500	1,467,940
1902	......	....	......	....	....	617,000	.....	....	....	.....	2,210,961	....	1,600,000

Year.	Petroleum.—*Continued.* Refined Products. (*h*)									Salt.	
	Illuminating Oils. *Imp. Gals.*		Lubricating Oils. *Imp. Gals.*		All Other Oils. *Imp. Gals.* (*c*)		Paraffine Wax. Metric Tons.		(*e*) Fuel Products		
1898	12,281,622	$1,243,490	2,043,226	$202,150	1,240,967	$121,840	1,186·6	$116,349	$386,705	53,874	$278,886
1899	11,697,910	1,059,485	2,087,475	189,294	1,394,530	148,963	1,266·8	136,066	218,544	51,143	317,412
1900	11,783,755	1,076,242	1,980,428	232,805	1,463,599	174,846	2,086·4	184.718	200,934	60,408	327,477
1901	9,468,262	798,149	764,861	78,975	1,075,999	122,781	1,582·8	165,882	189,758	54,744	323,058
1902	....	....	... .	....	....	....	....	....	....	....	344,620

Year.	Sewer Pipe.	Silver.		Stone. Total Value.	Total Value. (*f*)
		Kg.	Value.		
1898	$93,717	2,093·5	$51,960	$750,000	$7,201,891
1899	138,356	3,230 4	65,575	1,041,350	8,785,251
1900	130,635	4,995 9	96,367	650,342	9,242,044
1901	147,948	4,916·2	84,830	850,000	11,822,525
1902	191,965	....	80,000	....	....

(*a*) From the *Annual Reports of the Bureau of Mines of Ontario*, Toronto. (*b*) Quantity and value included with that of plain pressed brick. (*c*) Comprises benzine and naphtha. (*e*) Comprises gas and fuel oils and tar. (*f*) In 1898 total includes 521 metric tons calcium carbide ($34.443). In 1899, 5,300,000 paving brick ($42,550); 965 metric tons calcium carbide ($74,680); 91 metric tons of talc ($500); and 1,069 metric tons of zinc ($24,000). In 1900, 454 metric tons zinc ore ($500); 3,211 tons steel ($756,626); 3,629 tons feldspar ($5,000); 907 tons talc ($5,000). In 1901, 1,361 metric tons zinc ore ($1.500); 13,131 tons steel ($347.280); 4,628 tons feldspar ($6,375); 368 tons talc ($1,400;) 6,352 tons iron pyrites ($17,500;) 485 tons corundum ($53,115); 2,515 tons calcium carbide ($168,792); 473 tons actinolite ($3.126). (*g*) Not reported. (*h*) One barrel of crude oil is reckoned at 35 imperial gallons, and 1 barrel refined at 42 imperial gallons.

MINERAL PRODUCTION OF QUEBEC. (*a*) (IN METRIC TONS AND DOLLARS; ₮1 — $5.)

Year.	Asbestos.		Chrome Ore.		Copper Ore.		Gold.—Kg.		Granite.		Graphite.		Total Value. (c)
1899	21,106	$615,140	1,796	$21,440	39,654	$166,500	8·4	$5,050	......	....	55	$3,240	$2,142,400
1900	26,619	755,510	2,101	85,735	34,233	154,965	......	.....	......	....	364	9,725	1,480,780
1901	36,555	1,319,620	1,155	17,205	18,411	129,965	2·5	1,480	......	$150,000	76	4,820	1,879,420
1902	*b* 33,649	1,174,708	816	13,500	28,974	121,170	9·3	5,400	......	160,000	22	2,160	2,985,463

(*a*) From *Reports on the Mines of the Province of Quebec.* (*b*) Includes 8,858 metric tons asbestic ($12,788). (*c*) Includes, in 1902, 1,000,000 bu. lime ($140,000); 120,000,000 bricks ($625,000); stones ($580,000).

CHILE.

There are no official statistics of mineral production in Chile. The exports and imports are summarized in the subjoined table. With respect to the most important articles of mineral production, namely, copper and nitrate of soda, the exports practically represent the production. This is also the case with respect to iodine and borate of lime.

MINERAL EXPORTS OF CHILE. (*a*) (IN METRIC TONS AND CHILEAN DOLLARS.)

Year.	Borate of Lime.		Borax.		Clay.		Coal.		Cobalt Ore.		Copper Matte.	
1897....	3,154	$283,770	14	$2,860	20	$998	243,968	$1,869,310	6·0	$312	2,519	$251,915
1898....	7,028	1,194,509	6	3,391	(*b*)	....	282,663	4,239,943	13·2	1,817	3,079	861,999
1899....	14,951	2,242,618	14	7,214	20	1,000	241,995	4,839,900	55·0	8,181	1,710	684,965
1900....	13,177	1,317,676	27	13,314	*Nil.*	....	325,042	3,900,460	26·8	4,027	4,838	1,985,165
1901....	11,457	1,302,401	97	9,685	*Nil.*	....	226	3,106	76·0	11,519	2,905	1,084,727

Year.	Copper and Silver Matte.		Copper, Silver and Gold Matte		Copper Ore.		Copper and Silver Ore.		Copper, Silver and Gold Ore—Kg.		Copper, in Bars.	
1897....	904	$378,340	(*b*)	....	3,396	$169,810	161·8	$25,455	(*b*)	....	19,011	$5,226,199
1898....	419	167,556	17·8	$29,133	20,301	2,022,730	87·0	17,392	5,733	$1,300	20,600	18,759,493
1899....	1,094	546,880	93·0	37,162	35.854	3,585,443	184·0	36,799	12,000	2,633	17,311	14,928,278
1900....	1,918	1,130,836	241·8	145,067	20.213	2,021,267	238·5	40,722	360	90	20,840	17,899,200
1901....	1,779	1,340,420	208·0	124,729	15,929	1,614,178	119·0	46,436	60	500	24,480	19,627,114

Year.	Fire Clay Kg.		Gold Bullion. Kg.		Gold Ore.		Iodine.		Iron Ore.		Lead and Argentiferous Lead, in Bars.	
1897....	8,200	$82	1,131·7	$906,168	64	$28,535	243	$2,429,370	5·1	$256	369	$66,696
1898....	30,440	1,218	1,630·5	2,445,735	8	2,554	235	3,169,570	(*b*)	....	18	13,596
1899....	*Nil.*	....	1,625·0	2,461,234	12	6,051	304	4,108,427	(*b*)	....	171	34,221
1900....	*Nil.*	....	1,871·1	2.806,698	129	57,468	318	4,043,172	(*b*)	....	14	6 706
1901....	*Nil.*	....	687·0	1,088,577	66	33,696	385	3,559,075	(*b*)	....	455	208,236

Year.	Lime.		Manganese Ore.		Mineral Specimens.	Chile Saltpeter.		Silver Ore.		Silver and Gold Ore.	
1897....	0·8	$94	23,529	$1,411,648	$20,300	1,057,640	$37,461,559	984	$434,231	260	$46,631
1898....	0·7	21	20.851	447,028	1,400	1,294,227	90,675,297	284	205,386	269	57.635
1899....	1·0	42	40,981	1,227,922	64.521	1,380.718	96,650,283	302	247,597	370	129,416
1900 ...	0·3	10	25,715	761,406	3,550	1,465.935	109,945.156	225	130,947	217	34,249
1901....	6·0	179	18,430	554,409	....	1,291,958	118,860.181	6,166	4,929,815	196	42,710

Year.	Silver, in Bars, etc. Kg.		Silver, Old. Kg.		Silver-Lead Ore.		Silver Sulphuret Ore.		Tin.	
1897....	148,541	$3,781,125	448	$12,518	6·0	$686	186	[illegible]	47	[illegible]
1898....	189,756	6,987,816	55	2,219	11·8	1,587	290	484,749	8	4,909
1899....	75,899	3,791,589	(b)	....	32·0	4,844	339	1,017,110	8	4,979
1900....	45,623	2,506,497	140	5,383	1·4	218	178	863,388	0·2	108
1901....	46,164	2,690,049	3,467	204,783	....	....	284	872,779	4·0	2,604

(a) From the *Estadística Commercial de la República de Chile*, Valparaiso. It will be noticed that the values reported vary widely for the different years. This is probably to be referred to the fluctuations of the currency standard. (b) Not reported. There was also exported: In 1901, gold precipitate, 269 kg., $435,179.

MINERAL IMPORTS OF CHILE. (a) (IN METRIC TONS AND CHILEAN DOLLARS.)

Year.	Bitumen for Pavements.		Brass.		Cement, Roman.		Coal.		Copper.			
									Sheets.		For Various Uses	
1897....	237	$55,892	60	$26,906	18,205	$365,129	513,421	$4,122,918	55	$28,333	43	$23,894
1898....	83	52,473	.....	....	16,905	676,190	656,202	13,173,965	57	44,002	......	....
1899....	84	62,968	*Nil.*	....	16,166	646,588	623,527	12,469,478	75	57,343	......	....
1900....	180	93,089	*Nil.*	....	20,370	814·872	674,748	13,494,960	104	77,532	......	....
1901....	*Nil.*	....	59	47,828	22,355	896,469	719,400	14,888,000	183	146,882	......	....

Year.	Copper, Sulphate.		Earth for Smelting Furnaces.		Gold Coin.	Iron.							
						Bars and Ingots		Hoops.		Sheets, Ungalv.		Sheets, Galv.	
1897....	85	$10,737	100	$3,542	$4,440	7,604	$354,592	802	$63,943	1,859	$153,732	10,757	$1,292,176
1898....	218	65,358	30	1,785	*Nil.*	10,223	1,256,190	404	54,268	2,283	282,358	9,946	1,377,343
1899....	138	56,312	25	1,178	*Nil.*	8,224	870,768	913	120,831	2,558	234,995	3,837	525,250
1900....	121	85,970	97	5,547	*Nil.*	9,817	1,024,237	1,271	149,857	2,737	328,608	8,096	1,131,717
1901....	118	83,941	120	7,196	*Nil.*	5,559	291,862	866	107,061	3,651	444,526	9,500	1,341,595

Year.	Lead, Bars and Sheets.		Quicksilver.		Salt.				Silver.				
					Common.		Refined.		Bars—Kg.		Coin.	Ore.	
1897....	281	$37,832	40	$39,758	13,179	$90,742	320	$16,191	......	....	$36,930	9	$3,080
1898....	118	28,339	15	44,435	1,543	30,865	101	10,111	......	....	*Nil.*	21	5,455
1899....	70	16,742	21	63,306	397	7,971	38	3,823	......	....	*Nil.*	1	655
1900....	205	51,205	9	27,818	....	....	.....	....	11 1	$552,700	*Nil.*	3	190
1901....	133	82,045	1	2,481	....	....	.....	....	*Nil.*	....	*Nil.*	*Nil.*	....

Year.	Soda, Caustic.		Steel, Bars and Sheets.		Sulphur.		Tin.		Whiting and Gypsum.		Zinc.			
											Bars.		Sheets.	
1897....	2,604	$155,026	2,225	$268,181	2,655	$157,671	608	$82,149	492	$13,683	24	$3,314	252	$50,236
1898....	2,796	341,760	1,369	166,263	3,317	331,725	51	58,173	466	22 028	73	18,213	282	83,398
1899....	1,135	141,461	1,686	203,633	306	30,624	45	57,059	410	20,192	104	33,133	79	24,607
1900....	1,215	147,258	3,755	451,450	1,353	135,843	49	65,946	966	48,371	158	47,399	351	107,656
1901....	920	127,253	4,290	531,656	1,494	149,421	77	85,099	437	24,282	b746	196,301	.....	....

(a) From the *Estadística Commercial de la República de Chile*, Valparaiso. (b) Includes sheet.

CHINA.

There are no official statistics of mineral production in China. The exports and imports as reported by the Imperial Maritime Customs officials are summarized in the following tables:

MINERAL IMPORTS OF CHINA. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Brass Wire.		Cement.		Chinaware, Fine and Coarse.		Coal.		Colors.		Copper. Bar, Rod, Sheets, Plates, Nails.	
1897....	138·6	$33,915	(*b*)	$79,056	401·3	$109,119	558,149	$2,658,722	2,135·6	$138,723	499·6	$108,317
1898....	183·2	46,116	18,342	323,947	379·1	92,522	742,296	3,696,434	(*b*)	130,359	393·7	84,244
1899....	141·2	46,881	14,401	278,479	510·0	134,329	873,080	4,669,570	(*b*)	210,856	250·9	80,690
1900....	126·9	39,603	(*b*)	112,437	481·6	79,419	878,273	4,791,312	(*b*)	221,625	351·3	126,218
1901....	94·8	28,629	(*b*)	72,444	353·2	44,012	1,171,882	6,013,679	(*b*)	179,348	80·2	33,584

Year.	Copper—*Continued.*						Flint Stones.		Glass.		
	Slabs and Ore, Unmanufactured		Wire.		Wares, Unclassified.				Window—*Boxes.*		Wares.
1897....	2,525·8	$606,602	79·9	$20,743	34·4	$13,975	2,652·9	$30,707	138,553	$335,532	$238,784
1898....	1,817·7	429,702	80·6	21,718	23·0	8,382	2,868·7	32,339	93,409	222,611	247,538
1899....	1,191·4	402,053	28·7	9,567	61·6	29,247	2,010·0	23,826	116,896	350,272	264,948
1900....	1,083·5	395,649	69·4	25,386	95·9	46,863	765·5	10,896	100,021	282,492	240,612
1901....	620·4	222,892	47·5	16,917	69·5	30,042	2,589·1	24,379	73,147	203,510	367,885

Year.	Iron.											
	Bar.		Hoop.		Nail-Rod.		Old.		Pig and Kentledge.		Sheets and Plates	
1897....	6,367·9	$209,284	1,480·8	$54,836	11,611·4	$353,935	32,881	$587,278	1,458·5	$36,678	3,489·6	$164,802
1898....	11,309·6	352,081	1,923·3	70,683	21,253·6	643,671	48,018	798,206	10,179·2	280,540	4,709·2	215,454
1899....	8,518·8	334,114	1,211·9	51,004	12,837·8	505,612	38,599	760,297	2,780·3	71,969	6,595·2	370,908
1900....	7,154·1	308,454	980·8	50,736	7,477·2	310,833	26,570	601,476	1,801·8	27,048	8,619·3	561,117
1901....	12,056·4	503,271	1,284·7	57,781	11,534·1	448,170	29,077	636,244	4,155·2	82,113	4,154·3	232,448

Year.	Iron—*Continued.*			Jadestone.		Lead.				Machinery
	Wire.		Wares, Unclassified			Pig.		Tea and Sheet.		
1897....	2,529·1	$163,455	$299,645	227·5	$174,467	7,709	$494,721	102·2	$7,271	$1,956,051
1898...	2,968·0	184,461	334,580	249·5	135,311	8,832	587,558	101·2	7,500	1,231,081
1899....	2,984·7	188,920	490,551	221·5	115,768	9,342	708,080	109·4	10,440	1,114,382
1900....	2,192·7	175,189	372,847	164·7	91,941	2,199	410,591	130·2	15,060	1,087,568
1901....	4,158·5	273,717	564,575	217·4	110,706	7,658	524,298	460·9	44,856	878,880

Year.	Metals, Unclassed.	Nickel.		Paints.	Petroleum—*Liters.* (Refined.)		Quicksilver.		Spelter.	
1897......	$197,659	37·0	$23,884	$457,608	451,387,589	$9,575,878	55·3	$54,028	1,819·5	$169,636
1898......	247,245	67·9	43,393	518,659	366,728,870	8,340,289	70·4	67,481	693·1	71,684
1899......	260,878	104·3	49,560	580,541	358,658,226	9,491,199	50·9	58,305	(*b*)	78,045
1900......	488,608	75·8	49,931	401,338	334,390,096	10,466,685	57·1	65,050	184·2	15,495
1901......	276,237	63·7	50,970	522,306	524,474,094	12,451,298	41·7	54,219	75·7	9,531

Year.	Steel.				Tin.				White Metal. (German Silver)		Yellow Metal. Bar, Rod, Sheets, and Nails.	
	Common.		Mild, or Iron Ingots.		Plates.		Slabs.					
1897....	3,206·9	$198,455	711·4	$22,228	3,543·7	$209,447	4,128·9	$1,396,302	241·4	$122,901	1.758·6	$317,127
1898....	2,908·7	183,523	9,109·9	282,763	6,775·6	398,620	3,198·5	1,131,619	220·4	116,859	1,678·4	297,903
1899....	5,045·9	323,886	8,699·2	326,589	1,121·7	76,264	2,292·4	1,063,765	162·6	84,989	1,588·2	328,610
1900....	3,715·9	274,077	6,511·1	282,452	2,032·9	235,471	3,329·7	1,429,998	155·7	94,088	1,406·6	323,334
1901....	3,166·3	216,559	7,973·2	251,909	4,962·4	419,060	4,286·2	2,039,361	176·2	100,577	1,442·0	287,442

RE-EXPORT OF FOREIGN GOODS FROM CHINA. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Cement.		Chinaware.		Coal.		Colors.		Copper, Bar, Rod Sheets, Plates and Nails.		Glass.		
											Window. *Boxes.*		Ware
1897....	147·0	$1,985	0·1	$123	47,254	$238,561	33·8	$8,578	5·08	$1,008	1,024	$2,580	$1,992
1898....	122·4	2,088	0·1	81	55,238	284,501	(*b*)	5,880	(*d*) 1·98	517	1,373	2,459	2,675
1899....	57·6	889	0·2	40	64,269	347,305	(*b*)	7,997	(*d*) 6·42	2,275	688	1,901	2,014
1900....	(*b*)	123	0 7	162	54,208	267,518	(*b*)	4,734	(*d*)27·09	9,795	2,810	6,705	3,141
1901....	(*b*)	20,744	(*b*)	....	65,053	309,777	(*b*)	4,384	(*d*)72·36	17,454	5,460	15,298	1,536

Year.	Iron.							Lead—In Pigs.		Metals. Unclassed.
	Bar, Hoop, Nail-Rod, Sheets, Plates, and Wire.		Old.		Pig and Kentledge.		Wares, Unclassed.			
1897....	1,691·5	$69,655	258·5	$5,098	1,181·6	$33,774	$6,340	68·6	$4,981	$5,650
1898....	1,155·9	57,249	342·5	7,467	707·1	19,650	11,000	73·7	5,384	12,698
1899....	1,166·9	57,314	365·0	7,185	2,860·1	67,177	7,654	0·1	10	5,279
1900....	1,025·0	62,097	323·6	6,518	244·4	5,852	10,227	88·2	9,887	9,396
1901....	820·5	49,596	275·1	6,394	171·8	3,614	4,978	0·6	45	28,840

Year.	Nickel.		Paints.	Petroleum—*Liters.* (Refined.)		Quicksilver.		Spelter.		Steel.	
1897.......	3·443	$1,874	$15,996	1,982,607	$42,628	2·6	$2,689	12·08	$1,132	591·0	$20,695
1898.......	4·654	2,952	15,016	2,585,556	59,441	4·1	4,026	(*b*)	....	789·6	28,179
1899.......	1·212	772	22,718	50,160	1,505	1·0	1,177	(*b*)	....	615·6	23 570
1900.......	27·879	17,856	13,674	1,971,200	63,636	3·9	4,821	(*b*)	....	429·2	21,144
1901.......	4·303	3,155	7,129	648,850	18,759	1·7	2,056	(*b*)	....	582·1	26,950

RE-EXPORT OF FOREIGN GOODS FROM CHINA. *Concluded.*

Year.	White Metal. (German Silver)		Tin, in Slabs and Tinplates.		Yellow Metal, Bar, Rod, Sheets and Nails.	
1897....	1·3	$711	271·1	$32,430	0·2	$52
1898....	0·2	91	127·5	27,999	18·6	2,928
1899....	1·2	698	701·2	73,810	1·3	468
1900....	1·2	711	258·7	53,048	0·06	21
1901....	0·8	433	298·9	34,752	0·25	45

EXPORT OF NATIVE GOODS FROM CHINA. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Chinaware, Earthenware, and Pottery.		Glassware, Bangles, etc.		Gold and Silver Ware.	
1897...	20,453	$996,722	1,066·9	$252,573	2·597	$98,575
1898...	20,881	1,053,015	1,261·9	300,919	3·325	112,530
1899...	22,605	1,316,082	1,245·1	313,712	3·576	126,352
1900...	21,396	1,220,526	1,065·4	279,076	4·202	138,786
1901...	20,396	1,218,544	1,163·9	286,887	4·558	156,356

(*a*) From the *Returns of Trade and Trade Reports of the Imperial Maritime Customs*, Shanghai, China. In these reports the unit of quantity is chiefly the "picul," and that of value the "Haikwan-tael." In converting the original data to metric tons and dollars, the following relations were used: 1 picul = 0·060453 metric ton; in 1897, 1 Haikwan-tael = 72c.; in 1898, 70c.; in 1899, 71·4c.; in 1900, 71·7c.; in 1901, 74·2c., at the average sight exchange on New York, London, Paris, Berlin, Calcutta, and Hong-Kong respectively. (*b*) Not reported. (*d*) In 1898 there was also exported 4·41 metric tons of unclassed copperware valued at $1,891; in 1899, 0·25 metric tons ($158); in 1900, 0·42 metric tons ($218); in 1901, 0·12 metric tons ($47).

FRANCE.

THE official statistics of mineral production in France and her Colonies are summarized in the subjoined tables. With respect to the most important substances, reference should be made to the respective captions elsewhere in this volume.

MINERAL PRODUCTION OF FRANCE. (*a*) (IN METRIC TONS; 5 *f*.=$1.)

Year.	Antimony Ore.		Arsenic Ore.		Asphaltum.		Barytes.		Bauxite.		Bituminous Substances. (*c*)	
1897..	4,685	$64,915	....	....	17,982	$146,272	3,209	$8,736	41,740	$55,211	233,328	$339,898
1898..	4,433	65,046	....	....	18,832	153,758	2,763	7,338	36,723	67,133	229,108	333,888
1899..	7,393	140,093	2,600	$20,800	22,100	172,380	4,058	11,524	48,215	83,987	258,449	360,657
1900..	7,843	112,808	4,705	36,557	25,228	206,998	3,635	10,483	58,530	92,596	266,474	383,429
1901..	9,867	156,834	7,491	37,972	20,391	170,083	4,145	9,530	76,620	124,168	249,655	372,978

Year.	Cement.		Clay Products.				Coal.					
			Potters' Clay.		Refractory Clay.		Coal.		Lignite.		Peat.	
1897..	976,818	$4,716,471	270,292	$243,200	318,185	$333,498	30,337,207	$66,020,171	460,422	$781,517	98,067	$253,851
1898..	1,072,025	5,359,690	260,362	203,344	325,918	348,532	31,826,127	71,701,884	529,977	929,300	104,265	301,486
1899..	1,144,271	5,738,404	310,220	272,176	367,482	375,891	32,256,148	80,412,932	606,564	1,096,181	99,230	302,637
1900..	1,147,670	5,796,320	331,396	258,717	329,561	339,951	32,721,562	98,362,'14	682,736	1,487,314	95,630	286,968
1901..	1,127,206	5,609,774	341,407	249,235	298,208	345,156	31,633,300	99,868,200	691,700	1,564,200	118,433	349,131

Year.	Copper Ore.		Fluorspar.		Gypsum.				Iron Ore.		Lead-Silver Ore.	
					Crude.		Calcined.					
1897..	956	$3,645	2,722	8,160	292,753	$264,845	1,369,269	$2,458,337	4,582,236	$3,008,028	21,212	$556,261
1898..	382	2,841	3,077	9,231	303,531	281,690	1,449,384	2,596,870	4,731,394	3,207,447	23,342	640,226
1899..	2,021	64,416	5,140	15,888	263,879	261,192	1,372,067	2,475,616	4,985,702	3,640,115	17,505	543,146
1900..	3,031	151,090	3,430	10,341	192,916	192,679	1,405,845	2.579,542	4.676,740	3,545,312	24,276	721,716
1901..	3,413	112,784	3,970	11,554	355,995	338,536	1,623,710	3,111,211	4,260,747	3,111,422	20,644	562,963

Year.	Lime.		Manganese Ore.		Millstones.		Mineral Paints. (Ochers.)		Petroleum, Crude.		Phosphate Rock.	
1897..	2,201,428	$6,682,323	37,212	$208,085	32,175	$244,083	32,299	$156,180	10,233	$234,811	535,390	$2,854,887
1898..	2,339,850	5,975,874	31,935	166,211	*g*38,929	727,235	33,780	158,014	9,694	221,172	568,558	3,115,958
1899..	2,343,377	6,081,923	39,897	223,337	41,585	765,242	32,750	161,473	(*b*)	....	645,868	3,334,145
1900..	2,377,110	6,330,198	28,992	170,089	41,108	730,234	33,080	164,000	(*b*)	....	587,919	2,827,291
1901..	2,443,062	6,577,454	22,304	95,025	33,236	290,918	35,704	275,930	(*b*)	....	535,676	2,614,543

Year.	Pyrites.		Salt.		Slate.				Stone.	
					Roofing.		Slabs.		Building.	
1897..	306,488	$752,658	948,008	$2,289,894	310,820	$3,620,949	1,143	$31,282	10,105,488	$9,355,108
1898..	310,972	785,242	999,283	2,115,120	316,911	4,118,789	1,318	38,552	9,989,416	9,890,737
1899..	318,888	827,623	1,196,532	2,506,832	299,307	3,615,862	1,162	36,008	10,587,789	10,445,644
1900..	305,073	779,925	1,088,684	2,415,973	290,204	3,439,981	1,325	39,400	9,974,347	9,612,891
1901..	307,447	798,058	910,000	2,012,800	288,506	3,439,435	1,304	38,560	10,277,098	9,787,812

Year.	Stone.—*Continued.*						Sulphur Ore. (*d*)		Zinc Ore.	
	Limestone. (Flux.)		Marble.		Paving Blocks.					
1897....	709,563	$198,777	118,675	$927,134	568,677	$1,918,105	10,723	$31,252	83,044	$1,305,003
1898....	695,501	200,660	124,161	998,831	568,483	1,898,678	9,818	27,141	85,550	1,475,581
1899....	924,945	246,645	191,080	1,406,778	621,799	2,107,324	11,744	28,884	84,818	1,915,402
1900....	1,040,805	256,351	154,414	1,228,066	659,125	2,326,747	11,551	26,427	67,059	1,222,299
1901....	1,083,872	267,047	123,506	992,409	604,464	2,147,850	7,000	16,400	61,539	656,596

METALLURGICAL PRODUCTION OF FRANCE. (*a*) (IN METRIC TONS; 5 f.—$1.)

Year.	Aluminum.		Antimony.		Copper.		Gold—Kg.		Iron and Steel.			
									Iron, Pig.		Iron, Wrought.	
1897....	470	$235,500	1,083	$141,857	7,876	$1,845,243	276	$190,109	2,484,191	$29,121,027	584,540	$24,406,664
1898....	565	301,800	1,226	163,200	7,834	2,270,200	267	183,900	2,525,100	31,858,400	766,000	25,221,800
1899....	763	401,500	1,499	248,800	6,640	2,419,060	270	186,000	2,578,400	37,342,000	834,000	30,765,400
1900....	1,026	525,600	1,573	246,080	6,446	2,365,600	208	139,800	2,714,298	44,818,800	672,172	33,663,400
1901....	1,200	560,000	1,786	240,000	7,000	2,294,200	129	88,888	2,388,823	34,366,124	612,362	27,857,447

Year.	Iron and Steel—*Con*		Lead. (*f*)		Nickel.		Silver—Kg.		Zinc.	
	Steel. (*e*).									
1897.................. ..	994,891	$45,276,658	9,916	$630,928	1,245	$741,500	80,351	$1,639,160	38,067	$3,263,490
1898......................	1,174,000	55,042,800	10,920	738,400	1,540	920,000	90,583	1,817,000	37,155	3,598,600
1899......................	1,240,000	64,877,400	15,981	1,348,500	1,740	1,040,000	82,105	1,642,100	39,274	4,508,400
1900......................	1,226,587	70,813,000	15,210	1,253,820	1,700	1,020,000	85,646	1,712,920	36,305	3,569,680
1901......................	1,175,454	58,704,112	21,000	1,451,600	1,800	1,440,000	76,521	1,530,420	37,600	3,256,600

(*a*) From *Statistique de l'Industrié Minérale.* (*b*) Not reported. (*c*) Includes pure bitumen, bituminous schist. bituminous sand, and asphaltic limestone. (*d*) Sulphur and limestone impregnated with sulphur. (*e*) Wrought steel. (*f*) Lead produced from native ores only, and does not include the metal produced from foreign ores and bullion. (*g*) Finished product.

MINERAL IMPORTS OF FRANCE. (*a*) (IN METRIC TONS; 5 f.—$1.)

Year.	Bituminous Substances. (*b*)		Coal. (*c*)		Copper.		Gold.	Silver.	Iron and Steel.		Iron, Cast. (Crude.)	
1898..	20,385	$244,600	10,445,090	$41,438,200	52,976	$14,998,000	$39,881,575	$38,274,504	47,825	$1,941,800	(*d*)	$998,000
1899..	30,770	369,200	11,896,080	51,646,600	58,419	20,450,000	63,697,020	37,528,657	64,178	3,288,400	(*d*)	2,182,200
1900..	39,598	475,200	14,601,981	81,366,600	61,638	21,628,800	90,408,723	29,164,546	118,152	5,797,800	149,755	3,748,400
1901..	28,888	346,600	13,925,623	68,558,400	47,035	15,442,600	85,485,000	19,557,600	77,742	2,945,000	61,085	1,339,200
1902..	26,053	312,600	13,137,720	67,016,000	54,484	18,098,600	88,091,400	19,343,400	60,697	2,351,600	38,521	943,800

Year.	Lead.		Nickel.		Sodium Nitrate.	Stone.	Sulphur.		Tin.		Zinc.	
1898..	74,902	$5,843,600	330	$525,000	$8,026,400	$2,814,600	130,289	$2,800,400	9,247	$8,475,800	32,342	$3,662,400
1899..	67,149	6,657,400	286	399,600	9,341,600	4,494,800	120,062	2,818,000	6,907	4,495,400	25,516	3,467,600
1900 .	70,857	7,749,200	299	397,740	11,995,820	5,232,200	133,531	3,140,200	7,824	5,065,800	33,144	3,906,800
1901..	59,051	4,769,800	252	541,200	10,526,400	4,670,200	101,301	2,369,000	7,314	4,775,200	29,812	2,850,000
1902..	58,694	4,783,400	301	457,000	9,372,600	4,870,600	85,839	1,806,000	8,575	5,568,200	36,564	3,511,000

Year.	Alum.	Borax	Bromides.	Cement	Chromate of Potash and of Soda.	Copper Ore.	Hydrochloric Acid.	Iron.	
								Ore.	Pyrites.
1898..............................	27	189	30	11,290	2,890	8,779	1,994	2,082,240	71,569
1899..............................	34	123	46	13,640	3,147	8,517	1,905	1,950,665	109,646
1900..............................	23	111	10	13,612	3,293	9,766	1,962	2,119,003	156,825
1901..............................	39	128	8	16,232	2,784	13,383	1,903	1,662,875	205,617
1902..............................	36	141	3	15,720	2,861	17,862	2,763	1,563,334	170,783

Year.	Kaolin.	Lead Ore.	Lead Carbonate.	Lime, Chloride.	Lime.	Manganese Ore.	Mercury	Nitrate of Potash.	Nickel Ore.	Nitric Acid.
1898.......	40,352	14,377	1,376	1,288	346,000	100,243	221	1,008	24,985	922
1899.......	36,904	12,687	2,029	1,887	321,610	106,680	276	1,015	28,620	1,232
1900.......	39,842	19,772	1,739	1,215	399,092	120,790	161	1,928	17,687	1,140
1901.......	41,972	15,430	1,789	1,400	374,281	94,365	205	757	39,497	961
1902.......	41,165	18,121	2,223	2,130	359,210	85,629	224	1,547	58,874	1,404

Year.	Oxides.						Petroleum.	Phosphates.	Plaster.	Platinum. Kg.	Potash and Carbonate of.	Potassium Chloride.
	Cobalt	Copper.	Iron.	Lead.	Uranium.	Zinc.						
1898.........	9	52	1,021	1,874	15	1,256	291,961	326,842	2,040	505	2,418	10,929
1899.........	9	36	1,037	1,807	44	1,765	306,078	242,021	2,260	817	2,779	13,335
1900.........	9	84	1,023	1,284	36	1,743	302,482	283,921	3,648	2,398	2,768	13,524
1901.........	8	162	1,001	1,383	22	1,233	225,962	275,265	2,844	1,857	2,590	13,299
1902.........	10	111	1,051	1,415	25	2,178	148,170	302,898	2,440	2,940	1,539	10,802

Year.	Sal Ammoniac.	Salt.	Soda, Caustic	Sulphates.		Sulphide of Mercury.	Sulphuric Acid.	Superphosphate of Lime.	Tin Ore.	Zinc Ore.
				Copper.	Iron.					
1898.........................	20,426	35,863	1,772	30,897	896	19	4,666	178,569	357	60,481
1899.........................	12,210	37,970	1,494	21,733	1,698	21	4,588	171,681	486	73,192
1900........................	15,205	32,045	1,062	22,820	1,589	22	4,254	143,437	512	66,178
1901	9,268	32,347	869	15,813	45	23	5,386	165,361	365	74,553
1902.........................	15,445	32,505	643	22,273	17	24	7,798	116,098	748	69,451

MINERAL AND METALLURGICAL EXPORTS OF FRANCE. (*a*) (IN METRIC TONS.)

Year.	Aluminum.	Antimony.		Cement	Coal.	Copper.		Gold. Kg. (*e*)	Iron.				Iron Pyrites
		Ore.	Metal			Ore.	Metal		Ore.	Pig.	Bars.	Steel.	
1898 ..	192	616	100·6	241,150	1,320,616	1,788	14,350	1,812	236,169	162,991	27,494	47,278	60,406
1899....	256	304	254·7	244,480	1,229,090	2,078	17,949	2,622	291,346	153,792	29,112	33,584	53,395
1900....	324	154	336·0	232,577	1,201,210	9,197	16,791	883	371,799	114,361	18,763	19,535	64,530
1901....	307	645	741·3	242,010	908,583	16,066	14,776	1,369	258,925	96,463	25,220	56,347	52,952
1902....	748	595	665·7	210,590	910,760	20,489	14,423	1,517	422,677	213,081	23,828	121,932	68,920

Year.	Lead.		Manganese Ore.	Millstones and Pieces. *Number.*	Nickel. Refined	Phosphate Rock.	Plaster.	Silver. Kg. (*f*)	Tin.	Zinc.	
	Ore.	Metal.								Ore.	Metal.
1898....	10,216	3,663	12,229	208,584	596	93,742	106,790	1,886	587	60,664	16,995
1899....	3,909	1,163	12,289	112,620	280	70,517	112,520	....	666	76,104	14,958
1900....	2,845	958	8,392	65,436	599	89,135	108,387	15,470	716	54,663	12,712
1901....	3,490	718	5,289	52,383	1,031	81,405	101,063	16,745	438	42,995	15,022
1902 ...	2,414	648	1,948	45,647	397	62,375	110,270	17,184	654	47,724	16,158

(*a*) The figures are from *L'Economiste Français*, and represent the *Commerce Spécial* of France. (*b*) Includes bitumen, bituminous schist and sand, and asphaltic limestone. (*c*) Including coke. (*d*) Not reported. (*e*) Gold and platinum, in ore, sheets, leaves, or threads. (*f*) Silver in ore, sheets, leaves, or threads.

MINERAL PRODUCTION OF ALGERIA. (*a*) (IN METRIC TONS AND DOLLARS; 5 f. = $1.)

