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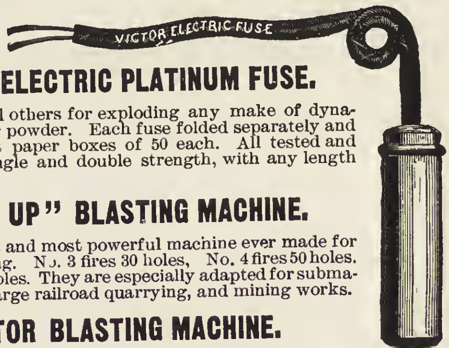

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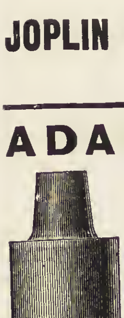

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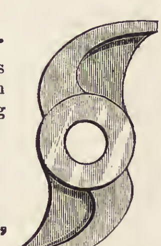

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THE MINERAL INDUSTRY,

ITS

STATISTICS, TECHNOLOGY AND TRADE,

IN THE

UNITED STATES AND OTHER COUNTRIES

TO THE END OF

1895.

VOL. IV.

EDITED BY

RICHARD P. ROTHWELL,

Editor of the Engineering and Mining Journal; Ex-President American Institute of Mining Engineers; Member American Society of Civil Engineers; Fellow Royal Statistical Society, London, Etc., Etc., Etc.

NEW YORK AND LONDON:
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1896.

PREFACE.

In presenting the fourth volume of this work we gratefully acknowledge the enthusiastic reception which the previous volumes have met with and the many testimonials of warm approval and commendation which have been accorded to them. The following extracts from the preface to Volume I. outline the objects in view when this stupendous undertaking was inaugurated, and the pages of the volumes themselves testify how far these aims have already been attained:

"This volume is a result of the development of the annual statistical numbers of the *Engineering and Mining Journal*, and owes its existence to the appreciation with which these statistics have been received by business men, by experts, and by others interested in the mineral industry throughout the world.

"The modern newspaper has made promptness in furnishing information not only familiar, but indispensable to the man of affairs, and accurate and timely statistics have now become absolutely necessary for the intelligent direction of industry, trade, and legislation. The collection of such statistics in an industry which extends over the face of the entire globe is, however, a work so vast and difficult that it has hitherto been considered impossible except through the unlimited resources of governments; and as the machinery of government is not adapted to the rapid attainment of results, the statistics of the mineral industry have been so tardily collected and published in all countries that their value has been greatly impaired. . . . For many years the *Engineering and Mining Journal*, as the leading representative of this great industry, has accumulated vast stores of statistical information relating to it and has greatly improved the machinery for the collection of these statistics. . . .

"The universal appreciation of the work done by the *Engineering and Mining Journal* called for its extension, and consequently in this initial volume there are given, for the first time, the statistics of substantially all the minerals and metals produced in the United States and in many other countries for the full year 1892, and often from the earliest times. This series of annual volumes it is intended shall, in due time, cover the entire mineral industry of the world, giving its statistics, its technology, and its trade, each succeeding volume not repeating the data given in previous issues, but supplementing them, and carrying forward the current history of the industry almost to the day of publication. Unaided by any governmental powers to enforce the making of returns, we have relied for success solely upon personal courtesy and confidence and upon the intelligent appreciation of the value of the work to the industry at large, and this great volume is the monument we have erected to the courtesy of those whose prompt and willing co-operation has alone rendered its success possible. Long experience in this kind of work has fully demonstrated the fact that men are in general more willing to give important and correct information to the private individual who can be held responsible for its proper use than to the more or less impersonal 'government.' It is indeed extremely rare that any producer neglects or refuses to give full, truthful, and satisfactory replies to our requests for information. . . .

"Accuracy should always be the first care of the statistician, but it is scarcely less important to the business man that the information should be promptly furnished. Belated statistics are ancient history, of little practical value in the active affairs of an industry, or as a guide for legislation affecting it. . . . Subjects which are uppermost in the business world naturally demand the greatest attention in this industrial work. . . .

"Much attention has been devoted to the subject of cost of production. The itemization of cost is the first essential step in securing economy in producing any article, and the history of every country and of every industry has shown that prosperity, whether national, industrial, or individual, is, in a general way, inversely proportional to the cost of supplying the rest of the world with what one produces. The great economies which command the markets for products are due, not to reductions in wages, but to increased knowledge and intelligence, and are accompanied by higher remuneration and a betterment of the condition of those engaged in the industry. . . .

"It is the object of the *Engineering and Mining Journal* to give in detail, and of this supplemental volume of the *Journal* to summarize, the facts which show how such results are accomplished; to photograph, as it were, from time to time, the condition of the several departments of the mineral industry in various parts of the world, placing within the reach of all the information that intelligence can apply to the reduction of cost in producing and marketing the useful minerals and metals and in promoting the welfare of those engaged in this industry. In every country this information will enable those who legislate for and those who administer this industry to do so with an intelligent appreciation of the conditions affecting it in its every department, and, widely disseminated, will promote the national prosperity.

"It is with the very greatest regret that we have been obliged in this work to use other than the metric system of weights and measures, which are now legalized in nearly every civilized country and should be universally adopted. The necessity of conforming to custom and popular prejudice in a work so expensive as this explains the use here of that nightmare of weights and measures which, as a relic of barbarism, survives and is used in all English-speaking countries as 'the English system.' We have, however, where possible, reduced the number of varieties of measures as used in the publications of the United States Government. All foreign statistics are given in this work in metric weights, and the United States products are given in the metric system as well as in the customary weights. . . .

"The advertising pages of this book 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 metallurgical 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 qualifications of the most eminent members of the engineering professions indicate the importance and directions of modern mining and metallurgy. 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 him who wishes 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."

Had any doubt existed as to the utility and even absolute need of such a work as this, it would have been quickly dispelled by the prompt and enthusiastic recognition of its value and the unstinted and unanimous words of praise which welcomed in every part of the world the first volume of THE MINERAL INDUSTRY, ITS STATISTICS, TECHNOLOGY AND TRADE. It is not too much to say that probably no other technical book was ever so universally praised, as is shown in the brief extracts given on another page from some of the thousands of letters received, and doubtless never before was a technical book sold in so large numbers within so short a time. These results are extremely gratifying not alone from a business standpoint, but chiefly because they constitute a flattering evidence of the value of the work as a whole, and of the ability of the many specialists who contributed to its pages.

This success has increased the obligation we are under to the great captains of the industry throughout the world who have, with uniform courtesy and unlimited confidence, furnished the data which alone have permitted the compilation and prompt publication of these valuable statistical volumes.

From the very first the amount of useful material grew so rapidly with the plans for the work that it quickly became evident that the book must become larger and more costly than anticipated. The original object has, however, been kept in view of placing it within the reach of all.

The importance of collecting in this volume, as far as possible, the existing statistics of production, imports, exports, and consumption of the various minerals and metals in every country, and the large space devoted to this and to the description of the best existing practice in the chief departments of metallurgy and chemical technology, have crowded over into the current issues of the *Engineering and Mining Journal* and into succeeding volumes of this book much valuable information, and retarded the issue of this book beyond the date at which it is expected future volumes will appear.

The data collected in these two volumes present already a good foundation on which to commence an intelligent study of the industry and of the conditions which affect it, and we earnestly invite the co-operation in this work of all who possess further facts which may be of use in it.

This introduction may be appropriately ended with the following closing paragraph of the preface to the first volume:

"No one can appreciate more fully than the statistician himself the limits and shortcomings which are inseparable from all statistical work of this character. As further facts come to light and a higher degree of accuracy rewards our continuous efforts to render these volumes trustworthy, corrections will be made in the statistics should errors of importance be found. He is but a dishonest statistician who retains known important erroneous statements in order that the public, in its ignorance, may believe, from the absence of corrections, that his figures are accurate. Readers of this book are therefore earnestly requested to notify its editor of any errors or omissions which may be found in it, in order that corrections may be made in subsequent volumes, and suggestions which may render future volumes more valuable will be gratefully received."

RICHARD P. ROTHWELL.

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Linear.					Capacity.							
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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 Hectaers.		Grains to Milligrams.	Avoirdupois Ounces to Grams.	Avoirdupois Pounds 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 hectaers.
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.	Hektoliters to Bushels.	Cubic Centimeters to Cubic Inches.	Cubic Meters to Cubic Feet.	Cubic Merets 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	0.676	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	16.40417	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 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 7000 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 Mètre 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 lbs. avoirdupois	=	1016 kilo.
Short ton: 2000 " "	=	907.2 "
Pound avoirdupois	=	453.6 grams.
Flask of mercury = 76½ lbs. avoir.	=	34.700 kilo.
Troy ounce	=	31.104 grams.
Gallon	=	3.785 litres.

Barrel of petroleum	= 42 gal. =	1.59 hec.
" " salt	= 280 lbs. =	127 kilo.
" " lime	= 200 " =	90.720 "
" " natural cement	= 300 =	136.080 "
" " Portland cement	= 400 " =	181.440 "
Gold coining value per oz. c.	$20.6718 =	$0.6646 per gram.
Silver " " " " c.	$1.2929 =	$0.04157 " "

OFFICIAL UNITED STATES VALUES OF FOREIGN COINS, APRIL 1, 1894.

Country.	Standard.	Unit.	Value in U.S. Gold.	Coins.
			cts.	
Argentina	Both	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 ($9.158). Silver: 1 and 2 florins. Present system—Gold: 20 crowns ($4.052) and 10 crowns ($2.026).
Belgium	Both	Franc	19.3	Gold: 10 and 20 francs. Silver: 5 francs.
Bolivia	Silver	Boliviano	46.3	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	
Central America: Costa Rica, Guatemala, Honduras, Nicaragua, Salvador	Silver	Peso	46.5	Silver: peso and divisions.
Chile	Both	Peso	91.2	Gold: escudo ($1.824), doubloon ($4.561), and condor ($9.123). Silver: peso and divisions.
China	Silver	Tael ‡	68.6 76.5	
Colombia	Silver	Peso	46.5	Gold: condor ($9 647) and double-condor. Silver: peso.
Cuba	Both	Peso	92.6	Gold: doubloon ($5.017). Silver: peso.
Denmark	Gold	Crown	26.8	Gold: 10 and 20 crowns.
Ecuador	Silver	Sucre	46.5	Gold: condor ($9.647) and double-condor. Silver: sucre & 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	Both	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.
Great Britain	Gold	Pound	486.65	Gold: sovereign (pound sterling) and ½ sovereign.
Greece	Both	Drachma	19.3	Gold: 5, 10, 20, 50, and 100 drachmas. Silver: 5 drachmas.
Haiti	Both	Gourde	96.5	Silver: gourde.
India	Silver	Rupee	22.1	Gold: mohur ($7.105). Silver: rupee and divisions.
Italy	Both	Lira	19.3	Gold: 5, 10, 20, 50, and 100 lire. Silver: 5 lire.
Japan	Both*	Yen	99.7 50.1	Gold: 1, 2, 5, 10, and 20 yen. Silver: yen.
Liberia	Gold	Dollar	100	
Mexico	Silver	Dollar	50.5	Gold: dollar ($0.983), 2½, 5, 10, and 20 dollars. Silver: dollar (or peso) and divisions.
Netherlands	Both	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.
Peru	Silver	Sol	46.5	Silver: sol and divisions.
Portugal	Gold	Milreis	108	Gold: 1, 2, 5, and 10 milreis.
Russia	Silver	Ruble ‖	77.2 37.2	Gold: imperial ($7.718) and ½ imperial† ($3.86). Silver: ¼, ½, and 1 ruble.
Spain	Both	Peseta	19.3	Gold: 25 pesetas. Silver: 5 pesetas.
Sweden	Gold	Crown	26.8	Gold: 10 and 20 crowns.
Switzerland	Both	Franc	19.3	Gold: 5, 10, 20, 50, and 100 francs. Silver: 5 francs.
Tripoli	Silver	Mahbub §	41.9	
Turkey	Gold	Piaster	04.4	Gold: 25, 50, 100, 250, and 500 piasters.
Venezuela	Both	Bolivar	19.3	Gold: 5, 10, 20, 50, and 100 bolivars. Silver: 5 bolivars.

* Gold the nominal standard. Silver practically the standard. † Coined since January 1, 1886. Old half-imperial = $3.986. ‡ Shanghai and Haikwan (Customs). § Of 20 piasters. ‖ Silver the nominal standard. Paper the actual currency, the depreciation of which is measured by the gold standard.

RICHARD P. ROTHWELL.

CONTRIBUTORS

It would be 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 those who have contributed special articles on technical and other topics, in order that readers may appreciate the high professional standing of those who have assisted in the work. In a number of cases these sketches are accompanied by portraits.

While space prevents us from further extending the list, we desire to express our grateful appreciation of the ready assistance and coöperation we have received from thousands of miners and other producers, and of State and other officials, in the collection of statistics of mineral production and other information for the present volume. It is this general appreciation of the value of the work, this hearty coöperation, that have enabled us to make the statistics complete and to bring the figures up to the latest dates; and we wish once more, not only for ourselves, but on behalf of all who are interested in the great industry which this volume represents, to thank those who have aided us in making it a faithful history of a year's progress of the industry.

The sketches of the special contributors are given below in alphabetical order.

Bain, H. Foster, graduated in 1890 from Moore's Hill College, in Indiana, taking the degree of B.S., to which M.S. was added in 1894. From 1891 to 1893 he was a graduate student in geology at the Johns Hopkins University, in Baltimore. In 1893 he was appointed assistant geologist in the Iowa Geological Survey, and still holds that position. Mr. Bain contributes to this volume the article on "Machine Coal Mining in Iowa."

Bell, Sir Lowthian, was born in 1816. After completing his studies in physical science at the University of Edinburgh and the Sorbonne at Paris, he entered the iron works at Walker. In 1850 he became connected with the chemical works of the late H. L. Pattinson in Durham, and under his direction they were greatly enlarged and extended. He retired from these works in 1873. In 1852, in connection with his brothers, Thomas and John Bell, he founded the Clarence Works on the Tees, which has grown to be one of the largest iron-making concerns in Great Britain and which is worked in connection with extensive collieries and mines of iron ore. The ability of Sir Lowthian Bell and his extensive knowledge, both practical and theoretical, of the metallurgy of iron have long been recognized. He has been a frequent writer on topics connected with his work, and his authority is universally recognized among English ironmasters. He has been president of the Iron and Steel Institute of Great Britain, the British Institution of Mechanical Engineers, the Society of Chemical Industry, and other learned bodies, and is also an honorary or corresponding member of several American societies. Sir Lowthian Bell has paid several visits to this country. In the course of one of them he investigated carefully the conditions of iron making in Alabama, and predicted that iron would be cheaper there than anywhere else in the world. He acted as a juror at the Centennial Exposition at Philadelphia in 1876, and was appointed to a similar position at the Paris Exposition of 1878. He has served as Mayor of Newcastle-on-Tyne and as a member of Parliament and has held other prominent positions, and was made a baronet in recognition of his distinguished services to science and industry. Sir Lowthian Bell has written for this volume on "Some Recent Proposals for Improving the Blast Furnace in the United States."

BLANDY, JOHN F., born in Newark, Del., 1833, studied at schools in his native place and at Delaware College. At 18 years of age he was attached to an engineer corps on the Philadelphia & Reading Railroad, but after a year's service went to Germany and studied there three years. From 1855 to 1863 he was engaged in the Lake Superior copper region and became thoroughly familiar with every section of it. In 1860 he published a paper on the region in *Silliman's Journal.* After managing various properties in the Pennsylvania anthracite and bituminous regions he went to Arizona in 1880, and has since resided in that Territory, with the exception of a short time spent in California. He has done much engineering work there, and was Territorial Geologist from April, 1889, to November, 1890, resigning because the appropriation was too small to permit any real work. Mr. Blandy has profound faith in the resources and future of Arizona, and has contributed many notes in relation to its mines and minerals.