Year.	Antimony Ore.		Cement.		Clays.		Copper Matte.		Gypsum, Crude.		Gypsum, (Plaster).		Iron.	
													Ore.	
1897..	781	$21,621	.....	....	67,180	$59,607	289	$28,880	350	$175	29,120	$109,473	441,467	$663,283
1898..	138	4,416	.....	....	78,690	60,275	488	54,200	150	75	29,750	110,585	473,569	708,667
1899..	200	10,400	.....	....	88,600	73,874	472	48,700	200	100	31,800	117,795	550,921	982,826
1900..	93	8,175	.....	....	94,000	76,140	......	....	500	250	37,100	188,940	174,000	268,821
1901..	....	....	1,500	$12,000	119,195	85,198	*b*7,267	25,173	600	300	34,740	131,986	161,808	251,740

Year.	Iron—*Con.*		Lead-Silver Ore.		Lime.				Marble.		Onyx.	
	Cast, 2d Fusion.				Hydraulic.		White.					
1897	699	$44,870	145	$3,041	20,425	$122,500	9,215	$32,260	1,660	$26,150	364	$25,480
1898	*Nil.*	....	120	3,120	18,000	78,000	12,975	46,783	985	30,004	219	12,483
1899	*Nil.*	....	889	10,483	12,000	72,000	13,645	48,961	225	428	217	12,397
1900	*Nil.*	....	222	6,382	12,000	72,000	13,700	49,050	.....	....	228	12,976
1901	*Nil.*	....	1,614	21,916	12,000	72,000	15,000	55,500	.....	....	294	16,753

Year.	Phosphate Rock.		Quicksilver Ore.		Salt.		Sand and Gravel.		Zinc Ore.	
1897	228,141	$912,564	.....	....	23,222	$78,058	80,860	$20,280	32,269	$301,538
1898	269,500	1,078,000	.....	....	21,300	86,000	72,185	17,717	29,800	281,400
1899	324,963	1,299,982	.....	....	17,378	67,300	72,760	15,827	42,970	502,579
1900	319,422	1,277,688	.....	....	18,925	76,288	71,860	14,569	30,281	307,594
1901	265,000	1,060,000	.....	....	18,518	79,976	86,727	18,870	26,913	262,522

(*a*) From *Statistique de l'Industrie Minérale.* (*b*) Copper ore.

MINERAL EXPORTS OF NEW CALEDONIA. (*a*) (IN METRIC TONS.)

Year.	Chrome Iron Ore.	Cobalt Ore.	Copper Ore.	Nickel Ore.
1897	3,949	3,200	2,200	26,464
1898	7,712	2,378	*Nil.*	74,614
1899	12,684	2,294	6,349	108,908
1900	10,474	2,433	2	100,319
1901	17,451	3,123	6,349	122,814

(*a*) From *Statistique de l'Industrie Minérale.* Additonal products in 1897: Lead ore, 200 metric tons.

MINERAL PRODUCTION OF TUNIS. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Salt.		Lead Ore.		Zinc Ore.	
1897	8,100	$32,400	2,123	$26,960	11,830	$147,200
1898	7,300	33,200	2,375	37,680	21,477	185,520
1899	8,850	35,400	2,263	53,400	20,079	313,400
1900	9,160	64,120	6,864	122,200	16,596	221,600
1901	16,900	74,360	8,158	183,800	17,879	216,200

(*a*) From *Annual General Reports*, by C. Le Neve Foster, and *Statistique de l'Industrie Minérale.* Additional products in 1899, 70,000 tons phosphate rock, valued at $168,000; in 1900, 178,000 tons, valued at $781,000; in 1901, 172,000 tons, valued at $598,600.

GERMANY.

THE mineral statistics of the German Empire, together with those of Baden, Bavaria, Prussia and Saxony, are summarized in the subjoined tables:

MINERAL PRODUCTION OF GERMANY. (*a*) (*b*) (IN METRIC TONS AND DOLLARS; 4 marks — $1.)

Year.	Alum.		Aluminum Sulphate.		Antimony and Manganese.		Antimony Ore.		Arsenic Ore.		Arsenical Products.	
1898	4,069	$91,086	35,366	$514,952	2,711	$302,892	*Nil.*	....	3,540	$53,414	2,679	$253,623
1899	3,358	73,500	37,693	568,250	3,149	434,000	*Nil.*	....	3,834	61,250	2,423	267,250
1900	4,355	93,750	44,872	673,000	3,338	473,750	*Nil.*	....	4,380	79,250	2,415	263,250
1901	4,145	93,000	46,807	736,750	2,526	268,250	(*f*) 8	....	4,060	78,000	2,549	256,750
1902	.?.....	....	47,905	770,250	3,542	348,750	......	....	....	....	2,827	260,000

Year.	Asphaltum.		Boracite.		Cadmium—Kg.		Coal.		Cobalt, Nickel and Bismuth Ores.		Copper, Ingot.	
1898	67,649	$104,084	230	$10,746	14,943	$31,162	96,279,992	$177,564,248	3,157	$138,545	30,696	$8,182,102
1899	74,770	130,250	183	8,750	13,608	21,250	101,639,753	197,862,000	1,270	133,500	34,683	12,519,000
1900	89,685	160,000	232	11,000	18,533	20,500	109,290,237	241,498,250	4,495	168,000	30,928	11,788,500
1901	90,193	168,750	184	8,000	13,144	20,500	108,539,444	253,818,500	10,479	185,500	31,317	11,577,250
1902	83,874	151,000	.. .	....	....	....	107,436,834	237,758,000	12,485	188,000	30,591	8,541,000

Year.	Copper Matte and Black Copper.		Copper Ore.		Gold—Kg.		Graphite.		Iron Ore.	
1898	62	$2,170	702,781	$4,921,152	2,847	$1,978,853	4,593	$97,916	15,893,246	$15,202,159
1899	95	4,000	783,619	5,217,000	2,605	1,814,750	5,196	120,250	17,989,635	17,542,500
1900	4,207	614,500	747,775	5,956,000	3,055	2,130,750	9,248	136,500	18,964,367	19,407,000
1901	365	75,250	777,339	6,074,750	2,755	1,922,900	4,485	58,000	16,570,182	17,999,750
1902	434	55,000	761,921	5,107,750	2,664	1,857,750	....	....	17,963,595	16,434,000

Year.	Iron, Pig.		Lead.		Lead Ore.		Lignite.		Litharge.		Magnesium Sulphate. (*f*)	
1898	7,215,927	$93,575,641	132,742	$8,555,606	151,601	$3,412,128	31,648,498	$18,339,869	3,837	$265,496	2,444	$5,277
1899	7,160,203	102,820,750	129,225	9,315,000	144,370	3,523,000	34,204,666	17,458,970	3,561	270,750	2,032	4,250
1900	7,549,655	122,989,750	121,513	10,174,750	148,230	4,518,000	40,498,019	24,436,500	3,088	266,750	1,750	3,750
1901	7,880,087	122,948,500	123,098	8,058,250	153,841	3,535,250	44,479,970	27,570,000	4,101	282,000	2,230	4,000
1902	8,529,900	113,924,750	140,331	7,837,250	167,855	3,359,000	43,000,476	25,594,500	4,197	258,250	....	....

Year.	Manganese Ore		Magnesium Chloride (From Solution.)		Magnesium Sulphate (From Solution.)		Mineral Paints.		Nickel & Various By-Products. (*c*)		Petroleum.	
1898	43,354	$111,786	19,319	$96,973	30,295	$122,667	3,081	$91,153	1,691	$1,465,254	25,789	$394,552
1899	61,329	177,750	21,369	81,250	39,540	148,500	3,351	97,000	1,747	1,556,000	27,027	394,500
1900	59,203	183,500	19,397	76,250	48,591	153,000	3,311	91,750	1,989	2,000,000	50,375	931,500
1901	56,691	175,750	21,018	83,750	46,714	171,750	3,334	96,250	2,207	2,165,250	44,095	737,500
1902	49,812	144,750	....	....	39,262	185,250	.....	....	2,196	2,181,000	49,725	837,750

Year.	Potassium Salts.									
	Chloride.		Kainite.		Potassium and Magnesium Sulphate.		Sulphate.		Unspecified.	
1898	191,347	$6,380,220	1,103,643	$3,835,856	13,962	$259,485	18,853	$763,397	1,105,212	$3,576,628
1899	207,506	6,801,250	1,108,159	3,838,250	9,765	195,000	26,103	1,027,500	1,384,972	4,202,000
1900	271,512	8,798,750	1,178,527	5,416,500	15,368	230,500	30,853	1,249,250	1,822,758	5,450,500
1901	294,666	8,782,250	1,498,569	4,327,250	15,612	286,500	37,394	1,460,000	2,086,826	5,448,250
1902	267,512	7,886,250	1,322,633	4,802,500	18,147	351,250	28,279	1,133,500	....	....

Year.	Pyrites.		Salt.		Salt, Rock.		Silver and Gold Ore.		Silver—Kg.	
1898....	186,849	$942,586	565,683	$3,116,087	804,658	$898,656	12,418	$836,657	480,578	$9,539,162
1899....	144,623	259,250	571,058	3,021,750	861,123	957,000	13,506	479,750	467,590	9,458,000
1900....	169,447	303,750	587,464	3,567,000	926,563	1,060,500	12,598	514,500	415,785	8,663,250
1901....	157,438	285,500	578,781	3,982,500	985,050	1,182,250	11,577	387,750	408,796	8,129,750
1902....	165,225	321,250	572,846	3,902,750	1,010,412	1,171,000	11,624	346,000	430,610	7,700,000

Year.	Sodium Salts. (Glauber Salt.)		Sulphur.		Sulphuric Acid. (*g*)		Sulphates. (*d*) Copper.		Sulphates. (*d*) Iron.		Sulphates. (*d*) Zinc.		Sulphates. (*d*) Copper and Iron Mixed.	
1898....	69,111	$452,509	1,954	$43,167	664,865	$4,065,784	4,352	$356,540	10,422	$42,707	6,104	$91,152	176	$6,991
1899....	79,062	504,000	1,663	36,000	832,666	5,737,000	5,142	460,750	10,931	38,750	7,117	107,000	212	9,000
1900....	90,468	663,750	1,445	31,000	829,876	5,885,000	5,076	587,000	10,747	41,000	6,027	80,250	166	7,000
1901....	76,065	492,000	968	20,250	835,000	5,856,750	5,192	572,750	11,019	41,250	5,552	74,250	129	5,500
1902....	83,978	548,500	.....	....	894,499	6,079,750	4,997	471,500	......	....	....	....	....	....

Year.	Tin		Tin Ore.		Uranium and Wolfram Ores.		Zinc.		Zinc Ore.		Vitriol and Alum Ores. Unspecified.	
1898....	993	$872,252	51	$3,550	50	$11,527	154,181	$14,708,459	641,706	$5,511,819	188	$388
1899....	1,481	870,750	72	10,000	50	13,000	153,155	18,737,750	644,538	8,853,000	533	750
1900....	2,031	1,832,750	80	11,250	43	11,250	155,790	15,516,750	629,215	6,438,250	350	500
1901....	1,451	849,000	82	12,500	43	7,500	166,233	13,696,750	647,496	5,375,500	1,056	1,500
1902....	1,986	1,161,500	......	....	......	....	174,927	15,451,000	702,504	7,452,750	....	....

(*a*) Including Luxemburg. (*b*) From *Vierteljahrs- und Monats-hefte zur Statistik des Deutschen Reichs.* (*c*) Including metallic bismuth, cobalt products, and uranium salts. (*d*) There was also produced nickel sulphate and tin chloride as follows: 1900, 148 tons, $31,500; 1901, 133 tons, $27,250. (*e*) Kieserite, glauberite, etc. (*f*) Including quicksilver ore. (*g*) There was also produced fuming sulphuric acid as follows: 1900, 20,495 tons, $235,500; 1901, 21,827 tons, $255.250; 1902, 70,557 tons, $640,000.

MINERAL IMPORTS OF GERMANY. (*a*) (IN METRIC TONS AND DOLLARS; 4 marks= $1.)

Year.	Alabaster and Marble, Crude.		Aluminum, Nickel Wares, etc.		Ammonium Sulphate.		Cement.		Clay Products. Brick and Roofing Tile.		Clay Products. Porcelain.		Clay Products. Kaolin, Feldspar and Fire Clay.	
1897	29,633	$900,000	417	$425.000	33,113	$1,325,000	42,364	$350,000	84,477	$1,325,000	812	$357,000	207,155	$2,050,000
1898	(*c*)	....	459	482,500	30,254	1,285,750	53,519	318,000	95,575	1,661,500	788	317,750	208,186	2,087,750
1899	(*c*)	....	495	557,000	28,868	1,443,500	63,388	806,000	100,063	1,827,500	704	284,500	235,233	2,509,000
1900	(*c*)	....	483	546.000	23,105	1,213,000	79,303	705,500	91,207	1,643,500	765	312,750	265,289	2,881,750
1901	(*c*)	....	438	484,500	44,408	2,442,500	87,262	668,500	68,456	1,448,750	737	318,500	249,180	2,205,750

Year.	Coal.		Coal. (Lignite.)		Coke.		Copper. Bars and Sheets.		Copper. Crude.	
1897.........	6,072,029	$16,625,000	8,111,076	$12,775,000	435,161	$1,950,000	400	$125,000	67,573	$17,025,000
1898.........	5,826,332	17,287,500	8,450,149	13,942.750	332,579	1,677,500	450	141,250	73,291	19,711,500
1899.........	6,220,489	21,350,250	8,616.751	15,079,250	402,577	2,587,750	610	251,750	70,091	26,008,250
1900.........	7,384,049	33,720,000	7,960,813	16,915,750	512,690	3,226.250	906	381,250	83,503	31,892,000
1901.........	6,297,389	23,129,500	8,108,943	18,853,250	400,197	2,278,000	786	311,750	58,620	21,265,000

Year.	Copper—*Con.* Scrap and Coin.		Copper and Brass Manufactures. Fine.		Copper and Brass Manufactures. Wire.		Copper and Brass Manufactures. Cartridge Cases, Coarse Wares, etc.		Glass Manufactures, All Kinds.		Gold. Bullion. Kg.		Gold. Coin. Kg.	
1897..	4,199	$930.000	846	$700,000	80	$25,000	612	$300,000	2,057	$475,000	34.991	$24,925,000	22,914	$14,350,000
1898..	4,720	1,153.500	881	791,000	55	18,250	546	275,500	2,408	504,750	62,937	43,772,750	60,355	37,779.250
1899..	4,992	1,753.250	962	937,250	79	34,250	565	329,500	2,337	517,250	51.539	35,948,500	50,769	31,870.250
1900..	4,603	1,674,250	1,007	989,250	76	31,250	504	304,500	2,746	557.500	37,094	25,873,000	54,859	34,437.750
1901..	4,586	1.427,250	834	783,250	91	37,250	439	264,000	2.561	701,250	43,084	30,051,000	54,412	34,157.250

Year.	Gold and Silver.				Gold, Silver, and Platinum Ores.		Graphite.		Iodine.		Iron.			
	Scrap, Pagament. Kg.		Manufactures. Kg.								Angle.		Blooms, Bars, and Ingots.	
1897..	36,664	$3,075,000	35,160	$750,000	8,927	$4,475,000	17,366	$607,750	164	$950,000	1,081	$25,000	1,038	$25,000
1898..	54,793	4,520,500	31,549	667,500	7,481	2,619,000	20,269	945,500	216	1,266,750	207	5,500	1,558	44,000
1899..	44,463	3,723,750	34,775	865,000	7,597	2,724,000	23,400	1,082,000	191	1,124,000	898	29,250	1,841	46,750
1900..	45,774	3,948,000	33,259	1,608,250	9,153	3,363,500	22,495	955,250	236	1,358,250	827	31,000	2,778	116,000
1901..	32,158	2,673,250	32,291	1,486,500	8,764	3,060,500	(c)	....	266	1,194,750	671	20,000	1,666	57,000

Year.	Iron.—*Continued.*											
	Ore.		Pig.		Rails.		Scrap.		Wire.		Wrought in Bars.	
1897........	3,185,644	$11,675,000	423,127	$5,375,000	774	$25,000	37,957	$450,000	5,609	$375,000	29,467	$1,225,000
1898........	3,516,577	13,621,000	384,561	4,904,000	267	6,750	23,328	295,750	7,166	470,750	26,014	1,107,000
1899........	4,165,372	17,562,000	612,652	9,963,750	1,319	33,000	63,141	1,040,250	8,582	664,750	37,179	1,790,000
1900........	4,107,840	18,795,500	726,712	14,604,250	348	10,250	100,383	2,152,250	8,711	692,250	37,809	2,097,000
1901........	4,370,022	17,425,750	267,508	4,258,750	545	14,250	26,363	462,500	7,922	496,500	22,518	1,063,750

Year.	Iron.—*Con.*		Lead, Pig and Scrap.		Lead and Copper Ores.		Lead, White.		Manganese Ore.		Nickel.	
	All Other Manufactures.											
1897..........	18,185	$1,975,000	35,092	$2,350,000	90,114	$3,395,500	696	$50,000	86,911	$925,000	1,390	$875,000
1898..........	20,158	1,892,750	47,497	3,249,750	64,727	2,793,750	822	65,750	130,711	1,315,750	1,467	860,750
1899..........	31,218	2,856,750	55,635	4,560,250	65,821	3,680,500	708	63,250	196,825	2,265,750	1,391	834,750
1900..........	28,906	3,492,000	70,252	6,272,750	62,268	4,531,000	698	66,250	204,420	2,461,250	1,712	1,220,000
1901..........	17,964	2,338,000	52,886	3,405,000	*d*100,196	5,101,500	423	32,750	222,010	2,436,500	1,947	1,387,250

Year.	Petroleum.				Phosphate Rock.		Potassium Salts.					
	Illuminating Oil.		Lubricating Oil.				Chloride.		Cyanide.		Iodide.	
1897..........	946,344	$12,300,000	83,957	$3,250,000	289,234	$3,625,000	715	$25,000	7	....	18	$23,500
1898..........	954,646	16,200,250	97,028	3,759,750	270,988	2,710,000	422	14,750	2	$1,000	16	51,250
1899..........	963,943	19,776,750	106,624	4,898,250	407,437	4,339,250	443	16,000	3	1,500	9	27,750
1900..........	989,361	21,000,250	124,505	5,602,750	320,136	3,681,500	484	17,250	2	750	10	54,500
1901..........	985,904	17,826,000	118,999	4,908,750	351,155	4,038,250	462	16,250	2	750	(*c*)	....

Year.	Potassium Salts.—*Continued*						Pyrites.		Quicksilver.		Salt.	
	Nitrate.		Oxide (Potash.)		Sulphate.							
1897...........	2,889	$275,000	1,734	$125,000	912	$25,000	356,869	$1,900,000	(*c*)	....	(*c*)	....
1898...........	1,895	173,000	1,486	104,000	999	27,500	376,817	2,184,500	560	$595,250	21,957	$141,250
1899...........	1,785	163,000	1,737	130,250	533	16,000	437,732	3,761,000	572	700,500	22,040	124,250
1900...........	2,047	194,500	1,522	121,750	856	25,750	457,679	3,980,750	555	762,750	21,788	15.500
1901...........	1,529	149,000	1,758	131,750	680	20,500	488,688	4,396,750	651	870,000	23,901	128,000

Year.	Silica, Sand, Marl, etc.		Silver.		Slag and Slag Wool.		Slag, Thomas Slag, Ground.		Slate.		Soda, Calcined.	
			Bullion—Kg.									
1897......	228,241	$225,000	147,034	$2,975,000	670,224	$3,575,000	110,216	$575,000	48,880	$1,075,000	916	25,000
1898......	239,708	239,750	104,770	2,075,750	685,118	2,633,750	88,374	487,500	57,571	1,408,000	524	11,750
1899......	279,089	280,750	89,930	1,821,000	892,764	3,941,500	68,305	475,500	63,309	1,541,250	515	12,250
1900......	386,028	387,750	167,482	3,488,750	974,947	4,694,250	103,481	827,250	54,646	1,327,500	373	9,250
1901......	264,686	274,000	197,855	3,969,500	733,981	2,989,250	87,152	663,500	41,570	....	178	4,500

Year.	Soda, Nitrate. (Chile Saltpeter.)		Stassfurt Salts.		Stone.						Sulphur.	
					Rough or Simply Hewn.		Limestone, Lime.		Grindstones, Polishing and Whetstones.			
1897...	465,498	$16,875,000	6	....	858,825	$4,275,000	235,715	$1,300,000	1,820	$113,750	25,305	$625,000
1898...	425,054	15,408,250	17	....	981,826	4,285,000	242,397	1,338,250	1,967	187,250	30,269	756,750
1899...	596,944	19,481,000	192	$1,250	1,021,755	5,199,750	229,912	804,750	2,182	208,500	31,196	702,000
1900...	484,544	19,881,750	130	750	1,072,483	6,478,750	272,324	1,021,250	2,236	208,750	40,689	915,500
1901...	529,568	22,506,750	155	750	926,994	4,738,750	261,659	915,750	(c)	....	32,750	818,750

Year.	Tin.				Zinc.								Zinc-White, Zinc-Gray, and Lithophone.	
	Crude.		Manufactures		Crude.		Drawn and Rolled.		Manufactures		Ore.			
1897..	12,395	$8,875,090	75	$75,000	19,734	$1,850,000	130	$25,000	146	$75,000	24,785	$400,000	3,532	$325,000
1898..	14,623	5,801,000	82	93,500	24,116	2,413,500	53	5,750	128	77,250	48,050	901,000	3,653	365,250
1899..	12,258	7,566,250	83	115,000	23,691	2,916,500	95	12,500	126	79,000	57,880	1,454,000	4,226	485,250
1900..	12,454	8,375,250	115	159,500	24,263	2,374,250	145	15,750	132	82,500	68,982	1,456,000	4,884	512,250
1901..	12,910	7,520,000	98	121,250	21,250	1,809,250	306	30,500	126	77,250	75,533	1,358,500	3,673	389,000

MINERAL EXPORTS OF GERMANY. (a) (IN METRIC TONS AND DOLLARS; 4 marks = $1.)

Year.	Alabaster and Marble, Crude.		Aluminum, Nickel Wares, etc.		Ammonium Sulphate.		Cement.		Clay Products.			
									Roofing Tile, and Building Stone.		Porcelain.	
1897......	2,727	$75,000	1,899	$1,950,000	2,623	$100,000	594,557	$4,500,000	99,128	$925,000	21,687	$8,750,000
1898......	(c)	....	2,045	2,187,500	4,083	178,500	551,744	5,004,000	122,285	1,160,500	21,644	6,408,500
1899......	(c)	....	2,812	2,583,250	1,558	77,750	580,255	5,162,500	152,819	1,458,750	23,110	9,015,75
1900......	(c)	....	2,396	2,680,250	2,431	127,500	600,886	6,359,750	148,668	1,533,250	26,642	10,727,750
1901......	(c)	....	2,270	2,465,250	9,842	541,250	560,612	4,608,500	100,301	1,064,500	27,649	12,870,250

Year.	Clay Products. *Con*		Coal.		Coal, Lignite.		Coke.	
	Kaolin, Feldspar and Fire Clay.							
1897.........................	121,535	$475,000	12,389,907	$33,375,000	19,112	$25,000	2,161,886	$9,150,000
1898.........................	129,082	651,250	13,989,223	39,925,500	22,155	36,500	2,183,179	10,197,750
1899.........................	143,406	729,000	13,943,174	45,046,250	20,925	36,500	2,187,985	11.490,500
1900.........................	159,855	941,000	15,275,805	54,234,500	52,795	105,500	2,229,188	13,942,250
1901.........................	128,174	794,500	15,266,267	52.420,500	21,718	43,500	2,036,981	13,189,250

Year.	Copper.						Copper and Brass Manufactures.					
	Crude.		Bars and Sheets, Unplated.		Scrap and Coin.		Fine.		Wire.		Cartridge Cases, Coarse Wares, etc.	
1897.......	7,188	$1.825,000	5,718	$1,825,000	2,164	$525,000	5,588	$4,625,000	6,176	$2,025,000	5,409	$3,350,000
1898.......	6,972	1,885,500	5,309	1,798,500	3,686	892,750	6,472	5,471,500	5,980	2,090,500	6,278	3,776,750
1899.......	7,061	2,598,750	4,871	2,118,500	5,217	1,804,750	7,561	6,986,500	7,579	3,369,750	5,846	3,951,250
1900.......	5,505	2,090,750	5,273	2,838,250	5,455	1,998,500	8,888	8,294,500	9,605	4,808,000	4,906	3,838,750
1901.......	5,097	1.765,750	4,952	2,072,000	5,181	1,597,250	7,852	7,361,750	7,833	3.289,000	4,968	3,323,250

Year.	Glass Manufactures, All Kinds.		Gold.				Gold and Silver Manufactures. Kg.		Gold, Silver, and Platinum Ores.		Graphite.	
			Bullion. Kg.		Coin. Kg.							
1897...	105,702	$9,050,000	32.312	$22,525,000	11,385	$7,150,000	101,429	$9,975,000	53	$25,000	2,422	$127,500
1898...	102,615	7,757,250	4,851	3,381,250	82,902	52,061,000	98,939	10,266,000	18	84,750	2,986	171,500
1899...	111,087	8,450,250	4,850	3,397,750	48,504	30,548,500	107,021	12,181,250	5	10,250	2,708	177,500
1900...	124,501	9,266,000	5,587	3,902,500	39,072	24,562,500	111,117	18,370,750	20	4,500	2,068	78,250
1901...	112,291	9,187,500	8,661	6,049,750	10,808	6,848,000	98,564	15,213,750	5	8,500	(c)	....

Year.	Iodine.		Iron and Steel.								Iron Ore.	
			Angle.		Blooms, Bars and Ingots.		Cast, Crude.		Manufactures, All Other.			
1897.	26	$150,000	169,287	$4,400,000	39,792	$900,000	170,084	$26,725,000	296,949	$22,450,000	3,230,391	$2,400,000
1898.	26	159,750	204,705	5,396,500	34,964	801,500	193,089	30,607,750	312,948	22,899,000	2,983,734	2,153,750
1899.	26	161,750	221,165	7,207,000	23,438	638,500	205,985	36,050,750	329,928	28,548,250	3,119,878	2,649,000
1900.	29	177,500	215,641	7,709,250	33,627	1,009,500	196,759	36,223,250	371,835	37,835,250	3,247,888	2,982,000
1901.	27	128,125	342,447	8,657,250	201,716	4,084,250	211,124	37,112,750	484,454	39,675,150	2,889,870	2,238,750

Year.	Iron and Steel.—*Continued.*										Lead and Copper Ores.	
	Iron, Pig.		Rails.		Scrap.		Wire.		Wrought, in Bars.			
1897	90,885	$1,250,000	113,473	$2,850,000	33,102	$550,000	198,909	$6,625,000	246,772	$7,075,000	26,317	$233,500
1898	187,375	2,534,000	123,889	3,259,500	85,095	1,302,000	188,718	6,623,500	263,698	7,662,250	24,163	218,000
1899	182,091	3,022,750	109,813	3,305,000	53,103	1,080,000	154,332	6,307,500	193,933	6,763,000	35,359	1,520,750
1900	129,409	2,560,000	155,656	4,895,000	61,096	1,249,750	169,839	7,464,500	172,533	6,358,000	26,995	718,000
1901	150,448	2,190,500	180,978	5,011,750	153,399	2,038,250	247,758	8,265,000	329,513	8,688,500	*d*391	31,250

Year.	Lead, Pig and Scrap.		Lead, White.		Manganese. Ore.		Nickel.		Phosphate Rock.		Potassium Salts.			
											Chloride.		Cyanide.	
1897..	24,075	$1,585,000	14,786	$1,225,000	8,615	$100,000	169	$100,000	4,000	$75,000	80,389	$2,850,000	1,068	$525,000
1898..	24,867	1,637,000	16,473	1,400,250	4,810	73,250	208	119,500	5,100	76,500	96,236	3,368,250	1,907	977,000
1899..	24,491	1,852,250	16,360	1,686,000	7,040	105,250	295	177,000	2,504	40,000	101,045	3,637,500	1,645	823,750
1900..	18,825	1,626,500	15,126	1,588,250	2,454	44,500	268	284,750	1,128	19,750	114,469	4,078,000	1,338	652,250
1901..	20,820	1,877,000	16,966	1,442,250	5,584	82,250	390	340,750	2,260	28,250	118,959	4,163,500	2,089	918,750

Year.	Potassium Salts.—*Continued.*								Pyrites.		Quicksilver.		Salt.	
	Iodide.		Nitrate.		Oxide. (Potash.)		Sulphate.							
1897..	124	$775,750	8,986	$850,000	13,100	$795,000	20,971	$675,000	15,387	$75,000	(*c*)	....	(*c*)	....
1898..	135	845,000	10,969	1,001,000	13,456	807,250	27,105	847,000	19,220	93,750	97	$105,750	225,548	$594,000
1899..	145	905,000	15,146	1,382,000	11,917	898,750	32,845	1,157,750	16,985	82,250	23	29,000	241,036	571,750
1900..	138	755,500	14,744	1,400,750	15,761	1,418,500	38,125	1,329,500	24,986	141,250	23	32,500	236,291	610,250
1901..	(*c*)	....	13,439	1,810,250	15,567	1,862,250	37,216	1,288,500	23,680	105,750	27	36,750	286,424	779,000

Year.	Silica, Sand, Marl, etc.		Silver.		Slag and Slag Wool.		Slag, Thomas Slag, Ground.		Slate.		Soda. Calcined.	
			Crude and in Bars. Kg.									
1897..	652,248	$575,000	371,086	$7,550,000	27,723	$100,000	169,336	$1,225,000	4,948	$100,000	45,673	$1,025,000
1898..	910,854	796,500	348,738	6,952,750	29,931	105,000	187,598	1,396,750	4,434	99,750	37,106	835,000
1899..	872,992	763,250	294,089	5,991,000	25,565	106,000	199,382	1,557,750	3,084	68,250	40,566	963,500
1900..	822,840	925,750	284,853	5,971,250	24,936	146,250	174,563	1,406,750	3,123	77,750	44,316	1,108,000
1901..	832,335	986,500	328,723	6,636,000	27,269	109,500	202,788	1,480,250	3,076	92,250	45,967	1,149,250

Year.	Sodium Nitrate. (Chile Saltpeter.)		Stassfurt Salts.		Stone.						Tin.	
					Crude or Simply Hewn.		Limestone, Lime.		Grindstones, Polishing and Whetstones.		Crude.	
1897......	11,364	$475,000	337,577	$1,700,000	545,723	$2,725,000	77,905	$350,000	7,390	$369,500	561	$275,000
1898......	12,684	531,500	370,829	1,761,500	556,561	3,231,750	84,892	332,000	7,268	363,250	874	321,250
1899......	13,910	573,750	367,828	1,977,000	597,286	4,269,750	84,915	332,000	8,188	508,500	1,121	698,000
1900......	14,159	601,750	468,277	2,868,250	675,605	6,453,000	78,758	384,000	8,795	879,500	1,626	1,101,500
1901......	13,481	600,500	592,347	3,085,750	600,654	4,994,500	76,079	342,250	(*c*)	....	1,683	989,000

Year.	Tin.—*Con.*		Zinc.								Zinc-White, Zinc-Gray, and Lithophone.	
	Manufactures.		Ore.		Crude.		Drawn and Rolled.		Manufactures.			
1897........	967	$800,000	30,047	$500,000	51,341	$4,400,000	17,453	$1,650,000	1,163	$800,000	17,631	$1,825,000
1898........	1,119	996,000	30,408	570,250	51,824	5,171,500	14,477	1,574,500	1,205	849,250	18,674	1,774,000
1899........	1,218	1,385,750	25,192	566,750	46,334	5,678,250	18,281	2,422,250	1,561	1,135,750	19,489	2,187,250
1900........	1,315	1,496,000	34,941	655,250	51,899	5,214,000	16,709	1,817,000	1,731	1,259,250	20,729	2,092,750
1901........	1,450	1,522,750	41,002	512,500	54,490	4,690,750	16,517	1,651,750	1,459	1,240,000	24,201	2,080,750

(*a*) From *Statistisches Jahrbuch für das Deutsche Reich.* (*b*) In 1898, 1899 and 1900, represents unglazed tile and brick only. (*c*) Not reported. (*d*) Lead ore only.

MINERAL IMPORTS AND EXPORTS OF GERMANY FOR THE YEAR 1902. (IN METRIC TONS.)

The following figures are taken from *Chemiker Zeitung*, of Feb. 4, 1903, and while probably from official sources, are subject to correction.

Substances.	Imports.	Exports.
Alum, and aluminate of sodium and alumina, including hydrate.	188	34,005
Aluminum	1,100	410
Ammonium salts	1,954	3,351
Ammonium sulphate	42,252	5,744
Ammoniacal liquor	10,267	15,857
Antimony	1,495	105
Antimony and arsenic ore	1,231	410
Arsenic	....	46
Arsenic, white	347	1,222
Arsénical compounds	42	812
Asbestos and asbestic mastic	3,417	709
Asphalt, pitch, and wood cement	58,536	40,595
Barium chloride	2,135	4,445
Barium salts, N. E. S	56	3,918
Baryta-white	1	2,922
Barytes	2,198	55,763
Bauxite, crude	26,698	32
Borax and boric acid	2,057	2,836
Brass and tombac	1,192	5,8 2
Bromide of potash and other bromine preparations	18	357
Bromine	....	153
Calcium chloride	203	1,346
Carbon bisulphide	26	193
Carbonic acid	625	3,368
Cement	52,018	699,459
Chloride of lime	51	29,694
Chloride of magnesium	35	14,757
Chrome alum	22	1,758
Chrome ore	10,152	846
Coal	6,425,658	16,101,141
Coal-tar oil, light	7,591	2,222
Coal-tar oil, heavy	6,800	5,704
Cobalt and nickel ore	15,551	3
Coke	362,488	2,182,383
Copper, crude	76,050	46,78
Copper, in bars and sheets	133	2,425
Copper alloys, in bars, sheets, etc.	407	3,763
Cinnabar	12	192
Cryolite	1,332	486
Explosives	68	3,819
Fluorspar	81	14,177
Gold, silver, and platinum ores	6,584	....
Gold preparations and salts	....	6
Graphite, crude	19,392	1,691
Gunpowder	79	1,230
Gypsum	8,177	42,859
Hydrochloric acid	2,449	12,307
Iodine	230	24
Iron, crude, all kinds	174,990	516,165
Iron, wrought, in bars	24,579	361,216
Iron alum and iron mordant	417	369
Iron ores	3,957,403	2,868,068
Iron oxide, red	2,057	1,755
Kaolin, feldspar, and refractory clay	229,556	136,928
Lead and copper ores	84,447	19,075
Lead	39,006	23,100
Lead, white	357	19,070
Lignite	7,882,010	21,766
Litharge	169	4,072
Magnesium, artificial carbonate	43	316
Magnesium, natural carbonate	12,237	2,955
Manganese ore	304,647	4,528
Manganese preparations	417	852
Mineral oil for use in the arts	5,762	403
Nickel	1,458	689
Nitric acid	1,374	1,650
Ozokerite, crude	1,585	672
Ozokerite, refined	77	1,856
Petroleum, crude	6,721	....
Petroleum, distilled	5,847	4,066
Petroleum, refined	926,562	875
Phosphorus	350	260
Pitch, except asphalt	24,266	5,152
Potash	2,112	14,041
Potash, caustic	42	13,804
Potassium and sodium chlorate	1,912	758
Potassium chloride	261	106,925
Potassium chromate	445	926
Potassium cyanide	8	3,257
Potassium iodide and other iodine preparations	10	152
Potassium sulphate	266	40,787
Quicksilver	648	109
Salt	26,404	328,324
Saltpeter, Chile	461,024	14,761
Saltpeter, potassium	1,889	9,734
Soda, calcined	121	33,109
Soda, caustic	106	5,650
Soda, crystallized	61	2,449
Soda chromate	197	1,731
Soda, carbonate	108	954
Sodium and potassium sulphide	397	4,565
Stone, refractory, from clay	23,018	91,005
Strontia minerals	34,035	762
Strontia preparations	74	546
Sulphur	32,798	576
Sulphuric acid	22,205	47,666
Superphosphate	109,374	77,818
Thomas slag, ground	103,107	162,008
Tin	13,760	2,271
Tin salts	70	301
Ultramarine	83	4,258
Vitriol, all kinds	3,308	6,055
Waterglass	250	6,623
Witherite	2 842	273
Zinc, ingot	25,936	70,303
Zinc ores	61,407	46,86[illegible]
Zinc, sheet	134	17,914
Zinc white, zinc gray, and zinc sulphate	8,954	19,773

MINERAL PRODUCTION OF BADEN. (*a*) (IN METRIC TONS AND DOLLARS; 4 marks = $1.)