BLAUVELT, WILLIAM HUTTON, after spending four years in chemical and blast-furnace work, entered Lafayette College, at Easton, Pa., and graduated from the mining and engineering course in 1886. He then returned to the iron business, but soon realizing the growing importance of the problems connected with the economical handling and use of fuel, he decided to enter that field, for which his previous training had well prepared him. In 1889 he began the study of fuel utilization, and has since devoted his whole time to the development of the manufacture and use of gas for fuel purposes, the manufacture of coke, and the economical use of fuel. Nearly three years of this time was spent in developing the use of the inferior coals of the far West and in improving the methods of using fuel in the silver and copper smelters of that region. Mr. Blauvelt contributes to Vol. IV. the very complete article on "By-Product Coke Ovens."

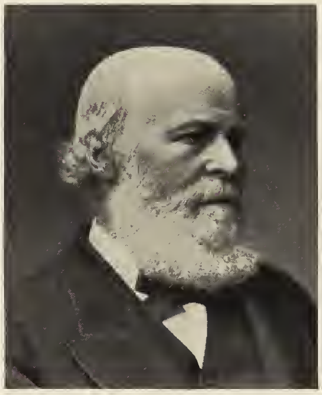
BLUE, ARCHIBALD, was born in 1840 in Oxford, Ontario, Canada. After engaging for some years as a teacher he entered the field of journalism, which he followed for nearly 14 years. In 1881 he was appointed to organize and take charge of a Bureau of Industrial Statistics in connection with the Department of Agriculture, and in 1884 was made deputy head of the Department. During 1889–90 he served as member and secretary of the royal commission appointed to inquire into and report upon the mineral resources of Ontario, and in 1891 resigned his office to become Director of the Bureau of Mines of Ontario, with his offices in Toronto. Mr. Blue supplies valuable statistics of Ontario to this volume.

BORCHERS, WILHELM, Ph.D., was born in 1856 in Goslar, Hanover, and studied at the universities of Greifswald, Erlangen, and Munich. In 1879 he became connected with the chemical works of E. de Haën in Hanover. In 1882 he went to the United States, and after spending a short time with the Cockrane Chemical Company in Boston, he built the works of the Colonial Chemical Company in West Medford, Mass., which he managed until 1887, when he returned to the works of De Haën in Hanover. In 1891 he left this position to make some special studies in the Mining School at Clausthal and to devote himself to electro-metallurgy, but in the following year he was made professor of metallurgy and technical chemistry in the Royal Engineering and Metallurgical School at Duisberg. Besides many short papers, Dr. Borchers has written and published *Elektrometallurgie* (1891, second edition 1895), *Anorganische Chemistrie* (1893), and in connection with Dr. W. Nernst, *Jahrbuch der Elektrochemie* (1895 and 1896). He contributes to this volume the article on the "Progress of Electro-Chemistry and Electro-Metallurgy."

BOTELLA Y HORNOS, FEDRICO, recently Inspector General of the Mining Corps and at present Chief of the Bureau of Mining Statistics at Madrid, Spain, is a mining engineer of high reputation in Spain. He is a member of the Academy of Sciences and author of several papers and other works on technical subjects. Señor Botella y Hornos has very kindly furnished the latest statistics of the mineral production of Spain.

BOWIE, AUGUSTUS J., has been for many years engaged in gold mining and milling in California and other States. He has been a member of the American Institute of Mining Engineers since 1872 and was vice-president in 1893–94; he has contributed several papers to the *Proceedings.* Mr. Bowie has a high reputation as an engineer; his book on *Hydraulic Mining in California* is not only a standard authority on that subject, but is also one of the best and most

SOME OF THE CONTRIBUTORS TO THE MINERAL INDUSTRY.



SIR LOWTHIAN BELL.

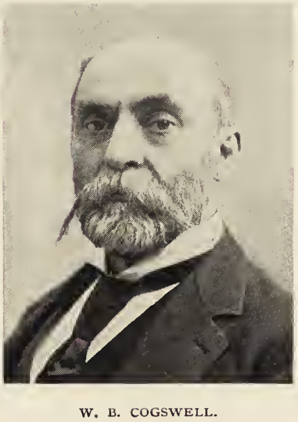
JOHN F. BLANDY

W. H. BLAUVELT.

ARCHIBALD BLUE.

W. BORCHERS.

WILLIAM M. BREWER.



W. B. COGSWELL.

thorough works of the kind in existence. Mr. Bowie contributes to this volume a paper on "Hydraulic Ditch Construction in Idaho."

BREWER, WILLIAM M., is a native of England, but came to America at an early age. He was for a number of years engaged in mining in the West, having held positions with several different mining companies in South Dakota and other Western States. For some years past he has been occupied in the South, and has been working for the Alabama, Georgia, and other State Geological Surveys. In the present volume Mr. Brewer contributes the article on "Bauxite," besides furnishing information on gold and silver in the Southern States, iron ores, and other topics.

BROWN, LUCIUS P., a native of Tennessee, graduated in chemistry at the University of Virginia, afterward taking a post-graduate course there for a year. He then held the position of acting chemist to the State Experiment Station of Tennessee for nearly a year, but resigned from it and went to farming; after some experience in that line he went to work analyzing and prospecting the newly discovered phosphate fields. He was located at first at Ætna, Tenn., leasing the laboratory of the Southern Iron Company, but later formed a partnership, which still exists, with Mr. C. G. Memminger. He has given much time to the subject of agricultural chemistry and fertilizers, especially the latter, and has been connected with the phosphate industry in Tennessee from the first opening of the deposits. Mr. Brown supplies the article on "Phosphates of Tennessee" in the present volume, besides information on other topics.

COGSWELL, WILLIAM B., was born in Oswego, N. Y., in 1838, and after some years of practical experience in civil engineering on the Oswego & Syracuse Railroad entered the Rensselaer Polytechnic Institute, Troy, N. Y., from which he graduated in 1852. After serving in the Lawrence Machine Shops, at Lawrence, Mass., he was made master mechanic of the Marietta & Cincinnati Railroad, and was subsequently in charge of the Broadway Foundry, in St. Louis. During the war he served as a civil engineer in the United States Navy, having charge of repair shops at Port Royal and elsewhere on the Atlantic coast. After spending some time in bridge building and other work, he was appointed manager of the Mine La Motte, in Madison County, Mo., and held the position for several years. In 1881 he was given charge of the construction of the Solvay Process Company's works in Syracuse, N. Y., and has since remained with the company as treasurer and general manager. Mr. Cogswell is a member of the American Society of Civil Engineers, American Society of Mechanical Engineers and the Institute of Mining Engineers, and a fellow of the Society of Chemical Industry. Mr. Cogswell furnishes for the present volume the valuable information concerning the Solvay Works which is given in the article on "The Chemical Industry," and also rendered assistance in the preparation of the important article on "By-Product Coke Ovens."

CREMER, RICHARD, born in Tecklenburg, Westphalia, Germany, early devoted himself practically to the development of the coal mines in Westphalia; he attended the courses of the Royal Mining Academy at Clausthal, also of the Mining Academy at Berlin. After completing his studies he received an appointment in the gold and silver assay establishment at Magdeburg, and later at the Ilsedor mining and milling works in Hanover. This was followed by an engagement in coal mines in Westphalia, and later he obtained his present positions of mining engineer to the Association for the Interests of Mining in the Oberbergamtsbezirk Dortmund in Essen and technical editor of the mining journal *Gluckauf.* Mr. Cremer contributes to this volume the article on "Spontaneous Combustion of Coal and its Prevention."

DENNIS, L. M., studied at the University of Michigan 1881–86, receiving the special degree of B.S. in chemistry. After teaching for two years in La Porte, Ind., he was for two years instructor in chemistry at Cornell University. From 1889 to 1891 he studied in Germany under Fresenius in Wiesbaden, Classen in Aachen, Hempel in Dresden, and Krüss in Munich. In 1891 he returned to Cornell University as assistant professor and was made associate professor of analytical chemistry in 1893. He has written for Vol. IV. the article on "The Rare Elements."

DONALD, J. T., M.A., professor of chemistry, medical faculty, Bishops College, graduated from McGill College, Montreal, Canada, in 1878, and during the following two years took a post-graduate course in chemistry. After spending some time in Europe, examining its mines and industries, he returned to Canada, and has since taken an active part in the development of the mineral industry of the Dominion. His laboratory in Montreal is a well-known institution. He has written for Vol. IV. a paper on the "Analysis of Chrome Ores."

Douglas, James, is a Canadian who 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, with which he has been intimately associated almost since its initiation. He is president of the Copper Queen Consolidated Mining Company and of other Arizona concerns, and is also president of the Arizona & Southern Railroad Company. 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. In 1895 he was elected as Cantor lecturer at the University of Oxford. Mr. Douglas contributes to this volume the "Historical Sketch of Copper Smelting iu the United States."

Ernst, Carl Ritter von, Superior Counselor of Mines, Counselor of Regency, Counselor of Commerce, Director of the Commercial Affairs of the Austrian Government Mines; born October 1, 1833, at Zara, Dalmatia, Austria; studied in the Technical Academy of Prague (Bohemia) and in the Mining Academy at Schemnitz (Hungary), and in 1855 entered the government service; was engaged in the State service in Venice, Lombardy, and Vienna, and appointed by the government to travel over the mining districts of Italy and of the island of Sardinia. In 1874 he became director of the commercial affairs of the Austrian government's mines. In 1881, in company with Professor Höfer at Leoben (Styria), he engaged in editing the *Oesterreichische Zeitschrift für Berg- und Hüttenwesen,* and some years later the publication of the annals of the Mining Academies of Leoben (Styria), Przibram (Bohemia), and Schemnitz (Hungary). Ritter von Ernst is one of the most eminent statisticians in Europe. He contributes to this volume statistics and information of Austria-Hungary and of Bosnia.

Ferry, Charles, was born in 1868 at Peterborough, N. H. He received his early education at Williston Seminary, Easthampton, Mass., and graduated at the Worcester Polytechnic Institute, Worcester, Mass., in 1888. For two years after leaving Worcester he was assistant to Dr. T. M. Drown, who was then director of the chemical department at the Massachusetts Institute of Technology in Boston. Here he gathered much valuable professional experience and acquired an earnest devotion to and interest in all classical research, which finally became concentrated upon refractory materials. For five years Mr. Ferry has been chemist of the Ostrander Fire Brick Company, the main office and laboratories of which are located at Troy, N. Y. In the interests of this company Mr. Ferry's practical and theoretical investigations have been along the lines of fireclays and their proper application to various classes of work. He has written for this volume the article on "Refractory Clays and Firebrick."

Fisher, Robert, born 1855 in Lanarkshire, Scotland, came to this country with his parents in 1863 and was educated in the common schools of Indiana. In different capacities he has worked in the coal mines of Kentucky, Indiana, and Illinois, studying law in leisure hours. The Indian Territory miners elected him president of the local branch of the Federation of Miners and Mine Laborers in 1887, from which position he resigned in 1888 and engaged in the practice of law in Brazil, Ind., which on account of ill health he felt obliged to abandon in 1892. Later he accepted the position of Inspector of Mines in the State of Indiana and took charge of the office March 15, 1895. To this volume Mr. Fisher contributes the article on "Labor Difficulties and the Coal Trade in Indiana."

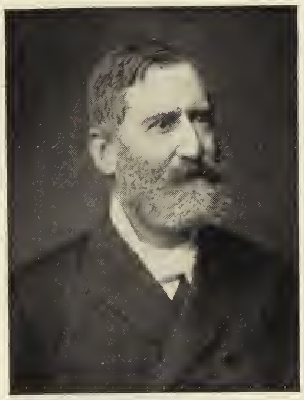
Ford, Worthington C., to whom we are indebted for statistics of the imports, exports, etc., of the United States, used in the compilation of the tables accompanying this volume, is now Chief of the Bureau of Statistics in the Treasury Department of the United States, in which he has introduced many notable improvements since his appointment to the position. Mr. Ford has had long and valuable experience in statistical work, and for several years filled the office of Chief of the Bureau of Statistics in the State Department, where his work was

SOME OF THE CONTRIBUTORS TO THE MINERAL INDUSTRY.

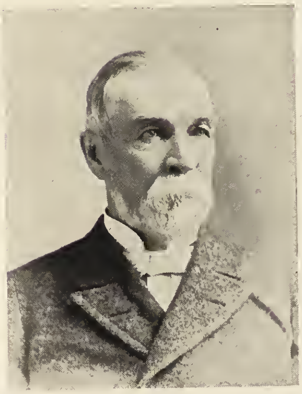
RICHARD CREMER.

JAMES DOUGLAS.

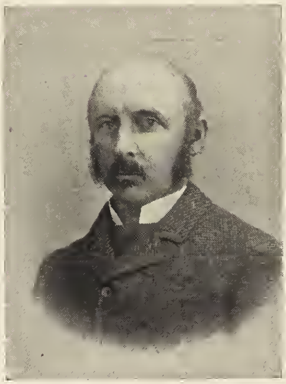
L. M. DENNIS.



CARL RITTER VON ERNST.



JOHN FRITZ.



EDWIN GILPIN, JR.

R. A. HADFIELD.

worthy of the highest commendation. The excellent statistical reports he now publishes are extremely valuable documents.

Fritz, John, universally known and respected as one of the founders and leaders of the modern iron industry in this country, was born in Londonderry Township, Chester County, Pa., in 1822. At the age of 16 he entered a general machine shop at Parkesburg, Pa. In 1846 he went to the Norristown Iron Works at Norristown, Pa., of which he was in charge for several years. In 1850 he went to Safe Harbor, Pa., as a mechanical engineer, and in 1854 again removed to Johnstown, Pa., where as chief engineer and general superintendent he rebuilt the great Cambria Iron Works, remaining in charge six years. During this period, in connection with his brother George, he designed and erected their well-known three-high bloomers with their automatic tables and their three-high rolling mill, besides working out the development of the feed tables. In 1860 he was called to take charge of the erection of the Bethlehem Iron Company's works at South Bethlehem, Pa., and from that time to 1893 he had direct charge as chief engineer and general superintendent of the great plant, which, with its complete equipment, owes its development and excellence very largely to his labors. He has been since 1893 consulting engineer of the company. His latest work was the erection of the magnificent armor plate and gun plant, including the 125-ton steam hammer, the largest now in existence. Mr. Fritz is a member of many technical societies and has been honored by all of them. In 1893 the British Iron and Steel Institute voted him the Bessemer medal. He has written for this volume an article on the "Past and Future of the Iron Trade in the United States."

Gilpin, Edwin, Jr., born in 1850 in Halifax, N S. Mr. Gilpin is the son of the Dean of Nova Scotia and grandson of Judge Haliburton, so widely known under his *nom de plume* "Sam Slick." In 1871 he graduated from King's College, Windsor, N. S., and then served his time at the Albion mines, Pictou County. After this he spent some time in England at the collieries of Sir George Elliott and others. Upon his return to Nova Scotia he engaged in professional work and later succeeded Sir William Dawson in examining and mapping the iron ores of Pictou County. In 1879 he was appointed Inspector of Crown Mines in Nova Scotia; in 1886 Deputy Commissioner of Public Works and Mines. Mr. Gilpin has written numerous papers and reports upon the mining and geological interests of Nova Scotia, and supplies the mineral statistics of Nova Scotia for 1895 to this volume of The Mineral Industry.

Green, John A., of Stone City, Iowa, ex-member of the Iowa Senate, entered the mineral field in 1860 by apprenticing himself to the monumental and stone trade, in which he has met with great success. After working about ten years he started in the building line, using only the material quarried by himself. The Boston Block in Minneapolis, at that time the finest building in the Northwest, and the first building derrick ever used in that city were erected by him; the stone for the great arch viaduct below the Falls of St. Anthony and four other bridges spanning the Mississippi River, besides that for hundreds of small bridges all over the Northwest, was supplied by him. Mr. Green contributes to this volume the article on "Stone City Limestone Quarries."