Year.	Alumina Sulphate.		Barytes.		Coal.		Fire Clay.		Gypsum.		Iron. Cast, Foundry.	
1897	1,824	$27,184	400	$300	4,752	$11,880	11,450	$6,654	40,702	$26,972	36,235	$1,876,262
1898	2,051	30,505	1,100	825	4,133	10,333	5,112	3,529	28,037	16,137	39,968	1,876,262
1899	2,153	29,610	2,430	2,126	4,700	13,000	4,775	3,475	29,419	18,371	53,608	2,769,252
1900	2,286	33,725	2,970	2,745	4,930	15,406	3,096	2,650	26,381	15,429	50,102	2,745,058
1901	2,260	33,900	e3,991	3,682	3,650	10,174	2,530	2,864	28,183	17,248	40,100	2,029,392

Year.	Iron.—*Continued.* Ingot.		Iron.—*Continued.* Wrought.		Lead and Copper Ores.		Limestone. (*d*)		Salt.	
1897	3,875	$147,718	1,167	$58,401	(*b*)	....	137,670	$19,502	31,445	$136,998
1898	3,875	147,718	1,167	58,401	(*b*)	....	164,979	26,104	31,445	136,993
1899	3,830	171,863	1,402	63,117	(*b*)	....	201,015	31,674	31,197	116,797
1900	3,532	184,999	1,364	85,217	67	*b*$3,308	221,097	36,312	32,099	192,204
1901	3,739	376,200	1,158	63,041	*f*369	15,025	168,245	27,843	32,885	243,849

Year.	Sand Quartz.		Stone Porphyry.		Sulphuric Acid.		Tripoli.		Zinc Ore.	
1897	1,648	$1,172	28,000	$7,000	18,865	$78,507	9·0	$1,800	(b)	....
1898	1,694	910	7,650	1,912	18,365	78,507	6·0	575	(b)	....
1899	1,461	798	22,261	5,565	18,660	68,300	11·8	1,498	357	$6,245
1900	2,668	1,212	23,421	5,855	15,938	92,840	9·4	1,289	3,004	39,898
1901	1,923	972	18,880	4,720	17,081	153,256	8·0	1,080	2,870	32,849

(a) Reported to THE MINERAL INDUSTRY by the *Grossherzogliche Badische Domänendirektion*, Carlsruhe. (b) Not reported. (d) Includes cement stone and bituminous shale. (e) Includes Florite. (f) Lead ore only.

MINERAL PRODUCTION OF BAVARIA. (a) (IN METRIC TONS; 4 marks = $1.)

Year.	Barytes.		Clay.				Coal.		Coal, (Lignite).	
			Fire Clay.		Kaolin.					
1897	3,365	$2,906	144,495	$300,495	24,086	$38,345	917,022	$2,267,086	39,043	$24,913
1898	4,339	6,465	282,994	671,465	29,196	35,426	964,611	2,449,264	38,668	32,842
1899	6,214	8,642	271,792	505,033	25,822	23,573	1,004,421	2,648,276	35,736	33,228
1900	10,515	15,067	187,501	463,689	58,795	68,274	1,185,206	3,349,126	39,165	36,117
1901	8,711	17,901	148,028	268,551	35,450	29,140	1,203,702	3,505,378	25,224	24,349

Year.	Copperas and other Sulphate.		Emery.		Feldspar.		Fluorspar.		Graphite.		Gypsum.		Iron.	
													Ore.	
1897	981	$38,540	217	$2,307	1,689	$4,678	4,904	$5,744	3,861	$66,126	26,153	$13,609	172,699	$173,809
1898	886	42,663	280	2,156	1,949	3,052	4,440	5,210	4,593	97,916	25,688	13,166	171,987	173,130
1899	900	44,236	399	4,180	287	1,065	3,681	5,366	5,196	120,292	29,727	20,652	181,981	194,348
1900	916	45,160	414	4,430	460	1,723	7,456	10,568	9,248	136,620	35,484	17,199	178,441	199,992
1901	590	37,613	366	3,456	788	1,914	5,220	7,075	4,435	57,985	3,581	5,891	158,820	181,889

Year.	Iron.—*Continued.*									
	Bar.		Cast, 1st Fusion.		Cast, 2d Fusion.		Pig.		Wire.	
1897	58,200	$1,884,224	138	$4,829	78,008	$3,735,979	83,418	$968,932	252	$6,895
1898	58,842	1,864,479	97	3,566	84,227	4,067,760	84,144	1,005,125	323	9,628
1899	61,415	2,102,492	(b)	....	92,459	4,623,992	83,821	1,019,184	111	3,372
1900	49,727	2,093,750	29	1,000	89,692	4,728,500	82,327	1,114,250	221	6,780
1901	29,978	1,025,844	76	2,543	76,191	4,037,243	72,071	947,969	12,661	417,306

Year.	Iron.—*Continued.*		Manganese Ore.		Marl. (For Cement.)		Mineral Paints.		Pyrites.		Rock Salt.	
	Steel.											
1897	115,580	$2,851,035	130	$197	97,831	$60,591	8,673	$25,872	2,211	$7,080	1,161	$5,582
1898	120,623	3,284,299	(b)	......	110,757	52,874	8,748	31,737	2,304	7,285	736	4,086
1899	134,007	3,898,125	(b)	......	220,716	79,917	9,287	33,351	2,516	7,689	802	6,610
1900	135,411	4,356,116	(b)	......	180,082	74,054	11,507	25,078	2,120	6,342	1,298	6,562
1901	109,464	3,594,844	(b)	......	76,663	63,982	84,929	102,385	2,649	8,180	1,319	6,209

Year.	Salt, Brine.		Silica (Quartz Sand).		Slate.		Soapstone.		Sodium Sulphate.		Stone.	
											Flagstones.	
1897	41,533	$338,029	31,678	$8,812	1,496	$14,001	2,464	$35,360	2,318	$12,749	14,647	$57,343
1898	39,717	469,629	45,907	17,444	3,956	24,039	1,912	29,193	2,332	14,185	16,720	81,892
1899	41,207	422,641	39,922	17,000	2,066	22,915	2,197	33,860	1,570	8,625	20,195	95,902
1900	46,293	482,550	42,671	20,046	1,904	21,457	1,977	32,240	1,821	10,765	16,268	76,898
1901	41,217	459,333	37,710	10,789	1,024	12,120	2,291	41,857	1,898	14,195	1,550	7,625

Year.	Stone—*Continued.*										Sulphuric Acid.	
	Granite and other Massive Rocks.		Limestone.		Lithographic.		Sandstone.		Whetstone.			
1897	663,749	$711,029	224,550	$76,385	13,941	$217,821	242,112	$315,117	95	$3,800	7,041	$63,709
1898	678,171	790,124	214,309	78,897	12,029	180,485	296,139	418,580	85	1,675	103,385	1,020,499
1899	490,712	729,632	267,180	93,891	11,962	239,240	315,786	417,917	81	1,125	123,273	1,217,000
1900	523,279	810,330	297,635	111,460	16,030	328,100	314,154	378,795	25	500	123,910	1,252,500
1901	521,288	758,244	356,239	158,486	9,500	232,750	355,850	324,776	10	500	115,775	1,170,144

(a) From the *Uebersicht der Production des Bergwerks-, Hütten-, und Salinen-Betriebes in dem Bayerischen Staate.* (b) Not reported.

MINERAL PRODUCTION OF PRUSSIA. (*a*) (METRIC TONS; 4 marks = $1.)

Year.	Alum Shale		Antimony and Alloys.		Arsenic Products.		Arsenic Ore		Asphalt.	
1897	129	$193	1,552	$152,744	1,924	$143,775	3,877	$50,655	11,466	$18,706
1898	107	161	2,612	251,642	1,694	121,818	3,298	49,470	12,822	20,402
1899	145	217	3,008	352,565	1,469	128,543	3,265	52,406	16,458	41,149
1900	108	154	3,162	386,117	1,583	138,549	3,531	66,403	23,891	59,725
1901	611	718	2,404	208,164	1,446	108,430	3,050	65,473	26,450	66,125

Year.	Boracite.		Cadmium. Kg.		Coal.		Coal. (Lignite.)		Cobalt Ore.		Cobalt Products.	
1897	185	$9,663	15,531	$44,157	84,253,393	$145,665,149	24,222,911	$13,324,245	121	$6,256	51	$166,015
1898	216	10,162	14,948	31,162	89,593,528	160,465,335	26,085,814	14,781,896	34	1,700	44	141,952
1899	171	8,337	13,608	21,336	94,740,829	179,284,452	28,418,596	15,876,512	17	850	46	149,725
1900	217	10,261	13,533	20.509	101,966,158	219,562,750	34,007,542	20,064,519	4	160	69	232,671
1901	164	7,198	13,144	20,459	101,203,807	231,139,097	37,491,412	22,606,583	36	2,168	66	228,609

Year.	Copper.		Copper and Iron Sulphate		Copper Ore.		Copper Matte		Copper Sulphate.		Epsom Salt.	
1897	25,997	$6,696,664	225	$8,548	690,338	$4,696,679	274	$13,157	2,689	$225,877	2,248	$4,882
1898	27.216	7,277,385	120	4,126	691,866	4,867,052	62	2,170	1,701	139,109	2,061	4,468
1899	30,902	11,336,549	154	6,019	722,884	5,137,918	95	4,045	1,586	142,124	1,793	3,676
1900	27,974	10,655,895	113	4.367	786,586	5,843,469	4,103	576,222	2,558	291,286	1,511	3,115
1901	28,423	10,541,937	78	3,049	765,241	5,975,486	210	34,334	1,951	213,276	1,962	3,593

Year.	Gold—Kg.		Iron.		Iron Ore.		Iron Sulphate.		Lead.	
1897	1,087·1	$756,184	4,892,059	$64,780,081	4,183,536	$8,432,766	9,064	$33,087	108,880	$6,556,528
1898	1,036·3	719,787	5,176,948	69,822,640	4,020,809	8,135,065	9,144	31,007	119,346	7,692,050
1899	1,016·4	708,524	5,644,614	83,302,190	4,295,575	8,780,892	10,186	31,732	116,995	8,433,993
1900	1,490·9	1,045,089	5,781.898	95,566,944	4,268,069	9,421,592	10,283	35,762	112,738	9,436,852
1901	1,157·5	806,468	5,815,628	88,442,417	3,831,670	9,682,051	10,239	35,269	113,989	7,455,839

Year.	Lead Ore.		Litharge.		Manganese and Alloys.		Manganese Ore		Nickel.		Nickel Ore.		Nickel Sulphate.	
1897	133,158	$3,122,880	1,999	$127,737	113	$58,000	45,254	$108,187	898	$760,562	204	$1,580	167	$42,327
1898	133,637	3,218,107	2,360	166,554	99	51,250	42.232	96,691	1,108	706,196	79	698	127	21.690
1899	128,942	3,476,974	2,482	191,601	143	81,250	60,379	158,946	1,115	705,125	91	1,067	123	21,246
1900	133,483	4,457,035	2,867	207,469	174	87,250	58,016	165,263	1,376	976,224	3,896	19,488	115	20,286
1901	139,285	3,487,397	2,885	206,404	121	60,100	55,866	163,545	1,660	1,220,891	9,922	49,378	121	21,206

Year.	Ocher and other Mineral Paints.		Petroleum.		Potassium Salts.				Pyrites.		Quicksilver. Kg.	
					Kainite.		Other Potash Salts.					
1897	2,400	$48,750	2,600	$73,038	716,348	$2.529,349	640,236	$1,898,647	121,766	$209,201	4,867	$4,684
1898	2,376	51,600	2,545	70,513	744,240	2,560,761	718,957	2,161.101	128,077	220,411	4,717	4,292
1899	2,770	57,682	3,405	91,714	744,657	2,559,169	941,055	2,622,148	134,564	234,596	2,611	3,264
1900	2,850	60,000	27,731	608,932	857,271	3,036,771	1.264.998	3,598,825	159.186	280,233	1,711	2,250
1901	2,800	62,500	24,098	461,018	1,068,287	4,010,879	1,131,708	3,597,620	148.457	263,788	1,713	2,175

Year.	Salt.				Selenium.		Silver—Kg.		Silver and Gold Ore.		Sulphur.	
	Common.		Rock.									
1897	274,888	$1,643,473	310,755	$358,697	23	$402	289,960	$5,907,572	6	$4,901	2.091	$42,860
1898	286,051	1,640,214	329,959	377,162	65	1,015	291,969	5,776,802	43	2,866	1,757	33,336
1899	288,588	1,645,182	331,943	391,403	46	723	293,858	5,983,217	7	30,547	1,419	30,008
1900	287,905	1,764,750	354,603	417,750	6	94	266,577	5,547,490	1	7,661	1,207	25,299
1901	290,869	1,877,762	353,557	418,575	*Nil.*	......	246,286	4,954,635	6	9,950	772	15,323

Year.	Sulphuric Acid.		Tin.		Zinc.		Zinc Ore.		Zinc Sulphate.	
1897	484,289	$2,890,702	912	$282,384	150,739	$12,608,525	663,739	$4,219,761	3,583	$54,601
1898	531,836	3,228,618	979	367,155	154,643	14,686,429	641,671	5,511,655	4,158	65,987
1899	573,733	3,617,024	1,461	358,581	152,987	18,215,992	663,763	8,847,039	4,864	77,585
1900	593,109	3,902,969	2,010	1,307,725	155,760	15,518,105	636,068	6,397,930	3,742	49,736
1901	609,041	4,019,921	1,448	846,854	166,223	13,691,093	644,504	5,342,268	3,369	44,794

(*a*) From *Zeitschrift für das Berg-, Hütten-, und Salinenwesen.*

MINERAL PRODUCTION OF SAXONY. (*a*) (METRIC TONS AND DOLLARS; 4 marks — $1.)

Year.	Arsenical, Sulphur, and Copper Pyrites.		Barytes		Bismuth, and Bismuth, Cobalt and Nickel Ores.		Coal. (Not Including Lignite.)		Coal. (Lignite.)		Fluorspar.	
1897	9,409·0	$29,112	218·4	$616	3,060·6	$131,952	4,571,685	$11,563,214	1,073,289	$666,358	592	$1,110
1898	6,410·3	16,269	477·9	1,270	3,043·4	136,167	4,436,455	11,829,001	1,180,928	728,156	775	1,458
1899	7,442·8	23,189	215·8	587	1,161·8	131,679	4,546,756	12,435,289	1,292,848	793,712	1,355	2,541
1900	8,591·9	27,026	516·4	1,725	594·7	148,192	4,802,700	15,076,017	1,540,512	1,077,085	1,462	2,741
1901	7,118·8	24,787	409·9	1,363	522·0	134,051	4,683,849	15,240,442	1,635,060	1,102,044	1,615	3,028

Year.	Iron Ocher, Swabian and Colored Earths		Iron Ore.		Limestone and Various Products. (*b*)		Manganese Ore.		Quartz, Mica and Uranium Ore.	
1897	92·7	$643	13,181·1	$12,887	65·1	$7,682	260	$637	39·7	$689
1898	440·4	1,317	5,671·2	6,197	(*j*)	8,110	(*j*)	......	116·9	1,698
1899	70·7	571	8,088·2	12,880	(*j*)	9,297	50	125	118·0	1,659
1900	275·9	1,121	5,840·0	12,094	(*j*)	8,598	(*j*)	......	52·6	1,162
1901	61·0	520	4,198·0	9,490	(*j*)	6,741	(*j*)	......	281·5	4,575

Year.	Silver Ores. (*c*)		Tin and Tinstone		Wolfram.		Zinc Blende.		Specimens	Totals.	
1897	11,428·5	$449,625	54·7	$5,981	36·7	$7,085	111·6	$579	$540	5,683,487	$12,878,552
1898	14,658·9	467,777	51·0	5,957	50·6	11,597	28·6	89	921	5,649,107	13,215,913
1899	13,565·8	449,274	71·8	13,750	50·4	12,948	305·9	1,525	729	5,871,570	13,888,700
1900	12,591·5	506,997	79·5	17,079	42·3	10,994	59·2	176	343	6,373,319	16,891,244
1901	11,565·0	375,795	81·9	15,148	42·0	7,241	29·1	187	367	6,344,834	16,925,728

Year.	Manufactured Products.							
	From a Part of the Coal.				From a Part of the Lignite.			
	Briquettes.		Coke.		Briquettes.		Lignite Bricks—*M*.	
1897	3,547	$13,517	77,507	$331,863	53,460	$107,451	60,166	$105,456
1898	5,321	18,368	72,245	340,685	71,576	148,436	62,244	112,804
1899	8,457	29,659	74,284	362,065	91,518	181,411	60,954	107,347
1900	11,582	46,160	73,508	423,464	97,150	220,872	71,767	144,870
1901	11,596	46,794	63,065	378,147	122,724	282,525	76,589	152,186

METALLIC CONTENTS OF THE MIXED ORES INCLUDED IN THE PRECEDING TABLE WHICH WERE DELIVERED TO THE FISCAL SMELTING WORKS AT FREIBERG. (*a*)

(IN METRIC TONS; 4 marks — $1.)

Year.	Total Mixed Ores.		Arsenic. Tons.	Copper. Tons.	Gold. Kg.	Lead. Tons.	Silver. Kg.	Sulphur. Tons.	Zinc. Tons.
1897	20,772	$477,664	353·1	9·6	0·1396	5,016·2	21,974·5	7,398·3	124·6
1898	31,724	658,756	85·4	3·5	(*j*)	5,769·7	21,404·9	5,445·9	305·3
1899	20,956	472,089	242·3	2·1	(*j*)	2,717·4	18,306·1	4,070·5	118·2
1900	20,794	580,079	171·0	1·4	(*j*)	2,492·6	19,915·6	4,216·2	84·9
1901	17,976	394,590	142·3	1·1	(*j*)	2,090·2	17,587·9	3,623·8	10·3

PRODUCTS SOLD BY THE FISCAL SMELTING WORKS AT FREIBERG AND THE COBALT WORKS AT SCHNEEBERG, GERMANY. (*a*) (IN METRIC TONS AND DOLLARS; 4 marks — $1.)

Year.	Arsenical Products. (*d*)		Bismuth. Kg.		Cobalt Products.		Copper Sulphate.		Fine Gold. Kg.		Lead.			
											Products. (*e*)		Sheet.	
1897....	1,063	$127,122	1,624	$3,801	628	$581,559	1,878	$162,881	889	$619,831	5,421	$332,652	634	$41,696
1898....	1,053	131,710	1,375	3,774	631	620,217	1,777	146,164	851	579,519	7,456	486,095	647	45,710
1899....	953	138,572	1,300	3,443	645	705,347	2,550	228,983	832	581,001	6,423	463,557	1,012	77,254
1900....	829	124,587	1,675	4,424	596	768,199	1,545	184,497	899	628,244	4,633	399,906	514	46,813
1901....	1,100	148,162	1,656	6,161	466	689,479	2,405	268,646	926	646,612	4,791	338,814	595	41,235

Year.	Lead.—*Continued.*				Nickel, Speiss.		Fine Silver—Kg.		Sulphuric Acid. (*g*)		Other Chemicals. (*h*)	
	Shot.		Other Manufactures of. (*f*)									
1897....	142	$9,850	224	$15,771	75	$4,166	72,862	$1,465,076	10,738	$73,450	472	$5,672
1898....	127	9,515	218	16,746	56	3,409	79,555	1,583,071	11,574	102,639	545	5,890
1899....	203	16,851	301	26,759	54	3,469	85,741	1,748,021	11,844	118,776	565	5,485
1900....	153	15,202	152	15,419	30	1,795	83,886	1,751,600	11,265	119,565	519	5,418
1901....	160	12,480	156	12,168	33	1,738	76,474	1,545,310	16,556	126,804	418	4,004

Year.	Zinc and Zinc Dust.		Clay and Chamotte Manufactures. (*i*)	Total Value.
1897....	120	$10,483	$16,855	$2,907,602
1898....	227	21,978	18,478	3,774,873
1899....	169	21,720	16,402	4,145,102
1900....	29	3,521	14,375	4,083,565
1901....	59	5,486	14,790	3,861,889

(*a*) From *Jahrbücher für das Berg- und Hüttenwesen im Königreiche Sachsen.* (*b*) Including arsenic powder, slags, washing-sand, granular ore, refuse stones and chippings. (*c*) Including silver-bearing lead, copper, arsenic, zinc and sulphur ores. (*d*) Including arsenious acid, red, yellow and white glass, and metallic arsenic. (*e*) Including assay lead, soft lead, antimonial lead, litharge, lead fume and tin-lead. (*f*) Including lead pipes, lead wire and various lead apparatus. (*g*) Including sulphuric acid of all kinds. (*h*) Includlug copperas aud glauber salt. (*i*) Including tiles, plates, figured stone, muffles, clay and graphite crucibles, and assaying utensils. (*j*) Not reported.

GREECE.

THE statistics of mineral production in Greece are summarized in the following tables:

MINERAL PRODUCTION OF GREECE. (*a*) (*c*) (METRIC TONS AND DOLLARS; 1 drachma—20 cents.)

Year.	Blende.		Calamine, Calcined.		Chrome Ore.		Emery.		Gypsum.		Iron Ore.		Iron Ore, Manganiferous.	
1898..	1,189	$22,320	30,906	$562,490	1,367	$18,000	3,932	$83,754	83	$1,500	287,100	$413,230	213.938	$641,840
1899..	1,187	30,986	21,770	589,890	4.386	55,310	4,860	92,868	81	1,465	331,030	499,430	294,320	596,500
1900..	(*b*)	....	18,751	395,270	5,600	70,200	6,828	134,786	129	2.281	279.880	481,394	248,920	782,940
1901..	454	6,400	17,764	274,070	4.580	47,770	5,691	115,446	671	7,190	278,640	414,000	196,152	579,110
1902..	(*b*)	....	18,670	348,528	11,680	140,160	4,727	100,685	(*b*)	....	364,340	526,510	170,040	459,108

Year.	Lead, Soft.		Lead Ore, Argentiferous.		Lead, Argentiferous.		Lead Fume.		Lignite.		Magnesite, Crude.	
1898..	305	$21,655	(*b*)	....	18,888	$1,832,136	2.655	$27,248	17,310	$34,620	14,829	$54,100
1899 .	291	23,862	(*b*)	....	18,768	2,156,443	2,584	28,424	12,150	24,300	17.184	68,580
1900..	245	19,650	878	$64,974	16,150	1,676,510	2,045	23,720	12,940	25,200	17,277	62.197
1901..	(*b*)	....	(*b*)	....	17,644	1,550,520	5,202	37,910	9,726	18,530	13,410	44,680
1902..	(*b*)	....	430	21,930	14,048	1,185,651	1,647	14,968	6,500	13,000	27,103	92,150

Year.	Magnesite, Bricks.		Magnesite, Calcined.		Manganese Ore.		Millstones. *Number*.		Puzzolan.		Sea Salt.		Sulphur.	
1898..	516	$11,352	129	$1,160	14,097	$90,220	18,500	$9.500	70,700	$72,114	25,250	$363,600	135	$2,880
1899..	542	19,512	3,087	71.100	17,600	98,560	12,563	6,307	46,375	39,882	37,125	579,150	1,150	24,150
1900..	534	19,225	807	17.754	8,050	45,170	13,386	8,305	49,426	42,506	22,411	396,165	891	19,424
1901..	500	17,140	2.009	31,090	14,166	52,610	16,400	9,371	80,223	68,190	23,079	351,700	3,212	67,290
1902..	935	30,294	4,730	63,382	14,960	56,848	13,564	7,695	45,400	35,412	25,200	362,750	1,391	26,710

(*a*) Statistics communicated by E. Grohmann, Seriphos. (*b*) Not stated. (*c*) There was produced also in 1898 ocher, 40 metric tons, value, $104; in 1899 speiss from lead smelting, 1,100 metric tons ($12,760); in 1900, asbestos, 9 tons ($72); soapstone, 97 tons ($585); speiss from lead smelting, 3,767 tons ($41,566); in 1901, asbestos, 43 tons ($345); soapstone, 150 tons ($1,100); in 1902, asbestos, 5 tons ($52); lead speiss and matte, 3,260 tons ($22·168); marble, 2,932 cubic meters ($42,220); marble plates, 3,800 square meters ($5,624); soapstone, 54 tons ($394).

INDIA.

THE official statistics of mineral production in British India, and the imports and exports, are summarized in the subjoined tables:

MINERAL PRODUCTION OF INDIA. (*a*) (IN METRIC TONS AND DOLLARS; 4 rupees = $1.)

Year.	Alum.		Asbestos. Kg.		Borax.		Clay.	Coal.		Copper Ore.		Fullers Earth.	
1897......	509	(*b*)	254	$10	280	$23,622	(*c*)	4,128,330	$3,116,647	33	$69	318	$125
1898......	762	$15,750	254	10	184	15,456	(*c*)	4,678,640	3,576,167	(*b*)	....	(*b*)	......
1899......	4	117	51	2	(*b*)	....	$508,868	5,016,055	3,884,968	52	256	(*b*)	......
1900......	...	....	51	2	(*b*)	....	1,088,716	6,216,882	5,086,555	77	61	(*b*)	......
1901......	...	....	...	.....	(*b*)	....	....	6,958,837	4,962,645	25	....	.....	......

Year.	Gold—Kg.		Granite. (*c*)		Graphite.		Gypsum.		Iron Ore.		Laterite.	
1897......	12,100	$5,581,439	638,302	*d*$129,381	61	....	8,187	$1,062	44,009	$38,075	5,399,794	*c*$94,074
1898......	12,773	6,031,890	806,131	*d*123,815	22	....	8,390	1,160	50,559	46,903	6,178,887	(*c*)
1899......	14,214	6,461,560	811,019	*d*136,444	1,548	*c*$5,825	6,546	592	61,697	46,343	6,010,582	*c*$428,826
1900......	15,946	7,094,266	368,759	*d* 72,020	1,859	9,104	4,415	424	64,085	41,481	565,251	147,259
1901......	16,589	7,240,265	....	....	2,771	....	.....	......	58,725	....	....	....

Year.	Limestone.		Manganese Ore.		Mica.		Petroleum—*Gallons*.		Rubies.
1897....................	1,861,309	$195,673	74,862	$147,500	708	$49,751	19,128,828	$565,948	$200,618
1898....................	1,924,577	(*c*)	61,469	120,900	271	56,265	18,972,368	254,580	217,313
1899....................	2,188,985	371,791	88,520	65,344	630	227,378	32,984,007	471,315	340,998
1900....................	1,201,875	190,102	*e*182,767	425,085	931	221,417	37,729,211	557,831	364,974
1901....................	8,504	....	164,650	359,464	1,013	248,973	50,075,117	766,288	384,417

Year.	Salt.		Saltpeter.		Sandstone.		Slate. (*c*)		Soapstone. (*c*)		Tin Ore. (*c*)		Trap Rock. (*c*)	
1897...	937,932	$1,219,074	12,819	$440,680	956,532	*c* $48,328	26,589	$10,102	1,008	$3,915	62	$9,888	140,764	$19,699
1898...	1,043,825	1,485,702	11,702	402,560	*c*1,174,454	(*c*)	26,954	10,755	1,839	(*b*)	40	9,572	128,772	(*c*)
1899...	977,240	1,324,748	11,397	408,660	1,070,799	184,369	26,372	18,859	735	5,111	50	17,987	358,871	53,015
1900...	1,021,426	1,146,363	11,709	407,414	400,543	107,662	7,341	6,993	2,339	7,507	106	32,002	756,291	33,488
1901...	1,120,187	1,405,682	12,751	....	....	....	4,269	....	.....	....	71	29,149	....	....

(*a*) From the *Review of the Mineral Production in India;* and the *Annual General Report upon the Mineral Industry of the United Kingdom of Great Britain.* (*b*) Not stated in the reports. (*c*) Incomplete. (*d*) Represents only a part of the product, about one-half in 1896, 1897, 1898, 1899 and 1900. (*e*) Exported.

MINERAL IMPORTS OF BRITISH INDIA. (*a*) (IN METRIC TONS AND DOLLARS; 4 rupees—$1.)

Year. (*b*)	Alum.		Arsenic.		Asphalt.		Brass.		Cement.		Chalk and Lime.		Clay Products. Clays.	
1896-97...	2,738	$62,372	88	$7,870	883	$12,002	499	$144,675	29,196	$278,617	1,745	$4,875	2,396	$22,720
1897-98...	5,248	115,980	98	9,520	1,082	13,307	670	187,542	37,354	371,690	1,040	5,177	2,788	26,950
1898-99...	3,607	70,637	119	11,490	1,090	12,725	448	186,800	36,170	369,797	1,735	7,757	2,914	24,332
1899-1900.	3,351	87,020	108	13,660	715	11,745	518	205,780	37,058	500,330	2,040	11,250	2,235	25,950
1900-01...	3,278	91,990	140	18,795	1,616	27,265	595	271,810	40,537	541,575	969	5,880	1,858	20,045
1901-02...	.....	....	...	....	.....	....	...	....	......	....	.....	....	....	....

Year. (*b*)	Clay Products.—*Continued.*					Coal.		Coke.		Copper and Copper Manufactures.		Glassware.
	Brick and Tile. *Number.*		Earthenware and Porcelain.	Earthenware (Piping).								
1896-97...	3,915,291	$72,475	$537,752	1,391	26,400	488,782	$2,396,890	18,568	$117,352	12,237	$2,686,535	$1,760,460
1897-98...	4,507,161	69,637	512,605	785	15,370	251,574	1,218,220	15,027	130,160	16,383	3,554,325	1,441,640
1898-99...	3,544,390	69,082	468,372	829	14,162	352,540	1,651,390	11,578	96,567	12,766	2,808,190	1,655,782
1899-1900.	3,641,594	71,420	663,455	663	13,655	404,882	2,451,040	13,899	162,885	4,615	1,768,790	2,555,565
1900-01...	4,008,897	74,925	671,585	780	31,220	110,312	749.665	18,434	209,770	7,998	3,057,110	2,517,255
1901-02...	....	....	....	......	....	....	....	....	....	....	....	....

Year. (*b*)	Iron, Pig. (*d*)		Iron and Steel, Manufactures of.		Lead.						Mineral Oils. *Gallons.*	
					Ore.		Pig.		Manufactures			
1896-97...	13,278	$190,152	262,562	$9,131,382	309	$17,810	709	$36,865	5,252	$368,720	68,421,148	$7,720,697
1897-98...	11,045	155,355	281,253	9,847,455	160	9,855	547	28,302	5,098	351,545	87,325,026	8,494,467
1898-99...	12,407	158,290	239,637	8,169,968	211	13,140	706	38,242	4,204	291,610	76,625,406	7,464,680
1899-1900.	13,369	265,015	211,892	11.135,815	288	24,050	618	55,115	4,318	448,265	70,440,116	9,799,940
1900-01...	9,673	226,710	256,921	15,015,895	186	16,675	732	65,815	5,197	621,215	72,601,898	10,844,790
1901-02...	....	....	....	....	...	....	.....	....	......	....	....	....

Year. (*b*)	Paints and Colors.		Precious Stones.	Quicksilver		Salt.		Stone and Marble.		Tin and Tin Manufactures.		Zinc and Zinc Manufactures.	
1896-97...	9,696	$674,395	$1,321,700	118	$102,992	833,557	$1,571,360	24,880	$62,980	1,849	$551,342	2,277	$175,580
1897-98...	9,238	670,680	1,126,225	143	119,050	494,508	2,171,795	36,745	96,485	1,962	554,078	3,185	244,312
1898-99...	10,159	643,207	974,882	115	99,895	418,455	1,653,067	31,200	78,552	1,483	416,930	3,795	291,012
1899-1900.	9,263	884,743	3,091,155	87	113,455	423,302	2,039,985	29,405	98,790	884	461.875	3,916	464.715
1900-01...	11,009	1,083,070	1,924,750	121	170,435	353,465	1,886,690	10,961	70,565	2,179	786,190	3,636	401,690
1901-02...	......	....	....	...	....	....	....	....	....	.....	....	.....	....

(*a*) From the *Tables Relating to the Trade of British India.* (*b*) Fiscal years ending March 31. (*c*) Also imported 2 tons copper ore, value $287. (*d*) Also imported, 1896-97, 2 metric tons iron ore, $82; in 1897-98, 52 metric tons; $735, in 1898-99, 597 metric tons of ore and old iron, $6,932; in 1899-1900, 1,879 metric tons, $29,670; and in 1900-1901, 711 metric tons, $12,290.

MINERAL EXPORTS OF BRITISH INDIA. (*a*) (IN METRIC TONS AND DOLLARS; 4 rupees—1.)

Year. (*b*)	Borax.		Brass.		Coal and Coke.		Copper, and Manufactures of.		Earthenware and Porcel'n.	Glassware.	Jadestone.		Lead.	
1896-97...	280	$23,622	188	$106,012	138,906	$352,810	111	$35,930	$11,432	$12,897	219	$153,780	210	$8,427
1897-98...	184	16,277	162	76,755	216,261	535,340	84	26,825	10,157	11,717	196	150,025	117	5,127
1898-99...	250	24,107	156	70,937	332,307	838,257	130	40,062	8.802	12,742	228	156,075	198	7,215
1899-1900.	224	31,520	270	138,635	309.459	1,093,870	494	164.975	13,200	21,430	142	234,785	237	12,505
1900-01...	162	25,100	581	196,949	550,290	1,979,560	1,860	574,180	17,735	25,340	218	221,015	85	2,385
1901-02...	....	....	...	....	533,062	....	.....	....	....	....	....	....	...	....

Year. (*b*)	Manganese Ore.		Mica.		Mineral Oils. *Gallons.*		Precious Stones.	Saltpeter.		Stone and Marble.		Tin.	
1896-97..........	48,067	$94,660	652	$288,340	191,424	$28,225	$34,670	26,845	$1,430,410	499	$14,072	86	$20,362
1897-98..........	80,090	157,507	590	267,142	15,568	2,860	30,970	21,218	996,862	995	16,010	49	10,945
1898-99..........	62,875	125,830	556	202,087	722,686	90,960	29,012	18,263	873,360	688	14.215	48	10,962
1899-1900........	96,749	254,015	1,148	366,860	1,302,227	218,690	40,995	20,188	1,280,980	1,069	32,865	39	23,120
1900-01.........	182,804	566,715	1,685	507,770	280,507	47,214	30,920	17,600	1,181,775	2,150	31,810	27	15,425
1901-02..........	....	.....	.....	....	....	....	....	......	....	.....	....	..	....

(*a*) From the *Tables Relating to the Trade of British India.* (*b*) Fiscal years ending March 31. (*c*) Not reported.

ITALY.

The official statistics of mineral and metal production in Italy, together with the imports and exports as reported in the official statistics of the Kingdom, are summarized in the following tables:

MINERAL PRODUCTION AND REFINED PRODUCTS OF ITALY. (*a*) (IN METRIC TONS AND DOLLARS; 5 lire — $1.)