Grohmann, E., to whom we are indebted for the statistics of Greece, is a resident of the island of Seriphos, where he is engaged in mining.

Hadfield, R. A., has been for a number of years connected with iron and steel works in Great Britain, and is now managing director of Hadfield's Steel Foundry Company, owner of the Hecla Works at Sheffield, England, having assumed this important post when still quite a young man upon the death of his father. He has devoted much time to investigation and experiment, and is inventor and patentee of a number of alloys and processes for the manufacture of steel. He has written for scientific societies and periodicals a number of important papers on the metallurgy of steel and allied subjects. Mr. Hadfield has always been much interested both in politics and in the amelioration of the condition of the working classes in England, being a Liberal in politics and taking a prominent part in the eight-hour movement. His faith in the latter he has shown practically, having nearly brought the eight-hour day to an accomplished fact in his works, his employees now working only 51 hours per week. He is himself an indefatigable worker, not only attending thoroughly to his business, but also to a very large scientific and political correspondence. His residence is at The Grove, Endcliffe near Sheffield. Mr. Hadfield contributes to Vol. IV. the article on "Alloys of Iron."

HARZÉ, EMILE, born in 1835, at Liège, Belgium; studied at the École des Mines attached to the university of his native place. In 1858 he entered the State Mining Corps and successively occupied important government positions at Mons and Liège, and in 1879 was made Director-General of the Central Mines Administration at Brussels. In 1890 he was one of the Belgium representatives at the Berlin Labor Conference. Mr. Harzé is a member of numerous technical and scientific societies and of a number of commissions, among them the Conseil Supérieur du Travail. He has published many valuable monographs and is one of the highest authorities in Europe on mine ventilation, statistics, and questions affecting labor. To the present volume Mr. Harzé furnishes the statistics of the Belgian industry.

HELMHACKER, R., born 1840 in Prague, having completed his education at the polytechnic schools and universities at Prague and Vienna, became attached to the mining and metallurgical school at Pribram, Bohemia, as a crown stipendiary. Later he was appointed mining engineer and surveyor in the coal mines at Rovitz, Moravia, and was afterward engaged as superintendent of the collieries and iron mines at Klachio, Bohemia; also at the gold and antimony mines and smelting works of Bohemia. He was then appointed professor of mineralogy, mining geology, and paleontology at the Royal Mining School at Leoben, Styria. The knowledge he obtained during his various engagements at the principal mines and metallurgical works enabled him to contribute many articles on scientific and technical subjects to home and foreign journals. As a member of the Bohemian Geological Survey he has explored the country thoroughly and published many geological reports and maps. His engagement as managing mining engineer and geologist in the Altai Mountain gold placers belonging to the Russian crown and at the imperial gold and platinum mines in the Ural Mountains having expired, he is now consulting engineer to a Franco-Russian company which intends to develop some coal and iron mines and erect smelting works in Siberia. Mr. Helmhacker contributes to this volume articles on "Quicksilver Reduction at the Idria Mines," "Chromite in Austria," and "Petroleum in Galicia."

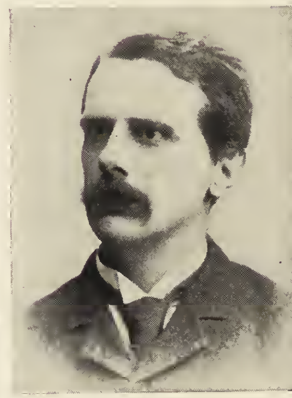
HOBART, FREDERICK, A.B. and A.M. of the College of the City of New York. Mr. Hobart has been connected with the Jersey City Locomotive Works; Bullock Machine Company, Jersey City; Wrigley Machine Works, Newark, N. J.; Grant Locomotive Works, Paterson, N. J.; has been assistant editor of the *Railroad Gazette*, associate editor *Railroad and Engineering Journal*, assistant editor *Engineering and Mining Journal*, a contributor to various technical periodicals, and is the translator of *Notes on Steam Hammers* and *Economies in the Combustion of Fuel.* Mr. Hobart has contributed to this volume the articles on "Gold and Silver," "Iron and Steel," and several of the shorter articles. He has also performed a very large part of the general work of preparing and arranging Vol. IV. and has made the very full index.

HOFMAN, H. O., was born in Heidelberg, Germany, and received his early training in that city, taking a course in mathematics, chemistry, and geology in the university. From Heidelberg he proceeded to the Royal Prussian School of Mines at Clausthal, where he graduated in mining, engineering, and metallurgy. He was then appointed chemist and assistant at the government refining and smelting works at Lautenthal in the Harz, where he was employed in carrying out a number of experiments. In 1881 he came to the United States and was employed successively at Mine La Motte in Missouri, at the Kansas City Smelting and Refining Works, and as metallurgist of the Delaware Lead Company in Philadelphia. When the last-named works were closed he went to Colorado, and after running the Rico smelter for a short time was engaged with Mr. Russell in a study of amalgamation and lixiviation of silver ores at the Ontario Mill in Park City, Utah. After a short time spent in charge of a smelter in Mexico he was appointed assistant to Professor Richards at the Massachusetts Institute of Technology in Boston; from there he went to the School of Mines of South Dakota, where he remained until called back to the Massachusetts Institute of Technology to the professorship which he now holds. Dr. Hofman's chief work is his admirable one on *The Metallurgy of Lead*, but he has published a number of shorter monographs and pamphlets. Dr. Hofman is now universally recognized as the highest living authority on the subject, on which he has written for this volume "Recent Improvements in the Treatment of Argentiferous Lead Ores."

SOME OF THE CONTRIBUTORS TO THE MINERAL INDUSTRY.

EMILE HARZÉ.

R. HELMHACKER.



FREDERICK HOBART.

H. O. HOFMAN.

T. C. HOPKINS.

J. W. HOWARD.

HENRY M. HOWE.

Hopkins, T. C., born in 1861 in Pennsylvania. In 1883 he entered De Pauw University at Greencastle, Ind., graduated in 1887, and took the degree of M.S. in 1890. For some time he had charge of the department of chemistry at this university. During 1889–90 Mr. Hopkins was assistant on the Geological Survey of Arkansas. In 1893 he was engaged as instructor in geology in the mining department at the State College, Pennsylvania. His published writings consist of valuable contributions to the Geological Survey Reports of Arkansas and papers read before various technical and scientific societies. To the present volume Mr. Hopkins contributes the article on "Sandstones of Western Indiana."

Howard, J. W., born in 1860 at West Point, N. Y., educated at Phillips Academy, Andover, Mass. He was engaged with the West Shore Railroad in construction work for some time, and followed this with study abroad and a year's practical experience in Nebraska; he then entered the Rensselaer Polytechnic Institute at Troy, N. Y., where he studied civil engineering and graduated. Mr. Howard has given special attention to the study of asphalt and the uses of this material and its compounds in engineering work, and contributed to Vol. II. and again to the present volume valuable articles on this subject.

Howe, Henry Marion, has been for a number of years instructor and professor at the Massachusetts Institute of Technology in Boston, and is one of the most eminent living authorities on the metallurgy of iron and steel. His close and careful studies and his thorough and scientific experimental work have been generally recognized, and his magnificent book on *The Metallurgy of Steel* is received everywhere as the highest authority on the subject. Mr. Howe has been president of the American Institute of Mining Engineers. In 1895 the British Iron and Steel Institution voted him the Bessemer medal, which is the highest honor it can bestow. In 1895 also the Franklin Institute of Philadelphia awarded him the Elliott Cresson medal for distinguished scientific services. Mr. Howe has written for this volume a paper on the "Relative Corrosion of Wrought Iron and Steel."

Ingall, Elfric Drew, born in 1858 at Greenhithe, Kent, England. Studied at the Royal School of Mines, London, and afterward in the mining districts of Cornwall and Wales. In 1880 he was sent to Canada to examine mining properties on Lake Superior, and afterward became manager of a company there. He subsequently spent some time in Wyoming studying copper deposits, after which he joined the Canadian Geological Survey and has remained its mining engineer in charge of the division of mineral statistics and mines since 1884. Mr. Ingall's work on the silver-bearing veins of the Thunder Bay district, the apatite deposits of Quebec, and the mineral developments around the Canadian shores of Lake Superior are well known, and with them the valuable data published each year by his division of the survey.

Ingalls, Walter Renton, a well-known mining engineer, has had a varied professional experience in the United States and Mexico. In 1890–92 he was assistant editor of the *Engineering and Mining Journal*, and he also at a later date assisted in the preparation of the earlier volumes of The Mineral Industry. In 1893 he went to Europe, where he spent some time in studying the mines and metallurgical works, paying especial attention to the working of zinc ores. In 1894–95 Mr. Ingalls was in charge of reduction works at Cripple Creek, Colo., and he is at present engaged in mining in Mexico. Mr. Ingalls furnishes for the present volume the article on the "Precipitation of Gold from Cyanide Solutions," which is the result of his practical experience at Cripple Creek.

Kemp, James Furman, entered Amherst College in 1877 and graduated (A.B.) in 1881; graduated from Columbia College as mining engineer in 1884; was private assistant to Prof. J. S. Newberry in 1884–85; instructor in geology, Cornell University, 1886–88; assistant professor of geology and mineralogy, 1888–91; adjunct professor of geology, Columbia College, 1891–92; and professor of geology in 1892. Professor Kemp has written much on subjects connected with economic geology and petrography, his most important work being *The Ore Deposits of the United States*, published by the Scientific Publishing Company, a work which has attracted world-wide comment and commendation. Professor Kemp is a prominent member of many scientific societies. He has written for this volume on "Views Held To-day on the Origin of Ores."

Kerl, Bruno, born 1824 at St. Andreasberg, Oberharz, Germany, after finishing his practical education in mining and milling at the School of Mines at Clausthal entered the University of Göttingen for the study of chemistry, physics, mineralogy, and technology. For some time he held an appointment at the Okerhütte of Unterharze, returning from there to the Clausthal School of Mines in 1846 as professor in the faculties of chemistry, assaying, iron and metal mining. During this period he held several other appointments, as mint warden, as assayer, and as surveyor to the Department of Mines and Forests, etc. He was called upon in 1867 to occupy the chair at the Mining Academy at Berlin as professor of metal mining, the art of assaying, and chemical technology, and he still holds the position of professor and counselor of mines. He has been also member of the Imperial Department of Patents and of the Royal Technical Department of Industry to the Prussian Ministry of Commerce. Professor Kerl retired from these positions several years ago and has since employed himself chiefly in writing. He is the author of several valuable technical works and has been associate editor of the *Berg- und Hüttenmännischer Zeitung* His contribution to this volume is the article on the "Production of Zinc Vitriol from the Zinc-Lead Ores of the Harz."

KEYES, DR. CHARLES ROLLIN, was born in Des Moines, Iowa, in 1864. He studied in Des Moines and at the Iowa State Academy at Iowa City, graduating in 1887. After graduating he spent some time in assisting Dr. Charles Wachsmuth in preparing a number of papers on zoölogy and geology. He then took a course at the Johns Hopkins University in Baltimore and commenced some original investigations which resulted in the preparation of several valuable papers. When the Iowa State Geological Survey was instituted Dr. Keyes was appointed Assistant State Geologist, and had a large share of the work and of the preparation of the several excellent reports issued by the survey. In 1894 he was called upon to take charge of the Missouri Bureau of Geology and Mines and undertook the work of completing the organization of that bureau. Dr. Keyes has published many monographs and articles, the most important of which are the three volumes of the Iowa Geological Survey upon *The Geological Formations of the State*, *The Coal Deposits*, and *The Gypsum Deposits*, and the *Report on the Paleontology of Missouri.* Dr. Keyes contributes to the present volume valuable information relating to the geology and mineral industry of Missouri and also an article on "Iowa Gypsum."

KNIGHT, WILBUR C., was born in Illinois in 1858 and moved to the Western frontier when a boy. Educated at the University of Nebraska, taking special work in geology and chemistry. Since graduation he has been the first Assistant Territorial Geologist of Wyoming for two years; for six years superintendent and general manager of mining corporations in Wyoming and Colorado. In 1893 he was called to the chair of mining in the School of Mines, University of Wyoming, and in 1894 was elected to the chair of geology and mining in the same school. Mr. Knight furnishes information on the coal and other minerals of Wyoming.

LANE, ALFRED C., graduated from Harvard University in 1883, and after several years spent in post-graduate study there and abroad received an appointment on the United States Geological Survey in 1888. A year later he went to the Michigan Geological Survey and has since been connected with that work. For some time he was also instructor in petrography and geology in the Michigan Mining School at Houghton, but the growth of the school made a separation of the work necessary, and Dr. Lane remained with the survey as Assistant State Geologist. He is an active member and treasurer of the Lake Superior Mining Institute. He has written for Vol. IV. the article on "How Deep Can We Mine?"

LANGELOTH, J., president of the American Metal Company and vice-president of the Balbach Smelting and Refining Company, has furnished very valuable information concerning the trade department of the mineral industry in which his company is so prominent a factor, and has, with unfailing courtesy and good will, aided in many ways our efforts to secure full and reliable information.

LEFEVRE, EDWIN, born in Colon, Republic of Colombia, in 1870. Studied mining engineering at Lehigh University, Bethlehem, Pa. He has been engaged in journalism for several years, and has contributed to numerous newspapers and literary periodicals in the United States and South America. Since 1890 he has been a member of the editorial staff of the *Engineering and Mining Journal.* Mr. Lefevre has contributed articles upon the commercial

SOME OF THE CONTRIBUTORS TO THE MINERAL INDUSTRY.

ELFRIC DREW INGALL.

WALTER RENTON INGALLS.

J. F. KEMP.

BRUNO KERL.

GEORGE LUNGE.

WILLIAM NELSON PAGE.

ROSSITER W. RAYMOND.

department of the industry and the chemical and mining-stock markets, with which his duties on the *Engineering and Mining Journal* have rendered him very familiar.

LUNGE, GEORGE, Ph.D., born in 1839 at Breslau, Silesia, Prussia. Studied at the University of Breslau, where he received the degrees of M.A. and Ph.D., and then at Heidelberg under Bunson and Kirchhoff. In 1884 he went to Great Britain, where he became connected with the coal-tar and ammonia industry. A few years later Dr. Lunge took an opportunity to connect himself with the sulphuric-acid and alkali industry. In 1876 he left England to accept the post made vacant by the death of Emil Kopp at the Swiss Federal Polytechnic School at Zurich, where he is now professor of technological chemistry and dean of the faculty of chemistry. Dr. Lunge has contributed to technical literature some of its most important works. His *Coal Tar and Ammonia, The Manufacture of Sulphuric Acid and Alkali*, and *The Alkali-Maker's Hand-Book* have each passed through several editions and are standard works on these subjects. Besides these, he is a contributor to the *Engineering and Mining Journal*, has published numerous articles upon various subjects of technical chemistry in this and other periodicals, and is in that important branch of industry one of the highest and most widely quoted authorities. Dr. Lunge contributes to this volume an article on the "Progress of the German Chemical Industry," besides other information.

NORWOOD, CHARLES J., State Inspector of Mines in Kentucky and Curator of the Geological Department of that State. Mr. Norwood was at one time assistant on the Missouri Geological Survey, and afterward assistant on the Kentucky Geological Survey under Prof. N. S. Shaler. From 1877 to 1881 he was also Norton professor of natural science in Bethel College, Russellville, Ky. For some years he was professionally engaged in various Southern and Western States, and in 1884 was appointed State Inspector of Mines for Kentucky, where he is now serving his third term. Mr. Norwood is one of the most efficient officials in this country whose duties are especially connected with the mineral industry. He has given valuable assistance in collecting promptly the coal statistics of Kentucky and in furnishing information concerning other useful minerals of that State.

PAGE, WILLIAM NELSON, born 1855 in Campbell County, Va., and began work as a civil engineer on the Chesapeake & Ohio Railroad in 1871, and after various work on that line he successfully located and built a very difficult line up Mill Creek. In 1875–76 he was engaged in government surveys for a double track road from Clifton Forge to Richmond, Va., and in working up estimates on the same for comparison with the James River & Kanawha Canal. From 1877 to 1881 he was in charge of the Hawk's Nest Coal Mines at Ansted, W. Va., and the results were so favorable that the Iron and Steel Works Association of Virginia, Ltd., was organized in London. As its general manager and financial agent he built the Victoria Furnace at Goshen, Va., which he operated until 1885. From 1885 to 1889 he was under contract with the Mount Carbon Company, Ltd., to develop and operate 10,000 acres of coal land in Fayette County, W. Va. From 1889 to the present time he has been connected with the Gauley Mountain Coal Company. Mr. Page is one of the most successful coal-mining engineers in this country and is recognized as one of the highest authorities on the economics of the industry in which he has made a record for good and economical work. His article in Vol. IV. is on "Coal-Mine Accounts."

PENHALE, MATTHEW, has been for a number of years practically engaged in mining in the United States and Canada. For a long time he has had charge of operations in the asbestos mines of Black Lake and has also been extensively interested at other mines in Quebec and Ontario. Mr. Penhale has made a careful and thorough study of asbestos mining, and few men are better acquainted with the Canadian mines and methods. He contributes to Vol. IV. the articles on "Asbestos" and on "Chrome Ore in Quebec," as well as valuable information on other points connected with Canadian mining.

RANDOL, J. B., has long been our highest authority on quicksilver trade statistics. He has furnished much of the statistical matter relating to quicksilver in this volume. For many years Mr. Randol was manager of the New Almaden Quicksilver Mining Company of California. Since his retirement from that position he has been engaged in conducting operations on his own account.

Raymond, Rossiter Worthington, Ph.D., is well known from one end of the world to the other as the highest authority in America on mining law, and he contributes to this volume an article on the "Force of the United States Mineral-Land Patent." For many years Dr. Raymond was the editor of the *Engineering and Mining Journal* and was practically its founder. He was for several terms president of the American Institute of Mining Engineers and has for many years been its most efficient secretary. Educated as a mining engineer at Freiberg, Saxony, in the days before mining schools were established in the United States, he quickly became one of the most prominent engineers in this country, and was influential in framing its early mining laws. No one else could speak with such authority on their influence on the marvelous development of the mineral resources of the country.

Richards, Robert Hallowell, professor of mining and metallurgy at the Massachusetts Institute of Technology; past president American Institute of Mining Engineers. Born in 1844 at Gardiner, Maine. In 1868 he graduated in the first class from the Institute of Technology and became assistant in chemistry in the institute, passing successively to the posts 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 school's mining and metallurgical laboratory has been developed to a high state of excellence. Professor Richards has also been actively engaged in professional work, and has contributed valuable papers to the technical press and various scientific societies. He has written for this volume an article on "Improvements in Ore Dressing."

Rickard, Thomas Arthur, E.M. Born in 1864 at San Terenzo, Italy. Educated in Russia and England, graduating at the Royal School of Mines, London, in 1885. Since then has been engaged professionally managing mines in Colorado and in professional examinations in various Western States and in Australia and New Zealand. Mr. Rickard is located as a consulting mining engineer in Denver and is State Geologist of Colorado. He is a member of various scientific societies and a well-known contributor to the literature of his profession. He furnishes to this volume articles on the "Gold Resources of Colorado" and on the "Philosophy of Stamp Milling."

Rothwell, John E., was born at Kingston, Ontario. He acquired his knowledge of mining and milling by practical experience, beginning in the machine shops attached to a mine and mill in Canada and subsequently working his way up gradually to be superintendent of the plant while still only a youth. He was afterward engaged under the late John Heard at the works of the Brunswick Antimony Company, near Boston, Mass. He then went to Deadwood, S. D., where he remodeled and afterward managed with great success the mill of the Golden Reward Company, using barrel chlorination. Subsequently he built several mills in Nevada and Colorado. Although experienced both in mining work and as a mechanical engineer, Mr. Rothwell has made a specialty of the roasting and treatment of refractory gold ores, making an excellent record for successful and economical work. He has made many improvements in chlorination plants and processes and has contributed valuable papers on the subject to our technical periodicals. For the present volume he has written a welcome and much-needed article on "Lead Burning."

Rutledge, John Joseph, born 1870 in Alton, Ill.; graduated 1894 in mining engineering from the University of Illinois. His ancestors have for generations been engaged in coal mining, and different members of the family are at present engaged in it in various parts of the globe. He has been concerned in coal mines the greater part of his life and has made coal mining his specialty. After graduation he was in the service of the Consolidated Coal Company of St. Louis, Mo., as assistant manager of the largest machine mine in Illinois, and at the present time is engaged in general mining engineering work. Mr. Rutledge has had special experience in machine mining, and has paid particular attention to the effect of the introduction of mining machines and to the comparison of hand and machine mining. During much of the time he has been preparing statistics of the cost of production, deterioration of mining property, methods of working, and general mine economy, and has also made a study of the different items in the cost of coal production, as well as of the social conditions of the miners. Mr. Rutledge contributes to this volume the article on "Coal Mining in Illinois."

SOME OF THE CONTRIBUTORS TO THE MINERAL INDUSTRY.

ROBERT H. RICHARDS.

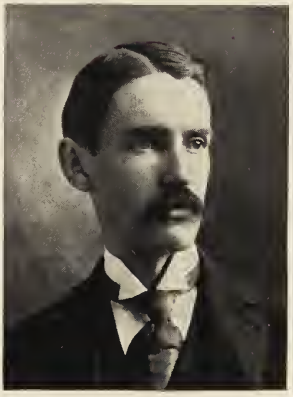
JOHN E. ROTHWELL.

T. A. RICKARD.

J. J. RUTLEDGE.

SAMUEL P. SADTLER.

W. R. SHIELDS.



C. H. SMYTH, JR.

many. Since 1891 he has been the architect in the Technical Bureau in the Department of Foundations (Tiefbau) in Berlin and technical contributor to various journals. His contribution to the present volume is the elaborate article on "Mineral Resources of the Caucasus."

ULKE, TITUS, Met.E., born in 1866 at Washington, D. C. In 1889 he 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 of Europe, Mr Ulke returned to this country and was engaged as chemist to the Harney Peak Tin Company in South Dakota. In 1891 he became assayer for the United Smelting Company, and afterward was engaged by the Anaconda Mining Company 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 connected with the great refining works of the Guggenheims at Perth Amboy, N. J. He has prepared for Vol. IV. the articles on "Parting and Refining Gold and Silver," the "Manufacture of Cyanide of Potassium," and several shorter articles.

VAN ESVELD, W. C., of Surinam, Dutch Guiana, chief director of the Surinaamsche Bank, in that capacity has a wide acquaintance with the business of Dutch and British Guiana. He has courteously furnished statistics of the gold production of the Guianas.

VAN VORSTENBERG, BERNARD, born 1856 in Amsterdam, Holland, was educated at various institutions, in Switzerland, Austria, Holland, and at Conway College, Conway, North Wales, and later received the degree of Bachelor of Arts from Christ College, Cambridge, England. From 1878 to 1887 he was engaged in the glass-manufacturing industry, part of the time as manufacturer, and later representing the Dutch Plate Glass Company of Amsterdam, Holland, in all civilized countries of the world. In 1885 he was one of the originators of the first Netherlands Trading Association doing business in the Transvaal, South Africa, acting as secretary until 1887. From 1887 to 1891 he represented a syndicate in the East Indies for the purpose of obtaining concessions in Sumatra on lands and certain mining rights in the Rhio Archipelago, Borneo, and Siam. He rendered valuable assistance in the collection of the statistics in Vol. III. of THE MINERAL INDUSTRY and had charge of that work in the present volume.

VOGT, Prof. I. H. L., born 1858 in Tvedestrand, Norway, was graduated as mining engineer at the University of Christiania in 1880, after which he followed a course at the mining school of the University of Stockholm and at the Royal Mining Academy at Freiberg, Saxony. Since 1886 he has been professor of metallurgy at the University of Christiania, and he has contributed various mineralogical, geological, metallurgical, and statistical studies to the scientific journals of Norway, Sweden, and Germany. Among the subjects he has treated are: Metallurgy of copper and nickel, the laws of crystallization of minerals, Norwegian and general ore deposits. His contribution to this volume is the article on "The Formation of Eruptive Ore Deposits."

WALKER, EDWARD, London representative of the *Engineering and Mining Journal* and the Scientific Publishing Company. Born in 1865 and educated at Owens College, Manchester, England. Mr. Walker has served on the editorial staff of *Industries*, London, and the *Engineering and Mining Journal*, New York; he now practices as a consulting engineer chiefly in connection with law cases and patents, and is in charge of the London offices of the *Engineering and Mining Journal* and the Scientific Publishing Company. Mr. Walker contributes to this volume much information concerning the mining stocks dealt in in London.

ZORNER, R., is an experienced mining engineer; has been for a number of years engaged in coal mining in Germany, and is now mine inspector at Saarbrücken. He has written on the "Fire-Damp and Coal-Dust Question in Germany," of which he has made a special study.

THAT most important department of this work, its business and financial administration, has been under the control of MRS. SOPHIA BRAEUNLICH, who is treasurer and business manager of the Scientific Publishing Company and of the *Engineering and Mining Journal*, and who has been for many years on the staff of that paper. To her remarkable business ability is due in no small degree the success which has crowned this undertaking.

SOME OF THE CONTRIBUTORS TO THE MINERAL INDUSTRY.

TIMOTHY W. SPRAGUE.

JOHN STANTON.

F. THEISS.

TITUS ULKE.

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SOPHIA BRAEUNLICH.

INTRODUCTION.

The opening of the year 1895 found the mineral industry of the United States in a state of depression and at the same time of expectancy. A year and a half of panic, of depression in business, and of the lowest prices ever recorded had left its impress on almost every branch of the great industry; but at the same time producers were well aware that the purchasing power of the nation was not gone; that the restrictions enforced by the panic period had reduced stocks everywhere; and that the least improvement in demand must cause an increase in production.

The continued dullness of the entire year 1894 had not prevented growth in some important branches of the industry. Gold production had increased and there was an advance also in the output of copper and of some of the minor metals. In iron and steel and all the materials of construction, however, there had been a great decrease in 1894, the statistics showing smaller returns than they had done for years before.

The earlier months of 1895 were somewhat disappointing, but as time went on there were signs of increasing prosperity manifested in growing demand and advancing prices, and by the middle of the year it was evident that there would be a greater mineral production in almost every direction than had ever been shown before in a single year.

The statistics which are massed in the accompanying table, and those which are given in detail in the following pages, show that these expectations were realized, notwithstanding the reaction which marked the closing months of the year.

The total value of the mineral and metal production of the United States in 1895, as shown in the accompanying table, amounted to the enormous sum of $678,000,734, which compares with a similar total of $581,211,258 for 1894, showing a total increase of $96,789,496, or 16.6%, for the year. Of the whole amount last year $240,617,370 represented the value of the metals; $437,383,364 that of the non-metallic products, including $5,000,000 for various unspecified products.

From these totals, however, we have to make some deductions for those articles which have been necessarily duplicated in the table. Among these are the iron ore used in making pig iron; a large part of the lead used in making white lead; the zinc used in making zinc oxide; the coal in making coke; the antimony ore used in making the metal; the manganese ore employed in making spiegeleisen, which is included in pig iron; the salt used in making soda, and some other articles of the kind. A careful estimate of the proper amount of these deductions would give about $45,600,000 in 1895, against $34,400,000 in 1894. Making these deductions, we have a total net value for 1895 of $632,400,734, as against $546,811,258 for 1894, the increase amounting to $85,589,496, or 15.6%.

In the *Engineering and Mining Journal* for January 4, 1895, we published a provisional statement of the production of a number of the important minerals and of all the metals. That statement was necessarily subject to some corrections, as the output for the month of December was estimated in part. Nevertheless its substantial accuracy is shown by the fact that in the case of pig iron the estimate differed from the corrected statement by only 0.5%; in the case of copper the variation was only 0.1% from the full returns now given; in lead it was 2.5%; in coal the difference was only 0.7%, and the list might be considerably extended.

We have included iron ore in our tables this year, though we do not report lead, copper, zinc, silver, or gold ore separately. This admitted inconsistency is in part due to the fact that the same ores yield gold, silver and copper, or gold, silver and lead, and in some cases also lead and zinc are obtained from the same ores, so that an exact distribution of quantities and values would be impossible and indeed of little practical value.

The production of so-called "mineral waters" is omitted, as heretofore, from these statistics. Waters cannot properly be considered as minerals except in cases where they are used to extract minerals from, as metals are won from their ores, and as salt, bromine, etc., are extracted from certain waters. All waters contain more or less mineral matter. If the production of "mineral waters" is to include all the water sold, then the supplies of our town and city water works should be counted, and they amount to over 1,000,000,000,000 gals., or say 42,100,000,000 short tons a year, sold at an aggregate value of about $200,000,000. Moreover, the vast amount sold for irrigating, for power, or other purposes, and not included in the above, should not be neglected, while a comparatively infinitesimal amount, largely artificial mixtures, varying from carbon dioxide water to "ginger ale," is cited by some authorities as the production of "mineral waters."

The totals given in the table are, of course, of values only, as it would be impossible to present a total of quantities made up of such varied products. In studying the table, however, it must be remembered that to make the comparison a fair one the quantities of the various articles produced should be considered. The year 1894 was one of extremely low prices, and while in some directions the recovery has not been as great as had been expected, in some important lines—principally in iron and copper—the level of prices in 1895 was much higher for a considerable portion of the year. The values, therefore, will naturally show a greater increase than the quantities.

The statistics given, like all those in THE MINERAL INDUSTRY, have been obtained, as a rule, directly from the producers themselves, and the greatest care has been taken in their collection and arrangement, in order to present accurately in a condensed form the results of the great industry represented.