Year.	Alum.		Aluminum. Sulphate.		Alunite.		Antimony.		Antimony Ore.		Asphalt, Mastic and Bitumen.	
1897........	1,080	$21,180	2,310	$40,160	6,500	$6,500	404	$57,072	2,150	$34,864	18,644	$89,125
1898........	1,165	25,060	2,915	54,560	7,000	7,000	380	62,550	1,981	43,822	17,818	111,611
1899........	945	22,350	2,330	43,287	5,800	5,800	581	87,900	3,791	44,862	41,789	248,084
1900........	1,097	27,181	2,403	46,467	5,200	7,280	1,174	154,360	7,609	72,468	33,127	201,863
1901........	1,075	23,815	2,260	37,830	4,900	11,760	1,721	195,550	8,818	68,518	31,814	177,741

Year.	Asphaltic Rock.		Barytes.		Borax, Refined.		Boric Acid.				Coal. (*b*)	
							Crude.		Refined.			
1897........	55,339	$189,655	(*c*)	....	990	$83,160	2,704	$173,056	260	$31,200	314,222	$467,111
1898........	93,750	265,645	12,400	$74,400	702	50,558	2,650	168,600	166	16,590	341,327	485,965
1899........	81,987	230,589	12,545	87,653	709	51,084	2,674	171,136	129	11,619	383,534	551,844
1900........	101,788	293,287	14,003	98,010	858	68,656	2,491	169,429	283	28,850	479,896	708,471
1901........	104,111	261,761	13,245	60,470	544	46,775	2,558	194,408	347	39,512	425,614	657,313

Year.	Coal. (Briquettes.)		Coke.		Copper.		Copper Ore.		Gold—Kg.		Gold Ore.	
1897......	549,050	$2,768,350	430,617	$2,669,285	2,980	$749,954	98,377	$431,229	316·0	$218,862	10,723	$178,010
1898......	594,500	3,373,900	469,228	2,943,821	3,230	878,509	95,128	426,299	187·9	131,818	9,549	148,826
1899......	566,000	3,262,000	485,951	3,102,354	3,032	1,164,697	94,764	687,772	118·8	79,095	11,859	91,416
1900......	703,740	4,750,360	487,831	3,605,303	2,707	1,096,424	95,644	631,808	57·5	39,987	5,840	53,257
1901......	754,800	5,082,890	490,803	3,516,907	3,097	1,252,427	107,750	680,970	4·1	2,852	890	8,120

Year.	Graphite.		Iron.									
			Ore.		Bar, Sheet, Pipe, Wire, etc.		Pig.		Sheet, Tinned.		Steel.	
1897..........	5,650	$11,300	200,709	$572,102	149,944	$7,176,951	8,393	$181,763	6,500	$546,000	63,940	$4,156,850
1898..........	6,435	17,423	190,110	549,248	167,499	8,178,165	12,327	259,897	7,200	660,000	87,467	5,417,096
1899..........	9,990	55,944	236,549	706,823	197,730	10,961,105	19,218	521,428	8,000	960,000	108,501	6,759,501
1900..........	9,720	55,720	247,278	917,104	190,518	10,312,290	23,990	625,834	10,000	1,200,000	115,887	6,865,153
1901..........	10,813	59,211	282,299	784,545	180,729	9,267,228	15,819	392,184	7,550	675,000	123,810	6,542,181

Year.	Lead.		Lead Ore.		Manganese Ore.		Manganiferous Iron Ore.		Marble.		Petroleum.		Petroleum, Benzine, etc.	
1897..	22,407	$1,462,909	36,200	$1,008,525	1,634	$15,008	21,262	$34,019	236,958	(*c*)	1,982	$98,456	3,392	$279,533
1898..	24,543	1,646,865	33,930	1,044,248	3,002	18,707	11,150	26,760	271,725	$2,109,440	2,015	117,826	5,040	395,821
1899..	20,548	1,580,423	31,046	1,122,161	4,356	22,432	29,874	77,149	318,744	2,438,624	2,242	118,812	5,384	420,710
1900..	23,763	2,088,469	35,103	1,447,793	6,014	30,995	26,800	67,000	310,336	2,409,410	1,683	98,354	6,077	526,255
1901..	25,796	1,805,027	48,449	1,820,872	2,181	16,634	24,290	60,239	334,146	2,635,821	2,246	134,218	4,211	416,607

Year.	Pumice.		Pyrites. (Cupriferous in part.)		Quicksilv'r.		Quicksilver Ore.		Salt.					
									Brine.		Rock.		Sea.	
1897..	(*c*)	....	58,320	$156,028	192	$192,000	20,659	$157,782	11,725	$63,100	19,801	$54,404	429,253	$885,637
1898..	2,766	$41,678	67,191	165,610	173	173,000	19,201	132,223	11,546	59,568	18,199	61,147	451,426	710,501
1899..	7,300	141,620	76,538	198,859	205	246,000	29,322	191,544	11,021	63,950	17,821	60,468	363,826	514,074
1900..	7,000	154,000	71,616	296,055	260	312,000	33,930	225,476	10,890	78,840	18,331	55,277	338,034	478,823
1901..	8,300	156,560	89,376	353,497	278	361,400	38,614	300,620	10,690	61,689	23,054	70,097	401,443	537,196

Year.	Silver—Kg.		Silver Ore.		Sulphur. Crude. (Fused.)		Sulphur. Ground.		Sulphur. Refined.		Talc.	
1897........	45,313	$917,670	405	$85,625	496,658	$8,995,647	69,178	$1,541,510	85,872	$1,874,642	(c)	....
1898........	43,437	894,157	435	76,048	502,351	9,708,050	146,001	3,259,999	99,494	2,273,058	12,760	$44,970
1899........	33,645	720,022	540	116,652	563,697	10,769,842	161,509	3,602,450	110,218	2,481,727	11,000	73,687
1900........	31,169	672,099	584	79,774	544,119	10,212,908	167,466	3,636,642	157,957	3,464,406	14,415	68,459
1901........	32,464	683,209	511	71,098	563,096	10,784,192	171,252	3,707,847	141,431	3,049,822	11,770	68,550

Year.	Zinc.		Zinc Ore.	
1897..........	250	$22,500	122,214	$1,656,065
1898..........	250	27,000	132,099	2,412,333
1899..........	251	27,662	150,629	4,846,666
1900..........	547	65,759	139,679	3,281,696
1901..........	511	48,692	135,784	2,473,868

(*a*) From *Rivista del Servizio Minerario.* (*b*) Includes anthracite lignite, fossil-wood, and bituminous schist. (*c*) Not reported.

MINERAL IMPORTS OF ITALY. (*a*) (IN METRIC TONS AND DOLLARS; 5 lire = $1.)

Year.	Antimony.		Arsenic—Kg.		Asbestos.		Asphaltic Prod. (Bitumen.)		Barytes.		Borax and Boric Acid.	
1898........	58	$11,077	700	$208	1,186	$118,640	1,150	$18,405	860	$22,365	147	$10,786
1899........	64	13,335	600	182	1,675	167,500	1,478	23,566	986	24,846	123	10,110
1900........	37	7,704	900	274	1,645	164,510	1,983	30,923	859	22,584	122	11,684
1901........	49	8,262	1,800	540	2,019	242,328	1,450	23,200	825	19,797	232	19,811
1902........	80	12,015	1,200	240	1,536	184.284	1,020	16,317	1,170	23,078	516	41,604

Year.	Cement and Hydraulic Lime.		Chalk.		Clay Products. Brick, Tile, etc.		Clay Products. Kaolin.		Clay Products. Majolica Wares.		Clay Products. Porcelain.	
1898........	12,029	$108,261	18,252	$127.764	21,681	$151,767	9,079	$72,632	101	$4,922	588	$109,519
1899........	14,391	125,178	13,738	96,166	22,410	156,870	12,105	96,840	461	6,230	894	248,268
1900........	15,494	139,060	15,436	92,180	25,702	179,914	9,595	76,720	148	7,918	1,008	280,007
1901........	14,872	133,516	20,731	103,655	35,534	248,738	12,809	102,472	451	21,690	1,002	272,905
1902........	13,732	123,026	15,216	76,080	29,344	205,408	14,165	113,320	507	25,519	1,076	293,682

Year.	Clay Products.—*Continued.* Potters' Clay and Manufactures.		Clay Products.—*Continued.* Terra Cotta.		Coal.		Copper Ore.		Copper Cement.	
1898........	825	$129,330	2,122	$67,785	4,431,524	$27,475,449	5,471	$820,650	2,040	$354,960
1899........	773	123,490	2,200	66,554	4,859,556	30,129,246	2,777	555,400	1,328	239,040
1900........	875	140,050	2,031	63,081	4,947,180	41,556,812	5,290	302,000	1,298	233,640
1901........	711	113,690	2,482	78,335	4,838,994	30,001,762	11,047	375,530	1,987	317,920
1902........	702	103,230	3,537	109,852	5,406,069	28,111,559	9,423	214,570	2,299	321,860

Year.	Copper, Brass and Bronze.		Copper and Iron Sulphates.		Glass and Manufactures.		Gold. Coin—Kg.		Gold. Unrefined. Kg.		Gold. Man'fact'res Kg.	
1898........	7,433	$2,645,153	25,560	$2,351,538	10,399	$363,916	154	$95,480	507	$263,640	1,844	$641,785
1899........	7,334	3,802,699	27,408	3,453,383	10,303	969,677	181	112,220	326	169,520	1,390	520,170
1900........	9,249	4,814,234	32,127	4,176,549	11,856	1,119,298	188	116,560	309	160,680	1,348	526,566
1901........	8,659	3,614.340	32,058	3,526,420	10,448	915,196	1,115	691,300	494	256,880	1,547	652,040
1902........	10,865	3,717,659	25,107	2,410,224	11,813	1,072,267	8,967	5,559,540	479	249,080	1,269	538,704

Year.	Graphite.		Iron. Ore.		Iron. Pig.		Iron. Wrought.		Iron and Steel. Plates, Rods and Manufactures.		Iron and Steel. Scrap.	
1898..........	382	$26,726	8,723	$23,552	169,059	$2,874,010	4,076	$307,371	98,564	5,583,233	138,426	$2,214,811
1899..........	606	42,581	20,799	58,237	191,613	4,213,495	4,158	337,234	142,645	7,182,446	245,616	4,666,710
1900..........	982	68,740	19,205	69,138	160,686	3,856,478	7,405	716,735	149,263	10,444,818	197,415	4,145,721
1901..........	102	7,140	4,054	12,973	159,972	3,199,434	5,695	499,969	146,970	9,139,727	148,305	2 669,481
1902..........	60	4,214	4,314	13,805	155,143	2,792,572	6,008	549,161	136,735	8,578,827	198,914	3,182,630

Year.	Lead.						Lead Oxide and Carbonate.		Mineral Paints.		Nickel Alloys and Manufactures.	
	Ore. (c)		Metal and Alloys in Pigs.		Manufactures.							
1898	10,947	$503,562	1,431	$100,142	435	$75,950	647	$54,814	692	$16,606	257·7	$345,798
1899	7,476	373,800	3,990	319,232	249	51,304	662	60,859	958	23,004	250·0	235,536
1900	9,134	456,700	3,248	286,727	233	53,301	557	58,705	958	22,997	231·9	259,758
1901	9,068	380,646	2,926	187,277	268	52,921	815	70,565	865	20,748	476·3	565,501
1902	1,680	68,840	7,563	423,550	288	53,232	846	69,102	670	16,075	561·1	604,908

Year.	Petroleum.		Phosphate Rock.		Potash, Ammonia and Caustic Soda.		Potassium Sulphate.		Precious Stones, Manufactures. Kg.	
1898	70,654	$2,402,253	65,126	$781,500	11,047	$498,393	928	$50,101	318·6	$1,629,008
1899	71,391	2,998,403	116,283	1,395,396	12,370	533,418	1,297	75,214	350·1	1,323,317
1900	73,089	3.215,903	140,281	1,683,372	14,077	684,169	1,670	98,554	423·0	1,801,264
1901	69,298	2,910,503	142,108	1,563,199	14,693	814,042	1.411	79,038	193·5	2,967,041
1902	68,781	2,731,240	159,341	1,593,410	17,617	923,747	1,566	87,674	405·8	3,885,484

Year.	Salt.		Silver.						Quicksilver.		Slag.	
			Coin—Kg.		Unrefined in Bars—Kg.		Manufactures. Kg.					
1898	26,686	$96,070	8.241	$329,640	901	$17,838	5,673	$86,594	39	$37,440	51,129	$563,197
1899	(b)	....	20,605	824,200	1,782	32,789	4,881	80,005	63	68,420	56,549	678,592
1900	3,367	12,121	29,291	1,171,640	2,678	50,846	4,358	66,901	49	58,800	82,254	387,050
1901	8,719	31,388	35,089	1,403,560	4,391	79,038	4,213	60,416	36	40,470	7,812	8,774
1902	2,274	7,732	28,662	1,146,480	8,768	140,288	3,455	46,056	57	61,020	5,634	5,634

Year.	Sodium Salts.						Tin.			
	Carbonate.		Nitrate. (Crude.)		Refined, and Potassium Nitrate.		Bars.		Manufactures.	
1898	20,845	$458,588	19,961	$818,409	702	$48,478	1,722	$688,680	109	$50,341
1899	22,654	498,388	22,885	940,170	671	56,659	1,940	842,996	96	63,380
1900	23,215	510,734	27,706	1,191,845	511	30,812	1,643	1,183,740	56	39,101
1901	21,956	548,892	40,498	1,700.920	815	27,518	1,858	1,115,100	91	61,014
1902	26,133	653,327	24,483	1,028,294	814	25,756	2,114	1,268,340	110	73,678

Year.	Zinc.								Metals Not Specified.			
	Ore.		Oxide.		Pigs and Old.		Manufactures.		Crude.		Manufactures.	
1898	216	$4,320	573	$63,008	2,818	$308,798	3,200	$441,066	1,612	$128,944	27	$14,416
1899	(b)	......	804	96,468	3,498	461,776	3,221	523,180	2,726	245,331	15	7,897
1900	85	1,870	1,034	139,141	3,627	391,738	3,543	491,104	2,737	206,582	43	23,166
1901	23	460	813	97,512	3,991	351,248	4,079	476,828	2,573	238,068	24	11,904
1902	131	2,882	904	108,468	3,805	350,097	4,167	496,925	2,850	234,576	23	15,342

(a) From the *Movimento Commerciale del Regno d' Italia.* (b) Not reported. (c) Includes argentiferous lead ore.

MINERAL EXPORTS OF ITALY. (a) (IN METRIC TONS AND DOLLARS; 5 lire = $1.)

Year.	Antimony.		Asbestos.		Asphaltic Product. (Bitumen.)		Barytes.		Borax and Boric Acid.		Cement and Hydraulic Lime.	
1898	338	$64,815	208	$16,672	19,465	$311,440	70	$1,828	2.167	$143,985	5,192	$41,536
1899	240	50,402	245	19,568	26,402	422,432	45	1,165	2,872	209,783	5,462	43,062
1900	467	96,140	261	20,864	24,287	388,586	40	1,105	2.114	167,909	6,860	53,510
1901	765	130.118	302	18,102	21,856	349,689	32	756	2.190	159,234	8.463	65,628
1902	359	53,895	144	8,634	20,884	334,146	91	2,194	1,847	123,987	7,930	59,324

Year.	Chalk.		Clay Products.									
			Brick, Tile, etc.		Kaolin.		Porcelain.		Potters' Clay and Manufactures.		Terra Cotta.	
1898	6,744	$40,504	125,614	$711,089	94	$752	86	$28,476	1,292	$196,600	2,751	$98,254
1899	5,386	32,316	136,402	769,182	94	658	124	39,253	1,347	233,040	2,796	102,298
1900	2,980	14,900	122,388	689,534	179	1,432	96	29,922	1,579	298,940	3,061	106,705
1901	3,428	17,140	108,057	609,331	368	2.944	266	69,072	1,958	332,770	3,325	112,817
1902	4,215	21,075	133,922	754,539	Nil.	.....	154	46,505	1,839	319,560	3,878	110,018

Year.	Coal.		Copper Ore.		Copper, Brass and Bronze.		Copper & Iron Sulphates.		Glass and Manufactures of.		Gold.	
											Coin—Kg.	
1898	17,749	$110,044	2,356	$42,408	857	$169,986	25	$2,300	5,209	$849,328	2,566	$1,590,920
1899	20,808	128,979	1,148	28,900	1,734	808,214	20	2,507	5,930	1,021,111	2,067	1,281,540
1900	23,926	200,978	1,179	29,475	1,209	590,658	60	7,839	6,158	1,222,629	2,345	1,453,900
1901	25,594	158,683	9	225	659	347,594	20	2,167	8,182	1,114,608	1,870	1,159,400
1902	33,374	173,545	11	220	874	365,230	39	3,782	5,131	922,184	1,897	1,176,140

Year.	Gold.—*Con.*		Graphite.		Iron.						Iron and Steel. Plates, Rods and Manufactures.	
	Unrefined. Kg.				Ore.		Pig.		Wrought.			
1898	1,739	$904,280	5,145	$56,599	217,556	$587,401	840	$14,280	699	$38,870	4,606	$533,233
1899	1,162	604,240	8,114	89,257	234,515	656,642	378	8,316	611	46,069	4,817	317,186
1900	2,763	1,436,760	7,820	86,020	170,256	618,030	329	7,894	440	32,798	5,610	875,708
1901	2,955	1,536,600	7,169	86,030	121,592	389,094	311	6,214	499	31,851	5,120	800,022
1902	733	381,160	7,098	85,181	209,070	669,024	395	7,114	1,054	52,848	5,540	812,600

Year.	Lead.						Lead Oxide and Carbonate.		Mineral Paints.		Nickel, Alloys, and Manufactures of.		Phosphate Rock.	
	Ore. (*b*)		Metal and Alloys in Pigs.		Manufactures.									
1898	4,492	$157,220	5,870	$410,886	1,764	$189,362	414	$41,418	2,884	$57,684	29	$28,586	(*c*)	....
1899	3,129	118,902	2,497	199,736	910	133,925	389	42,004	2,784	55,678	33	36,856	(*c*)	....
1900	3,741	142,158	5,018	442,828	1,408	176,146	367	39,640	2,977	59,534	3	4,030	1,726	$18,986
1901	3,977	123,287	4,463	285,681	2,128	237,736	410	38,609	2,913	58,252	22	30,690	1,290	14,190
1902	3,354	90,558	5,650	316,378	2,258	227,408	404	35,318	2,953	59,050	8	8,022	894	8,940

Year.	Potash, Ammonia, and Caustic Soda.		Quicksilver.		Salt, Sea and Rock.		Silver.				Slag.	
							Coin—Kg.		Unref'd in Bars, etc.—Kg.			
1898	85	$11,718	244	$234,432	126,867	$197,913	8,241	$329,640	68,607	$1,427,026	6,861	$6,861
1899	120	10,422	223	243,850	114,056	136,867	32,085	1,283,400	32,432	687,558	4,898	5,878
1900	142	8,616	259	310,320	112,902	126,450	10,501	420,040	25,310	546,696	4,222	5,067
1901	198	14,351	301	343,140	114,216	159,902	14,446	577,840	42,825	871,895	3,261	3,913
1902	186	11,196	215	231,660	145,199	217,798	10,978	439,120	20,427	367,686	3,615	3,615

Year.	Sodium Salts.						Stone.			
	Carbonate.		Nitrate. (Crude.)		Refined, and Potassium Nitrate.		Alabaster, Crude.		Building Stone.	
1898	391	$8,599	79	$3,255	256	$17,323	457	$11,882	35,945	$178,024
1899	438	9,638	136	5,725	124	8,823	714	18,577	53,904	259,519
1900	486	10,690	58	2,494	129	10,808	489	12,724	54,051	266,498
1901	377	9,422	116	4,893	59	5,291	474	12,329	53,668	249,249
1902	446	11,142	346	14,536	259	18,801	727	18,899	74,086	379,563

Year.	Stone.—*Continued.*				Sulphur, Crude and Refined.		Tin.			
	Marble, Crude.		Marble and Alabaster.				Pigs, Bars, etc.		Manufactures.	
1898	88,404	$1,060,848	68,150	$2,154,092	405,823	$8,359,969	34	$13,760	177	$80,169
1899	98,485	1,181,820	84,104	1,768,198	424,018	8,692,375	69	47,124	176	114,864
1900	91,650	1,099,800	72,619	2,378,338	479,139	9,486,942	147	108,426	153	104,288
1901	96,631	1,256,203	73,599	2,595,321	414,018	8,240,227	202	121,440	187	123,830
1902	112,967	1,468,571	83,172	3,052,870	439,242	8,928,286	236	141,600	174	115,036

Year.	Zinc.							
	Ore.		Oxide.		Pigs and Scrap.		Manufactures.	
1898	130,064	$2,601,280	110	$12,122	156	$16,887	14	$13,021
1899	140 107	3,362,568	123	14,820	227	29,977	21	4,249
1900	111,870	2,461,140	102	13,517	359	38,781	24	5,558
1901	103,020	2,060,400	140	16,754	349	30,694	18	3,484
1902	114,894	2,527,668	122	14,676	338	31,096	66	10,586

(*a*) From the *Movimento Commerciale del Regno d'Italia.* (*b*) Includes argentiferous ore. (*c*) Included with other stone.

JAPAN.

THE mineral production of Japan is reported in the subjoined tables.

MINERAL PRODUCTION OF MINES IN JAPAN WORKED BY THE GOVERNMENT. (*a*)
(In metric tons.)

Year	Gold.—Kg.	Silver.—Kg.	Copper.	Iron—Pig.	Lead.	Antimony.		Manganese	Salt. *Hektoliters.*
						Ore.	Metal		
1896.	963·61	64,644·83	20,113·57	27,420·77	1,857·66	827·58	517·28	17,967·05	9,443,459·79
1897.	1,088·38	54.387·40	20,424·67	28,039·88	773·15	348·22	824·20	15,447·51	11,144,672·77
1898.	1,161·27	60,547·04	21,060·20	23,651·77	1,695·79	1,006 08	233·16	11.517·56	11,481,876·52
1899.	1,678·05	56,264·00	24,317·90	23,076·36	1,891·51	713·33	229·38	11,355·70	10,482,500·78
1900.	2,128·15	58,906·78	25,309·41	24,841·68	1,878·05	80·88	349·00	15,830·72	11,889,701·52

MINERAL PRODUCTION OF JAPANESE PRIVATE MINES. (*a*) (IN METRIC TONS.) (*b*)

Year.	Antimony.		Arsenic Kg.	Coal.	Copper.	Copperas	Gold. Kg.	Graphite.	Iron.	Lead.	Manganese Ore.
	Ore.	Metal.									
1897 (*d*).	348·2	824·5	18,061·4	5,888,157	20,425	4·2	1,088·38	391	28,040	772·3	15,448
1898 (*d*).	1,006·1	233·2	7,141·0	6,696,038	21,060	20·1	1,161·27	347	23,652	1,705·5	11,517
1899 (*d*).	712·0	229·0	5,000·0	6,721.798	24,818	864·0	1,679·39	55	23,076	1,988·8	11,340
1900 (*d*).	81·0	349·0	5,000·0	7,429,457	25,304	982·0	2,130·00	94	22,712	1,877·0	15,223
1901 (*d*).	118·5	429·3	10·3	8,945,989	27,489	222·8	2,479·83	66	70,172	1,806·1	16,298

Year.	Ocher, Red.	Petroleum, Refined.	Quicksilver. Kg.	Silver. Kg.	Sulphur. Refined	Tin.
1897 (*d*)	35·7	34,748	2,682	54,387·4	13,606	47·7
1898 (*d*)	7·9	42,184	1,401	60,547·0	10,389	42·7
1899 (*d*)	28·0	*e* 72,478,787	(*c*)	56,308·5	10,241	18·5
1900 (*d*)	33·0	*e* 121,906,240	2,700	58,958·0	14,435	12·0
1901 (*d*)	82·7	147,825	7,513	54,839·2	16,577	14·1

(*a*) From *Résumé Statistique de l'Empire du Japon*, Tokio, and special reports from the Japanese Government. The data contained in the table of production of the Government mines are nearly exact, but those contained in the table of private mines, being the figures furnished by the mine owners themselves, are only an approximation and considerably less than the actual figures. (*b*) In making the conversions from the Japanese units to metric tons, hektoliters and dollars, the following relations were employed: 1 kwan = .0037565 metric tons; 1 koku = 1·8039 hektoliters; 1 yen = $1; 1 kg. = 32·151 troy ounces. (*c*) Not reported. (*d*) Includes production of Government mines. (*e*) Liters of crude oil. In 1901, there were also produced 17,619 metric tons of pyrites.

MINERAL IMPORTS OF JAPAN. (*a*) (IN METRIC TONS AND DOLLARS.)

(1 kin = 0·00060104 metric tons; 1 yen = $1.)

Year.	Brass.				Coal.		Coke.		Copper.			Gold.
	Crude and Old.		Tubing.	Other M'f'res.					Sheet, Rod, and Old.		Tubes, and oth'r M'f'res.	Coin and Bullion.
1896..	47	$20,188	$92,300	$41,243	50,315	$519,330	6,179	$42,537	91	$46,507	$94,306	$10,217,458
1897..	20	10,496	89,170	41,092	70,299	578,570	7,600	56,154	76	43,899	201,833	64,318,498
1898..	37	13,872	167,968	36,250	42,297	399,189	10,099	83,264	101	58,486	170,975	37,027,753
1899..	42	17,848	89,273	15,564	51,154	987,094	6,074	134,588	127	83,763	131,421	20,080,696
1900..	46	23,450	242,172	26,624	98,660	2,100,053	9,933	314,690	122	104,463	243,424	8,967,198
1901..	....	....	....	....	....	....	....	....	....	....	....	10,651,210

Year.	Iron.									
	Pig.		Bar and Rod.		Plate and Sheet.		Various Manufactures. (*b*)		Railway Materials	Pipe and Tubes, and other M'f'res. (*c*)
1896........	39,028	$739,556	50,464	$2,359,705	27,642	$1,659,417	36,306	$2,641,885	$1,280,430	$1,534,259
1897........	43,633	934,010	55,236	3,046,132	23,888	1,724,918	33,944	2,603,807	2,001,119	1,734,987
1898........	66,702	1,400,755	73,851	4,061,805	23,179	1,405,855	32,973	2,905,246	2,552,823	1,807,977
1899........	45,978	965,544	49,126	2,603,676	26,401	2,220,414	42,266	4,775,158	260,170	1,889,474
1900........	22,545	962,910	55,795	5,243,407	41,577	4,080,542	37,815	5,837,494	2,645,141	4,119,887
1901........	....	1,593,311	....	3,511,756	....	....	....	....	....	....

Year.	Iron and Steel for Rails.		Steel, including Wire and Wire Rope.		Steel Manu-fact'res	German Silver.		Kerosene. *Hektoliters.*		Lead.	
										Pig.	
1896........	65,387	$2,595,450	6,810	$1,022,108	$446,275	44·4	$39,830	2,318,073	$6,331,066	2,411	$257,888
1897........	87.076	3,325,005	4,227	577,260	358,255	44·4	41,790	2,472,669	7,667,350	2.298	257,805
1898........	69,256	2,631,721	6,823	1,256,150	135,846	18·0	16,450	2,486,418	7,552,880	3,112	365,202
1899........	11,449	435,054	5,983	1,299 497	197,040	24·8	26,075	2,554,230	7,918,149	3,092	412,155
1900........	64,415	4,758,371	5,423	1,511,031	638,266	35·4	40,998	3,230,577	14,162,651	6,075	927,152
1901........	....	1,612,540	....	....	....	....	....	....	14,943,401	....	....

Year.	Lead—*Continued.*			Nickel.		Plumbago. Kg.		Quicksilver.		Silver.	Tin.	
	Sheet and Tea.		Pipe.							Coin and Bullion.		
1896..	2,147	$259,593	144,504	28	$30,983	36,620	$8,075	78	$130,308	28,924,750	270	$146,418
1897..	1,972	269,638	76,910	44	50,321	155,595	15,418	80	156,527	17.153.220	264	145,174
1898..	1,339	199,402	38,772	127	150,600	31,169	6,520	89	176,308	5,536,028	359	227,257
1899..	1,492	256,011	154,320	42	50,991	14.547	4,058	92	219,012	82,805	366	361,286
1900..	1,833	362,362	57.692	86	123,812	18,570	5,545	101	258,698	2,550,687	390	478,108
1901..	....	....	....	....	....	....	....	....	....	309,540	....	....

Year.	Tin—Plate.		Yellow Metal.					Zinc.				All Other Metals and M'f'res.
			Plates.		Rods.		M'nfac-tures.	Ingot.		Sheet and Old.		
1896......	2,696	$251,344	172	$74,940	24	$9.408	$375	1,078	$144,240	2,991	$512,241	$1.778,014
1897......	5,677	559,654	116	51.419	13	6.334	4.703	836	127.708	4,164	799,930	1,053,682
1898......	4,012	411,421	57	23,696	6	2.710	1,820	532	80,991	3.224	648,824	648.120
1899......	3,946	569.923	56	31,722	6	3.460	2,310	1,081	259,606	3,947	1,051.538	456,644
1900......	4,596	832,149	60	36,072	8	4,280	3,560	3,028	686,080	3,763	977,702	917,058

(*a*) From data specially furnished THE MINERAL INDUSTRY by the Japanese Government. (*b*) Includes old iron, hoop and band, roofing or corrugated and galvanized, nails, and galvanized telegraph wire, iron wire and wire nails (old), and other manufactures. (*c*) Includes also anchors and chain cables, screws, bolts, nuts, etc., and other iron ware.

MINERAL EXPORTS OF JAPAN. (*a*) (IN METRIC TONS AND DOLLARS.)

(1 kin = 0·00060104 metric tons; 1 yen = $1.)

Year.	Antimony.			Brass.			Bronze.			Coal.	
	Metal.		M'factures.	Wire.		M'factures.	Ingot.		M'factures.	For Ships' Use.	
1896	694	$83,806	$104,010	222	$108,612	$35,526	54	$14,570	$180,318	588,963	$2,636,334
1897	1,577	267,548	63,831	147	72,414	66,388	27	8,373	183,022	582,081	3,229,094
1898	1,338	216,598	51,130	218	112,052	19,712	*Nil.*	....	207,345	381,426	2,928,177
1899	1,045	206,515	58,468	148	92,006	17,362	*Nil.*	....	230,148	473,919	3,380,135
1900	877	107,707	75,777	147	102,759	17,105	*Nil.*	....	208,173	946,763	6,328,448

Year.	Coal—*Continued.*				Coke.		Copper.			
	Dust.		Other Kinds.				Ingot.		Old.	
1896	299,102	$960,704	1,850,458	$5,812,227	3,399	$29,114	6,756	$2,423,116	0·22	$113
1897	188,182	859,514	1,366,498	7,457,262	2,950	45,384	2,741	1,075,945	6·81	2,077
1898	(*b*)	....	1,805,864	12,240,621	3,381	56,914	385	160,583	*Nil.*	....
1899	(*b*)	....	2,018,695	11,784,730	3,556	57,248	96	51,481	*Nil.*	....
1900	(*b*)	....	2,402,785	13,708,654	5,221	86,610	70	45,750	*Nil.*	....

Year.	Copper—*Continued.*							Gold.	Iron Wares.
	Refined.		Slab.		Wire.		M'factures.	Coin and Bullion.	
1896	6,134	$2,461,089	1,644	$594,448	72	$33,717	$135,079	$1,996,576	$105,481
1897	6,172	2,680,807	5,045	2,017,947	98	46,947	228,234	8,863,798	178,037
1898	16,069	7,106,491	144	75,481	83	46,998	182,040	46,231,843	200,595
1899	21,208	11,331,876	136	99,881	56	40,278	59,136	8,768,865	185,220
1900	20,407	12,680,184	190	137,992	79	58,490	75,829	51,761,620	247,538

Year.	Other Metal Wares.	Manganese Ore.		Silver.	Sulphur.		Other Mineral Products.	Total.
				Coin and Bullion.				
1896	$358,126	20,986	$274,434	$9,602,308	12,325	$308,588	$1,920	$27,759,986
1897	485,862	14,665	205,318	10,855,365	9,209	321,341	1,396	38,710,334
1898	287,556	9,985	156,332	40,706,188	12,627	477,018	(*c*)	111,518,119
1899	346,992	9,395	152,687	2,409,882	16,684	574,367	(*c*)	39,846,779
1900	286,179	12,902	224,396	4,945,448	17,836	698,283	(*c*)	91,791,986

(*a*) From data furnished to THE MINERAL INDUSTRY by the Japanese Government. (*b*) Included in other kinds. (*c*) Not stated.

MEXICO.

THE Mexican Government collected no statistics of production previous to 1900; those compiled by THE MINERA INDUSTRY, which represent all the important substances, will be found under the respective captions "Lead," "Copper," "Coal," etc. The official statistics of mineral and metallurgical production, imports and exports are summarized in the following tables:

MINERAL PRODUCTION OF MEXICO. (*a*) (IN METRIC TONS AND MEXICAN DOLLARS.) (*b*)

Year.	Antimony.		Antimony Ore.		Copper.					
					Ingot and Matte.		Ore.		Ore and Other Ores.	
1900..........	2	$237	....	....	27,518	$14,659,352	....	....	....	....
1901..........	2	296	3,325	$70,434	30,914	17,365,043	412,312	$4,734,137	30,394	$125,588

Year.	Gold.						Iron.			
	Bullion.—Kg.		Ore.		Ore and Other Ores.		Pig.		Ore.	
1900........	8,219·0	$6,704,946	......	....	....	....	3,306	$382,311	....	....
1901........	13,989·9	12,951,004	43,908	$1,784,698	1,099,981	$36,755,768	3,240	215,100	4,958	$43,094

Year.	Lead.								Metal Concentrates.	
	Ingot.		Ore.		Ore and Other Ores.		Oxide.			
1900..........	63,827	$4,051,246	....	....	....	....	....	....	....	....
1901..........	94.194	5,030,527	23,141	$479,838	41,530	$133.325	46	$8,040	13,446	$2,562,200

Year.	Peat.		Quicksilver.						Silver.	
			Metal.		Ore.		Cinnabar.		Bullion.—Kg.	
1900..........	....	....	194·1	$269,721	....	....	....	....	1,347,879·0	$53,989,549
1901..........	52	$372	198·0	306,982	50,623	$146,758	955	$131.000	1,465,718·5	57,130,083

Year.	Silver.—*Continued.*				Sulphur.		Zinc Ore.		Other Metals.	
	Ore.		Ore and Other Ores.							
1900..........	....	....	....	....	....	....	....	....	....	....
1901..........	377,741	$12,928,753	1,085,656	$18,115,891	110	$7,000	160	$5,000	59	$10,231

MINERAL IMPORTS OF MEXICO. (*a*) (IN METRIC TONS AND MEXICAN DOLLARS.) (*b*)

Year.	Aluminum and Sand.		Calcium Carbonate and Spanish White.		Copper.				Gold, Silver and Platinum Ore.		Graphite.	
					Ingots, Plates and Sheets. (*c*)		Ore and Matte.					
1901.	3,727	$16,256	215	$2,735	302	$117,906	2,590	$340,910	56	$1,051,243	46	$4,735

Year.	Gypsum and Stucco.		Marble or Alabaster.		Quicksilver Ore.		Refractory Earth and Tripoli.		Sulphur.		Talc.		Tin.	
1901..	100	$2,074	881	$19,108	895	$25,906	1,275	$13,281	896	$25,908	450	$9,353	60	$36,768

(*a*) From the *Anuario Estadístico de la República Mexicana.* (*b*) The average value of the Mexican dollar in New York was, in 1900, $0·509; in 1901, $0·490.