It is true that no statistics of this kind, representing so many and varied prod-

No.	Products.	Customary Measures.	1894.				1895.			
			Quantity.		Value at Place of Production.		Quantity.		Value at Place of Production.	
			Customary Measures.	Metric Tons.	Totals.	Per M. Ton.	Customary Measures.	Metric Tons.	Totals.	Per M. Ton.
	NON-METALLIC.									
	Abrasives:									
1	Corundum & emery	Sh. T.	1,220	1,106	$109,500	$99.00	385	349	$56,400	$161.60
2	Garnet	Sh. T.	1,000	907	35,000	38.60	2,065	1,873	93.350	50.00
3	Grindstones	Sh. T.	29,989	27,200	257,596	9.50	36,389	33,004	290,378	8.49
4	Millstones	Sh. T.	....	....	4,447	......	....	....	8,525	......
5	Tripoli & inf. earth.	Sh. T.	1,663	1,508	22,825	15.13	1,788	1,622	26,049	16.00
6	Whetstones	Sh. T.	1,735	1,574	84,450	54.29	1,609	1,459	78,303	53.67
7	Alum	Sh. T.	72,000	65,304	2,160,000	33.00	75,000	68,025	2,225,000	32.70
8	Antimony ore	Sh. T.	165	150	9,075	60.50	1,083	982	37,905	38.60
	Asbestos and talc:									
9	Asbestos	Sh. T.	265	240	4,300	18.91	1,010	916	11,400	11.35
10	Fibrous talc	Sh. T.	50,500	45,804	505,000	11.03	66,500	60,316	665,000	11.03
11	Talc and soapstone	Sh. T.	21,044	19,087	401,892	21.00	18,885	17,129	361,353	21.00
12	Asphalt	Sh. T.	4,198	4,080	75,654	18.50	14,300	12,970	300,000	23.13
13	Bituminous rock	Sh. T.	34,199	31.018	148,120	4.77	43,778	39,707	143,456	3.61
14	Barytes	Sh. T.	23,758	21,548	95,032	4.41	20,255	18,371	99,020	5.39
15	Bauxite	L. T.	10,732	10,908	42,928	3.94	14,145	14,371	56,580	4.00
16	Borax	Lbs.	13,140,584	5,962	919,841	154.28	13,506,356	6,126	742,850	121.09
17	Bromine	Lbs.	379,444	172	98,655	573.53	394,854	179	102.662	573.53
18	Cement, nat. hydraul.	Bbls *a*	7,813,766	1,064,297	4,455,928	4.20	7,694,053	1,047,006	4,597,285	4.30
19	Cement, Portland	Bbls *b*	611,229	110,877	1,209,446	11.00	749,059	135,879	1,430,089	10.53
20	Clay, refractory	Sh. T.	3,375,738	3,061,794	4,050,885	1.32	*i*3,750,000	3,401,250	4,500,000	1.35
21	Clay, kaolin	Sh. T.	24,552	22,246	185,169	8.32	30,910	28,035	258,431	9.22
22	Coal, anthracite	Sh. T.	52,010,433	47,183,345	80,879,404	1.71	58,362,985	52,965,538	89,948,699	1.69
23	Coal, bituminous	Sh. T.	*h*117,865,348	106,813,171	103,758,967	.97	*h*137,398,347	126,627,141	125,344,248	1.00
24	Coke	Sh. T.	8,495,295	7,706,846	12,654,558	1.64	9,927,348	9,006,090	15,258,935	1.69
25	Cobalt oxide	Lbs.	6,550	3	8,843	2937.66	6,400	3	8,640	2880.00
26	Copperas	Sh. T.	14,897	13,511	104,160	7.72	14,118	12,805	69,846	5.46
27	Copper sulphate	Lbs.	*i*60,000,000	27,215	2,016,000	74.07	45,000,000	20,412	1,350,000	66.13
28	Chrome ore	L. T.	2,653	2,697	35,125	13.02	1,450	1,473	16,795	11.39
29	Feldspar	L. T.	18,704	19,003	83,465	4.39	22,195	22,550	104,082	4.67
30	Fluorspar	Sh. T.	6,400	5,805	58,304	10.04	4,000	3,628	36,440	10.04
31	Graphite	Lbs.	770,846	349	34,689	9.94	392,008	178	17,640	9.95
32	Graphite, amorphous	Sh. T.	165	150	1,252	8.35	1,100	998	4,700	3.00
33	Gypsum	Sh. T.	301,536	273,493	910,831	3.33	298,572	270,804	974,219	3.60
34	Iron ore	L. T.	11,880,000	12,070,080	20,790,000	1.72	16,950,000	17,221,200	29,662,500	1.72
35	Lime	Bbls *c*	*i*56,750,000	5,148,320	28,375,000	5.52	*i*60,000,000	5,443,164	30,000,000	5.50
36	Magnesite	Sh. T.	1,370	1,243	7,864	6.32	2,200	1,995	14,700	7.39
37	Manganese ore	L. T.	11,735	11,924	74,890	6.28	14,883	15,121	92,044	6.12
38	Mica, ground	Lbs.	829,500	377	35,957	96.65	750,000	340	31,956	94.00
39	Mica, sheet	Lbs.	9,900	4	11,103	2766.00	6,200	3	6,400	2133.00
40	Mineral wool	Sh. T.	5,776	5,239	58,936	11.25	6,742	6,115	69,481	11.36
41	Monazite	Lbs.	750,000	340	45,000	132.41	1,900,000	862	114,000	132.40
42	Natural gas	......	....	....	13,000,000	......	....	....	12,000,000	......
43	Paints, mineral	Sh. T.	47,593	43,167	1,011,182	23.43	47,084	42,705	1,086,767	25.40
44	Paints, vermilion	Sh. T.	91	83	111,209	1340.00	118	107	118,190	1105.00
45	Paints, white lead	Sh. T.	87,242	78,155	8,445,174	108.00	95,389	86,537	9,061,965	104.00
46	Paints, zinc oxide	Sh. T.	22,814	20.697	1,711,275	82.60	22.690	20,498	1,588,300	77.43
47	Petroleum (crude)	Bbls *d*	48,527,336	6,158,119	40,762,962	6.62	50,652,025	6,420,742	42,547,701	6.60
48	Phosphate rock	L. T.	952,155	967,485	2,856,465	3.05	831,498	844,802	2,577,643	3.00
49	Marls	L. T.	225,000	228,622	607,500	2.66	217,700	221,183	587,790	2.67
50	Precious stones	......	....	....	150,000	......	....	....	250,000	......
51	Pyrites	L. T.	107,462	109,192	466,466	4.27	81,000	82,296	353,160	4.29
52	Salt, evaporated	Bbls *e*	11,798,659	1,498,193	5,586,326	3.73	12,521,498	1,539,178	5,844,348	3.78
53	Salt, rock	Bbls *e*	2,341,922	297,376	784,063	2.64	1,367,638	173,662	518,740	2.99
54	Silica, sand & quartz.	L. T.	477,670	485,313	418,612	.86	523,640	532,018	553,128	1.04
55	Slate, roofing	Sq'es.	611,776	180,474	2,007,321	11.12	645,361	190,277	2,062,239	10.83
56	Slate, manufactures.	Sq. ft.	4,395,125	12,966	399,758	30.90	3,786,599	11,170	369.062	33.00
57	Soda, natural	Sh. T.	1,500	1,361	20,000	14.70	1,900	1,724	47,500	27.56
58	Soda, manufactured.	M. T.	....	120,000	2,760,000	23.50	....	167,000	3,841,000	23.00
59	Stone, limestone (flux)	Sh. T.	3,544,398	3,601,458	2,126,636	.59	3,390,000	3,444,240	2,542,509	.74
60	Stone, marble	Sh. T.	6,331,279	518,532	3,576,853	6.89	6,942,533	568,593	4,086,261	7.18
61	Stone, onyx	Cu. ft	1,450	110	29,000	263.63	800	66	10,750	163.00
62	Other building stones	......	....	....	*i*30,000,000	......	....	....	33,000,000	......
63	Sulphur	L. T.	441	488	7,056	15.75	1,650	1,676	126,950	15.75
64	Est. prod. unspecified	......	....	....	5,500,000	......	....	....	5,000,000	......
	Total non-metals.	......	....	....	387,117,939	......	....	....	437,383,364	......
	METALS.									
65	Aluminum	Lbs.	817,600	371	490,560	1322.24	900,000	408	495,000	1213.23
66	Antimony	Sh. T.	220	205	39,200	191.22	433	393	68.847	175.28
67	Copper	Lbs.	353,504,314	160,349	33,540,489	209.00	386,453,850	175,294	36,944,988	210.76
68	Gold	Ozs. *f*	1,923,619	*j*59,824	39,761,205	*j*664.60	2,265,612	*j*70,470	46,830,200	*j*664.60
69	Iron, pig	L. T.	6,657,388	6,764,572	71,966,364	13.44	9,446,308	9,597,449	108,632,542	10.77
70	Lead, value at N. Y.	Sh. T.	160,867	145,906	10,585,048	72.55	156,854	142,298	10,132,768	71.20
71	Platinum	Ozs. *f*	100	....	1,200	......	150	....	2,250	......
72	Quicksilver	Flks *g*	30.440	1.056	1,095,840	1037.73	33,978	1,179	1,313.589	1114.00
73	Silver, comm'l value.	Ozs. *f*	49,846.875	*j*1,550,387	31,403,531	20.26	46,331.235	*j*1,441,087	30,254,296	20.99
74	Zinc (spelter)	Sh. T.	74,004	67,135	5,209,882	77.60	81,858	74,245	5,942,890	80.04
	Total metals	......	....	....	194,093.319	......	....	....	240.617,370	......
	Grand totals	......	....	....	581,211,258	......	....	....	678,000,734	......

(*a*) Barrels of 300 lbs.; (*b*) 400 lbs.; (*c*) 200 lbs.; (*d*) 42 gals.; (*e*) 280 lbs. (*f*) Troy ounces. (*g*) Flasks of 76½ lbs. (*h*) Bituminous coal includes brown coal and lignite. The anthracite production is the total for Pennsylvania, Arkansas, and Colorado. (*i*) Estimated. (*j*) Kilograms.

Abbreviations: Sh. T., short tons (2000 lbs.); L. T., long tons (2240 lbs.); M. T., metric tons (2204.6 lbs.); Sq'es, squares (100 sq. ft., lapped and laid).

ucts and in a country as large as the United States, can be absolutely correct, but we believe that these figures are the fullest and the most nearly accurate that have ever been obtained. In making the comparisons the figures for 1894 as published in Vol. III. of THE MINERAL INDUSTRY have been revised wherever necessary in accordance with our practice, which is to present the latest and best information.

We have given the production of the different articles in metric tons (or kilograms in the case of precious metals), as well as in the customary measures, for the reason that the metric measures are those recognized and used by almost all of the civilized world, and are rapidly gaining recognition in the few remaining countries which have not yet fully adopted them. In our own country they are already legalized, with the prospect of their compulsory and exclusive use at an early date. How desirable such a change will be can be best appreciated by those who have had occasion to collect or use statistics of this kind.

Monthly Production of Metals.—As it is a matter of much interest and importance to many producers to be able to follow the fluctuations of production and prices as closely as possible, we have given in the following table the monthly production and average prices of the leading metals. In this table the prices given of silver, copper, lead, and spelter are based on the New York quotations, while those of pig iron are the average of the selling prices in Pittsburg, the leading primary iron market.

This table shows the very gradual recovery in the earlier part of the year and the activity of the later months. The fluctuations of business and demand are best shown by the variations in the produ^ction of iron. The course of prices will also furnish material for a careful study.

MONTHLY PRODUCTION AND PRICES OF THE CHIEF METALS IN 1894 AND 1895 IN THE UNITED STATES.

1894.

Metals.	January.	February.	March.	April.	May.	June.	July.
Gold, ozs	155,692	135,812	136,794	142,226	142,084	151,178	165,728
Silver, ozs	6,082,769	5,562,062	6,828,354	5,541,996	5,097,612	5,530,699	4,347,800
Price per oz	67.91c.	63.43c.	59.49c.	62.92c.	62.76c.	62.57c.	62.45c.
Copper, long tons	12,105	11,518	15,032	13,748	13,939	13,245	13,912
Price per lb	10.13c.	9.63c.	9.81c.	9.50c.	9.80c.	8.94c.	9.00c.
Lead, short tons	15,176	17,019	18,031	17,717	18,452	20,311	14,781
Price per lb	3.19c.	3.31c.	3.37c.	3.43c.	3.39c.	3.31c.	3.50c.
Spelter, short tons	6,227	5,852	6,554	5,863	5,657	4,873	5,458
Price per lb	3.56c.	3.85c.	3.89c.	3.62c.	3.47c.	3.40c.	3.42c.
Pig iron, long tons	458,779	417,517	526,210	582,857	483,966	315,076	400,426
Price, ton, gray forge	$9.91	$9.77	$9.62	$9.51	$9.71	$9.86	$10.00
Price, ton, Bes'mer pig	10.80	10.69	10.31	10.34	12.02	15.59	12.26

Metals.	August.	September.	October.	November.	December.	Totals.	
						Cust. Meas.	Metric Tons
Gold, ozs	219,151	207 329	210,103	189,414	185,873	2,041,384	(a)63,495
Silver, ozs	6,481,126	5,817,017	6,285,043	6,239,766	6,375,322	70,189,568	(a)2,183,176
Price per oz	63.88c.	64.14c.	63.06c.	63.13c.	60.48c.	63.00c.	....
Copper, long tons	13,247	12,690	14,124	12,576	10,677	157,814	160,339
Price per lb	9.13c.	9.40c.	9.88c.	9.60c.	9.80c.	9.49c.	....
Lead, short tons	18,581	20,843	20,924	19,754	18,363	220,955	200,450
Price per lb	3.41c.	3.17c.	3.12c.	3.14c.	3.10c.	3.29c.	....
Spelter, short tons	6,266	6,309	6,986	6,912	7,047	74,004	67,135
Price per lb	3.38c.	3.44c.	3.45c.	3.36c.	3.43c.	3.52c.	....
Pig iron, long tons	528,466	683,901	706,618	750,178	803,376	6,657,388	6,764,572
Price, ton, gray forge	$10.03	$10.16	$9.94	$9.73	$9.47	$9.80	....
Price, ton, Bes'mer pig	15.01	11.32	11.02	13.36	10.24	11.91	....

1895.

Metals.	January.	February.	March.	April.	May.	June.	July.
Gold, ozs	169,669	161,631	186,249	186,164	206,999	227,239	223,754
Silver, ozs	6,244,825	6,378,921	6,658,842	5,944,042	6,603,208	6,311,144	5,632,613
Price per oz	59.69c.	59.90c.	61.98c.	66.61c.	66.75c.	66.64c.	66.75c.
Copper, long tons	11,800	12,735	14,248	13,669	14,995	12,856	13,749
Price per lb	10.00c.	10.00c.	9.75c.	9.75c.	10.25c.	10.63c.	11.25c.
Lead, short tons	18,333	17,186	14,251	17,856	18,290	18,983	19,402
Price per lb	3.10c.	3.12c.	3.12c.	3.08c.	3.16c.	3.25c.	3.25c.
Spelter, short tons	7,006	6,355	7,491	7,081	6,508	6,353	6,344
Price per lb	3.28c.	3.20c.	3.23c.	3.30c.	3.50c.	3.65c.	3.75c.
Pig iron, long tons	762,474	641,550	688,170	666,315	664,600	664,449	730,156
Price, ton, gray forge	$9.15	$9.15	$9.08	$9.32	$9.70	$10.70	$11.40
Price, ton, Bes'mer pig	9.96	10.12	10.22	10.70	11.30	12.60	14.13

Metals.	August.	September.	October.	November.	December.	Totals.	
						Cust. Meas.	Metric Tons
Gold, ozs	236,594	221,618	228,264	218,056	216,701	2,482,937	(a) 77,229
Silver, ozs	6,532,103	6,159,011	6,715,977	6,584,380	6,672,005	76,437,071	(a) 2,377,499
Price per oz	66.61c.	66.90c.	67.64c.	67.40c.	66.47c.	65.28c.	....
Copper, long tons	15,535	15,496	16,270	16,485	14,685	172,523	175,203
Price per lb	12.00c.	12.25c.	12.00c.	11.00c.	10.50c.	10.76c.	....
Lead, short tons	19,983	17,048	21,622	23,500	21,145	227,599	206,478
Price per lb	3.50c.	3.35c.	3.33c.	3.25c.	3.22c.	3.23c.	....
Spelter, short tons	6,827	6,812	7,310	6,948	6,823	81,858	74,245
Price per lb	4.15c.	4.30c.	4.10c.	3.55c.	3.49c.	3.63c.	....
Pig iron, long tons	780,855	899,400	940,630	979,933	1,027,776	9,446,308	9,597,449
Price, ton, gray forge	$12.10	$13.48	$13.20	$12.70	$11.35	$10.65	....
Price, ton, Bes'mer pig	14.95	17.60	16.25	14.60	12.35	13.03	....

(a) Kilograms.

Production of Metals from Foreign Ores.—In our large table the figures are limited strictly to our domestic production. In the cases of gold, silver, copper, and lead the representation is an altogether inadequate one, for large quantities of those metals are obtained from foreign ores and base bullion smelted or refined here. The particulars are given fully in the articles on the different metals, and we add here a supplementary table, showing the total amount of this production in 1895. This is necessary in order to show fully and fairly the work done by our metallurgical establishments:

METALS PRODUCED FROM FOREIGN ORES AND BULLION IN 1895.

Metals.	Customary Measure.	Quantities.		Values.
		Customary Measure.	Metric Tons or Kilos.	
Copper	Lbs.	14,000,000	Tons..........6,350	$1,330,000
Gold	Troy ozs.	205,763	Kilos..........6,400	4,253,121
Lead	Short tons.	70,745	Tons..........64,166	4,570,127
Nickel	Lbs.	3,880,000	Tons.......... 1,760	970,000
Silver	Troy ozs.	28,193,524	Kilos........876,838	18,380,222
Total values	....	....	....	$29,593,543

These metals were obtained chiefly from material received from Mexico and British North America. In the case of our northern neighbor the smelting ores from the mines are usually sent to our smelters at Tacoma, San Francisco, and elsewhere. From Mexico we receive chiefly base bullion, from which a very considerable part of our lead supply is obtained, as noted elsewhere. The nickel is all from ores or matte received from the Sudbury mines in Ontario. We have not included above the iron smelted from foreign ores, which is small in actual amount and insignificant in comparison with the total output.

The lead industry is the trade most affected by the use of foreign material, the quantity of copper being small in comparison with the total output. In the case of nickel scarcely any ores of that metal are now produced in the United States.

THE METALLIC PRODUCTION.

The metallurgical production, representing the results of the mineral industries in finished form, attracts the most general attention. We give here a brief summary of the conditions prevailing during 1895; full accounts will be found under proper heads in the following pages.

Aluminum.—The output of aluminum increased about 10%, owing to an improvement in the manufacturing facilities of the only active producer. The use of this metal in the arts is growing slowly, though it is still limited by the high price.

Antimony.—An increase, large in proportion, though not in actual amount, is reported in the output of this metal. Its history for 1895 has been a record of a moderate growth in demand, a more rapid increase in production, and a consequent lowering in prices.

Copper.—The production of this metal in 1895 amounted to 175,294 metric tons (386,453,850 lbs.). Thus the output, which showed an actual increase in quantity even during the years of depression, again displayed a steady growth, and the increased demand at one time during the year forced prices up to the highest level known for several years. While this gain was not fully maintained, there was still a substantial improvement in the average price for the year. Nearly all the leading mines maintained their output, and many of the smaller ones increased it considerably. There was a decrease of about 12% in the exports of copper for the year, so that the increase in price was largely due to the heavy domestic demand.

Gold.—There was a notable gain in the amount of gold obtained from our mines, which in 1895 reached a total of 70,470 kgms. (2,265,612 ozs.) fine metal, value $46,830,200, showing a gain over 1894 of 10,646 kgms. (341,993 ozs.). This result shows that the impetus given to gold mining all over the world by the events of the past two years has not reached its maximum. Since there has been no general resumption of hydraulic mining in California, the increased production of gold has been due to an extension of the working of old mines, to the opening of new mines, and to a continued improvement in the methods of working and reduction of ore which now permits the profitable exploitation of mineral properties too low in grade of their ores to pay under former wasteful or imperfect systems. While the increase in the production of the yellow metal has been very generally distributed, a very notable gain has been made in Colorado, where it was due not only to the active working of the Cripple Creek mines, but to the steady growth reported from the older gold districts of the State. The other Western States have also shown considerable gains, Montana and Idaho both recording advances, while California showed a very large increase, and the development of the gold fields of Utah proceeded quietly but on an important scale. In Arizona, owing to local circumstances, there was a decrease in the gold output. In the Southern States there has been little change.

Iron.—The production of iron in 1895, as compared with the previous year, presents the most remarkable change ever shown in two consecutive years in this country. Not only was there a sharp reaction from the depression of the previous year, but the output reached the highest level yet attained. There was made in the United States last year 9,597,449 metric tons (9,446,308 long tons) of pig iron, an increase of 42% over 1894, when the total was 6,764,572 metric tons (6,657,388 long tons). The highest production on record previously was 9,353,020 metric tons (9,202,702 long tons), in 1890. This advance once more puts the United States in the position of the leading iron-producing nation of the world. A comparison of the four principal countries shows that if we take our own output of pig iron at 100, that of Great Britain was 79, Germany 60, and France 21.

An increasingly large portion of this iron is each year converted into steel, and our steel production in 1895 was over 6,000,000 metric tons, of which approximately five-sixths were Bessemer and one-sixth open-hearth steel. The total was 20% greater than the largest heretofore reported in any one year.

In making this pig iron there were used a total of 17,753,710 metric tons (17,-474,123 long tons) of iron ore, of which 17,221,200 metric tons (16,950,000 long tens) were produced from our own mines and 532,510 metric tons (524,123 long tons) were imported. Thus about 3% of the pig iron was made from imported ores, though native coal and flux were used in its manufacture.

Lead.—The production of lead from domestic ores in 1895 showed a decrease from the previous year. It amounted to 142,298 metric tons (156,854 short tons), a decline of 2.5%. This was due to the very large quantity of lead smelted from foreign ores or refined from foreign bullion, the total consumption showing a considerable increase.

Platinum.—The small amount reported is from California. It is not mined separately, but is obtained as a by-product in refining gold at the San Francisco Mint. There was a considerable increase in 1895.

Quicksilver.—There was a marked increase in production in 1895, the total being 1179 metric tons (33,978 flasks), against 1056 metric tons (30,440 flasks) in 1894. The metal was entirely from the California mines, no new sources of production having been developed during the year.

Silver.—The silver production again showed a decrease. In 1895 it amounted to 1,441,087 kgms. (46,331,235 ozs.) of fine metal, of the commercial value of $30,244,296, a decrease of 109,300 kgms. (3,515,640 ozs.) from 1894, while the total was about 76% of the production of 1893. The quantity of silver actually refined and put upon the market by the various smelters and refiners in the United States was considerably greater than this, but we have carefully deducted all the metal produced by them from foreign ores and bullion, and the quantity given is only that of the metal obtained from domestic ores. The reduction in output, combined with other circumstances, has had the effect of raising the price of silver slightly, the average price or commercial value for the year being 65.3c. per oz., or about 2.3c. per oz. greater than in 1894. We may note here the fact that in spite of the continued low price and the general decrease in output some of our larger mines have continued steadily at work with fairly profitable results. Such mines as the Ontario and the Daly, in Utah, have shown no disposition to abandon production, and the silver-lead mines of Idaho have diminished their output rather on account of other circumstances than because of the price of the white metal.

Zinc.—The total production of spelter, or commercial zinc, in 1895 was 74,245 metric tons (81,858 short tons). The year was marked by an extension of mining and of output to an extent greater than the consumption, resulting in continued low prices. With the present abundant supply these may be expected to continue until new uses are found for the metal and the demand is correspondingly enlarged, and this cannot be done unless the metal is furnished at a price low enough to induce its employment.

THE NON-METALLIC PRODUCTS.

The total amount of non-metallic products is greater than that of the metals, because of the large quantities and values of a few items.

Abrasives.—Little remark is called for on these substances. The results shown are varying, corundum and emery showing a decrease, as do also tripoli and infusorial earth, while there was an increase in grindstones and whetstones. The production of carborundum was 226,000 lbs., valued at $67,800.

Alum.—The growth of this industry is steady and satisfactory, as is shown by the large production. Some alum is made from imported bauxite and other materials, including cryolite, which is not produced in this country.

Asbestos and Talc.—The output of asbestos showed a considerable increase in 1895, chiefly due to the working of mines in Georgia which have been opened within the past two years. We still continue to import a large part of our supply. The output of fibrous talc was increased to meet a growing demand; it all comes from a limited area in New York, where the mines are actively worked under a combination. The production of talc and soapstone declined slightly.

Asphalt.—The asphalt and bituminous rock reported are chiefly from California. The gilsonite deposits of Utah are not actively worked, owing to difficulties of transportation. The use of asphalt in the United States is rapidly extending, but the chief reliance is on imported material, the island of Trinidad furnishing the largest part of the supply.

Barytes.—There was a slight decrease in this mineral, coupled with an increase in its value.

Bauxite.—A considerable increase is reported, due to the organization of new companies and the opening of new beds in Georgia and Alabama. No other deposits have been worked.

Borax.—No change in production or methods is to be reported. The output —wholly from California and Nevada—shows a slight increase.

Bromine.—Only slight changes are noted, with no difference in methods.

Cement.—Notwithstanding the extent of our natural resources in cement materials, an increased demand in 1895 was supplied from abroad, and our own production shows little change.

Clays.—The production of brick and other clays increased with the demand for building materials. An increase was also to be noted in the refractory clays used for the manufacture of firebrick and the like, and in the china clays, such as kaolin and feldspar.

Coal and Coke.—As might be expected in a year of industrial activity, the coal production showed a notable gain. In the *Engineering and Mining Journal* of January 4 we estimated the total output for 1895 at 176,904,000 metric tons (195,000,000 short tons). The fuller returns now received put the total at 179,-592,679 metric tons (195,731,332 short tons), showing a change of 0.7% from our preliminary statement and an increase of 17% over the output in 1894.

The total quantity of coke made increased largely, as might be expected; it was 9,006,090 metric tons (9,927,348 short tons) in 1895.

Our coal resources are so large and the competition of the different producing regions for the important markets is so sharp that there was very little change in the average prices; less, indeed, than in any of the other staple articles in the list. The anthracite coal production was perhaps unduly large, owing to the peculiar conditions of that trade during the year. The output of bituminous coal and of coke was stimulated by the activity of the iron market and in manufacturing industries generally. Some efforts were made during the year to increase our export trade in mineral fuel, but with comparatively little success, in spite of the abundance of our supplies and their excellent quality.

Cobalt Oxide.—The small production showed little change in its amounts or sources.

Copperas.—But little change is reported, but there was a decrease in prices and values.

Copper Sulphate.—This is an important product, and our exports last year to Europe and Mexico reached a considerable figure.

Fluorspar.—The single producing mine in Illinois showed a decrease, this being one of the few products which declined in amount.

Graphite.—No new developments have been made, and the home production is still chiefly controlled by a single interest.

Gypsum.—The use of this material varies little from year to year. Considerable developments have been made in the extensive fields existing in Iowa.

Lime.—This widely made material, like others used in construction, shows a fairly steady growth, but no special features are to be reported. A total of 5,443,-164 metric tons (60,000,000 bbls.) shows the importance of the industry, but the statistics of production are not satisfactory, owing to the burning of lime in so many places and by farmers who keep no record of their output.

Magnesite.—The production in 1895 showed a total of 1995 metric tons (2200 short tons). It is derived from the California deposits entirely, and the production increases slowly as the use of the material extends.

Manganese Ore.—Our production—15,121 metric tons (14,883 long tons) in 1895—is chiefly limited by the cheapness with which supplies can be imported. There was an increase of nearly 25% in 1895.

Mica.—The production of 343 metric tons (38,356 lbs.) continues to come chiefly from New Hampshire and North Carolina. Some new deposits in Idaho are being developed.

Mineral Wool.—We have introduced this product for the first time, its manufacture from blast-furnace slag representing the partial utilization of material formerly wasted. There were 6115 metric tons (6742 short tons) made in 1895.

Monazite.—The special demand for this mineral continues to increase, and the total reached 862 metric tons (1,900,000 lbs.), or much more than double that of 1894.

Mineral Paints.—An increased demand is apparent in the figures of the table. The largest gain is in white lead, of which in 1895 there were 86,537 metric tons (95,387 short tons) of "dry" produced.

Phosphates and Marls.—The output of mineral fertilizers for domestic use showed some increase, but owing to the diminished exports the total production of phosphate rock fell off both in quantity and in value. The cause of the smaller sales abroad is found to be in part the opening up of the deposits of phosphates in Tunis and Algiers, and in part the use of other sources of phosphoric acid, such as the Thomas slag from the basic-steel process.

Precious Stones.—No change was made in our small production.

Pyrites.—The total production, chiefly used in the manufacture of sulphuric acid, was 82,296 metric tons (81,000 long tons), showing a decrease from 1894, largely due to the cheapness of imported supplies.

Petroleum and Natural Gas.—The petroleum and natural-gas industries show but little change. While our petroleum production is not diminishing, and while the consumption steadily increases here, the exports are slowly decreasing, owing to the increased competition of Russian oil in the Eastern markets, which were formerly supplied entirely from this country; and in Europe not only to the use of the Russian oil, but to the large and rapidly gaining production of Galicia, which threatens in time to be sufficient to supply a large part of Eastern and Southern Europe.

Salt.—Of the minerals necessary to existence, salt shows an increase a little greater in proportion than the normal growth of our population, due to our growing chemical industries, and that demand may be expected to continue increasing as those industries are developed on a scale approximating the growth which they have already attained in Europe.

Soda.—The production of manufactured soda reached 167,000 tons in 1895, showing an increase of 47,000 tons, or 39.2%, over 1894. This gain is particularly gratifying as showing a substantial growth of the chemical industry, which is of great importance to this country.

Slate, Stone, and Other Buildiug Material.—All these substances show increases, due to the greater amount of construction work and the revival of business. The value of these products in the aggregate is large, but it is extremely difficult to secure accurate statistics of some of them, owing to the widely scattered nature of the industries and the fact that they are largely carried on in a small way and intermittently, as demand requires. The estimate given is as close as the circumstances will permit.

Sulphur.—The production was chiefly from Utah, but a small output was also reported in 1895 from Louisiana. The latter was chiefly experimental, but an increase is expected.

RELATIVE IMPORTANCE OF MINERAL PRODUCTS.

The relative importance of the chief articles of the mineral production is not easily determined, and opinions must always vary widely. If we take the standard of values, which is the only one that can readily be expressed in figures, the first place must be assigned to coal, the total value of which represented 31.8%, or very nearly one-third of the entire mineral production. Pig iron holds the second place, its value being about 16% of the total. These two products have values far exceeding those of any other in the list, and there is a wide gap between iron and gold, which comes third in place. Its proportion is 6.9% of the total; it represents less than half of the iron and one-fourth of the coal. Petroleum is fourth in place, furnishing 63% of the total value. Copper is fifth with 5.5%. It will be seen that coal and iron together formed 47.8%, or very nearly one-half of the production in value; if we add the extra amount obtained by that portion of the coal which is converted into and sold as coke, they would slightly exceed one-half. Silver is well down on the list, its proportion being only 4.5% of the total, while its value was less than that of the building stone and but little greater than that of the lime.

None of the other products, except natural gas (1.8%) and lead (1.5%), represented by itself over 1% of the total value.

In some respects this classification by values accords very well with what may be called the economic rank of the minerals. Certainly coal holds the first rank in our modern civilization, and no country can be industrially or commercially great without abundant supplies of fuel, while iron is quite as clearly entitled to the second place. Our abundant and cheap supplies of both may be relied on to secure in due time the economic leadership of the world.

To go further down the list, petroleum and copper, besides their importance to our own people, furnish our chief articles of mineral export. We hope that the time will come when iron in its innumerable manufactured forms will take their place, but that day appears to be still distant, and we are permitting competitors with far less natural advantages than our own to absorb the trade of South America, Asia, and Africa, a very considerable share of which we might fairly claim.

Opinions will naturally vary most as to the importance of the production of the precious metals, which occupies so prominent a position in the public estimation. The discussion of this point, however, would involve too much to be entered into here, as to consider it properly would require a consideration of the whole financial question.

The minor products, making up together nearly one-third of the total, include many of special interest and importance in different industries. In some of the least known and least considered, even, there are many possibilities. Indeed, it often happens that a mineral considered as useless or as waste may be brought suddenly into notice by a new discovery, as was the case with monazite, for instance, a case which may be repeated often in future.

After all, with our already known resources the opportunity for future development is in the use and application of those resources; and this will be done largely by the great chemical industry, which is the true assistant and the best promoter of the mineral industry.

CONCLUSION.

Generally it may be said that in the precious metals gold showed a large increase and silver a smaller decrease than had been expected. In the useful metals and minerals coal showed an enormous increase, amounting to 17%, and the materials of construction also gained largely in amount. Our production has been developed on a few new lines, while showing no very important changes in direction during the year.