MINERAL EXPORTS OF MEXICO (a) (IN METRIC TONS AND MEXICAN DOLLARS.) (e)

Year.	Antimony Ore.		Asphalt.		Building Material.		Coal.		Copper.			
									Ore.		Ingot.	
1897	5,873	$71,835	10	$282	1,808	$7,858	105,298	$434,624	1,094	$176,891	16,858	$3,329,331
1898	5,932	98,815	(b)	....	597	3,561	118,553	486,596	13,146	3,738,738	10,862	2,314,790
1899	10,382	115,292	47	1,623	956	5,928	113,192	453,303	223	54,828	25,293	7,915,827
1900	2,318	23,319	627	12,815	2,623	9,804	88,076	157,282	408	49,736	27,970	9,445,498
1901	5,103	51,065	145	5,528	687	3,265	17,281	70,922	5,576	1,472,185	33,818	10,952,541

Year.	Gold.					Graphite.		Gypsum.	
	Coin.	Ore.	Bullion.	Cyanide	Sulphide.				
1897	$202,223	$365,226	$6,220,765	$226,986	$33,916	739	$6,698	2,095	$7,775
1898	(b)	1,087,202	6,498,735	294,780	64,031	(b)	....	1,650	8,250
1899	183,474	335,840	7,017,286	115,961	266,782	2,305	22,847	1,050	5,250
1900	192,456	306,392	7,435,864	128,675	177,193	2,561	25,650	1,600	8,000
1901	210,431	284,722	8,324,681	178,803	81,744	762	7,615	800	3,504

Year.	Iron Ore.		Jewels and Precious Stones. *Grams.*		Lead.				Marble.		Pearls—*Carats*	
					Ore.		Base Bullion.					
1897	(b)	......	3,880	$5,626	1·9	$87	60,029	$3,006,821	2,176	$185,001	1,420	$6,000
1898	21	$206	11,241	27,867	(b)	....	60,918	3,291,014	469	46,724	[d]327	3,500
1899	(b)	......	2,489	801	1·0	175	67,441	3,885,747	870	83,220	......	17,000
1900	(b)	......	1,447	875	468·0	11,425	74,944	4,278,608	1,030	108,759	(b)	....
1901	88	3,535	3,182	542	(b)	....	79,097	4,599,074	1,063	120,877	(b)	....

Year.	Quicksilver. Kg.		Silver.						Tin.	
			Coin.	Ore.	Slag.	Bullion.	Sulphide.	Cyanide		
1897	1,845	$3,150	$21,925,347	$11,401,176	$39,800	$35,775,125	$1,663,581	$123,946	0·6	$40
1898	(b)	......	(b)	11,048,358	46,488	37,137,599	1,668,501	257,342	(b)	....
1899	(b)	......	5,580,834	10,766,099	4,810	37,585,911	1,929,085	76,942	....	......
1900	(b)	......	22,679,655	12,495,524	87,883	41,468,745	1,898,646	67,607	·096	43
1901	(b)	......	12,038,158	9,615,989	93,549	36,348,374	2,141,685	259,282	(b)	....

(a) From the *Estadística Fiscal*. The figures for 1901 are from the *Anuario Estadístico de la República Mexicana*. The figures for the calendar years were arrived at by combining those of the successive semesters of the different fiscal years. Additional exports 1898: salt, 1,538 metric tons, $13,449; zinc ore, 1,001 metric tons, $10,016. (b) Not reported. (d) There was also exported pearls, 42 g., $1,000. (e) The average value of the Mexican dollar in New York was, in 1897, $0·4671; in 1898, $0·4641; in 1899, $0·473; in 1900, $0·509; in 1901, $0·490.

NOTE.—There was exported of zinc in 1900, 638 metric tons, worth $6,384; of zinc ore, 1,027 tons, worth $9,885; of salt, 1,518 tons, worth $4,151. Of minerals classed in the *Boletin de Estadística Fiscal* as "other mineral products not specified," there were exported 749 tons, valued at $5,347. Additional exports in 1901: zinc ore, 166 tons, worth $16,639; salt, 426 tons, worth $3,828 and mineral products not specified, 38 tons, worth $6,202.

NORWAY.

THE official statistics of mineral production, imports and exports, are summarized in the following tables:

MINERAL PRODUCTION OF NORWAY. (*a*) (IN METRIC TONS AND DOLLARS; 1 krone—27 cents.)

Year.	Apatite.		Chrome Ore.		Cobalt Ore.		Copper Ore.		Feldspar.		Iron Ore.	
1896..	1,106	$17,280	*Nil*	....	29	$2,700	29,910	$306,747	12,328	$54,540	2,000	$8,780
1897..	872	12,960	*Nil*	....	24	2,700	27,606	303,907	17,392	79,650	3,627	5,670
1898..	3,598	58,858	*Nil*	....	21	2,160	37,047	425,466	11,855	49,050	4,495	7,993
1899..	1.500	22,140	41	$216	*Nil.*	....	43,858	589,140	19,260	78,030	4,576	8,100
1900..	300	4.445	165	810	*Nil.*	....	46,858	684,450	17,609	81,050	17,925	35,910

Year.	Nickel Ore.		Pyrites, Iron and Copper.		Rutile.		Silver Ore and Native Silver.		Zinc Ore.	
1896........	$15	....	60,507	$261,901	30	$9,720	597	$108,000	450	$3,645
1897........	*Nil.*	....	94,484	390,150	32	5.400	642	108.950	908	7,290
1898........	*Nil.*	....	89.763	336,586	35	5,940	497	89.640	320	2,592
1899........	220	$810	95,636	461,180	30	4,590	429	83.970	379	3,105
1900........	1,888	12,690	98,945	635,580	40	6,480	475	89,100	204	1,820

Metallurgical Production.

Year.	Cobalt—Kg.		Copper.		Gold.	Iron, Pig and Cast.		Iron, Bar and Steel.		Nickel.		Silver—Kg.	
1896........	29	$2,700	1,067	*b* $237,610	$9,450	336	$3,780	400	$21,060	16	$8,100	4,664	$129,600
1897........	24	2,700	1,054	252,450	675	417	4,590	452	23,760	*Nil.*	....	5,372	101,790
1898........	21	2,160	941	233.680	1.539	231	2,700	379	20,520	*Nil.*	....	4,802	95,850
1899........	*Nil.*	....	1,209	378,000	2,700	406	4,590	666	33,750	5	2,700	4,600	89,100
1900........	*Nil.*	....	1,280	148,500	2,430	444	5,400	614	31.050	13	9,720	4,600	90,720

(*a*) From *Tabeller vedkommende Norges Bergvaerksdrift. Statistisk Aarbog for Kongeriget Norge*, 1896, and from *Meddeleser fra Det Statistiske Centralbureau*, No. 7, 1899, published by Det Statistike Centralbureau, Christiania. (*b*) Including, copper in mattes.

MINERAL IMPORTS OF NORWAY. (*a*) (IN METRIC TONS AND DOLLARS; 1 krone —27 cents.)

Year.	Borax and Boric Acid. Kg.		Cement and Hydraulic Lime. *Hektoliters.*		Coal, Coke, and Cinders.—*Hektoliters.*		Copper and Brass. Plates, Bolts, and Bars.		Copper and Brass. Wares.		Glass and Glassware.	
1897..	44,495	$4,941	18,734	$174.258	15,374,572	$4,234,167	1,140	$307,827	591	$495,802	4,262	$548,802
1898..	71,590	6,804	25,408	239,057	15,409,902	4,659,957	1,064	316,089	807	643,248	3,905	411,615
1899..	62,060	5,940	*d* 33,251	335,857	*d* 1,478,080	6,485,076	1,000	391,473	1,120	926,071	3,229	412,344
1900..	71,124	6,210	24,511	244,890	19,002,000	9,491.480	696	281,880	1,164	877,020	2,874	378,940
1901..	68,000	6,750	20,993	198,450	17,665,000	8,346,780	1,018	398,520	761	697,140	1,798	251,100

Year.	Iron. Pig and Cast.		Iron. Bars, Hoops, Ships' Knees, etc.		Iron. Ships' Anchors and Cables.		Iron. Rails.		Iron. Nails, Spikes, Bolts, Screws, etc.		Iron. Other Manufactures of Iron.	
1897........	21,606	$389,791	29,038	$1,018,364	1,367	$87,237	7,637	$247,428	2,097	$153.738	47,494	$4,590,918
1898........	23,106	339,579	26,208	951,345	1,485	105,057	10,327	362,475	2,097	159.921	62,197	5,450,868
1899........	21,445	395,550	25,879	1,099,494	1,394	104,868	8,137	281,205	1,529	130.842	78,827	7,091,946
1900........	20,844	467,740	23,010	1,198,260	1,208	114,480	11,952	458,190	1,219	103,410	58,040	5,659,200
1901........	19,112	394,800	20,672	894,040	1,708	146,020	22,959	619,920	1,808	144.720	62,104	5,378,270

Year.	Steel.		Locomotives and Machines.	Lead, in Pigs and Sheets.		Lead White and Zinc Oxide.		Paraffin Oil, Petroleum, etc.		Potash.	
1897	4,350	$246,645	$2,058,885	848	$54,972	1,119	$98,686	39,810	$1,021,113	919	$76,928
1898	2,428	144,234	2,437,371	732	51,408	1,491	140,886	36,504	887,081	754	63,099
1899	2,652	164,673	2,893,509	869	66,744	1,296	139,995	42,182	1,138,914	802	71,496
1900	2,083	152,010	2,259,630	670	59,670	1,216	181,490	39,657	1,070,820	635	59,940
1901	1,905	118,260	1,534,410	590	42,930	1,321	135,540	47,011	1,142,370	518	48,870

Year.	Salt. *Hektoliters.*		Saltpeter.		Soda.		Sulphur. (*b*)		Tin, in Blocks, etc.		Zinc, in Plates, Bars, etc.	
1897	1,645,716	$630,963	277	$15,708	5,492	$59,319	10,701	$260,087	296	$82,917	1,102	$107,082
1898	1,278,405	488,211	477	34,776	4,823	52,083	9,589	258,908	257	98,307	1,370	162,729
1899	*d*184,583	508,734	278	20,250	4,555	61,506	10,734	289,818	546	314,226	1,509	202,906
1900	1,434,000	619,380	356	25,920	4,576	61,830	14,827	400,410	149	100,340	1,254	149,040
1901	1,276,000	489,240	208	15,120	5,220	84,510	11,149	301,050	141	89,640	1,027	110,970

MINERAL EXPORTS OF NORWAY. (*a*) (IN METRIC TONS AND DOLLARS; 1 krone — 27 cents.)

Year.	Apatite.		Clay Products.				Cobalt Ore—Kg.		Copper.			
			Bricks. *Thousands.*		Earthenware.				Ore.		Ingot.	
1897	872	$12,960	11,711	$59,454	260	$27,378	45,000	$9,720	15,111	$204,012	552	$181,081
1898	3,593	53,352	15,534	69,677	2	948	25,000	5,400	13,587	183,411	444	113,886
1899	1,500	22,275	11,949	56,457	2	270	*Nil.*	....	7,198	116,618	747	242,001
1900	300	4,590	5,266	17,010	2	270	*Nil.*	....	5,756	93,150	723	258,600
1901	738	11,070	12,103	35,910	7	810	*Nil.*	....	6,041	89,640	691	233,260

Year.	Copper—*Con.*		Feldspar.		Glassware.		Iodine—Kg.		Iron.			
	Old Metal.								Ore.		Pig and Old.	
1897	670	$81,459	17,392	$79,839	1,432	$78,894	2,395	$11,151	4,242	$8,019	4,631	$53,136
1898	1,206	156,249	11,355	49,059	841	81,212	5,474	29,565	4,601	8,694	3,844	44,118
1899	1,038	224,316	19,260	78,003	840	26,838	16,180	87,372	12,517	23,652	6,085	69,822
1900	1,168	268,110	17,609	71,280	1,531	40,230	11,210	49,680	27,158	55,080	8,141	98,890
1901	774	156,870	18,323	74,250	2,142	70,470	10,000	38,880	39,178	68,450	3,250	35,100

Year.	Iron.—*Continued.*				Steel.		Machinery.		Nickel Ore. Kg.	
	Bars and Hoops.		Nails and Spikes.							
1897	56	$2,376	9,097	$636,552	167	$9,936	992	$267,840	(*c*)	....
1898	25	1,134	7,270	489,402	158	9,369	507	136,971	30,000	$135
1899	337	16,848	6,089	463,833	377	22,410	464	125,928	68,200	351
1900	135	8,640	5,643	460,350	220	17,820	811	218,970	272,000	1,690
1901	370	18,900	6,001	439,290	179	12,690	980	264,600	55,000	270

Year.	Pyrites.		Silver Ore—Kg.		Stone, Ashlar.		Whetstones.	
1897	70,552	$238,113	118,900	$3,861	74,492	$367,065	112	$7,587
1898	67,502	236,925	79,000	2,565	98,692	546,264	137	9,261
1899	83,912	294,543	14,160	972	104,933	566,649	170	11,475
1900	84,604	456,840	90,210	4,860	100,914	490,320	186	9,180
1901	104,151	435,780	6,000	2,700	120,961	587,790	181	12,150

(*a*) From *Statistisk Aarbog for Kongeriget Norge.* (*b*) Inclusive of flowers of sulphur. (*c*) Not reported. (*d*) Metric tons.

PORTUGAL.

THE mineral statistics of Portugal are summarized in the subjoined table, for which we are indebted to the courtesy of Senhor Severiano Augusto da Fonseca Monteiro, chief of the Reparticao de Minas, Ministerio das Obras Publicas of Portugal.

The statistics of mineral production in Portugal in years prior to 1897 may be found in THE MINERAL INDUSTRY, Vol. III. and Vol. VIII. The mineral industry of Portugal has not yet attained much importance, the output of copper and copper ore forming the chief part of the total. This is principally the production of Mason & Barry Co., Ltd.

MINERAL PRODUCTION OF PORTUGAL. (*a*) (IN METRIC TONS AND DOLLARS; 1 milreis = $1·08.)

Year.	Antimony Ore.		Arsenic.		Coal. (Anthracite.) (*b*)		Coal. (Lignite.) (*b*)		Copper Ore.		Copper. (Cement.)	
1897..	418	$28,063	524	$20,369	7,996	$32,816	9,342	$24,215	241	$4,496	3,304	$408,262
1898..	245	6,736	751	44,764	10,250	37,082	12,291	52,656	290	12,799	3,149	533,581
1899..	59	2,123	1,083	61,356	11,980	46,398	10,269	41,161	408	29,920	2,521	520,099
1900..	38	554	1,081	62,522	24,066	90,777	(*c*)	....	(c)	....	2,948	513,226
1901..	(*c*)	....	527	35,277	16,000	55,881	(*c*)	....	(c)	....	2,061	340,067

Year.	Copper Pyrites.		Copper Pyrites. (Dressed.)		Gold Ore.		Iron Ore.		Lead Ore. (Galena.)		Manganese Ore.	
1897......	66,473	$178,014	210,265	$387,254	17·0	$12,085	(c)	....	2,180	$56,300	1,652	$11,596
1898......	54,368	133,899	248,218	366,268	6·8	4,687	2,519	$3,265	3,242	100,480	907	2,595
1899......	71,576	358,128	275,658	378,018	13·0	78	15,078	25,564	3,468	104,627	2,949	21,484
1900......	57,540	183,550	345,390	539,044	*e* 2·6	1,728	19,808	46,247	3,620	116,846	1,971	10,437
1901......	93,316	354,531	345,081	521,720	*e* 2·0	1,868	21,599	38,451	445	9,790	904	5,858

Year.	Silver—Kg.		Tin Ore.		Tungsten Ore.	
1897	79	$2,042	*d* 9	$2,550	29·4	$7,263
1898................	119	2,362	102	23,278	59·3	16,714
1899................	(*c*)	......	30	9,418	55·0	13,513
1900................	(*c*)	......	81	26,017	49·0	8,677
1901................	(*c*)	......	31	13,366	90·0	12,994

(*a*) From a report specially furnished THE MINERAL INDUSTRY by Senhor Severiano Augusto da Fonseca Monteiro, Chief of the Department of Mines of the Ministerio das Obras Publicas. (*b*) Consumed in the country. (*c*) No report. (*d*) Includes metallic tin and cassiterite. (*e*) Gold metal, kilograms. In 1902, 79 metric tons ($3,496) gold and antimony concentrates.

RUSSIA.

THE official statistics of mineral production, imports and exports, are given in the subjoined tables. The Russian official statistics of production are somewhat tardy in appearance, the latest being for 1900.

MINERAL PRODUCTION OF RUSSIA. (*a*) (*b*) (IN METRIC TONS AND DOLLARS.)

Year.	Asbestos.		Asphaltum.		Chrome Iron Ore.		Coal.		Cobalt Glance.	Copper.		Gold—Kg.	
1896......	1,274	$7,666	22,192	$145,428	6,682	$16,816	9,377,551	$18,198,424	4	5,888	$1,494,076	37,199	$16,845,122
1897......	1,022	37,444	22,222	184,616	13,483	32,804	11,203,738	15,578,184	3	6,940	1,961,589	38,198	17,255,532
1898......	1,665	60,600	12,018	128,176	15,467	37,600	12,307,450	17,148,000	3	7,290	2,183,531	38,880	17,250,141
1899......	2,698	97,342	23,081	170,880	19,146	46,742	14,274,861	22,801,400	4	7,583	2,692,800	38,985	17,415,522
1900......	3,845	(*c*)	25,090	(*c*)	18,284	(*c*)	16,156,088	22,877,200	216	8,258	2,924,000	38,771	17,519,075

Year.	Graphite.		Iron, Cast.		Kaolin.		Lead.		Manganese Ore.		Petroleum.		Phosphorites.	
1896....	...	....	1,620,812	$25,315,436	6,099	$24,575	262	$12,775	208,025	$898,000	7,105,768	$12,583,860	3,776	$11,065
1897....	98	....	1,880,135	31,636,289	5,036	20,244	450	25,285	370,190	1,102,124	7,831,254	14,623,058	5,917	22,122
1898....	29	....	2,241,290	40,478,800	6,648	30,320	241	13,560	329,276	688,031	9,002,190	19,860,631	1,870	4,784
1899....	...	....	2,708,749	48,460,000	7,466	34,050	322	18,079	659,301	1,096,000	9,809,105	34,607,206	16,868	58,640
1900....	...	....	2,933,783	50,120,000	32,821	(*c*)	221	13,480	802,234	784,000	10.378,002	39,788,000	29,663	(*c*)

Year.	Platinum—Kg		Pyrites.		Quicksilver		Salt.		Silver—Kg.		Sodium Sulphate.	
1896....................	4,930	$1,083,600	11,550	$32,485	491	$432,058	1,846,947	$2,079,388	7,818	$235,172	5,196	$9,600
1897....................	5.602	1,238,040	19,380	54,426	616	541,440	1,551,894	2,711,077	4,788	172,581	7,230	13,352
1898....................	6,011	1,439,912	24,570	68,800	362	321,754	1,505,600	2,566,906	5,148	182,500	5,045	9,216
1899....................	5,962	1,754,480	23,251	57,240	362	321,814	1,681,362	2,767,168	4,422	168,062	7.466	10,898
1900....................	5,094	1,663,850	23,154	(*c*)	304	332,000	1,968,006	3,124,000	2,298	84,432	5,036	(*c*)

Year.	Sulphur.		Tin.		Zinc.	
1896....................	437	$5,339	2	$476	6,257	$458,369
1897....................	574	11,917	2	476	5,868	549,114
1898....................	1,018	21,244	...	......	5,664	581,124
1899....................	451	9,412	...	......	6,326	575,708
1900....................	1,587	(*c*)	4·2	(*c*)	5,968	509,600

(*a*) From the Russian official mining report "Sbornik Statisticheskekh Svedenie o Gornozavodskoi Promyshlennostye Rossie v Zavodskom Godu," St. Petersburg. (*b*) In the Russian reports the quantities are stated in poods and the values in silver rubles. In making the reductions the following relations were employed: 1 pood = ·01638 metric ton; 1 silver ruble = 40 cents. (*c*) Not reported.

MINERAL IMPORTS OF RUSSIA. (*a*) (IN METRIC TONS AND DOLLARS.)

(1 pood = ·01638 metric ton; 1 ruble = 40 cents.)

Year.	Asbestos.		Asbestos Manufactures		Asphalt Rock.		Barytes and Witherite.		Clay, Bauxite and Talc.		Coal.		Coke.	
1895..	107	$8,186	241	$58,668	566	$3,465	7,708	$65,297	55,212	$327,838	1,984,289	$5,993,392	310,113	$961,475
1896..	137	5,510	378	85,482	947	8,183	7,053	56,528	*e*64,135	419,564	1,979,649	5,489,378	364,427	1,146,668
1897..	123	6,598	514	98,829	787	7,892	7,826	78,060	66,980	346,115	2,122,361	4,183,062	399,909	1,675,072
1898..	246	11,078	536	90,676	885	6,785	7,210	69,164	65,716	371,211	2,582,687	4,907,490	458,247	2,078,747
1899..	223	16,226	598	94,696	418	3,920	7,876	66,846	74,851	313,088	3,896,306	9,754,787	578,777	2,512,848

Year.	Copper and Alloys.		Copper and Brass Manufactures.		Glauber Salts.		Gold Bars and Coin.	Iron. Castings.		Iron. Pig.	
1895..........	11,679	$2,725,159	*d*1,598	$ 1,045,872	3,308	$79,863	....	4,799	$602,644	127,202	$2,227,129
1896..........	15,726	3,997,911	*d*1,601	1,100,247	3,619	76,067	....	7,810	759,814	75,317	1,454,865
1897..........	18,590	2,818,848	*d*1,947	1,159,106	4,550	90,664	....	10,280	876,949	98,409	1,357,485
1898..........	15,167	2,841,423	*d*2,269	1,408,894	5,208	63,865	$40,369,200	13,490	1,061,521	86,486	919,750
1899..........	12,855	3,236,785	*d*2,367	1,494,547	3,440	43,688	32,888,400	15,699	1,469,066	136,732	1,702,070

Year.	Iron—*Continued.* Tin Plate.		Iron—*Continued.* All Other.		Iron—*Continued.* Iron and Steel Manufactures.		Iron—*Continued.* Steel, All Kinds.		Lead.		Magnesite.	
1895....	30,489	$2,194,164	218,965	$10,182,897	20,214	$3,205,418	52,523	$3,008,229	29,556	$1,820,843	1,127	$20,094
1896....	23,144	1,707,033	274,288	12,787,963	26,969	3,771,949	72,509	3,931,378	31,368	1,720,550	1,484	5,510
1897....	2,717	146,557	308,345	11,686,733	26,568	3,636,605	87,413	4,201,118	31,236	1,496,581	2,395	23,418
1898....	586	46,370	301,518	8,963,712	27,337	3,984,983	73,468	2,850,043	29,402	1,415,446	4,377	42,248
1899....	840	59,660	268,309	8,176,359	29,264	4,567,396	56,473	3,029,075	36,308	2,039,069	6,848	77,183

Year.	Mica—Kg.		Naphtha, Crude.	Oil, Kerosene, Benzine, etc.		Ores, Except Graphite.		Other Metals, Manufactures of.		Phosphorites.		Pyrites.	
1895..	2,407	$917	(*b*)	587	$44,494	1,584	$19,800	12,870	$3,374,097	(*b*)	....	22,410	$241,398
1896..	3,047	1,301	8	120	7,084	21,468	58,003	4,858	1,987,570	18,156	$176,868	20,631	149,582
1897..	(*b*)	....	48	1,811	57,961	21,887	59,619	....	....	(*b*)	....	33,733	157,396
1898..	4,382	1,811	(*b*)	244	21,242	24,015	51,046	18,088	3,486,218	(*b*)	....	41,127	196,650
1899..	(*b*)	....	167	1,719	156,280	24,461	54,672	1,480	1,487,554	5,991	14,096	44,821	241,266

Year.	Quicksilver.		Salt.		Saltpeter, Chile.		Salts, Stassfurt.		Silver.	Strontianite and Celestite.		Sulphur.	
1895..........	7	$6,966	10,832	$57,400	12,315	$294,788	4,468	$41,098	....	34	$1,118	19,525	$233,233
1896..........	15	10,499	10,218	62,492	18,337	414,770	5,558	51,250	....	216	12,690	19,532	227,428
1897..........	10	6,267	8,467	46,710	12,988	241,360	5,491	40,322	....	881	10,676	20,715	258,160
1898..........	6	4,216	10,128	54,645	18,712	275,989	5,414	44,240	$12,226,400	143	1,710	18,925	341,627
1899..........	6	5,642	8,849	46,822	15,371	347,866	7,558	46,755	....	404	8,328	22,472	511,450

Year.	Tar, Asphaltic Mastic, etc.		Tin.		Zinc. Ingot and Sheet.	
1895......................	2,721	$77,668	3,417	$705,597	9,194	$962,106
1896......................	3,011	89,810	4,481	841,436	7,516	766,164
1897......................	6,841	116,869	3,998	808,947	9,546	640,755
1898......................	10,340	170,345	4,191	1,057,406	11,018	683,176
1899......................	13,184	231,858	3,880	1,555,081	11,034	879,572

(*a*) From the Russian official report "Sbornik Statisticheskekh Svedenie o Gornozavodskoi Promyshlennostye Rossie v Zavodskom Godu," St. Petersburg. (*b*) Not reported. (*d*) Includes bronze manufactures. (*e*) Represents clay used for furnaces.

MINERAL EXPORTS OF RUSSIA. (*a*) (IN METRIC TONS AND DOLLARS.)

(1 pood = ·01638 metric ton; 1 ruble = 40 cents.)

Year.	Bronze and Manufactures.	Clay, Bauxite and Talc.		Coal.		Copper and Alloys.		Copper and Brass Manufactures.		Gold Coin and Bullion.
1895..	$10,290	166	$1,227	7,544	$20,870	47	2,154	......	$86,146	....
1896..	5,709	1,522	3,542	16,566	25,180	31	8,229	129	62,064	....
1897..	....	2,050	4,412	33,142	51,879	29	9,353	......	120,460	....
1898..	....	2,014	3,771	48,084	69,140	18	8,801	246	114,582	$143,200
1899..	....	1,981	2,555	13,238	36,795	12	2,178	......	107,418	20,324

Year.	Iron.						Manganese Ore.		Metals, Other		Naphtha.			
	Castings.		Pig.		All Other.						Crude.		Residuum.	
1895..	298	$30,070	192	$7,040	2,312	$117,207	146,840	$1,194,065	202	$30,308	9,266	$22,856	54,658	$408,076
1896..	430	39,001	184	7,950	4,534	289,499	165,600	1,215,399	127	12,150	2,942	40,514	54,451	449,876
1897..	547	60,191	238	6,708	4,150	184,139	187,396	1,188,894	(c)	....	9,605	47,576	62,945	565,210
1898..	384	29,487	134	4,698	2,655	189,054	245,061	1,235,855	178	44,594	8,671	44,540	54,335	451,300
1899..	735	68,898	123	3,984	4,096	212,000	395,000	2,245,408	117	13,223	4,879	24,898	61,787	549,926

Year.	Oil, Kerosene, Benzine, etc.		Ores of Metals and Minerals, Except Graphite.		Paraffin.		Phosphorites.		Platinum, Crude—Kg.		Quicksilver.	
1895..	709,406	$5,642,097	432	$10,260	b1	$370	10,918	$184,836	4,599	$778,000	140	$164,398
1896..	845,751	8,129,780	20,626	40,071	b93	3,746	8,840	107,898	4,700	777,900	430	383,629
1897..	917,216	9,507,619	16,890	40,874	b740	15,516	2,917	36,369	4,767	700,780	643	575,409
1898..	1,115,106	10,555,454	15,864	118,332	b5,197	52,505	1,694	26,465	4,475	825,600	357	274,684
1899..	1,390,818	11,771,924	13,688	63,301	b8	699	5,699	70,760	3,423	1,142,732	338	247,494

Year.	Salt.		Silver.	Slags.		Steel.		Zinc.			
								Ore.		Ingot and Sheet.	
1895..	7,028	$17,790	....	5,173	$11,334	167	$14,855	208	$2,820	1·0	$446
1896..	6,814	16,461	....	5,606	11,274	173	15,338	194	4,390	3·5	264
1897..	9,022	21,668	....	9,702	22,447	160	17,579	....	....	12·4	1,552
1898..	9,534	25,008	$1,804,000	17,088	40,878	312	28,989	....	....	76·9	5,806
1899..	7,852	29,151	....	13,995	28,359	174	16,242	362	4,849	56·0	3,337

(a) From the Russian official report "Sbornik Statisticheskekh Svedenie o Gornozavodskoi Promyshlennosty Rossie v Zavodskom Godu," St. Petersburg. (b) Includes vaseline. (c) Not reported.

SPAIN.

THE official statistics of mineral production, imports and exports, are summarized in the following tables:

MINERAL AND METALLURGICAL PRODUCTION OF SPAIN. (*a*) (IN METRIC TONS AND DOLLARS; $1 = 5 pesetas.)

Year.	Aluminous Earths.		Antimony Ore.		Arsenic Sulphide.		Asphalt, Refined.		Asphalt Rock.		Barytes.		Cement, Hydraulic.	
1897....	409	$2,046	354	$6,718	244	$29,256	1,878	$22,582	1,656	$3,812	429	$2,449	159,439	$325,202
1898....	505	2,525	130	2,149	111	13,320	2,354	29,626	2,383	4,772	364	2,074	164,862	358,501
1899....	685	3,225	50	1,560	101	12,156	2,646	34,068	2,542	5,144	887	3,071	165,645	363,441
1900....	420	2,100	30	900	150	18,036	2,331	31,602	4,193	8,632	833	1,568	185,811	422,725
1901....	305	1,526	10	150	120	14,400	4,182	55,710	3,956	8,137	1,067	3,406	189,909	494,774

Year.	Coal.								Cobalt Ore.		Coke.	
	Anthracite.		Bituminous.		Briquettes.		Lignite.					
1897......	8,758	$15,745	2,010,960	$3,409,636	332,272	$1,318,532	54,232	$54,027	13	$3,400	755,394	$3,167,416
1898......	20,105	36,190	2,414,127	4,147,333	369,418	1,277,425	66,422	93,310	(*b*)	....	768,151	3,211,300
1899......	34,842	98,256	2,565,437	4,780,114	348,838	1,216,562	70,901	78,630	(*b*)	....	341,443	1,311,816
1900......	68,427	238,015	2,514,545	4,700,324	341,156	1,585,691	91,183	101,467	(*b*)	....	381,000	2,716,706
1901......	85,266	190,143	2,566,591	5,786,479	338,684	1,440,245	95,867	101,326	(*b*)	....	455,586	2,699,746

Year.	Copper.						Copper Ore.			
	Fine.		In Matte.		In Precipitate.		Argentiferous.		Pyrites.	
1897....................	7	$1,400	16,120	$967,210	29,652	$4,138,725	*c*18,488	$35,922	2,161,182	$2,124,893
1898....................	598	118,623	16,024	961,438	29,703	4,158,418	203	1,831	2,299,444	2,735,261
1899....................	4	921	15,775	946,506	41,927	5,859,545	1,103	16,909	2,443,044	2,985,001
1900....................	5	1,919	18,159	1,452,728	29,652	7,279,250	2,006	21,047	2,714,714	9,246,018
1901....................	79	28,692	15,634	1,250,760	28,433	7,825,980	(*b*)	....	2,672,365	9,151,164

Year.	Fluorspar.		Gold and Silver Ore.		Iron and Steel.					
					Forged Iron.		Pig Iron.		Steel.	
1897................	2	$36	2,456	$9,873	80,894	$3,190,139	146,940	$2,267,403	66,007	$2,873,930
1898................	5	75	555	2,165	65,900	2,826,743	118,492	2,059,232	50,362	2,332,019
1899................	810	750	*f*1,110	7,060	40,832	1,120,514	118,071	2,011,536	112,982	4,138,817
1900................	4	60	*f*1,300	7,800	54,307	1,920,942	91,126	2,671,978	144,355	4,831,309
1901................	......	......	*f*1,595	9,570	47,085	2,501,824	135,600	2,657,146	121,023	5,612,226

Year.	Iron Ore.				Kaolin. (China Clay.)		Lead.			
	Argentiferous.		Non-Argentiferous.				Argentiferous.		Non-Argentiferous.	
		$								
1897..........	5,559	19,347	7,419,768	$5,457,327	6,294	$6,717	91,258	$6,312,109	75,112	$4,343,187
1898..........	24,190	68,216	7,197,047	6,232,484	5,445	5,518	88,981	6,026,450	78,370	5,188,394
1899..........	17,139	26,051	9,397,733	8,600,211	2,790	7,540	70,874	4,895,323	91,739	7,450,466
1900..........	26,348	66,661	8,675,749	7,598,921	3,794	8,034	74,341	6,124,426	98,189	8,676,061
1901..........	27,726	75,970	7,906,517	8,166,476	2,220	1,708	73,895	5,199,232	95,399	6,308,904

Year.	Lead Ore.				Manganese Ore.		Mineral Waters.		Ocher.	
	Argentiferous.		Non-Argentiferous.							
1897......	186,692	$6,735,013	110,469	$2,058,611	100,566	$136,250	16,180,585	$115,874	200	$800
1898......	244,068	8,023,772	150,472	4,948,056	102,228	343,045	15,610,222	122,265	200	800
1899......	184,906	7,624,507	123,753	4,774,408	104,974	353,088	19,770,187	118,907	100	400
1900......	182,016	6,875,290	131,487	5,449,629	112,897	330,321	19,289,928	144,744	58	233
1901......	207,188	6,715,510	174,326	2,733,133	60,325	201,414	18,306,654	141,128	164	528

Year.	Phosphorites.		Pyrites.		Pyrites. (Arsenical)		Quicksilver.		Quicksilver Ore.		Salt.	
1897......	2,084	$16,672	100,000	$ 0,000	(b)	......	1,728	$1,564,333	32,378	$1,328,443	508,606	$1,159,294
1898......	4,500	45,003	70,265	35,135	230	$575	1,691	1,598,921	31,361	1,252,094	479,358	1,085,682
1899......	3,510	35,100	107,386	105,182	(b)	......	1,361	1,481,229	32,144	1,274,608	598,108	1,091,133
1900......	4,170	18,590	34,688	24,247	515	515	1,095	1,479,333	30,216	1,104,237	450,041	834,535
1901......	4,220	16,880	33,953	35,897	1,328	1,328	754	1,105,890	23,367	1,040,107	345,063	599,934

Year.	Silver—Kg.		Silver Ore.		Soapstone.		Sulphur.		Sulphur, Crude Rock.	
1897............	71,168	$1,555,636	962	$101,797	3,601	$21,341	3,500	$70,000	18,845	$32,588
1898............	76,295	1,865,156	767	106,094	2,618	14,504	3,100	68,400	e105,757	198,128
1899............	88,409	2,161,581	764	78,721	4,844	26,623	1,100	31,250	58,922	108,150
1900............	140,457	3,651,800	742	181,068	8,109	46,004	750	18,000	64,364	109,947
1901............	94,977	2,246,088	391	59,157	4,880	29,061	610	18,115	49,856	59,208

Year.	Tin Ore.		Topaz of Hinojosa. Kg.		Tungsten Ore		Zinc.					
							Ore.		Sheet.		Slabs.	
1897............	d2,378	$5,795	44	$751	10	$309	73,848	$363,846	2,337	$378,594	3,907	$445,212
1898............	4	468	90	1,454	37	5,325	99,836	991,886	1,781	322,040	4,300	602,000
1899............	57	8,450	44	751	151	14,142	119,710	1,208,987	2,084	387,684	4,100	574,000
1900............	47	7,163	95	751	1,958	100,332	86,158	617,651	2,756	512,616	2,855	399,784
1901............	115	10,091	310	1,125	6	488	119,708	805,805	2,781	517,266	2,573	360,234

(a) Figures for 1897 are from the *Reports of the Comisión Ejecutiva de Estadistica Minera*. The figures for 1898 are from the official *Reports of the Junta Superior Facultativa de Minas*, Madrid. There was also produced in 1897, gold ore, 450 metric tons, $1,850; lead and zinc ores, 40 metric tons, $40; in 1898, lead and zinc ore, 88 tons, $88; gold, $2,338. (b) Not reported. (c) Represents non-argentiferous copper ore. (d) Undressed ore. (e) 70,814 tons, $152,309, of this product is the contents of copper pyrites from Huelva. (f) Gold ore only.