The figures given show that the United States last year took the first rank as a producer, not only of gold (ceding the first place in silver to Mexico), but also of the more important of the useful metals, iron and copper, while in coal it is still second only to Great Britain, with the certainty that in a few years it will take the first place. That this degree of development has been reached in a comparatively short period makes it all the more extraordinary, even when we consider the wonderful resources of the country.

All those who are interested in comparing our own growth with that of the older mineral countries of the world will find the material for such a study in the following pages, which contain mineral statistics of all countries brought up to the latest possible dates.

The history of mining and metallurgy for the past four years, as recorded in the present and preceding volumes of The Mineral Industry, shows that a period of depression is not always an unmixed evil. During such a period we find often that great advances are really made. Attention is given to improvements in systems, economies in operation, and reductions in cost, which are too apt to be neglected in prosperous times. The necessity of producing at low prices if production is continued at all is often a stimulus to invention, and there have been many notable cases where the results have been most fruitful. The past two or three years have been no exception to the general rule.

To sum up, we may say that our mineral industries made a notable advance during 1895, not only in the quantity of their production, but in the methods and in many cases in the quality of the output. The figures given show the very great importance of those industries to the prosperity of the country, to which their growth has contributed so large a share.

ABRASIVES.

THE abrasive industry covers the production of a number of mineral substances, some of which are used nearly in the state in which they are mined, while others are the result of more or less elaborate manufacturing processes.

The following table shows the production of abrasives, properly so called, in the United States for the three years ending with 1895:

PRODUCTION OF ABRASIVES IN THE UNITED STATES.

(In tons of 2000 lbs.)

Commercial Names.	1893.		1894.		1895.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Carborundum	8	$17,000	26	$55,000	113	$67,800
Corundum and emery	1,747	140,589	1,220	109,500	385	56,400
Garnet	1,520	55,800	1,000	35,000	2,065	93,350
Steel, crushed and emery	278	44,457	306	48,985	315	50,400
Tripoli (a)	1,351	25,625	1,801	36,687	1,788	26,049
Totals	4,902	$283,471	4,353	$285,172	4,666	$293,999

(a) Includes infusorial earth (so-called "tripoli"), of which 251 tons were mined in 1893 and 275 tons in 1894. Also embraces in 1894 filters, disks, blotters, etc., 36,000 pieces, worth $17,500; in 1895, 36,000 artificial pieces, worth $10,000.

Carborundum.—This abrasive continues to be made here only by the Carborundum Company at its Niagara Falls works, and it has met with such success that the plant is now being enlarged. The arrangements made a year ago for the manufacture of carborundum in Europe are now being carried out.

Corundum and Emery.—The production of these minerals continues to be chiefly from North Carolina; the mines and deposits there were described in Vol. III. of THE MINERAL INDUSTRY. A good deal of prospecting has been going on during the year, and some discoveries have been reported, though there are no new producers.

Some emery, of a rather low grade, is mined in Westchester County, N. Y., near Peekskill. The mineral is found in several other localities in Westchester County, notably near Rye, but only in very small pockets, so scattered that it would be impossible to work them. The finer grades of emery continue to be imported, the Turkish and Greek being considered the best.

It must be noted that the price of emery is very variable, not so much on account of variations in the quality as because a large part of the emery sold is impure, being mixed with garnet and other minerals, from which its separation is a matter of some difficulty.

Garnet.—The demand for and production of this material continues to increase, and in 1895 the quantity reported was more than twice as great as in 1894. A little is mined in Delaware County, Pa., but the main supply comes from Warren County, N. Y., where it is found, usually in pockets or masses.

Steel Emery and Crushed Steel.—A small increase in the sales of this material shows that its excellences for certain purposes are being recognized. It is being introduced in many quarters and has found much favor for grinding stone especially; in grinding and polishing metals it is also finding a place.

Tripoli and Infusorial Earth.—The quarries of the American Tripoli Company in Newton County, Mo., continue to be the largest and indeed almost the only source of supply in the United States. The greater part of the product is put on the market in manufactured form and the demand is a very steady one.

Infusorial earth, which does not vary very much from tripoli, is found in many places in the United States, and has been mined in Virginia, Maryland, Connecticut, and Massachusetts. At present the chief supply is from Massachusetts and Virginia. A large deposit of infusorial earth was found in Florida two years ago, and is now controlled by parties who expect to work it on a large scale.

Whetstones, Scythestones, and Grindstones.—These materials are included under abrasives properly, though they are of a somewhat different character from those already mentioned. The following table shows the production in the United States for the three years ending with 1895:

PRODUCTION OF WHETSTONES, SCYTHESTONES, AND GRINDSTONES IN THE UNITED STATES.

Kind of Stone.	Measures.	1893.		1894.		1895.	
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Oilstones, etc.:							
Hindostan (finished product)	Pounds	300,000	$9,750	300,000	$9,000	300,000	$6,250
Indiana sandstone (finished product)	Pounds	150,000	3,375	150,000	3,375	100,000	7,500
Arkansas stone ("rough rock")	Pounds	50,000	2,000	100,000	4,000	460,000	10,800
Washita stone ("rough rock")	Pounds	400,000	5,000	250,000	3,125	203,200	10,614
Scythestones:							
New Hampshire (Indian Pond, etc.)	Gross	10,000	27,500	11,000	30,250	12,000	33,000
Vermont (Lamoille, etc.)	Gross	4,000	14,000	4,700	16,450	3,500	12,250
Ohio and Michigan grit	Gross	10,700	27,925	7,000	19,250	4,814	12,889
Grindstones:							
Ohio and Michigan	Short tons.	45,340	345,920	29,989	257,596	36,389	290,378

The use of millstones in this country has decreased very much in recent years, owing to the adoption of the roller process for making flour. Only the coarser kinds, for grinding plaster and similar substances, are now in much demand.

The production shows an increase in 1895, with the exception of two or three items only. The totals reach a very respectable figure. The values are somewhat difficult to fix, as the prices, of millstones especially, vary very widely—from $25 to $125 per ton, according to quality. With grindstones also there is a wide variation according to both quality and size. There has been some decrease recently in the demand for the best grindstones, emery wheels having taken their place in shop work to a very great extent in recent years.

The Testing and Relative Efficiency of Abrasives.

One of the aims of this contribution is to call attention to the chaotic condition of the abrasive industry owing to the lack of uniform standards of testing, and under which misrepresentation and adulteration induced by sharp competition now go on unchecked. This condition of affairs should induce manufacturers and consumers of abrasives to coöperate in securing reliable and uniform tests of their comparative efficiency.

We will first consider the fundamental principles underlying this subject and then describe the present methods of testing abrasives and the results secured. The abrasive power of any mineral or simple abrasive is dependent on its cohesion, and is a function chiefly of its hardness and in second line of its cleavability, parting, and brittleness. Abrasives are principally used in the following shapes: Loose, in grains, sand, and powder; as abrasive or emery cloth and paper; imbedded in lead, etc., on the lapidary's wheel; on wood and leather wheels; in the shape of solid wheels.

The method of testing any abrasive must naturally be suited to the way in which it is used. A simple test of the hardness and toughness of an abrasive crystal is made by ascertaining its greater or less resistance to scratching and crushing. The usual test of quality of an abrasive powder is to compare a weighed sample of it with an equal amount of a standard grade by rubbing together two weighed pieces of plate glass, between which the sample is placed. The process is continued until the plates no longer lose in weight from the abrasion, the amount of loss being a measure of the abrading power of the sample. Abrasive wheels are usually graded (by numbers) according to the depth (in fractions of inches) they will grind down a piece of flat iron held against them with uniform pressure for a given time, and also on the amount of wear on the corners of the tested wheel (measured in fractions of an inch). The iron piece is generally about $\frac{3}{8}$ in. thick and moves between guide rolls in a line perpendicular to the face of the wheel. The surface of the iron acted upon by the abrasive wheel is therefore $\frac{3}{8}$x1 in. in area when the face of the wheel is 1 in. wide. The iron is pressed against the wheel by means of a weighted lever arm and rest. The number of revolutions of the wheel required to cut into the iron to a depth, say, of $\frac{1}{2}$ in. multiplied by its diameter (in feet) gives the number of running feet or miles which forms the basis of comparison. The degrees of powdering or "gumming" of the wheel are also factors which must be taken into consideration in determining its grade or quality. Another method of measuring the abrading powers of wheels is as follows: The apparatus may be called an abrasometer. By suitable means, such as a pivoted clamp arm or frame running in guides forming an extension of fixed axle supports, a substance of known hardness and of suitable shape, which may be designated as the abrasion block, is brought to bear with constant pressure against the abrasive wheel in the manner in which it is applied in the arts. The wheel is uniformly rotated at a given speed. By determining the weight of the abrasion block and that of the wheel before and after the test, we find the loss of each by abrasion and may now compare this loss with that of a standard wheel of the same dimensions used in the same way. The principle underlying this method is that the abrasive action of the wheel can be measured by the loss in weight of the abrasion block, which loss varies directly as the hardness and cohesion of the wheel, the pressure between the wheel and the abrasion block, and the surface speed of the wheel, and inversely as the cohesion and hardness of the abrasion block. Although the same formula will also apply to the loss in weight of the abrasive wheel, the latter is in most cases so slight that it may be neglected. The abrasion block may be of iron, glass, or other suitable material. Thus abrasive wheels may be tested and graded according to a standard scale. The need of the general adoption of a reliable and uniform system of grading such wheels is especially felt by all large users of such materials.

The quality of an abrasive wheel is dependent, firstly, on the efficiency of the abrasive employed, and, secondly, on the particular flux or cement used and the process by which the wheel is manufactured. Two wheels made of the same abrasive, in the same quantity and of the same size, may differ (1) in the manner in which they are affected by heat, (2) in cohesiveness, which enables them to resist centrifugal strain, and (3) in the degree of their adhesion with metals, causing one to glaze, while the other remains free from fused and adhering metallic matter. This shows the influence of the composition and structure of the wheel, due to the particular mode of its manufacture. There are two general methods of manufacturing abrasive wheels, known as the vitrifying process, in which a relatively high degree of heat is employed and considerable time (2 to 4 weeks) is generally required, and the cement process, by which a wheel can be made in less than 24 hours. By far the larger part of the wheels upon the market are made by the latter process.

A very interesting series of comparative tests of the different abrasives in common use was recently made by C. N. Jenks, of Asheville, N. C. The following conditions were imposed: All wheels of the different products used in competition to be made of the same size, grain, or number of mesh, and each number to constitute a series of tests. All wheels in each series of tests to be made by the same formulas, and consequently of the same degree of hardness, of the same size, 12 in. in diameter, 1¼ in. face, and perfectly balanced; and to be mixed, molded, and handled through the various processes by the same workmen under the same supervision. The abrasive in each class having the greatest cutting efficiency to be adopted as a standard. The lathe employed was to carry two wheels on the same spindle, the speed thus being the same during the contest; the feed and pressure to be automatic. The speed employed in the tests to be from 1200 to 2500 revolutions per minute, the pressure to be from 5¼ lbs. upward, as deemed desirable for the purposes of the test. The metals employed to be Jessop's tool steel in bars 1½x1½ in. and cast iron in bars 1 in. square. The wheels to be dressed as required with a Huntington dresser or a diamond, and careful measurements taken to ascertain the wear of wheel material after each test, and the amount of metal displaced to be carefully recorded. Special attention to be given to heat, glazing, and other peculiarities.

Mr. Jenks gives as the result of his investigation a list in the order here named showing the relative efficiency of abrasives when made into cement wheels: Diamond; North Carolina corundum (Jackson County); North Carolina and Georgia corundum (standard); Chester (Mass.) corundum (emery); Turkish emery (best); Bengal or so-called India corundum and a few other foreign emeries; Naxos emery; Peekskill (N. Y.) emery; garnet, best North Carolina, occurring in chlorite matrix; carborundum; preparations of crushed and chemically prepared steel grains; best flint, quartz crystal, and ordinary garnet; common quartz, flint, buhr stones, sand, etc.

This list clearly shows that certain softer wheels are found to cut faster in the long run than similar wheels made of a harder abrasive, which, although cutting with great rapidity for a few moments without dressing, soon cease to cut and merely rub shoulders.

Regarding emery and corundum, Mr. Jenks states that he has found good cement wheels generally more efficient, durable, and economical than vitrified wheels as the result of his comparative tests. The vitrified wheels thus employed were ordered from the leading manufacturers of such wheels, and it was specified that they were to be used in such tests and that they were to be made of the same corundum and emery as the cement wheels. The average cement wheel, however, is less efficient than the average vitrified wheel, because vitrified wheels are generally made from the best obtainable corundum and emery, as the chief impurities contained in them crack, disintegrate, or evaporate under the intense heat employed. Any excess of impurity of this character would doubtless result in a ruined wheel. But it does not follow that vitrified wheels necessarily consist of purer corundum or emery or are more efficient than cement wheels; as for example the Hampden Emery and Corundum Company manufactures a good vitrified wheel containing only 50% of corundum, the remainder being quartz and garnet. A good cement wheel containing 95% of corundum would obviously be a far better wheel for most purposes.

The efficiency of the different European emeries employed by different cement-wheel concerns in the American trade varies greatly, ranging from 100 (the best Turkish) down to 32 (the poorest). Some cement-wheel manufacturers use only the best obtainable emery stone; others are governed almost entirely by price. It is therefore not astonishing that pure corundum possesses, say, nine times the efficiency and economy of the poorest emery now on the American market. As certain so-called clear emery wheels made of this poorer product contain only a small quantity of corundum, it becomes a very difficult matter to judge even approximately of the value or safety of wheels bought in the open market, unless of standard brands.

Owing to the present ruinous competition in the American emery-wheel trade, the poorest grades of emery stone are shipped to the United States. It is also a fact that the American market is flooded with wheels of poor efficiency and economy and dangerous to a degree. This is largely due to the lack of uniform methods and standards of testing. A pure corundum wheel in the trade commands a price only 15% greater than an emery wheel of the same size, but greatly inferior in efficiency.

The qualities necessary to make a grain corundum of the greatest possible efficiency, according to Jenks, are as follows:

It should contain 95% of pure corundum and be as free as possible from all impurities containing water or iron.

It must possess great hardness and at the same time the property of disintegra tion that so many corundums lack and comparatively few possess in the most desirable degree.

It must be of such structure that it will crush or disintegrate under pressure into shotty fragments rather than into pieces flat, flaky, long, or cubical.

In conclusion, we may state the following proposition: The rapidity of grinding and the consequent economy of work of an abrasive or abrasive compound, other things being equal, is proportional to the hardness of the abrasive and to its facility of so disintegrating that new cutting edges are continually presented to the surface to be abraded. Other elements to be considered are high speed under pressure, heat, chemical changes, and the retention on the wheel of impurities contained therein through disintegration. These factors determine the durability and efficiency of any abrasive agent, and especially its continuous and rapid cutting abilities, which are the real measure of its value.

ALUMINUM.

VERY little that is new is to be reported concerning this metal in 1895. The manufacture in this country has remained in the hands of a single producer, and no new makers have entered the market.

Since the establishment of its works at Niagara Falls the Pittsburg Reduction Company has increased its output. The main feature of the new works has been in the increase of power and the reduction of cost due to working on a larger scale. The company is making increased use of bauxite as a raw material for the manufacture, and is understood to control the Georgia Bauxite Company, which owns a mine in Bartow County, Ga., the mineral from which is shipped to the Pennsylvania Salt Company at Natrona, where it is worked up and the Reduction Company is supplied with alumina (Al_2O_3) and the fluorides of aluminum and sodium used in its processes. The company has lately arranged to double the size of its plant and to increase the production accordingly. The additional plant is expected to be in operation by the middle of 1896. It has contracted for the use of 4500 horse-power from the power plant at Niagara, in addition to that which it now uses. The company's old works at New Kensington, in Westmoreland County, Pa., are still retained, and there most of the manufacturing into sheets, bars, tubes, and other forms is carried on.