MINERAL IMPORTS OF SPAIN. (a) (IN METRIC TONS AND DOLLARS; $1—5 pesetas.)

Year.	Asphalt and Pitch.		Alkaline Carbonates		Coal.		Coke. (b)		Gold Bars—Kg.	
1897........	23,324	$368,700	28,428	$1,210,426	1,633,333	$8,837,595	214,768	$1,159,731	268	$187,600
1898........	28,720	459,528	26,574	1,169,245	1,224,345	7,466,073	196,224	1,177,346	2	1,440
1899........	37,827	605,231	34,805	1,395,614	1,555,800	9,184,802	208,789	1,252,735	10,210	7,553,400
1900........	29,983	479,733	31,463	1,286,519	1,794,119	14,352,956	197,516	1,580,134	(c)	....
1901........	32,569	521,119	29,470	1,355,668	1,966,024	12,582,558	197,104	1,261,465	(c)	....

Year.	Gold Coin	Iron, Pig.		Iron, Bar.		Iron and Steel, Forged.		Petroleum, Crude.		Silver Bars. Kg.	
1897.......	$12,149	1,855	$25,972	13,558	$571,048	24,087	$1,472,690	34,972	$1,259,011	243,540	$6,341,894
1898.......	(c)	1,575	28,352	(c)	....	5,164	267,159	32,731	1,505,671	158,475	4,143,895
1899.......	(c)	2,267	40,793	(c)	....	5,687	256,119	23,522	1,082,019	46,504	1,209,104
1900.......	(c)	4,717	113,227	(c)	....	5,404	230,465	42,840	1,718,619	(c)	....
1901.......	(c)	4,930	101,460	14,575	682,917	6,351	376,909	37,352	1,509,414	(c)	....

Year.	Silver Coin.	Sodium Nitrate.		Sulphur.		Tin Plate.		Tin Ingots.	
1897	$22,325,312	34,862	$2,091,729	5,310	$128,833	565	$46,098	923	$369,359
1898	(*c*)	33,322	2,146,085	5,665	158,621	653	52,237	833	350,028
1899	(*c*)	56,408	3,158,871	6,835	178,791	1,661	132,859	987	393,492
1900	(*c*)	118,105	4,724,224	7,634	244,290	914	83,920	1,143	914,789
1901	(*c*)	137,330	5,493,233	4,319	146,875	1,740	146,210	1,012	890,267

(*a*) The figures for 1898 and 1899 are from the *Anuario de la Mineria Metalurgia y Electricidad de España*, while those for the years 1896 and 1897 are from the *Revista Minera*, Madrid, Feb. 18, 1898, and for the year 1901 were obtained through the courtesy of Don Adriano Contreras, Profesor de la Escuela de Ingenieros de Minas. (*b*) In terms of coal. (*c*) Not reported.

MINERAL EXPORTS OF SPAIN. (*a*) (IN METRIC TONS AND DOLLARS; $1 — 5 pesetas.)

Year.	Antimony Ore.		Cement, Hydraulic		Coal.		Copper Ore.		Copper, in Matte and Precipitate.	
1897	20	$1,176	(*b*)	....	2,539	$13,300	832,570	$5,613,482	51,487	$7,373,928
1898	50	2,982	(*b*)	....	2,643	14,277	899,238	6,474,516	49,570	7,466,956
1899	92	5,537	3,502	$24,521	8,073	45,518	948,917	6,852,205	44,008	6,688,755
1900	23	1,862	2,499	14,997	8,588	56,678	1,029,141	7,409,812	48,676	7,893,468
1901	9	588	2,165	12,991	12,143	63,148	1,006,669	7,248,023	15,519	1,707,149
1902	10	600	....	....	....	....	982,726	6,715,607	22,585	4,896,998

Year.	Iron Ore.		Iron Pyrites.		Iron and Steel.		Lead Ore.			
							Argentiferous.		Non-Argentiferous.	
1897	6,884,244	$13,180,064	217,545	$569,287	43,612	$610,776	*c*8,267	$462,595	(*b*)	....
1898	6,558,060	14,427,736	256,341	615,218	46,127	880,291	7,191	410,178	(*b*)	....
1899	8,606,558	18,934,429	319,285	766,881	40,879	735,826	8,019	497,168	2,334	$102,961
1900	7,823,270	18,775,848	356,018	854,445	23,554	626,986	4,971	239,294	1,109	51,004
1901	6,898,863	20,681,590	404,815	971,558	45,410	1,166,947	1,462	87,769	1,860	95,457
1902	7,546,512	22 639,586	473,649	1,138,757	....	....	1,391	71,108	1,578	88,182

Year.	Lead, Pig.				Manganese Ore.		Quicksilver.		Salt.	
	Argentiferous.		Non-Argentiferous.							
1897	*d*171,774	$10,122,220	(*b*)	....	95,756	$1,091,621	1,742	$1,436,293	235,871	$707,616
1898	*d*178,517	11,340,015	(*b*)	....	139,050	1,597,706	1,741	1,880,703	219,670	659,099
1899	*d*161,098	9,987,370	(*b*)	....	139,352	1,588,815	3,221	3,478,789	331,081	998,212
1900	71,493	5,719,486	82,446	$5,771,196	131,450	1,445,945	1,101	1,188,646	205,561	411,122
1901	67,984	6,118,569	84,009	5,880,635	90,975	971,558	864	971,558	303,410	606,820
1902	79,691	7,172,196	91,296	6,390,753	67,266	739,921	1,176	1,271,614	278,046	556,092

Year.	Silver—Coin, Jewelry, etc.		Soapstone.		Sulphur.		Tin.		Zinc.		Zinc Ore.	
1897	(*b*)	....	(*b*)	....	(*b*)	....	(*b*)	....	2,170	$239,716	41,040	$353,121
1898	(*b*)	....	(*b*)	....	(*b*)	....	(*b*)	....	4,553	500,791	65,573	697,473
1899	(*b*)	....	2,427	$77,663	1,891	$52,968	26	$10,585	2,390	260,889	95,068	989,671
1900	133	$4,218,649	(*b*)	....	7	251	30	20,692	2,061	228,882	61,199	646,006
1901	140	4,604,019	4,839	135,505	1,410	47,944	20	14,650	2,101	231,190	75,827	748,274
1902	95	2,895,696	....	....	....	....	....	....	....	....	95,705	947,462

(*a*) From the *Anuario de la Mineria Metalurgia y Electricidad de España*, Madrid, except the figures for 1901, which were obtained through the courtesy of Don Adriano Contreras, and 1902, figures from other sources. (*b*) Not reported. (*c*) Includes non-argentiferous lead ore. (*d*) Includes non-argentiferous.

SWEDEN.

THE official statistics of mineral production, imports and exports are summarized as follows:

MINERAL PRODUCTION OF SWEDEN. (*a*) (IN METRIC TONS AND DOLLARS; 1 krone — 27 cents.)

Year.	Alum.		Clay (Fire).		Coal.		Cobalt Oxide. Kg.		Copper.		Copperas.		Copper Ore.		Copper Sulphate.	
1897..	131	$3,896	112,983	(*c*)	224,843	$434,710	700	$2,457	289	$68,645	232	$3,235	25,207	$92,712	1,315	$99,860
1898..	153	4,548	131,891	(*c*)	236,277	465,936	3,001	10,125	235	59,689	124	1,783	23,335	99,749	1,165	78,840
1899..	164	4,917	129,875	(*c*)	239,344	485,239	1,345	4,536	179	60,028	105	1,483	22,384	110,462	1,287	108,000
1900..	167	4,402	160,585	62,290	252,820	550,721	*Nil.*	......	186	45,830	18	2,806	22,725	92,678	1,265	125,000
1901..	121	3,612	175,876	82,647	271,509	685,911	*Nil.*	......	187	45,050	146	2,289	23,660	102,111	1,224	125,580

Year.	Feldspar.		Gold—Kg.		Gold Ore.		Iron.				Iron Ore.		Iron Ore. (Bog.)	
							Pig.		Bloom.					
1897..	19,298	$53,992	113·3	$75,517	1,662	$9,214	538,197	$9,467,855	189,633	$5,045,705	2,086,119	$2,700,639	1,047	(*c*)
1898..	20,787	64,572	125·9	106,818	2,136	6,136	531,766	9,414,123	198,923	5,407,843	2,302,546	2,969,966	368	(*c*)
1899..	16,017	50,041	106·2	71,081	*Nil.*	......	497,727	9,823,735	195,331	5,866,026	2,434,606	3,627,517	594	(*c*)
1900..	15,228	46,457	83·5	55,224	*Nil.*	......	526,868	11,968,097	188,455	6,324,423	2,607,925	3,788,237	1,575	2,251
1901..	18,502	44,264	62·7	42,305	*Nil.*	......	528,875	11,276,019	164,850	5,153,442	2,793,566	3,900,555	1,594	1,966

Year.	Iron and Steel Bars, Rods, Sheets, etc.		Lead.		Lead Ore.		Manganese Ore.		Pyrites.		Silver. Kg.	
1897	304,537	$12,624,486	1,480	$76,876	99	$3,240	2,749	$12,810	517	$1,496	2,318	$41,471
1898	299,846	11,948,458	1,559	102,464	50	1,620	2,358	11,142	386	1,037	2,083	38,867
1899	328,909	14,223,434	1,606	106,846	85	1,184	2,622	12,080	150	364	2,390	43,411
1900	324,604	14,790,197	1,424	105,697	85	2,950	2,651	12,294	179	385	1,927	35,831
1901	260,507	11,661,968	988	62,752	56	2,836	2,271	11,340	*Nil.*	......	1,557	30,249

Year.	Silver and Lead Ore.		Steel.						Sulphur.		Zinc Ore		Zinc Ore. (Calcined.)	
			Bessemer.		Crucible.		Martin.							
1897....	10,068	$63,123	107,679	$3,091,109	691	$73,540	165,836	$4,652,524	(*c*)	......	56,636	$494,742	24,563	$358,490
1898....	6,743	53,631	102,254	2,836,079	1,013	106,318	160,706	4,512,212	50	$1,620	61,627	608,647	25,250	443,137
1899....	5,730	60,070	91,898	2,710,926	1,225	126,765	179,357	5,549,606	(*c*)	......	65,159	743,869	24,200	516,186
1900....	5,300	65,534	91,065	2,968,514	1,121	102,893	207,418	6,768,626	70	1,750	61,044	477,034	26,772	401,580
1901....	11,366	56,907	77,231	2,369,772	1,088	94,015	190,877	6,115,791	(*c*)	......	48,030	382,894	26,160	360,223

(*a*) From *Bidrag till Sveriges Officiela Statistik, Bergshandteringen.* In 1899 there was also an output of 500 tons of graphite ore valued at $540. (*c*) Not reported.

MINERAL IMPORTS OF SWEDEN. (*a*) (IN METRIC TONS AND DOLLARS; 1 krone — 27 cents.)

Year.	Alum.		Aluminum Sulphate.		Ammonium.										Antimony Crude.	
					Carbonate.		Chloride.		Hydrate.		Nitrate.		Sulphate.			
1897..	103	$3,072	733	$9,896	109	$20,516	110	$20,873	59	$5,605	42	$9,013	67	$4,536	58	$11,058
1898..	186	4,036	968	13,074	99	18,723	101	19,168	105	9,886	12	2,565	81	5,477	53	9,996
1899..	158	4,688	866	11,699	89	16,906	112	21,764	110	10,391	12	2,561	181	12,231	59	11,170
1900..	133	3,948	1,197	16,165	141	13,829	99	18,675	100	18,923	5	1,129	227	15,297	85	16,151
1901..	346	10,266	1,192	16,058	131	12,389	113	21,449	92	17,332	1	253	285	19,233	50	10,544

Year.	Arsenious Acid.		Asbestos. (*c*)		Asphalt. (*d*)		Barytes.		Borax.		Boric Acid.		Bromine and Bromides of Potassium and Sodium. Kg.	
1897....	38	$3,528	119	$32,151	5,458	$58,947	270	$14,595	175	$18,952	56	$9,006	5,549	$4,495
1898....	38	4,390	112	30,359	5,409	58,420	299	16,140	196	21,148	75	12,071	5,401	5,687
1899....	12	1,642	567	153,193	6,286	67,898	293	15,812	190	20,529	65	10,596	4,914	5,175
1900....	22	3,029	763	206,145	5,676	61,305	441	23,795	194	20,950	66	10,743	6,084	6,406
1901....	12	1,663	178	47,950	4,524	48,864	295	15,735	253	27,288	68	11,048	6,602	6,952

Year.	Cement.		Chalk. White, Unground. *Hektoliters.*		Chalk. Other Kinds. (*e*)		Chemico-Technical Preparations N.E.S. (*f*)	Chloride of Lime.		Clay Products. Brick & Tiles.	Clay Products. Clay.	Clay Products. Porcelain.	
1897....	1,826	$17,259	14,368	$1,552	142	$1,069	$100,021	1,676	$72,388	$263,379	$80,010	362	$273,784
1898....	1,656	15,652	7,016	758	308	1,318	115,499	1,668	72,048	259,374	109,738	298	213,572
1899....	1,363	12,877	16,079	1,737	86	1,402	121,878	2,402	103,777	267,299	95,582	346	244,687
1900....	1,941	18,839	12,059	1,302	64	1,160	130,328	2,948	127,146	323,283	138,655	382	267,992
1901....	2,868	27,101	13,569	1,465	57	639	144,380	2,926	217,703	352,614	115,007	386	268,869

Year.	Coal. (*g*)		Copper, and Copper in Alloys and Metals.		Copper & Iron Sulphates.	Emery.		Glass and Glassware. (*h*)		Gold Bars, and Gold M'f'res. Kg.		Gold Coin.	Graphite.	
1897..	2,240,247	$9,829,066	4,944	1,156,202	$5,805	128	$17,296	1,618	$507,491	4,267	$2,086,848	$948	158	$8,519
1898..	2,392,451	12,112,784	5,227	1,220,805	6,512	131	17,649	2,560	551,169	3,998	1,875,585	2,396	167	9,008
1899..	3,047,618	16,457,135	4,740	1,105,524	11,202	125	16,902	2,218	582,609	362	287,075	9,774	162	8,729
1900..	3,033,885	21,502,660	4,745	1,281,249	4,963	136	18,399	1,728	461,291	3,365	2,282,429	98,905	218	11,486
1901..	2,793,809	15,063,867	5,153	1,717,371	4,817	169	22,873	1,280	392,134	1,454	1,005,221	736,852	180	9,697

Year.	Gypsum. (*j*)		Iron and Steel. Crude.		Iron and Steel. Manufactures.	Lead, Crude.		Lime. *Hektoliters.* (*k*)		Litharge.		Nitric Acid.	
1897....	7,260	$75,270	89,606	$1,420,175	$3,785,043	2,098	$206,076	20,050	$7,369	199	$26,925	41	$3,285
1898....	7,979	66,187	76,882	1,326,910	4,641,613	2,139	207,842	23,079	8,724	160	21,592	34	3,252
1899....	6,457	65,486	68,909	1,282,713	5,867,895	2,125	215,996	34,348	10,782	177	23,918	77	7,308
1900....	6,794	69,715	82,957	1,906,169	5,152,371	2,067	213,786	25,047	10,144	148	19,974	66	6,276
1901....	6,589	54,866	66,131	1,844,818	4,413,679	1,991	196,817	12,204	4,617	165	21,816	40	3,770

Year.	Phosphorus. Kg.		Platinum. Kg.		Potassium. Chloride.		Potassium. Cyanide. Kg.		Potassium. Hydrate. (Caustic.)		Potassium. Oxide.		Quicksilver. Kg.	
1897....	57,972	$70,436	63	$11,907	363	$58,817	2,922	$2,367	1,381	$410,247	1,432	$135,370	3,125	$3.544
1898....	66,466	80,756	49	9,261	259	28,006	2,604	1,757	1,451	431,080	1,112	105,119	2,631	2,963
1899....	59,969	72,887	59	11,151	225	36,466	2,313	1,561	1,266	376,029	1,231	116.293	4,210	4,774
1900....	67,557	82,082	99	18,711	364	58,945	2,221	1,662	1,915	568,627	1,257	118.740	3,629	4.115
1901....	70,672	85,866	172	32,506	260	42,055	2,658	1,794	1,435	426,231	1,266	119,640	5,958	6,756

Year.	Salt. Common.		Salt. Refined.		Sand.	Silver and Man'factures Kg.		Silver Coin.	Sodium Salts. Carbonate.		Sodium Salts. Hydrate.	
1897....	87,050	$411,548	3,055	$148,479	$19,509	20,557	$473,801	$136,823	14,625	$276,417	625	$33,764
1898....	85,246	403,380	2,188	106,332	29,169	21,696	442,622	191,766	11,917	225,230	575	31,064
1899....	98,417	410,917	3,160	153,884	35,848	11,565	304,825	156,707	13,323	251,806	929	50,151
1900....	70,302	313,058	3,098	150,547	36,054	11,559	309,820	62,315	12,680	239,658	1.038	56,033
1901....	79,033	352,002	3,072	149,317	34,084	7,476	240,592	78,416	13,669	258,347	800	43,210

Year.	Sodium Salts.—*Continued.* Nitrate. (*l*)		Sodium Salts.—*Continued.* Sulphate. (*i*)		Stone. (*m*)	Sulphur.		Sulphuric Acid.		Tin. (Crude.)		Tin and Lead Ashes.	
1897...............	12,531	$602,709	11,384	$153,683	$227,476	9,723	$236,269	1,418	$28,709	541	$196,478	16	$28,709
1898...............	15,419	685,657	11,544	172,435	108,260	10,887	263,341	1,742	35,278	595	224,890	25	27,455
1899...............	15,006	708,150	15,140	204,384	98,648	13,505	328,165	2,558	51,797	486	295,458	8	8,704
1900...............	14,245	673,072	15,590	211,972	94,188	20,152	489,683	2,472	50,052	680	408,021	18	19,297
1901...............	17,614	808,451	15,494	209,169	77,680	20,715	503,365	1,960	39,490	541	312,331	9	9,996

Year.	Tin Salts. Kg.		Zinc.	
1897....	3,823	$1,032	2,551	$261,249
1898....	3,874	1,046	3,080	343,014
1899....	5,404	1,459	2,889	343,758
1900....	3,248	876	2,912	319,898
1901....	2,334	680	2,900	289,428

(a) From *Bidrag till Sveriges Officiela Statistik*. (c) Includes raw product and manufactured articles. (d) Natural and artificial asphalts. (e) Ground chalk, pastels, etc. (*f*) N. E. S.—*Not elsewhere specified*. (g) Includes coal-dust. (h) Exclusive of powdered glass. (i) Includes also sodium bisulphate. (*j*) Raw, ground and calcined gypsum. (k) Slaked and unslaked lime. (*l*) Includes both sodium and potassium salts. (m) Building stone, etc.

MINERAL EXPORTS OF SWEDEN. (*a*) (IN METRIC TONS AND DOLLARS; 1 krone = 27 cents.)

Year.	Alum.		Ammonium Sulphate.		Antimony, Crude.		Asbestos. Kg.		Cement.		Chalk.				Chemico-Technical Preparations.
											Unground. *Hektoliters*.		All Other.		
1897....	54	$1,604	180	$12,150	0·8	$156	1,348	$364	27,112	$219,611	1,188	$128	4,422	24,032	$40.351
1898....	32	947	36	2,491	4·7	896	1,055	285	28,676	232,276	365	39	4,844	26,209	80,377
1899....	26	772	2	124	2·6	497	2,812	759	31,101	251,917	616	66	5,392	29,550	194,948
1900....	24	674	2	120	4·6	880	2,436	658	42,564	344,771	165	21	5,813	28,788	304,145
1901....	56	1,642	156	10,717	1·8	336	2,179	538	17,794	144,180	940	101	5,193	23,102	322,822

Year.	Clay.	Clay Manufactures.	Coal.		Copper and Iron Sulphates	Copper Ore.		Copper and Copper in Alloys and Metals.		Glass, All Kinds.		Graphite. Kg.	
1897....	$28,931	$684,340	74	$325	$97,449	(*b*)	....	983	$426,089	9,399	$1,134,495	7,215	$390
1898....	43,005	641,730	496	2,513	92,191	1,102	$7,441	1,346	293,159	9,838	1,148,087	9,108	492
1899....	46,589	642,079	762	4,112	129,676	815	3,337	1,230	269,428	9,194	756,683	16,664	900
1900....	50,796	750.177	1,108	6,282	124,498	448	3,313	2,012	543,201	10.000	848.488	17,719	977
1901....	37,462	656,077	716	3,803	106,897	602	4,468	1,243	432,318	13,002	898,916	16,761	905

Year.	Gypsum and Manufactures.		Iron Ore.		Iron and Steel.			Lead and Manufactures.		Lime. *Hektoliters*.	
					Unwrought.		Manufactures.				
1897....	9·6	$5,727	1,400,801	$2,779,890	279,525	$9.175,910	$2,378,230	1,478	$91,998	106,053	$31.925
1898....	27·3	2,609	1,439,860	2,942,930	301,192	9,399,827	1,644,096	570	36,090	123,939	40,401
1899....	8·3	1,384	1,628.011	3,406,613	320,742	11,398,918	2,109,438	818	62.049	80,158	25,391
1900....	10·4	1,182	1,619,902	3,525,230	304,175	13,473,711	2,045,304	1,209	98.271	84.242	26,871
1901....	54·5	1,645	1,761,257	3,775,783	268,143	9,448,279	1,965,242	1,028	64,296	69,000	24.189

Year.	Peat.		Phosphorus. Kg.		Potassium Chlorate.		Salt, Refined. Kg.		Sand.	Silver.			
										Bullion—Kg.		Manufactures—Kg.	
1897....	1,816	$4,902	1,627	$1,977	462·5	$74,927	1,424	$69	$969	329	$6,396	119	$6,426
1898....	1,616	4,364	4,085	4,963	506·4	82,041	216	11	3.336	130	2,492	238	12,744
1899....	1,979	5,342	1.890	2,296	334·9	54,259	110	5	1,929	367	7,134	258	13,930
1900....	3,843	9,776	875	1,063	930·7	150,783	407	18	2,034	296	5,968	108	5,562
1901 ...	3,061	8,273	1,254	1,524	707·9	114,679	1,556	76	1,261	179	3,456	9	486

Year.	Soda.		Sodium Sulphate.		Stone. (*c*)	Sulphur.		Sulphuric Acid.		Tin and Lead Ash.		Tin.			
												Ingot.		Manufactures—Kg.	
1897....	686	$12,970	3·4	$46	$2,062,011	11	$258	7·6	$205	1·7	$1.336	25·6	$8,305	7,113	$4,328
1898....	509	9,618	5·1	69	2,385,735	11	272	2·8	76	15·8	17,018	20·8	7,591	1,263	734
1899....	227	4,298	13·2	180	2,613,158	68	730	2·7	74	20·6	22,211	8·8	5,371	1,083	592
1900....	238	4,871	20·5	389	2,804,594	20	474	16·5	447	11·9	12,882	21·5	13.935	1,521	849
1901....	237	4,471	14·1	304	2,737,260	12	289	6·3	171	22·4	24,194	20·4	11,809	8,110	4,790

Year.	Zinc.				Minerals, Not Specified.	
	Ore.		Crude and M'f'rs.			
1897..................	44,425	$527,769	135	$9,009	442	$5,423
1898..................	49,597	723,129	184	18,799	2,596	40,526
1899..................	45,634	788,564	157	13,824	197	1,597
1900..................	40,879	518,749	156	12,274	288	2.332
1901..................	41,248	434,340	101	6.387	880	13.079

(*a*) From *Bidrag till Sveriges Officiela Statistik*, Handel. (*b*) Not stated in the reports. (*c*) Building stone, etc., wrought and unwrought.

UNITED KINGDOM.

The statistics of the mineral production, imports and exports, are given in the subjoined tables. The statistics of the most important substances for 1902 will be found under the respective captions elsewhere in this volume.

MINERAL PRODUCTION OF THE UNITED KINGDOM. (*a*) (METRIC TONS AND DOLLARS; £1—$5.)

Year.	Alum Shale.		Arsenious Acid.		Arsenical Pyrites.		Barytes.		Bauxite.		Chalk.	
1897......	691	$380	4,232	$373,975	13,347	$53,670	23,087	$120,585	13,540	$14,115	3,990 183	$397,975
1898......	13,835	3,510	4,341	368,985	11,272	40,720	22,581	116,365	12,600	14,490	4,366,782	903,255
1899......	5,918	3,640	3,890	271,180	13,735	60,690	25,059	123,230	8,187	9,355	4,752,982	1,048,125
1900......	1,329	890	4,146	335,140	9,727	43,550	29,987	146,230	5,871	6,750	4,444,765	1,040,161
1901......	4,019	2,470	3,416	197,270	2,620	21,875	26,844	139,050	10,357	14,515	4,399,043	982,255
1902......	5,755	......	2,165	....	842	....	28,986	....	9,192	....	4 466,004	....

Year.	Clay. (*b*)		Coal.		Copper Ore.		Copper Precipitate.		Fluorspar.	
1897......	12,908,479	$7,265,640	205,364,010	$298,700,045	7,246	$93,530	234	$11,600	302	$1,985
1898......	14,974,290	8,081,790	205,287,388	330,846,910	9,145	129,945	132	6,500	57	245
1899......	15,305,895	7,713,285	223,616,279	417,405,685	8,274	168,990	178	7,750	796	4,205
1900......	14,279,181	7,855,215	228,772,886	608,262,980	9,257	172,515	336	12,250	1,472	8,090
1901......	14,398,196	7,987,410	222,614,981	512,432,760	6,512	123,830	391	12,770	4,232	11,130
1902......	15,549,002	....	230,728,562	....	6,210	....	(*c*)	....	6,388	....

Year.	Gold Ore.		Gravel and Sand.		Gypsum.		Iron Ore.		Iron Ore. Bog. (*d*)	
1897................	4,589	$31,410	1,378,496	$556,660	184,287	$334,890	14,008,484	$16,088,975	7,238	$8,905
1898................	715	5,790	1,652,701	677,690	199,174	356,580	14,403,769	17,083,140	5,505	6,770
1899................	3,096	50,850	1,800,208	661,995	215,974	382,280	14,692,711	19,477,425	4,390	5,400
1900................	21,185	214,625	1,867,211	690.815	211,436	348.210	14.257,344	21,122,000	4,221	5,190
1901................	16,641	69,600	1,990,926	745,940	204,045	344,650	12,475,700	16,232,300	2,649	3,255
1902................	30.432	....	2,100,829	....	238,264	....	13.641,036	....	4,983	.....

Year.	Jet—Kg.		Lead Ore.		Manganese Ore.		Mineral Paints.		Oil Shale.		Petroleum.		Phosphate, Lime.	
1897......	31	$40	35,903	$1,377,045	609	$1,755	14,658	$64,985	2,259,325	$2,779,680	12	$145	2,032	$17,500
1898......	*Nil.*	......	33,518	1,337,010	235	1,000	20,144	65,015	2,172,201	2,672,490	6	70	1,575	13,565
1899......	*Nil.*	......	31,494	1,433,920	422	1,245	16,575	67,895	2,246,197	2,765,015	5	60	1,469	12.564
1900......	*Nil.*	......	32,487	1,745,470	1,384	3,875	15,448	66,930	2,318,736	3,139,220	*Nil.*	....	630	5,425
1901......	*Nil.*	......	33,084	1,120,548	1,673	4,470	14,780	69,585	2,392,812	2,945.810	8	95	71	680
1902......	*Nil.*	......	25,000	....	1,298	....	17,018	....	2,141.255	....	25	....	87	....

Year.	Pyrites.		Salt.		Silica.				Slates and Slabs.	
					Chert and Flint		Quartz.			
1897................	10,752	$22,625	1,933,949	$3,104,490	95,209	$82,475	459	$1,695	618,941	$8,247,880
1898................	12,302	24,020	1,908,728	3,100,575	83,370	72,565	*Nil.*	....	679,461	9,501,140
1899................	12,426	23,385	1,945,531	3,220,870	69,955	66,080	*Nil.*	....	650,077	8,985,855
1900................	12,484	28,940	1,878,601	3,059,600	78,971	69,500	*Nil.*	....	595,498	7 641,680
1901................	10,405	23,820	1,812,180	2,864,950	132,700	99,435	*Nil.*	....	496,756	6,523,235
1902................	9,313	......	1,924,183	....	100,933	....	*Nil.*	....	525,641	....

Year.	Stone.								Strontium Sulphate.	
	Granite.		Limestone. (*f*)		Sandstone.		Whinstone, Basalt, etc.			
1897......	1,876,880	$2,763,020	11,179,580	$5,779,965	5,043,535	$7,628,500	2,398,248	$2,206,955	15,227	$21,550
1898......	1,905,880	2,888,986	12,172,267	6,280,770	5,325,968	8,163,930	2,644,181	2,327,715	13,148	18,370
1899......	4,785,284	5,478,815	12,499,736	6,675,335	5,296,026	8.268,520	(*g*)	....	12,831	31,570
1900......	4,709,997	6,193,735	12,099,940	6,501,570	5,101,868	7,980,225	(*g*)	....	9,270	22.800
1901......	5,131,787	6,610,625	11,368,202	6,186,905	5,199,234	8,185,105	(*g*)	....	16,923	41,625
1902......	....	....	12,367,617	....	5,570,860	....	....	....	32,798	....

Year.	Tin Ore (Black Tin).		Tungsten Ore.		Uranium Ore.		Zinc Ore.	
1897	7,234	$1,271,090	127	$10,040	30	$6,835	18,586	$345,770
1898	7,498	1,441,625	331	79,220	26	5,925	23,929	588,920
1899	6,494	2,202,545	96	19,155	7	1,375	23,505	697,410
1900	6,911	2,618,020	9	1,755	42	7,585	25,070	488,080
1901	7,407	2,292,865	21	2,040	80	14,615	23,967	353,890
1902	7,681	....	9	....	53	....	25,460	....

METALS OBTAINABLE BY SMELTING FROM THE ORES IN THE ABOVE TABLE. (*a*) (IN METRIC TONS AND DOLLARS: £1 = $5.)

Year.	Copper, Fine.		Gold—Kg.		Iron.		Lead.		Silver—Kg.		Tin.		Zinc.	
1897	526	$135,480	63·2	$35,925	4,942,679	$56,978,895	26,988	$1,662,890	7,750	$143,070	4,524	$1,456,630	7,162	$634,115
1898	650	177,615	12·3	6,495	4,928,347	63,700,215	25,761	1,664,975	6,575	118,640	4,722	1,729,060	8,711	897,910
1899	647	249,840	103·5	60,430	4,992,468	85,174,370	23,929	1,776,895	5,969	109,710	4,077	2,540,470	8,837	1,100,660
1900	777	299,975	437·6	260,735	4,743,172	97,984,550	24,762	2,094,800	5,964	112,325	4,337	2,989,345	9,214	942,865
1901	541	188,305	194·5	110,210	4,158,745	64,138,110	20,361	1,272,995	5,452	98,890	4,634	2,782,855	8,555	745,870

(*a*) From *Mineral Statistics of the United Kingdom*. (*b*) Including china clay, potters' clay, and fuller's earth. (*c*) Included under copper ore. (*d*) Bog ore, which is raised in Ireland, is an ore of iron, used principally for purifying gas. (*e*) Not reported. (*f*) Not including chalk. (*g*) Included with granite. (*h*) Statistics not yet available.

Additional products: In 1897: Mica, 5,063 metric tons, $8,635; soapstone, 28 metric tons, $490; nickel ore, 305 metric tons, $1,500. Metals obtainable by smelting in 1897: Aluminum, 315 metric tons, $229,400; nickel, 7¼ metric tons, $5,250; sodium, 86 metric tons, $63,750.

MINERAL IMPORTS OF THE UNITED KINGDOM. (*a*) (METRIC TONS AND DOLLARS; £1 = $5.)

Year.	Alkali.		Asphaltum.		Borax.		Brass and Bronze Manufactures.		Chemical Products.	Clay Products, Porcelain and Earthenware.		Coal, Culm and Cinders.		Copper Man'f'res Unenumerated.
		$												
1898	12,179	673,180	46,398	$635,110	1,255	$77,140	2,357	$1,068,380	$6,939,150	16,405	$4,301,740	11,191	$81,550	$2,662,400
1899	12,078	669,890	59,073	807,840	3,076	154,075	1,988	919,980	7,478,170	18,841	4,604,100	1,777	16,985	3,406,300
1900	16,360	840,790	53,061	728,355	15,667	777,045	2,335	1,086,180	7,417,490	18,399	4,647,390	10 112	60,770	5,248,255
1901	*e*18,429	424,715	74,694	948,805	15,710	768,590	2,469	1,200,290	8,423,795	20,754	4,994,860	7,685	111,115	3,538,975
1902	*e*26,292	819,110	65,896	817,415	13,390	560,785	3,403	1,476,255	8,514,545	19,029	4,907,405	3,331	20,505	4,277,770

Year.	Copper.—*Continued.*						Diamonds—*Carats.*		Glass, All Kinds.	Gold Leaf. *Number.*	
	Ore.		Regulus and Precipitate.		Wrought, Unwrought & Old.						
1898	91,141	$3,291,150	76,201	$9,779,790	70,018	$17,988,325	3,476,509	$22,619,075	$16,423,915	63,632,700	$624,960
1899	130,611	5,460,735	84,015	12,562,945	60,502	21,572,275	2,730,502	20,597,910	16,044,400	49,108,570	486,430
1900	102,365	5,863,110	89,123	17,587,530	72,223	26,309,780	1,882,673	17,168,180	15,997,555	54,346,025	540,855
1901	102,508	6,259,700	93,838	18,348,315	68,809	23,652,900	2,525,212	24,385,210	17,647,635	59,048,856	589,890
1902	90,007	4,881,085	74,684	12,532,365	92,849	24,600,940	2,634,207	26,901,950	18,484,960	59,334,023	591,920

Year.	Gold Ore.		Graphite.		Iron.						
					Bar, Angle, Bolt and Rod.		Iron and Steel Mfres	Iron and Steel, Old and Scrap.		Ore.	
1898	1,019	$1,393,175	15,118	$1,506,805	70,331	$2,782,745	$33,379,160	24,619	$349,280	5,555,889	$20,173,210
1899	295	761,755	17,777	2,307,935	74,326	2,880,790	39,527,075	32,427	452,180	7,168,061	26,875,190
1900	(*c*)	1,432,970	14,962	1,733,805	81,436	3,280,070	40,131,630	31,687	559,720	6,398,639	28,195,015
1901	(*c*)	2,747,195	18,494	1,510,195	99,671	3,674,500	*f*45,337,400	44,721	608,865	5,637,670	22,752,815
1902	(*c*)	2,688,170	13,506	1,148,920	174,666	5,423,065	*f*46,864,645	39,582	564,090	6,542,798	24,895,770

Year.	Iron.—*Continued.*				Lead.						Manganese Ore.	
	Pig and Puddled.		Steel, Unwrought.		Ore.		Pig and Sheet.		Manufactures.			
1898	162,075	$2,688,445	40,875	$1,263,025	44,457	$1,512,535	197,591	$12,606,780	419	$66,880	156,890	$1,700,555
1899	174,159	3,104,255	78,257	2,170,100	30,263	1,269,560	201,551	14,419,185	241	42,415	261,740	2,927,105
1900	184,049	4,024,395	182,210	6,090,875	21,566	1,095,410	198,416	16,607,870	(*d*)	....	270,098	3,423,080
1901	201,676	3,961,805	185,810	5,581,825	29,944	1,221,625	221,549	14,219,980	(*d*)	....	195,736	2,293,300
1902	230,467	3,990,780	285,404	7,076,675	25,838	906,375	235,522	12,923,940	(*d*)	....	237,066	2,384,050

Year.	Mica, Sheet.		Mica and Talc.		Paraffine.		Petroleum. *Liters.*		Phosphate Rock.		Painters, Colors and Pigments.
1898....	517	$711,855	1,398	$419,095	48,104	$4,045,160	829,995,751	$18,668,150	334,334	$2,499,360	$5,619,885
1899....	519	710,630	6,025	701,880	54,712	5,055,335	908,107,248	22,863,945	426,330	3,414,700	5,842,063
1900....	469	633,570	7,952	1080,380	50,033	6,686,355	965,167,850	27,796,295	361,309	2,943,490	6,747,800
1901....	(*b*)	....	7,117	707,675	42,643	5,081,870	960,650,967	25,358,510	360,568	2,758,585	6,489,710
1902....	1,078	372,915	6,127	*g*149,485	52,023	5,017,945	1,078,095,152	25,967,910	370,697	2,769,610	6,367,390

Year.	Platinum, Wrought and Unwrought. Kg.		Potassium Nitrate.		Pyrites, Iron and Copper.		Quicksilver.		Silver Ore.	Slate.	Sodium Nitrate.	
1898....	3,389	$734,205	13,323	$1,016,215	665,544	$5,404,415	1,856	$1,940,880	$5,729,525	$1,646,005	132,412	$4,864,005
1899....	5,404	1,177,870	12,635	1,022,425	712,393	5,821,335	1,759	2,077,150	5,162,750	1,690,720	163,387	5,348,875
1900....	5,027	1,139,270	12,793	1,0.5,325	752,605	6,186,115	1,118	1,486,215	5,154,430	1,232,175	143,461	5,777,310
1901....	4,917	1,140,760	12,115	1,033,020	664,041	5,606,225	1,202	1,616,390	5,309,920	1,364,880	108,822	4,550,385
1902....	3,027	711,650	11,526	975,760	620,948	4,984,005	1,129	1,453,915	5,383,515	1,481,030	116,791	5,387,850

Year.	Stone, Marble, Hewn or Manufactured.		Sulphur.		Tin in Blocks, Ingots, Bars, or Slabs.		Tin Ore.		Zinc, Crude, in Cakes.	
1898....	883,699	$5,179,950	19,642	$450,155	20,665	$6,948,005	5,710	$785,285	78,761	$7,211,345
1899....	905,433	5,526,225	21,906	508,075	27,608	16,290,910	6,324	1,258,260	71,068	8,316,905
1900....	961,492	5,664,225	22,993	545,240	33,648	21,795,665	7,449	1,879,550	61,504	7,210,160
1901....	1,159,276	6,811,860	22,440	495,610	35,397	21,078,190	10,690	2,619,425	68,633	5,885,355
1902....	1,192,023	6,878,770	23,863	568,005	35,713	20,771,755	12,255	3,242,235	89,688	7,644,810

Year.	Zinc Manufactures.		Zinc Ore.		Ores, Unclassified.		Metals, Unclassified, Wrought, Unwrought, and Old.	
1898..........................	21,613	$2,390,440	53,945	$1,100,705	51,660	$1,476,625	14,459	$3,545,690
1899..........................	21,531	2,969,650	38,143	1,121,370	80,322	1,899,360	18,475	4,095,120
1900..........................	21,751	2,798,525	42,755	1,179,250	68,368	1,663,505	16,269	5,517,915
1901..........................	21,343	2,451,080	38,660	825,990	77,193	1,661,930	15,533	5,528,730
1902..........................	21,717	2,447,770	45,812	1,028,235	74,901	1,696,015	17,214	5,270,630

(*a*) *Accounts Relating to Trade and Navigation o^f^ the United Kingdom*. (*b*) Not reported. (*c*) Entered by value only in 1900. (*d*) Included with Metals, unclassified, wrought. (*e*) Classified as soda compounds in 1901 and 1902. (*f*) Includes machinery and mill work. (*g*) Includes French chalk, steatite, etc.

MINERAL EXPORTS OF THE UNITED KINGDOM. (*a*) (IN METRIC TONS AND DOLLARS. £1 —$5.)

EXPORTS OF DOMESTIC PRODUCE.

Year.	Alkali.		Ammonium Sulphate.		Brass and Manufactures		Cement.		Chemical Products.	Clay Products Porcelain and Earth'nw.	Coal and Culm.	
		$										
1898	191,578	5,033,025	139,806	$6,450,155	5,418	$2,346,205	331,648	$3,058,615	12,577,815	$8,258,640	35,619,865	$85,779,115
1899	193,492	5,158,115	142,577	7,781,860	5,797	2,815,835	359,278	3,466,755	13,750,635	9,314,255	41,839,217	128,451,970
1900	185,783	5,604,310	147,528	8,183,390	6,131	3,155,075	365,742	3,365,310	13,762,185	10,193,970	46,845,739	193,082,230
1901	*d*189,332	5,627,755	154,282	8,033,880	5,905	2,965,005	318,216	2,919,870	12,503,020	9,963.985	42,547,114	143,724,920
1902	*d*230.343	6,414,985	165,213	9,346,975	6,384	3,067,205	308,104	2,602,560	13,178,790	9,497,995	43,849,591	131,536,755

Year.	Coke and Cinders.		Coal, etc., for Steamers. (*b*)	Coal Products.	Copper Sulphate.		Copper.			
							Unwrought, In Ingots, etc.		Mixed or Yellow Metal.	
1898....	782,053	$2,755,580	$11,444,431	*c*$7,624,740	52.573	$4,224,085	27,102	$7,154,225	10,452	$2,542,915
1899....	881,172	3,743,745	12,422,429	*c* 7,712,965	40,822	4,261,185	32,449	11,994,300	7,088	2,186,940
1900....	1,001,131	6,078,680	11,940,353	*c* 9,058,220	43,601	5,066,000	18,300	6,987,425	8,940	2,925,650
1901....	820,594	3,503,930	18,804,222	5,756,265	36,601	4,231,585	26,935	9,761,720	9,252	2,949,175
1902....	699,664	2,758,480	15,390,383	5,991,025	43,995	4,180,660	21,658	6,010,145	18,314	3,703,680

Year.	Copper.—*Con.*		Glass, All Kinds	Iron.							
	Wrought or Manufactured. N. E. S. (*e*)			Pig and Puddled.		Bar (Except Railroad), Angle, Bolt and Rod.		Railroad, of All Sorts.		Iron and Steel Wire and Manufactures, (Except Telegraph Wire.)	
1898....	13,765	$4,629,430	$4,410,205	1,058,973	$18,684,020	152,911	$4,978,125	619,976	$15,081,290	44,954	$3,864,220
1899....	11,231	4,296,590	4,578,415	1,401,365	23,921,785	161,679	6,136,680	601,266	15,652,560	50,041	4,441,005
1900....	10,765	4,711,095	5,172,910	1,451,406	29,971,530	159,628	7,715,715	471,383	15,960,335	39,104	4,520,710
1901....	11,156	4,737,870	5,285,775	852,609	18,152,650	119,962	5,207,675	591,888	18,172,765	48,107	4,839,215
1902....	14,075	4,954,350	5,489,650	1,120,675	17,855,925	127,064	5,187,390	727,669	20,773,755	55,927	5,214,845

Year.	Iron.—*Continued.*									
	Hoops, Sheets (Ungalvanized) and Boiler and Armor Plates.		Galvanized Sheets.		Black Plates for Tinning. (Iron and Steel.)		Tinned Plates.		Cast and Wrought, and Manufactures. N. E. S. (*e*)	
1898....	102,638	$3,916,335	230,219	$12,653,350	59,289	$2,706,485	255,797	$13,768,540	361,927	$23,630,065
1899....	111,773	4,661,900	242,167	15,607,050	86,986	4,139,790	260,735	15,838,415	363,855	26,160,495
1900.. .	86,382	4,696,840	251,208	18,942,885	66,810	3,558,645	278,338	19,883,980	344,901	29,340,870
1901....	76,360	3,779,460	254,290	15,964,250	52,217	2,674,590	275,661	18,520,440	326,518	25,180,955
1902...	81,590	3,968,910	333,572	20,663,680	58,588	3,021,170	316,859	21,665,830	344,052	25,832,530

Year.	Iron.—*Concluded.*							
	Old.		Steel, Unwrought.		Manufactures of Steel and Iron.		Total of Iron and Steel.	
1898............	86,608	$1,201,050	290,188	$13,208,560	35,657	$4,518,470	3,299,826	$113,200,460
1899............	118,262	1,952,620	333,837	16,842,310	45,181	5,109,295	3,777,098	140,463,900
1900............	96,567	1,846,610	313,330	18,420,325	42,939	5,111,645	3,602,013	159,963,375
1901............	86,559	1,366,615	217,236	11,827,385	52,681	5,724,425	3,250,456	126,410,400
1902............	104,890	1,632,690	307,471	14,445,585	49,156	5,812,615	3,634,113	146,019,375

Year.	Lead.				Mica and Talc.		Potassium Nitrate.		Salt, Rock and Brine.		Slate.
	Pig.		Sheet, Pipe and Other Manufactures.								
1898..	18,964	$1,231,360	19,720	$1,499,410	89	$69,065	1,348	$134,610	698,862	$2,300,075	$938,905
1899..	21,083	1,512,850	19,840	1,667,135	70	62,400	1,283	131,725	638,213	2,237,080	4,605
1900..	17,764	1,596,820	18,812	1,912,480	71	46,350	1,288	131,180	556,704	2,286,700	739,000
1901..	18,426	1,201,880	19,740	1,725,845	95	45,635	1,310	136,665	627,078	2,545,700	614,700
1902..	14,912	840,410	18,625	1,446,955	45	26,215	1,334	141,155	623,552	2,533,115	734,280

Year.	Stone, All Kinds.		Tin, Unwrought.		Zinc.						Metals, Unclassified Wrought & Unwrought.
					Ore.		Crude.		Manufactures.		
1898....	27,569	$606,930	5,557	$1,974,430	6,483	$93,365	7,577	$618,875	1,237	$168,685	$3,164,995
1899....	30,728	612,690	4,785	2,937,655	8,171	144,420	5,493	561,460	1,249	207,280	3,559,880
1900....	36,309	770,210	5,713	3,816,700	13,918	207,770	7,136	650,620	1,159	183,605	4,195,940
1901....	47,498	800,165	5,584	3,397,320	13,981	176,580	7,519	542,050	1,256	182,965	4,192,220
1902....	51,672	907,735	6,210	3,678,330	16,717	271,080	6,756	497,475	1,345	187,815	4,813,590

EXPORTS OF FOREIGN AND COLONIAL PRODUCE. (*a*) (IN METRIC TONS AND DOLLARS; £1 — $5.)

Year.	Chemical Products.	Copper, Unwrought, Partly Wrought, and Old.		Glass.					Iron, Bar, Angle, Bolt, and Rod.		Steel, Unwrought.	
				Bottles, *Gross.*		All Other Kinds		Total.				
1898....	$1,509,195	13,454	$3,578,710	12,694	$29,875	3,961	$353,905	$383,780	26,891	$1,135,450	2,619	$154,480
1899 ...	1,085,185	24,515	9,160,530	13,768	33,840	3,172	257,180	287,095	19,058	879,680	3,289	149,165
1900....	1,178,710	19,163	7,204,950	15,195	52,685	2,544	250,020	302,705	11,116	547,065	2,837	139,870
1901....	2,000,245	23,502	8,171,765	16,830	38,675	2,707	279,545	318.220	12,610	583,165	1,751	127,380
1902....	1,681,965	21,893	5,986,635	15,548	33,350	2,940	316,320	349,670	8,582	364,095	1,142	599.500

Year.	Iron and Steel, N. E. S., Wrought and Manufactured. (*e*)		Petroleum. *Liters.*		Potassium Nitrate.		Quicksilver.		Tin, in Blocks, Ingots, Bars, or Slabs.	
1898.....................	29,509	$5,658,860	6,479,451	$217,200	2,775	$203,080	1,157	$1.199,500	15,885	$5,310,350
1899.....................	28,874	5,094,390	6,699,181	279,505	1,573	122,240	1,097	1.316,130	17,120	9,953,060
1900.....................	......	4,407,155	7,562,725	354.495	1,581	128,295	880	1,188,705	20.069	13,101,260
1901.....................	.....	1,985,865	13,566,754	560,085	1,403	112.0[illegible]	914	1,194,100	21,271	12,888,125
1902.....................	......	1,306,575	15,587,246	684,420	1,517	123,545	664	838,120	23,344	13,683,560

(*a*) From *Accounts Relating to Trade and Navigation of the United Kingdom*. (*b*) Number of tons shipped for the use of steamers engaged in the foreign trade. This not being an export in the ordinary acceptation of the term, the value thereof is not given in the trade returns. (*c*) Including naphtha, paraffine, paraffine oil and petroleum. (*d*) Classified as Soda Compounds in 1901 and 1902. (*e*) N. E. S. signifies "not elsewhere specified."

UNITED STATES.

STATISTICS and full particulars of the mineral production of the United States will be found in the introduction and the articles on the different substances. We give below the mineral imports and exports for five years:

MINERAL IMPORTS OF THE UNITED STATES. (*a*)

Year.	Aluminum.							Ammonium Sulphate.			
	Crude.				Leaf.		Mfd.				
	Lb.	Kg.	Value.	Value per Kg.	Pkgs.	Value.	Value.	Lb.	Metric Tons.	Value.	Value per Met. Ton.
1898	60	27	$30	$1·11	2,000	$174	$4,675	11,057,762	5,016	$210,078	$41·88
1899	53,622	24,323	9,425	0·39	693	112	5,308	17,121,968	7,766	406,573	52·35
1900	256,559	116,374	44,455	0·38	1,103	103	3,111	24,024,188	10,897	591,987	54·32
1901	564,808	251,657	104,168	0·41	*Nil.*	*Nil.*	5,580	31,711,085	14,384	728,085	50·62
1902	745,217	338,028	215,082	0·64	219	32	3,645	35,535,558	16,119	858,086	53·23

Year.	Antimony.				Antimony Ore.			
	Lb.	Metric Tons.	Value.	Value per Metric Ton.	Lb.	Metric Tons.	Value.	Value per Metric Ton.
1898	2,025,183	919	$143,909	$156·59	3,725,222	1,690	$50,256	$29·74
1899	3,160,697	1,434	240,983	168·09	3,982,133	1.806	47.841	26·49
1900	3,632,843	1,648	285,749	173·41	6,035,734	2,738	78,581	28·70
1901	3,674,923	1,667	255,346	153·17	1,731,956	786	24,256	30·86
1902	5,742,708	2,605	347,899	133·55	1,639,043	743	29,476	39·67

Year.	Asbestos.			Asphaltum.			
	Crude. Value.	Manufactured. Value.	Total Value.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1898	$287,636	$12,899	$300,535	67,711	68,794	$202,452	$2·94
1899	303,119	8,949	312,068	100,168	101,771	319,089	3·14
1900	331,796	24,155	355,951	113,557	115,374	404,921	3·57
1901	667,087	24,741	691,828	132,079	134,192	516,515	3·85
1902	729,421	33,013	762,434	139,944	142,183	439,570	3·09

Year.	Barium Sulphate.								Bauxite.			
	Manufactured.				Unmanufactured.							
	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Value per Met. Ton.
1898	687	698	$8,678	$12·43	1,022	1,038	$2,678	$2·58	2.690,240	1,220	$4,238	$3·47
1899	2,111	2,145	22,919	10·69	1,739	1,767	5,488	3·11	14,931,840	6,773	23,768	3·51
1900	2,454	2,493	24,160	9·69	2,568	2,609	8,301	3·18	19,389,440	8,795	32,967	3·75
1901	2,454	2,493	27,062	10·85	3,150	3,200	12,380	3·87	40,021,120	18,153	66,107	3·64
1902	3,907	3,970	37,889	9·42	3,929	3,992	14,322	3·59	35,369,600	16,043	54,410	3·39

Year.	Brass and Manufactures of. Value.	Chloride of Lime, or Bleach. Lb.	Metric Tons.	Value.	Value per Met. Ton.	Cement. Barrels. (b)	Metric Tons.	Value.	Value per Met. Ton
1898............	$24,611	108,462,828	49,198	$1,229,978	$25·00	2,013,819	365,383	$2,624,228	$7·18
1899............	58,916	123,583,061	56,056	1,203,864	21·47	2,108,218	382,512	2,858,256	7·47
1900............	20,118	132,520,478	60,111	1,524,205	25·36	2,386,684	433,037	3,330,458	7·69
1901............	35,976	120,611,346	54,709	1,673,190	30·58	944,892	170,481	1,306,692	7·66
1902............	51,626	112,874,478	50,973	1,456,435	28·57	1,994,790	361,932	2,581,883	7·13

Year.	Chrome Ore. Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Chromic Acid. Lb.	Kg.	Value.	Value per Kg.	Clays or Earths, Including Kaolin. Long Tons.	Metric Tons	Value	Value per Met. Ton.
1898..	16,304	16,565	$272,234	$16·43	5,329	2,417	$1,758	$0·73	113,280	115,092	$779,491	$6·77
1899..	15,793	16,046	284,825	17·75	33,134	15,029	6,360	0·42	122,035	123,988	807,792	6·52
1900..	17,542	17,823	305,001	17·11	35,452	16,081	7,232	0·45	146,524	148,868	966,579	6·49
1901..	20,112	20,434	363,108	17·77	53,462	24,202	10,861	0·45	181,018	183,589	1,176,633	6·41
1902..	39,570	40,208	582,597	14·49	g92,401	41,913	11,692	0·28	191,764	194,832	1,228,945	6·31

Year.	Coal. Anthracite. Long Tons.	Metric Tons.	Value.	Value Per Met. Ton.	Bituminous. Long Tons.	Metric Tons.	Value.	Value Per Met. Ton.	Total. Metric Tons.	Value.	Value Per Met. Ton.
1898	8,149	8,199	$8,609	$2·69	1,270,557	1,290,886	$3,569,572	$2·77	1,294,085	$3,578,181	$2·77
1899	61	62	245	3·95	1,400,461	1,422,868	3,882,430	2·73	1,422,930	3,882,675	2·73
1900	118	120	549	4·58	1,909,258	1,939,806	5,019,558	2·59	1,939,926	5,020,102	2·59
1901	286	291	1,844	6·34	1,919,962	1,950,681	5,291,429	2·71	1,950,972	5,293,273	2·71
1902	73,006	74,174	323,517	4·36	2,478,375	2,518,029	7,016,274	2·79	2,592,203	7,339,791	2·83

Year.	Coke. Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Cobalt Oxide. Lb.	Kg.	Value.	Value per Kg.	Copper, Ore and Regulus. Lb.	Metric Tons.	Value.	Value per Met. Ton.
1898	41,185	41,844	$142,334	$3·40	$33,731	15,300	$49,245	$3·22	6,861,120	3,112	$654,355	$210·26
1899	27,855	28,301	142,504	5·04	46,791	21,224	68,847	3·24	70,866,880	32,145	2,243,583	65·56
1900	03,175	104,826	371,341	3·54	54,073	24,527	88,651	3·61	121,696,960	55,201	5,195,010	90·76
1901	172,729	78,893	266,078	3·61	71,969	32,645	134,208	4·11	215,188,686	97,584	14,692,645	150·58
1902	107,437	109,156	423,774	3·98	79,984	36,281	151,115	4.16	406,707,840	184,470	8,695,780	47·14

Year.	Copper, Ingots, Old, etc. Lb.	Metric Tons.	Value.	Value per Met. Ton.	Copper, Manufactures. Value.	Copper. Total Value.	Cryolite. Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1898....	54,166,467	24,570	$4,120,680	$167·71	$39,467	$4,814,502	6,201	6,300	$88,501	$14·05
1899....	71,922,340	32,624	10,139,390	310·80	42,000	12,424,975	5,879	5,973	78,676	13·17
1900....	68,796,808	31,206	10,557,870	338·33	23,390	15,776,370	5,437	5,524	72,763	13·17
1901....	73,826,406	33,488	11,812,216	352·73	24,775	26,529,636	5,383	5,469	70,886	12·96
1902....	103,129,568	46,778	13,051,159	279·17	52,464	21,799,403	6,188	6,287	85,640	13·62

Year.	Earthen, Stone, and China Ware Value.	Emery Grains. Lb.	Metric Tons.	Value.	Value per Met. Ton	Emery Rock. Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Emery Manufactures. Value.	Emery. Total Value.
1898....	$7,278,471	577,655	262	$23,320	$89·01	5,547	5,636	$106,269	$18·86	$3,810	$133,399
1899....	8,101,093	728,209	330	29,124	88·17	7,435	7,554	116,493	15·42	11,514	157,131
1900....	9,148,536	661,482	300	26,520	88·39	11,392	11,574	202,980	17·54	10,006	239,506
1901....	9,816,074	1,116,729	506	43,207	85·37	12,441	12,640	240,856	19·05	10,927	294,990
1902....	9,838,426	1,665,737	756	60,079	79·47	7,166	7,281	151,959	20·87	13,776	225,814

Year.	Fertilizers.									Gold and Silver in Coin and Bullion.	
	Guano.				Phosphates, Crude.				All Other. Value.		
	Long Tons.	Metric Tons	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.		Gold.	Silver.
1898....	5,259	5,343	$56,938	$10·66	66,129	67,187	$308,635	$4·52	$1,045,118	$158,146,159	$9,572,810
1899....	2,700	2,743	26,787	9·76	115,918	117,768	523,258	4·44	986,127	40,070,599	8,940,842
1900....	6,620	6,726	67,413	9·91	137,086	139,273	791,189	5·68	1,400,336	45,703,256	14,695,965
1901....	4,949	5,028	71,140	14·15	175,765	178,577	872,508	4·87	1,506,965	33,237,629	12,957,987
1902....	8,407	8,542	164,783	19·29	137,386	139,584	646,264	4·63	1,725,338	22,710,957	8,502,614

Year.	Gold and Silver in Ores.		Iron Ore.				Pig Iron.			
	Gold.	Silver.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1898.....	$5,017,798	$19,559,070	187,098	190,086	$253,243	$1·33	25,152	25,554	$704,431	$27·56
1899.....	11,264,365	21,908,087	674,082	684,867	1,082,847	1·58	40,398	41,039	1,339,405	32·64
1900.....	21,045,828	25,404,574	879,831	893,908	1,306,196	1·46	52,565	53,406	1,907,361	35·71
1901.....	21,524,251	18,188,795	966,950	982,421	1,659,278	1·69	62,990	63,987	1,792,014	28·08
1902.....	21,482,360	17,900,821	1,165,470	1,184,118	2,583,077	2·18	625,383	635,389	10,935,831	17·21

Year.	Scrap Iron and Steel.				Bar Iron, Rolled and Hammered.			
	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Value per Met. Ton.
1898..................................	1,783	1,812	$33,330	$18·39	42,837,276	19,426	$844,368	$43·47
1899..................................	10,925	11,100	168,045	15·14	44,338,056	20,109	942,347	46·86
1900..................................	34,431	34,982	663,231	18·96	44,098,825	19,094	1,058,761	55·45
1901..................................	20,130	20,452	339,827	16·56	46,573,996	21,126	1,093,736	51·77
1902..................................	109,510	111,262	1,606,720	14·44	64,610,479	29,307	1,286,238	43·88

Year.	Bars, Railway, of Iron or Steel.				Hoop, Band, or Scroll.				ngots, Blooms, Slabs, Billets, etc.			
	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Met. Tons.	Value.	Value per Met. Ton.	Lb.	Met. Tons.	Value.	Value per Met. Ton.
1898.	200	203	$5,181	$25·52	7,527	3	$224	$74·66	23,868,682	10,827	$1,008,360	$93·18
1899.	2,134	2,168	70,751	32·65	1,485,720	674	33,392	49·54	28,225,64	12,808	1,287,725	100·58
1900.	1,448	1,471	56,129	38·15	369,165	167	12,409	74·08	28,468,81	12,913	1,332,896	103·19
1901.	1,905	1,935	67,052	35·17	,660,909	3,021	116,841	38·67	18,259,39	8,282	1,330 985	160·69
1902.	63,522	64,538	1,576,679	24·43	,581,512	3,416	131,052	38·36	642,478,70	291,426	7,888,309	27·07

Year.	Sheet, Plate, and Taggers Ironor Steel.				Tin Plates, Terne Plates, and Taggers Tin.			
	Lb.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Value per Metric Ton.
1898.................	5,085,287	2,307	$181,031	$78·47	149,576,525	67.847	$3,311,658	$48·81
1899.................	15,777,163	7,156	464,297	64·88	181,970,441	59,861	3,738,567	62·45
1900.................	11,521,161	5,226	426,541	81·62	185,264,791	61,356	4,617,818	75·26
1901.................	12,601,896	5,716	443,880	77·65	173,364,176	78,638	5,294,789	67·33
1902.................	22,541,024	10,225	611,630	59·82	184,668,426	61,085	4,023,421	65·87

Year.	Wire Rods.				Wire, and Articles made from.				Manufactures. Value.
	Lb.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Value per Met. Ton.	
1898.........	35,807,368	16,242	$767,909	$47·28	4,516,761	2,049	$318,553	$155·46	$5,299,542
1899.........	40,239,103	18,252	873,396	47·85	5,293,069	2,401	400,958	166·99	6,481,702
1900.........	47,245,140	21,430	1,212,594	56·58	4,138,991	1,877	409,087	217·90	8,747,069
1901...... ...	37,640,504	17,073	964,744	56·50	9,248,231	4,192	585,354	139·64	8,356,646
1902..........	47,895,417	21,725	1,033,074	47·55	7,769,247	3,524	606,724	172·17	11,769,148

Year.	Total Value of Iron Imports. (e)	Lead, Pig, Bars, Scrap, and in Ore.				Lead, Sheet, Pipe, Shot, etc.	
		Lb.	Metric Tons.	Value.	Value per Metric Ton.	Lb.	Metric Tons.
1898..........	$12,474,572	179,291,290	81,826	$2,585,362	$31·18	242,759	110
1899..........	15,800,579	192,877,074	87,488	2,816,783	32·20	110,372	59
1900..........	20,443,911	228,793,449	103,780	3,957,695	38.13	27,945	13
1901..........	20,394,995	224,942,329	102,332	4,841,644	47·52	56,735	26
1902..........	41,468,826	215,232,455	97,629	4,551,516	46·62	224,206	102

Year.	Lead, Sheet, Pipe, Shot, etc.—*Continued.*		Lead, Other Manufactures. Value.	Lead, Total Value.	Manganese Ore.			
	Value.	Value per Met. Ton.			Long Tons.	Metric Tons.	Value.	Value per Met. Ton
1898..........	$9,389	$85·35	*Nil.*	$2,544,751	114,885	116,723	$831,967	$7·13
1899..........	4,402	74·61	$12,983	2,834,168	188,349	191,363	1,584,528	8·28
1900..........	1,398	109·68	5,854	3,964,942	256,252	260,352	2,042,361	7·84
1901..........	2,773	106·65	4,654	4,849.071	165,720	168,372	1,486,573	8·83
1902..........	7,765	76·13	18,918	4,578.199	235,576	239,345	1,931,282	8·07

Year.	Marble and Stone, and M'f'res of.			Metals, Metal Compositions, and Manufactures of, N.E.S.			Mica, Mineral Substances, and Nickel.		
	Marble and Manufactures of.	Stone and Manufactures of.	Total.	Bronze Manufactures.	All Other.	Total.	Mica.	Mineral Substances N. E. S.	Nickel.
	Value.	Value. (*d*)	Value.	Value.	Value.	Value.	Value.	Value.	Value.
1898	726,343	$229,909	$956,252	$503,814	$3,479,221	$3,983,035	$150,082	$19,160	(*f*)
1899	726,070	200,192	926,262	710,086	4,008,942	4,719,028	275,984	78,453	(*f*)
1900	945,705	256,624	1,202,329	791,306	5,420,483	6,211,789	319,560	71,377	(*f*)
1901	1,226,524	237,191	1,463,715	945,702	5,162,392	6,108,094	335,054	109,043	$1,637,166
1902	1,435,454	222,438	1,657,892	816,668	5,942,017	6,758,685	466,332	119,842	1,156,372

Year.	Oil, Mineral.				Paints, Mineral. Zinc Oxide in Oil.				Paints and Colors.	Platinum, Man'f'ur'd.
	Gallons.	Liters.	Value.	Value per Liter.	Lb.	Metric Tons.	Value.	Value pr. Met. Ton.	Value.	Value.
1898......	2,024,090	7,661,808	$146,718	$·019	27,050	12	$2,279	$189·92	$1,142,670	$371
1899......	1,107,077	4,190,630	106,047	·025	41,699	19	4,154	219·79	1,412,877	876
1900......	3,039,094	11,503,913	274,766	·024	38,706	18	3,098	176·02	1,491,902	827
1901......	2,294,684	8,686,389	151,918	·018	128,198	58	8,983	154·88	1,524,195	2,518
1902......	4,274,622	16,181.325	247,158	·015	163,081	74	11,534	155·86	1,744,971	2,705

Year.	Platinum, Unmanufactured.			Plat'm Vases, Retorts	Potash, Chlorate of.				Potash, Chromate & Bichromate.			
	Kg.	Value.	Val. per Kg.	Value.	Lb.	Metric Tons.	Value.	Val. per Metric Ton.	Lb.	Met. Tons.	Value.	Value per Met. Ton.
1898	3,142·07	$1,178,142	$374·96	$52,012	4,805,332	2,180	$288.965	$132·55	1,160,710	526	$86,134	$163·75
1899	3,041·32	1,482,157	487·34	54,877	1,534,657	696	102,189	146·82	1,180,965	513	73,510	143·29
1900	3.450·06	1,728,777	501·81	35,887	1,243.612	564	68,772	121·94	111,761	51	7,758	152·02
1901	2,796·90	1,673,713	598·42	21,969	811,127	368	61,348	166·71	430,996	195	29,224	149·86
1902	3,234·60	1,950,362	602,97	34,913	1,209,148	548	60,429	110·27	231,009	105	15,161	144·39

Year.	Potash, Muriate of.				Potash, Nitrate of.				Potash, all other.	
	Lb.	Metric Tons.	Value.	Val. per Metric Ton.	Lb.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.
1898..........	103,368,701	46,888	$1,620,720	$34·57	11,461,823	5,199	$281,504	$54·15	37,736,761	17,117
1899..........	117,449,708	53,275	1,819,448	34·15	18,961,270	8,601	377,371	43·88	46,453,415	21,071
1900..........	130,175,481	59,047	1,976,604	33·48	10,545,392	4,783	276,664	57·84	54,904,088	24,904
1901..........	148,189,387	65.404	2,316,577	35·39	9,656,898	4,380	253,286	57·81	72,489.913	32,881
1902..........	140,980,460	63,947	2,141,553	33·49	10.505,474	4,765	299,416	62·84	92,857,009	42,119

Year.	Potash, all other. *Continued.*		Precious Stones.		Pyrites.				
			Rough & Uncut.	Cut.					
	Value.	Value per Metric Ton.	Value.	Value.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Average Sulphur Contents.
1898	$897,556	$48·35	2,550,076	$7,388,086	171,879	174,629	$544,165	$3·12	Over 25%
1899	1,014,862	48·16	4,955,587	11,653,917	310,008	314,968	1,074,855	3·41	Over 25%
1900	1,407,308	56·51	3,751,219	9,612,127	332,517	337,837	1,095,598	3·24	Over 25%
1901	1,636,856	49·78	6,637,860	17,166,049	398,969	405,353	1,407,244	3·47	Over 25%
1902	1,820,585	43·22	8,282,760	18,494,288	437,319	444,316	1,623,430	3·65	Over 25%

Year.	Quick-silver.	Salt.				Soda, Nitrate of.			
	Value.	Lb.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value Per Met. Ton.
1898	$51	374,310,225	169,786	$587,348	$3·46	147,494	149,854	$2,298,240	$15·34
1899	88	386,378,988	175,260	587,103	3·35	146,492	148,836	3,486,318	23·42
1900	1,061	415,865,592	188,636	633,192	3·36	182,108	185,022	4,955,580	26·78
1901	....	389,932,428	176,871	670,648	3·79	208,654	211,992	5,997,595	28·29
1902	....	377,440,559	171,206	654,648	3·82	295,245	299,969	5,996,205	19·99

Year.	Soda, Bicarbonate.				Soda, Caustic.			
	Lb.	Metric Tons.	Value.	Value per Metric Ton.	Lb.	Metric Tons.	Value.	Value per Metric Ton.
1898	280,988	127	$5,794	$45·62	24,981,878	11,333	$354,270	$31·26
1899	162,398	74	5,219	70·81	13,363,529	6,062	186,008	30·68
1900	133,137	60	4,509	74·65	8,408,749	3,812	150,530	39·49
1901	154,658	70	4,727	67·58	3,812,847	1,725	94,308	54·65
1902	176,480	80	6,482	81·08	3,334,697	1,518	77,482	51·28

Year.	Soda Ash and Sal Soda.				All other Soda Salts.			
	Lb.	Metric Tons.	Value.	Value per Metric Ton.	Lb.	Metric Tons.	Value.	Value per Metric Ton
1898	73,064,707	33,142	$447,119	$13·49	23,354,802	10,594	$256,962	$24·26
1899	56,058,837	25,426	425,255	16·72	26,598,238	12,062	360,721	29·90
1900	73,815,425	33,482	613,379	18·32	20,484,938	9,292	259,802	28·02
1901	31,415,788	14,250	276,261	19·39	14,491,559	6,573	184,548	28·08
1902	31,869,092	14,456	284,634	19·69	17,150,182	7,779	283,745	36·48

Year.	Sulphur, Crude.				Sulphur, Flowers.				Sulphur, Refined.			
	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1898	159,790	162,347	$3,081,974	$18·98	507	515	$14,548	$28·25	163	166	$4,391	$26·45
1899	140,841	143,094	2,494,387	17·43	336	341	9,917	29·08	184	187	4,519	24·17
1900	166,457	169,120	2,918,610	17·26	628	638	17,437	27·33	243	247	6,279	25·43
1901	174,162	176,949	3,256,951	18·40	748	761	20,201	26·54	268	272	6,308	23·20
1902	176,951	179,782	3,360,562	18·69	738	750	19,954	26·60	14	15	369	24·60

Year.	Talc.				Tin.			
	Lb.	Metric Tons.	Value.	Value per Metric Ton.	Lb.	Metric Tons.	Value.	Value per Met. Ton.
1898	889,645	404	$5,526	$13·68	62,748,399	28,462	$8,770,221	$308·49
1899	508,553	231	3,534	15·32	71,248,407	32,318	16,746,105	518·17
1900	158,497	72	1,070	14·88	69,989,502	31,747	19,458,586	612·93
1901	4,771,781	2,164	27,015	12·49	74,560,487	33,820	19,024,761	562·53
1902	5,717,761	2,594	35,336	13·62	85,043,353	38,575	21,263,387	551·22

Year.	Zinc.					
	Block, Pig, and Old.				Manufactures of. Net Value.	Total Value.
	Lb.	Metric Tons.	Value.	Value per Met. Ton.		
1898..........	2,742,357	1,244	$109,624	$88·12	$13,448	$123,072
1899..........	2,985,463	1,354	151,956	112·23	14,800	166,756
1900..........	2,018,196	918	97,772	107·05	86,826	184,598
1901..........	775,881	352	30,920	87·84	42,643	73,563
1902..........	1,665,366	755	46,926	62·15	40,693	87,619

(*a*) From *Summary of Commerce and Finance of the United States.* (*b*) Custom-house returns for these years are given in pounds, which are reduced to barrels of 400 lb. for convenience of comparison. (*d*) Including slate. (*e*) Not including ore. (*f*) Not reported. (*g*) Includes lactic acid.

MINERAL EXPORTS OF DOMESTIC PRODUCTION OF THE UNITED STATES. (*a*)

Year.	Aluminum and Manufactures of.	Asbestos.	Brass & Manufactures of.	Cement.				Chemicals, Drugs and Medicines.	Coal.	
									Anthracite.	
		Value.	Value.	Bbls.	Metric Tons(*m*)	Value.	Value per Met. Ton.	Value.	Long Tons.	Metric Tons.
1898....	$239,997	$54,660	$1,237,027	36,732	6,665	$73,838	$11·08	$9,732,734	1,350,948	1,372,568
1899....	291,515	77,409	1,607,072	81,090	14,718	166,073	11·29	11,949,834	1,707,796	1,735,121
1900....	281,821	124,971	2,068,072	100,400	18,216	225,306	12·37	13,771,682	1,654,610	1,681,084
1901....	183,579	113,316	2,078,178	373,934	67,898	679,296	10·79	14,267,110	1,993,307	2,025,200
1902....	116,052	130,437	1,809,312	340,821	61,838	526,471	8.51	13,487,367	907,977	922,505

Year.	Coal.—*Continued.*									Copper Ore. (*c*)	
	Anthracite.—*Con.*		Bituminous.				Total Long Tons.	Total Metric Tons.	Total Value.		
	Value.	Val. per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.				Lb.	Metric Tons.
1898	$5,712,965	$4·16	3,152,457	3,202,896	$6,699,248	$2·09	4,503,405	4,575,459	$12,412,233	20,923,320	9,492
1899	7,140,100	4·12	4,044,354	4,109,064	8,573,276	2·09	5,752,150	5,844,184	15,713,376	8,393,280	3,807
1900	7,092,489	4·22	6,262,909	6,363,631	14,431,590	2·27	7,917,519	8,043,996	21,524,079	22,415,680	10,168
1901	8,937,147	4·41	5,390,086	5,476,327	13,085,763	2·49	7,383,393	7,501,527	22,022,910	43,933,120	19,927
1902	4,301,946	4·66	5,218,969	5,302,472	13,927,068	2·62	6,126,946	6,224,977	18,229,009	40,398,400	18,324

Year.	Copper Ore.—*Con.* (*c*)		Copper, Pig, Sheet, and Old.				Copper. Manufactures. Value.	Copper. Total Value.	Earthen, and China Ware.
	Value.	Val. per Metric Ton.	Lb.	Metric Tons.	Value.	Val. per Met. Ton.			Value.
1898..............	$755,448	$79·59	291,955,905	132,430	$33,598,869	$253·71	$1,190,989	$35,545,251	$251,821
1899..............	442,868	116·32	246,826,331	111,960	41,190,287	367·90	1,852,499	43,485,654	511,732
1900..............	1,332,829	131·08	337,978,751	153,304	55,285,047	360·51	2,257,563	58,875,439	558,794
1901..............	2,536,549	127·30	194,249,828	88,111	31,692,563	359·70	1,842,336	36,071·448	596,820
1902..............	1,336,131	72·87	354,668,849	160,876	43,392,800	269·73	2,092,798	46,811 729	604.646

Year.	Fertilizers.								Glassware.	Gold and Silver in Coin and Bullion. (*e*)	
	Phosphates, Crude.				All Other.						
	Long Tons.	Metric Tons.	Value.	Value per Met. Tons	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Value.	Gold.	Silver.
1898....	570,948	580,083	$4,672,463	$8·05	16,714	16,981	$442,977	$26·09	$1,289,919	$16,113,258	$53,673,605
1899....	867,790	881,675	6,770,102	7·68	49,082	49,867	1,031,882	20·69	1,716,843	45,317,461	53,422,242
1900....	619,925	629.915	5.217.560	8·25	25,976	26,392	537,908	20·38	2,042,683	54,064,697	65.705.909
1901....	729,539	741,212	5,839,245	7·88	14,153	14,379	332,964	23·17	2,087,043	56,717,350	55,526,975
1902....	802,086	814,919	6,193,372	7·60	16,451	16,714	383,438	22·94	2,094,701	35,722,835	49,228,308

Year.	Gold and Silver in Ores. (*f*)		Iron Ore.				Iron, Pig.			
	Gold.	Silver.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1898.......	$81,696	$123,499	31,579	32,084	$67,548	$2·11	253,057	257,106	$2,702,551	$10·51
1899.......	61,950	39,495	40,665	41,316	76,287	1·85	228,678	232,337	3,282,641	14·13
1900.......	69,926	515,755	51,460	52,288	154,756	2·96	286,687	291,404	4,654.582	15·97
1901.......	1,012.589	111,883	64,708	65,748	163,465	2·49	81,211	82,510	1,257,699	15·39
1902.......	307,756	44,651	88,445	89,860	294,168	3·27	27,487	27,927	502,947	18·01

Year.	Iron, Bar.				Iron, Band, Hoop and Scroll.				Billets, Ingots, and Blooms.			
	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1898	7,074	7,188	$241,499	$33·60	1,593	1,619	$58,731	36·28	28,600	29,058	$544,771	$18·75
1899	10,898	11,073	413,694	37·36	2,869	2,915	117,002	40·14	25,487	25,895	533,241	20·59
1900	13,298	13,512	558,576	41·33	2,976	3,024	137,437	45·45	107,385	109,108	2,915,871	26·72
1901	17,706	17,998	674,671	37·50	1,561	1,586	74,056	46·69	28,614	29,072	708,887	24·38
1902	22,262	22,618	869.519	38·44	1,560	1,585	82,322	51·94	2,409	2,447	74,938	30·62

Year.	Iron, Nails and Spikes, Cut.				Iron Nails & Spikes; Wire, Wrought, Horseshoe and all other, inc. Tacks.				Plates and Sheets of Iron.			
	Lb.	Metric Tons.	Value.	Val. per Metric Ton.	Lb.	Metric Tons.	Value.	Val. per Met. Ton.	Lb.	Metric Tons.	Value.	Val. per Metric Ton.
1898	35,247,266	15,988	$641,779	$40·20	35,409,739	16,062	$839,299	$52·25	10,003,903	4,538	$204,170	$44·99
1899	22,342,543	10,135	482,882	47·64	79,727,846	36,164	1,957,773	54·14	13,880,092	6,296	356,791	56·67
1900	25,005,308	11,342	626,497	55·24	65,444,387	29,681	1.816,813	61·21	20,902,367	9,481	600,600	63·34
1901	20,835,944	9,452	450,331	48·70	46.298,262	21.001	1,152,368	54·87	15,466,168	7,015	452,695	64·53
1902	16,060,612	7,285	339,227	46·57	64,565,655	29,287	1,456,768	49·74	7,647,160	3,469	229,887	66·27

Year.	Plates and Sheets of Steel.				Rails or Bars of Iron.				Rails or Bars of Steel.			
	Lb.	Metric Tons.	Value.	Val. per Metric Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1898	60,647,662	27,510	$787,245	$28·62	8,311	8,444	$101,109	$11·97	293,592	298,289	$5,838,464	$19·57
1899	113,422,814	51,448	1,690,490	32·86	6,442	6,545	96,135	14·69	271,272	275,612	6,122,383	22·21
1900	101,995,225	46,264	1,638.478	35·41	5,374	5,460	119,206	21·83	356,245	361,945	10,895,416	30·10
1901	53.588,154	24,308	959,471	39·48	901	915	32,357	35·36	318,055	323,044	18,628,781	26.71
1902	33,299.206	15,104	725.547	48·03	211	214	4,639	21·67	67,455	68,534	1,902,396	27·76

Year.	Structural Iron and Steel.				Wire.				Wire Rods. (Steel.)			
	Long Tons.	Metric Tons.	Value.	Val. per Met. Ton	Lb.	Met. Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Val. per Met. Ton
1898	34,038	34,583	$1,255,451	$36·30	167,252,882	75,865	$3,036.818	$40·03	41,462,598	18.807	$390,144	$20·74
1899	54,244	55,112	2,059,289	37·37	260,549,627	118,184	5,526,930	46·83	38,062,438	17,265	524,466	30·38
1900	67,714	68.797	3,570,769	51·90	174,751,042	79,267	4,604,047	58·08	23,860,018	10,823	505,529	46·62
1901	54,005	54,869	3,031,861	55·26	197,652,789	89,654	4,805,608	53·71	18,289,584	8,250	271,552	32·91
1902	53,859	54,721	2,828,460	51·69	219,169,178	99,414	5,140,702	51·71	55,133,307	25,008	831,067	33·23

Year.	Lead & Manufactures.	Marble, Stone, & Manufactures of.	Mica.	Nickel. (*g*)	Petroleum (1 – 1,000 in Quantities and total Values.)							
					Crude.				Naphtha.			
	Value.	Value. (*k*)	Value.	Value.	Gallons.	Liters.	Value.	Value per Liter.	Gallons.	Liters.	Value.	Value per Liter.
1898	$215,289	$1,842,220	$6,272	$1,359,609	120,436	455,888	$5,016	$·011	17,258	65,326	$1,071	$·016
1899	273,919	1,900,763	4,655	1,151,923	117,690	445,495	5,958	·013	18,210	68,930	1,597	·023
1900	459,574	1,556,981	165	1,382,727	138,161	523,000	7,341	·014	18,570	70,295	1,681	·024
1901	625,234	1,785,515	3,584	1,521,291	127,008	480,781	6,038	013	21.685	82,087	1,742	·021
1902	696,010	1,587,957	....	924,579	145,234	549,775	6,331	.011	19,683	74,509	1,393	·018

Year.	Petroleum —*Continued.*											
	Illuminating.				Lubricating.				Residue, etc.			
	Gallons	Liters.	Value.	Value per Liter.	Gallons.	Liters.	Value.	Value per Liter.	Gallons (*j*)	Liters.	Value.	Value per Liter.
1898	764,823	2,894,191	$38,895	$·013	65,526	248,038	$7,626	$·031	30,436	115,209	$815	$·007
1899	733,382	2,776,184	49,172	·018	71,116	269,195	8,658	·032	21,609	81,798	658	·008
1900	739,163	3,104,593	54,693	·018	71,211	269,540	9,933	·037	19,750	74,760	845	·011
1901	827,479	3,131,399	58,491	·017	75,306	285,010	10,260	·036	27,596	104,463	1,255	·012
1902	778,797	2,948,089	49,079	·017	82,200	311,163	10,872	·035	38,316	145,043	922	·006

Year.	Petroleum.—*Concluded.* Paraffine. Lb.	Metric Tons.	Value.	Value per Met. Ton.	Quicksilver. Lb.	Metric Tons.	Value.	Value per Met. Ton.	Tin Manufactures. Value.
1898	166,317	75·4	$6,368	$84·34	961,497	445	$440,587	$990·08	$281,794
1899	181,861	82·5	7,650	92·74	1,264,872	573	609,586	1,063·92	401,217
1900	157,108	71·2	8,186	114·86	778,191	353	425,812	1,206·61	467,354
1901	151,695	68·8	7,960	115·70	843,988	383	475,609	1,241.79	495,425
1902	176,269	79·5	8,398	105·64	1,013,484	459	575,099	1,252.94	529,061

Year.	Zinc Ore. Lb.	Metric Tons.	Value.	Value per Met. Ton.	Zinc Oxide. Lb.	Metric Tons.	Value.	Value Per Metric Ton.
1898	23,564,800	10,689	$299,870	$28·05	7,849,059	3,560	$252,194	$70·83
1899	56,441,280	25,600	725,944	28·36	10,685,226	4,847	366,598	75·64
1900	84,123,200	38,158	1,133,663	29·71	11,391,666	5,167	496,380	96·06
1901	88,312,000	40,058	1,167,684	29·15	9,122,288	4,138	393,269	95·03
1902	109,226,880	49,542	1,449,104	29·25	10,716,364	4,861	433,722	89·22

Year.	Zinc; Pigs, Bars, Plates and Sheets. Lb.	Metric Tons.	Value.	Value per Met. Ton.	All Other Manufactures. Value.	Total Value.
1898	20,996,418	9,525	$1,033,959	$108·55	$133,165	$1,794,188
1899	13,509,316	6,128	742,521	121·17	143,232	1,978,225
1900	44,802,577	20,322	2,217,693	109·13	99,288	3,947,024
1901	6,780,221	3,071	288,906	94·08	82,046	1,981,895
1902	6,473,185	2,936	300,557	102·37	114,197	2,297,580

MINERAL EXPORTS OF FOREIGN PRODUCE FROM THE UNITED STATES. (*a*)

Year.	Antimony. Lb.	Metric Tons.	Value.	Value Per Metric Ton.	Antimony Ore. Lb.	Metric Tons.	Value.	Value Per Metric Ton.
1898	25,275	11·4	$1,729	$151·67	34,321	15·6	$784	$50·26
1899	16,815	7·6	1,275	167·76	*Nil.*	....	....	....
1900	23,520	10·7	2,352	219·81	*Nil.*	....	....	....
1901	*Nil.*	*Nil.*	*Nil.*	*Nil.*	49,655	22·1	1,536	69·50
1902	37,184	16·9	2,710	160·35	208,531	94·6	4,603	48·64

Year.	Asphaltum or Bitumen (Crude.) Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Brass and Manufactures of. Value.	Cement. Lb.	Metric Tons.	Value.	Value per Met. Ton
1898	1.514	1,538	$28,666	$18·64	$1,080	6,574 858	2,982	$24,283	$8·14
1899	1,194	1,213	24,486	20·19	766	11,672,694	5,295	47,384	8·95
1900	629	639	10,044	15·73	2,155	15,815,851	7,174	63,850	8·90
1901	2,209	2,244	18,078	8·06	813	17,476,590	7,927	72,761	9.18
1902	2,930	2,977	23,564	7·98	938	18,037,564	5,918	48,797	8·25

Year.	Chemicals. Salts of Potash. (*h*) Lb.	Kg.	Value.	Value per Kg.	Chloride of Lime. Lb.	Kg.	Value.	Value per Kg.	Nitrate of Soda. Lb.	Kg.	Value.	Value per Kg.
1898	183,804	82,466	$5,444	$·07	28,605	12,975	$381	$·03	1,646,400	746,802	$24,825	$·03
1899	402,230	182,450	12,594	·07	*Nil.*	....	....	....	5,510,400	2,499,501	78,877	·03
1900	808,701	366,824	43,524	·12	148,116	67,185	1,987	·03	6,919,360	3,138,601	112,550	·04
1901	633,100	287,182	43,446	·15	13,916	6,312	312	·05	5,559,660	2,518,543	101,489	·04
1902	1,266,125	574,310	59,789	·14	198,794	90,172	2,997	·03	8,232,000	3,733,800	144,650	·04

Year.	Chemicals—*Continued.*											
	Caustic Soda.				Sal Soda and Soda Ash.				All Other Salts of Soda.			
	Lb.	Kg.	Value.	Value per Kg.	Lb.	Kg.	Value.	Value per Kg.	Lb.	Kg.	Value.	Value per Kg.
1898	1,237,257	561,216	$22,202	$·04	4,247,945	1,926,855	$14,255	$·01	120,548	54,677	$1,400	$·03
1899	1,032,831	468,489	18,330	·04	1,173,781	532,424	4,198	·01	93,520	42,420	2,085	·05
1900	1,139,954	517,080	24,228	·05	78,017	85,388	1,126	·03	270,307	122,610	2,788	·02
1901	1,001,940	452,482	21,511	·05	369,521	167,614	5,184	·03	133,400	60,510	3,398	·05
1902	1,343,182	609,246	28,704	·05	62,658	28,419	981	·03	115,491	52,386	1,626	·03

Year.	Clays or Earths of All Kinds, including China Clay.				Coal, Bituminous.				Copper.			
									Ore and Regulus.			
	Long Tons.	Metric Tons.	Value	Value per Met. Ton.	Long Tons.	Metric Tons.	Value	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Val. per Met. Ton.
1898	91	92	$657	$7·11	2,890	2,936	$2,675	$0·91	7,622,720	3,458	$547,960	$158·46
1899	152	154	1,304	8·44	6,806	6,915	9,596	1·39	3,841,600	1,743	265,826	152·22
1900	78	79	572	7·22	6,740	6,848	19,740	2·88	2,159,360	979	170,191	173·75
1901	80	81	825	10·18	3,796	4,403	10,627	2·41	22,155,840	10,050	1,406,648	139·95
1902	123	125	1,284	10·27	7,559	7,680	22,158	2·88	32,359,040	14,657	2,229,912	152·14

Year.	Copper.—*Continued.*					Earthen, Stone, and Chinaware. Value.	Fertilizers.			
	Pigs, Bars, Ingots, Old, and Other Unmanufactured.				Manufactures. Value.		Guano.			
	Lb.	Metric Tons.	Value.	Value per Met. Ton.			Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1898.....	23,647,968	10,727	$1,437,464	$134·00	$4,637	$30,646	*Nil.*	....	....	....
1899.....	2,550,149	1,157	350,919	303·30	10,250	38,393	....	....	$8	....
1900.....	1,281,782	581	212,264	365·19	21,032	38,008	*Nil.*	....	....	....
1901.....	12,888,088	5,846	2,145,468	366·99	9,462	24,080	*Nil.*	....	....	....
1902.....	11,629,877	5,275	1,604,522	304,17	10,989	18,969	75	76	1,480	$19·47

Year.	Fertilizers—*Continued.*					Glass and Glassware.	Graphite.			
	Phosphates, Crude or Native.				Other Fert'z's					
	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Value.	Value.	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.
1898............	10	10	$306	$30·12	$13,499	$13,805	165	168	$11,645	$69·32
1899............	723	735	8,718	11·87	4,510	11,179	5	5	338	67·60
1900............	75	76	386	5·07	31,716	14,614	3	3	115	37·72
1901............	71	72	1,655	22·99	1,178	16,749	*Nil.*	....	....	....
1902............	*Nil.*	....	....	....	29,996	34,236	*Nil.*	....	....	....

Year.	Iron and Steel, and Tin Plate.											
	Pig Iron.				Scrap Iron and Steel, fit only to be remanufactured.				Bar Iron, Rolled or Hammered.			
	Long Tons.	Metric Tons.	Value.	Value per Met. Ton	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Value per Met. Ton.
1898	581	590	$7,098	$12·03	63	64	$270	$4·22	48,151	22	$1,648	$74·91
1899	597	607	7,908	13·04	195	198	2,671	13·49	85,630	39	3,159	81·42
1900	151	153	6,579	43·00	9,079	9,224	131,241	14·23	107,984	49	2,447	49·94
1901	189	191	6,148	32·19	3,331	3,384	61,663	18·22	149,207	68	7,569	120.14
1902	250	254	6,286	24·75	1,542	1,567	25,020	15·97	48,525	22	1,875	85·23

Year.	Iron and Steel, and Tin Plate.—*Continued.*											
	Railway Bars of Iron or Steel, or in Part of Steel.				Ingots, Blooms, Slabs, Billets and Bars of Steel, and Steel in Forms, N. E. S.				Sheet, Plate and Taggers, Wire Rod, Wire, and Wire Rope and Strand, Iron or Steel.			
	Long Tons.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Value per Met. Ton.	Lb.	Metric Tons.	Value.	Value per Met. Ton.
1898	140	142	$3,479	$24·50	100,417	46	$3,829	$83·24	824,738	374	$21,231	$56·77
1899	*Nil.*	....	....	....	10,769	5	1,718	350·61	377,403	171	11,148	65·19
1900	*Nil.*	....	....	....	5,849	3	1,842	559·17	468,790	213	11,599	54·56
1901	*Nil.*	....	....	....	4,682	2	1,059	498·58	426,077	193	17,272	89·48
1902	297	301	23,87	7·184	286,868	170	6,774	39·85	528,598	240	14,221	59·25

Year.	Iron and Steel, and Tin Plate—*Concluded.*					Lead and Manufactures of. Value.	Marble and Stone and Manufactures of. Value. (*k*)	Metal Compositions and Manufactures. Value.
	Tin Plates, Terne Plates, and Taggers Tin.				Manufactures. Value.			
	Lb.	Metric Tons.	Value.	Value per Met. Ton.				
1898....................	899,757	408	$22,271	$54·59	$279,717	$2,599,784	$5,452	$58,810
1899....................	378,866	172	11,308	65·82	346,795	2,881,641	7,525	57,050
1900....................	1,038,694	471	37,395	79·39	328,704	3,843,681	5,721	79,216
1901....................	264,359	120	8,519	70·99	149,771	4,190,525	17,068	35,428
1902....................	219,681	99	7.471	75·45	242,225	3,553,144	11,210	108,831

Year.	Oil, Mineral.				Paints and Colors. Value.	Precious Stones. Value.	Salt.			
	Gallons.	Liters.	Value.	Value per Liter.			Lb.	Met. Tons.	Value.	Value per M. Ton.
1898.........	3,219	12,185	$486	$0·04	$15,854	$39,974	4,827,288	2,189	$4,751	$2·17
1899.........	150	568	38	·07	12,104	49,256	5,216,112	2,366	9,858	4·17
1900.........	4,706	17,814	800	·04	18,814	14,189	3,548,724	1,610	3,907	2·43
1901.........	1,475	5,584	831	·15	17,923	32,607	3,699,411	1,678	7,155	4·26
1902.........	2,000	7,572	210	·03	14,217	*Nil.*	2,043,459	927	4,544	4·89

Year.	Sulphur or Brimstone (Crude).				Tin, in Bars, Blocks, Pigs, Grain or Granulated.				Zinc and M'f'res
	Long Tons.	Met. Tons.	Value.	Value per M. Ton.	Lb.	Met. Tons.	Value.	Value per Met. Ton.	Value.
1898.......	1,414	1,437	$31,822	$22·14	740,326	336	$113,334	$337·30	$1,536
1899.......	477	485	10,804	22·29	999,815	453	265,188	585·02	1,604
1900.......	590	599	13,495	22·53	1,108,124	503	335,377	667·28	3,048
1901.......	207	210	5,086	24·22	2,103,723	954	562,350	589·46	1,641
1902.......	1,253	1,273	28,024	22·01	1,071,921	486	286,897	590·13	765

(*a*) From *Summary of Commerce and Finance of the United States.*

(*c*) Ore, so called, consisting chiefly of matte.

(*e*) Total exports of coin and bullion: that is, includes both domestic and foreign not elsewhere specified.

(*f*) Only approximately correct. The Bureau of Statistics reports only the value of silver ores exported, but a much larger amount of silver leaves the country in copper matte which is classified as copper ore and no record is kept of its silver contents. The gold in copper matte exported is not included in the exports of gold given in the above table. These figures include ore of both domestic and foreign origin.

(*g*) Including nickel oxide and matte.

(*h*) Includes chlorate, muriate, and nitrate of potash, and all other salts of potash.

(*j*) Reported in bbls. and reduced to gals. at 42 gals. = 1 bbl.

(*k*) Including slate.

(*m*) Calculated at 1 bbl. = 400 lb.

(*n*) Not enumerated.

(*o*) Not reported separately. Included with crude phosphates.

(*p*) Not reported separately. Included with antimony.

NOTE.—N. E. S. signifies not elsewhere specified.

INDEX.

The Buyers' Manual

Preface.

THE advertising pages of the annual volumes of this work will well repay the careful perusal and study of every reader who wishes to be well informed upon the present condition of the mineral industry. They give an admirable and practical insight into the present state of the mining and metallurgic arts, for in them nearly every manufacturer or dealer of note in this country advertises the machines, appliances, and processes which are now in vogue, or which it is sought to introduce; while the names and specialties of the most eminent members of the engineering professions, as indicated in their cards, show the direction of modern mining and metallurgical progress.

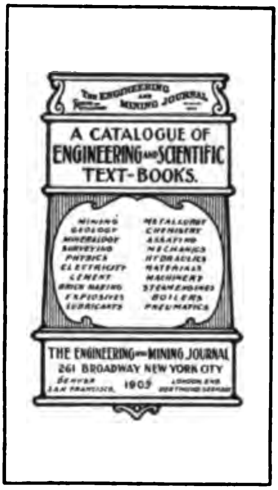
These advertising pages are no less important to those who desire a clear knowledge of the means by which this country has come to be far the most important producer of minerals and metals than to those who wish to know where to get that full and reliable information concerning the values of properties, machinery, processes, and products which should precede the investment of capital.

Every country in the world is wisely striving to develop its mineral resources, and to build up its mineral industry, and in all of them this volume, which gives the latest and best practice in every department of the industry, has become indispensable. It is constantly consulted for the best technical skill and the most advantageous machinery and appliances in use. All enterprising manufacturers of such wares appreciate this fact, and know that in no other way can they so effectively bring their goods before those who may need them as through the advertising pages of THE MINERAL INDUSTRY. These pages have become a veritable directory of the best in everything relating to the industry, and American, German and English manufacturers there compete for the orders of the whole world. $1,000,000,000 a year is certainly not an overestimate of the annual expenditure for technical skill, machinery and supplies used in the industry of which THE MINERAL INDUSTRY and *The Engineering and Mining Journal* are not only the chief but the only universal representatives published in any language.

The Publishers.

Buyers' Manual of The Mineral Industry

Alphabetical Index



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Buyers' Manual of the Mineral Industry

Classified Index.

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Krupp, Fried., Grusonwerk.
McKiernan Drill Co.
Rand Drill Co.
(See Machinery—Ventilating Machinery.)

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Rand Drill Co.

ALUMINUM.

(See Metals.)

AMALGAMATORS.

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(See Machinery.)

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ANTIMONY.

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Devoe, F. W., & C. T. Raynolds Co.

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Ricketts & Banks.
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BATTERIES (STAMP).

Allis-Chalmers Co.
Holthoff Machinery Co.
Krupp, Fried., Grusonwerk.
(See Machinery.)

BATTERY PLATES.

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Holthoff Machinery Co.
Krupp, Fried., Grusonwerk.
Matthiessen & Hegeler Zinc Co.
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(See Perforated Metals—Screens.)

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Matthiessen & Hegeler Zinc Co.

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Jeffrey Mfg. Co.
Krupp, Fried., Grusonwerk.

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BLASTING SUPPLIES.

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BLOWERS AND EXHAUSTERS.

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Colorado Iron Works.
Krupp, Fried., Grusonwerk.
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Allis-Chalmers Co.
Krupp, Fried., Grusonwerk.
Lidgerwood Mfg. Co.
(See Machinery.)

BOOKS.

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(See Machinery.)

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Colorado Iron Works.
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(See Machinery.)

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Krupp, Fried., Grusonwerk.
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Krupp, Fried., Grusonwerk.
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(See Machinery.)

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Holthoff Machinery Co.
Krupp, Fried., Grusonwerk.
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Jeffrey Mfg. Co.
Krupp, Fried., Grusonwerk.
Rand Drill Co.

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(See Machinery.)

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Balbach Smelting & Refining Co.
Matthiessen & Hegeler Zinc Co.
Orford Copper Co.
Ricketts & Banks.

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Krupp, Fried., Grusonwerk.
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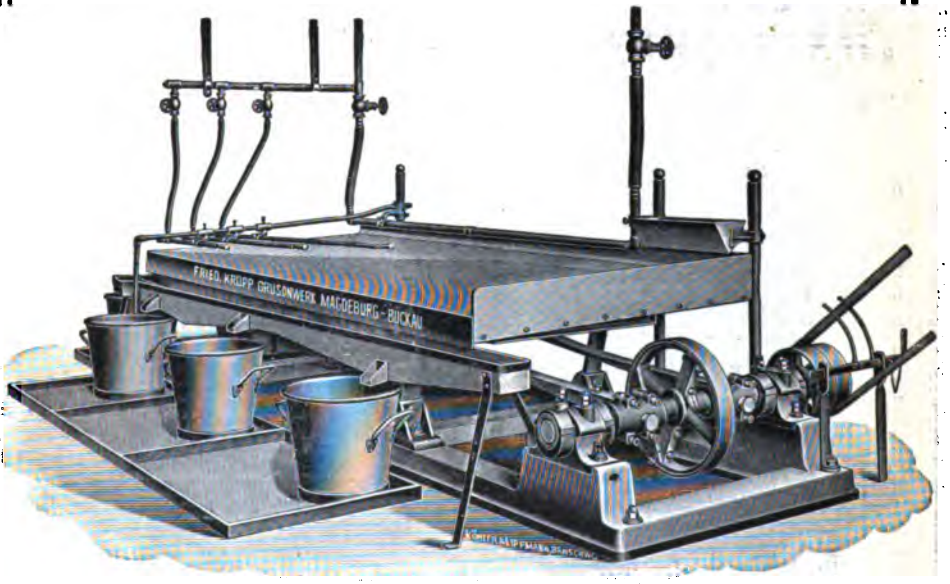

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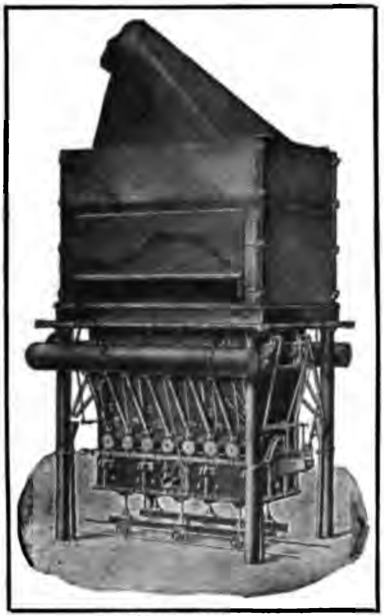

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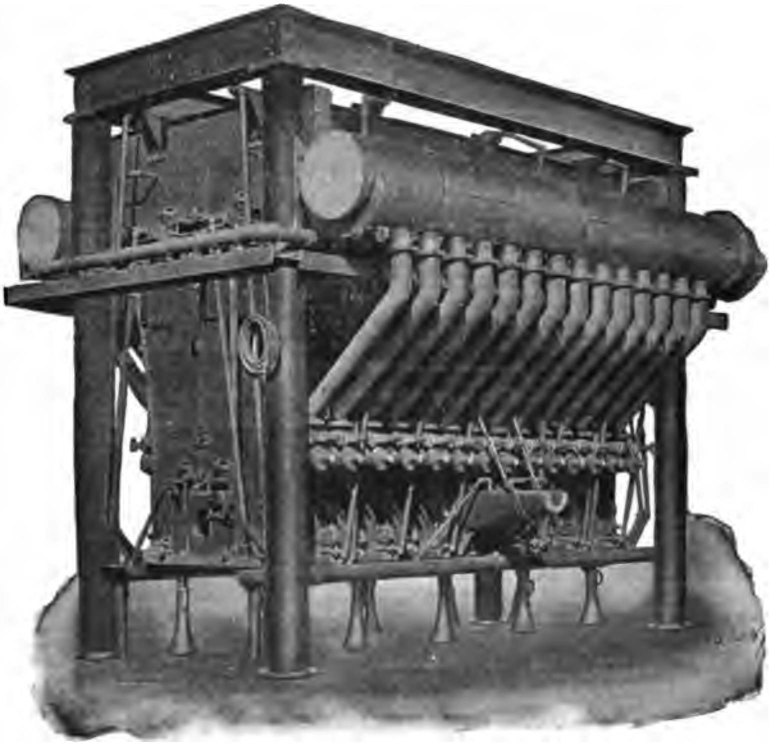

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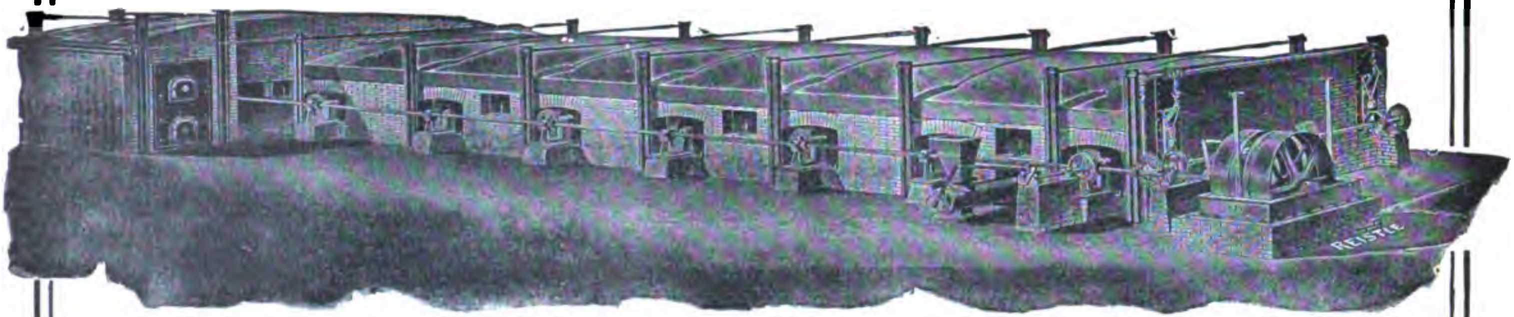

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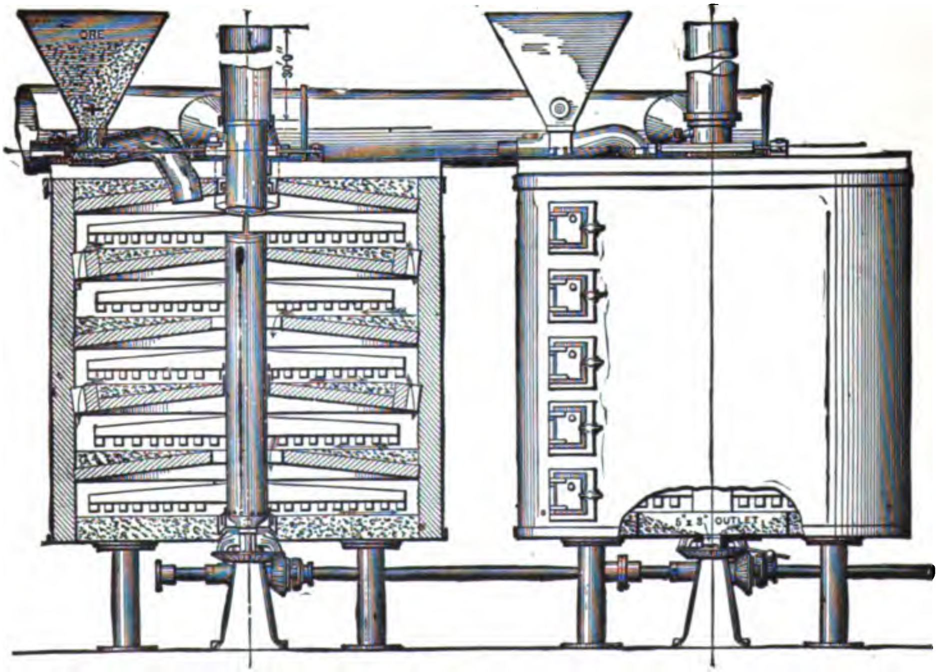

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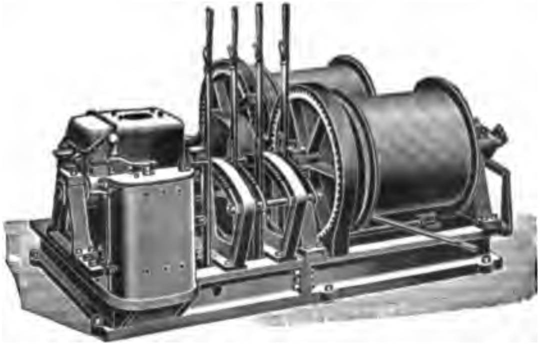

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