The production of aluminum in the United States in 1895 was 850,000 lbs., the value of which, at an average of 50c. per lb., would be $425,000.

The production in Europe is still chiefly furnished by the Aluminum Industrie Gesellschaft from its works at Neuhausen, in Switzerland. This company controls the Société Electro-Metallurgique de Froges, in France, with which the Société Française de l'Alumine Pure was consolidated in 1894. The works of the French company at Froges are to be extended, as announced some time ago, but they are not yet completed.

The European production has not been increased by any considerable amount. The Neuhausen Company turned out about 650,000 kgs. and the Froges works 100,000 kgs., a total of 750,000 kgs. No German production is reported.

The British Aluminum Company, which intends to make aluminum from Irish bauxite, has not yet completed its works, and it is not certain when it will become a producer. This company will use a process similar to that employed at the Neuhausen works, having secured control of the Cowles and other patents covering the process in Great Britain. It has also several other British patents.

The following table shows the production and imports of aluminum in the United States for five years, ending with 1895; the figures for production include the aluminum used in alloys:

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

Year.	Production.		Imports.		Consumption.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1891	168,075	$126,056	3,922	$6,266	171,997	$132,322
1892	295,000	191,750	43	51	295,043	191,801
1893	312,000	202,800	7,816	4,683	319,816	207,483
1894	817,600	490,560	5,303	2,524	822,903	493,084
1895	900,000	495,000	25,294	7,814	925,294	502,814

The production of aluminum in the world in 1895 was, approximately, 1150 metric tons, of which the United States furnished about one-third.

Uses.—No important new uses for aluminum were developed during the year. The demand for the pure metal has been largely for the manufacture of small articles and household utensils, the sale for which is increasing. The cost, as heretofore, continues to limit the use, and it will not extend much until the metal can be furnished at a price approaching that of copper at least. Some further experiments have been made with aluminum bronzes of varying composition, but with no special result. No official reports have been made of results obtained in the use of the aluminum launches built for the French navy, but it is understood that in this and some other promising fields the results have not been altogether satisfactory.

Prices.—At the opening of the year the price fixed by the producer here was 58@63c. per lb. for No. 1 metal, 98% pure, in ingots for rolling; 53@60c. per lb. in ingots for remelting, the variation in price being according to size of order; No. 2 metal, 94% pure, 50@55c. per lb. in ingots for remelting. In March a slight reduction was made, prices being fixed at 55@60c. for No. 1 in ingots for rolling; 50@55c. in ingots for remelting; No. 2 metal, 48@53c. per lb. A further reduction was made in November, and prices stood at the close of the year as follows: No. 1 metal, rolling ingots, 50@55c. per lb.; No. 1 metal, ingots for remelting, 48@53c. per lb.; No. 2 metal, ingots for remelting, 45@50c. per lb. There was a reduction in price varying from 5 to 8c. per lb. in amount, or about 12.5% in proportion. The producer evidently recognizes the policy of increasing the use of the metal by reducing prices as rapidly as possible.

In Europe the Neuhausen Company has kept the price at 5 fr. per kg., making, however, a discount, varying in amount, on large orders. This price is for No. 1 metal, which is 98 to 99% pure. The quotation in Paris, which was 5 fr. per kg. for the greater part of the year, dropped to 4.65 fr. in November.

The London quotation for ingots, 98% pure, was at the close of the year 17@18d. per lb. for large quantities and 18½@19d. per lb. for small orders.

ANTIMONY.

The production of antimony in the United States in 1895 not only showed a very large increase over 1894, but was the largest on record. The amount reported by the producers was 433 short tons, in addition to which 12 tons of ore were reported as disposed of before reduction to the metallic form. This amount of metal, taking the ore at the grade usually purchased by the smelters, implies a production of about 1090 short tons of ore.

The imports also increased largely over those of 1894 and approached closely the figures of 1892. The total supply of the metal was 635 short tons.

The following table shows the production and imports of antimony in the United States for the five years ending with 1895. Statistics for the years prior to 1891 will be found in The Mineral Industry, Vols. I., II., and III., with a full description of the metallurgical production of the metal:

PRODUCTION AND IMPORTS OF ANTIMONY IN THE UNITED STATES.

Year.	Production.				Imports.				
	Metal.		Ores.		Crude and Regulus.		Ores.		Total Value.
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	
1891........	556,000	$47,007	1,400,000	$45,500	3,258,701	$388,850	1,433,531	$36,232	$425,082
1892........	400,000	36,000	1,700,000	51,000	3,950,864	392,761	192,344	7,338	400,099
1893........	700,000	63,000	1,700,000	41,000	2,780,432	243,341	116,495	5,253	248,594
1894........	440,000	39,000	330,000	9,075	1,205,752	79,265	375,468	18,068	97,333
1895........	866,000	60,620	2,189,000	44,000	3,449,901	251,850	668,610	31,893	230,946

The production of ore in 1895 was entirely from the California and Nevada mines. Those of the Idaho Antimony Company at Kingston, Idaho, and of the United States Antimony Company in Montana were not active during the year, and the Arkansas mines were also closed. The production of the metal in the United States continued in the hands of Mathison & Co., the only competition being from the imported regulus.

The uses of antimony do not broaden, and the increased supply had the effect of reducing prices, as shown below. At the present range of values there is not very much encouragement to extend production, and only those mines which are well situated and able to work economically can keep at work profitably.

The following table shows the world's production of antimony ore from 1891 to the latest attainable dates:

WORLD'S PRODUCTION OF ANTIMONY ORE, IN METRIC TONS.

Year.	Austria.		France.		Greece.		Hungary.		Italy.		Japan.		Mexico.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1891......	333	$20,835	5,316	$133,518	210	....	......	....	782	....	2,268	....	2	......
1892......	97	5,646	5,103	135,200	425	....	853	$34,937	621	$45,672	2,814	....	......	......
1893......	441	24,339	7,171	130,000	......	....	881	32,160	1,193	40,402	1,649	....	9	......
1894......	686	32,843	6,144	81,231	......	....	567	27,216	1,504	45,059	......	....	35	......

Year.	New South Wales.		New Zealand.		Portugal.		Queensland.		Spain.		United States.		Victoria.	
	Tons.	Value.	Tons.	Value.	Tons.	Value	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value
1891......	930	$110,285	421	$24,750	......	....	220	$18,125	693	$20,805	635	$45,500	67	$5,940
1892......	740	73,400	370	24,500	......	....	26	1,390	395	12,467	744	51,000	299	11,390
1893......	1,803	125,460	336	17,335	666	$51,789	30	1,440	88	2,784	771	41,000	89	2,155
1894......	1,270	....	338	....	803	47,698	28	....	15	....	150	9,075	81	......

The tables do not include the antimony contained in hard or antimonial lead, the production of which in the United States is considerable, amounting to 4337 tons in 1894. This production is not increasing.

France continues to be the largest producer of antimony ore, the output being somewhat variable, but showing upon the whole an increase. The production in Japan is growing, though no definite figures can be obtained for two years past. The Italian production is on the increase also, though the amount of metal made is small, a large part of the output being shipped to works in Germany. The production of ore in Austria is increasing; most of this ore goes to works in Bohemia for treatment. The Canadian mines remained closed last year. Greece has also dropped out of the list of producers. Portugal is a considerable producer, though the amount reported is variable.

In Hungary the production in 1894 showed a decrease; it has varied considerably in past years, and the reduction is due to the lower prices. The chief producers are the works of J. M. Miller and the mines of Lehota.

Nothing has yet been done to open or develop the deposits of antimony ore discovered in the French colony of Tonkin some two years ago.

The Australian mines have furnished a considerable share of the world's output and they are capable of largely increasing their production. The following descriptions of two important districts are from recent reports of the mines departments in New South Wales and New Zealand:

New South Wales.—According to the report of the Mines Department, Hillgrove, in the Peel and Uralla mining district, produces the bulk of the antimony won in New South Wales. The amount reported in 1894 was 632 tons. Of this amount the Eleanora Company produced 472 tons of metal. The ore carries gold also, the company having obtained 3394 ozs. gold in the same year. The Hillgrove Antimony Mining Company turned out 160 tons in 1894, the mine being worked on tribute. The West Sunlight Reef Gold Mining Company reported 76 tons of antimony ore, and 100 tons more of ore were mined by Griffin & Co. from an adjoining tract. The production from the two properties last named is irregular, and work has been stopped owing to low prices. At Bowraville, in the Kempsey district, about 370 tons of antimony ore were mined in 1894. A good deal of prospecting has been done about Bowraville and also at Deep Creek and other places in the same district, but nothing of importance has been found. The low prices of ore have discouraged new work.

New Zealand.—The report of the Minister of Mines of this colony states that the principal workings of antimony ore are at Endeavor Inlet, Queen Charlotte Sound. The company now operating there is the third one to embark in the undertaking. The two former companies failed to make the venture pay, though a large amount was spent in opening up the mine and placing machinery and supplies on the ground. The mine was finally sold to the present company. Considerable sums were expended in the erection of furnaces to produce crude antimony from the ore, but without success until recently, when a process, said to be invented by a Mr. Seagar, for reducing the ore at a comparatively low cost was introduced. It is claimed that 1 ton of regulus can be produced by the use of 1 cord of wood as fuel. Several months' continuous working with the Seagar furnace are said to have given very satisfactory results. By this method also the slimes from the mills where the ore is concentrated, hitherto regarded as waste, can be treated. Continued success may have the effect of reopening the antimony mines at Waipori, which have not been worked for some time.

Uses.—It cannot be said that the decreasing price of this metal has developed any new demand or that new uses have been devised for it. Antimony continues to be employed chiefly in alloys, the best known of which is type metal, and it is in this direction only that its use seems to be increasing, as no cheaper substitute has yet been found for it. Some of the alloys of antimony, such as pewter and britannia ware, are going out of use, having been replaced by other metals which have found more favor with the public; in part also because of the lower price of silver. Antimony is largely used in most of the different alloys employed as antifriction metal for bearings. No further experiments seem to have been made with the alloys of antimony and aluminum, about which a good deal was said two or three years ago.

THE NEW YORK ANTIMONY MARKET IN 1895.

Antimony was a most uninteresting metal, the market remaining without any special feature throughout the year.

No quantities worth speaking of were received from California. Importations from Japan, however, are still on the increase, and thus the standard English brands are being more and more supplanted, which is not at all to be wondered at in view of the fact that European producers are very loath to make concessions in prices, while the new brands, some of which are said to be of excellent quality, are easily obtainable at more reasonable figures. Production on the whole is still increasing, but consumption remained about the same as last year, in consequence of which the market followed a declining tendency throughout the year.

In January the prices quoted for Cookson's, Hallett's, and the United States French Star antimony were $8\frac{1}{2}$, $7\frac{1}{4}$, and $8\frac{1}{2}$c. respectively. Values receded about $\frac{1}{4}$c. during the following three to four months, the higher tendency for other metals not having had the slightest influence on this.

The market continued quiet but steady during July and August, with an occasional slight rally hardly worth mentioning. Quotations at the end of the year were 7¾c. for Cookson's, 7½c. for United States Star, 7c. for Hallett's, and 7c. for Japanese antimony. This refers to small lots; larger quantities could undoubtedly be obtained at still lower figures.

The accompanying table shows the prices of antimony in New York in each month of the past five years, the figures being taken from the weekly market reports of the *Engineering and Mining Journal.* For the years previous to 1891 the figures can be found in THE MINERAL INDUSTRY, Vols. I., II., and III.

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
1891....	Cookson's..........	19.00	18.00	17.50	17.13	16.00	14.50	13.63	12.00	11.63	13.25	16.00	16.25	15.50
"	Hallett's...........	16.50	16.75	16.00	15.50	14.75	13.00	12.00	10.63	10.00	11.00	12.25	12.75	13.50
"	L. X................	17.13	17.00	16.75	16.00	15.13	13.63	12.50	11.38	10.63	12.00	15.25	15.13	14.38
1892....	Cookson's..........	15.88	15.00	14.90	15.00	15.13	14.40	14.20	13.50	11.50	11.80	12.00	11.50	13.75
"	Hallett's...........	14.40	11.00	10.90	11.00	11.50	11.25	11.00	10.75	10.50	10.50	10.63	10.75	12.10
"	L. X................	12.13	12.13	12.50	12.50	13.00	12.75	12.50	11.88	11.25	11.20	11.19	10.80	12.00
1893....	Cookson's..........	11.00	10.75	10.75	10.75	10.13	10.50	10.50	10.25	10.30	10.25	10.00	10.25	10.50
"	Hallett's...........	10.25	10.38	10.00	10.00	10.00	9.90	9.88	9.75	9.60	9.75	9.50	9.25	9.88
"	L. X................	10.50	10.63	10.38	10.25	10.38	10.00	10.13	10.00	10.00	10.00	10.00	10.00	10.20
1894....	Cookson's,..........	10.25	10.00	10.13	10.13	10.13	9.75	10.00	10.00	9.50	9.63	8.50	8.38	9.63
"	Hallett's...........	9.50	9.38	9.50	9.38	9.25	9.13	8.75	8.88	8.88	8.25	8.25	8.13	8.88
1895....	Cookson's..........	8.00	8.25	8.15	8.00	8.00	8.00	8.00	7.85	7.85	7.75	7.75	7.75	7.95
"	Hallett's...........	7.25	7.25	7.10	7.00	7.00	7.05	7.10	7.20	7.25	7.13	7.00	7.00	7.11
"	U. S. Star..........	8.25	7.50	7.38	7.50	7.35	7.50	7.50	7.75	7.50	7.50	7.50	7.50	7.56
"	Japanese......	7.00	7.00	6.88	6.88	6.88	7.00	7.00	7.20	7.00	6.88	6.88	6.88	6.94

THE LONDON ANTIMONY MARKET IN 1895.

ANTIMONY showed little variation during the year from a dead level. In 1894 there was a fall in the price from £37 to £32 per ton, and in 1895 hardly any of this was regained, while a part of it was lost toward the close. The market opened with some show of strength at £33 per ton for regulus and held that level till March, when there was a drop to £32 10s. In April there was a further fall to £32, and from that time on to the end of November the market was entirely without event and prices varied only within a very narrow range, £32 and £33 being the outside limits. In December there was again a slight fall, regulus dropping below the lower limit quoted and closing at £31 10s., with no tendency to rise. The causes of the low range were a slight increase in production, with little or no change in demand.

The following table shows the range of prices of regulus in London during the year and for the six years 1890–95, inclusive:

PRICES OF ANTIMONY REGULUS PER TON IN LONDON.

Month, 1895.	Highest.	Lowest.	Month, 1895.	Highest.	Lowest.	Year.	Highest.	Lowest.
January........	£33	£33	July............	£33	£33	1890........	£76	£70
February	33	33	August	33	33	1891........	72	40
March	33	32½	September.....	33	32½	1892........	52	43
April...........	32½	32	October........	32½	32	1893........	43	37
May	33	32	November......	32	32	1894........	37	32
June	33	33	December	32	31½	1895........	33	31½

For the years previous to 1890 the prices can be found in THE MINERAL INDUSTRY, Vols. I., II., and III.

ARSENIC.

Arsenic is widely distributed in nature, but occurs only in comparatively few localities in sufficient abundance to form the basis of an industry. It is found chiefly in combination with other elements, generally as a metallic arsenide combined with sulphides of iron, nickel, cobalt, copper, and other metals. Its most abundant appearance is in combination with iron and sulphur in arsenical pyrites, or mispickel, as the mineral was named by the German miners. In combination with sulphur it occurs as realgar, As_2S_2, and orpiment, As_2S_3. In one case, at Nagyag, Transylvania, it has been found in small quantities in a metallic form, but no other similar appearance is known.

Nearly all the supply of commercial arsenic, or arsenious acid, is obtained from Cornwall and Devon, England, and from the mines of Freiberg, Germany. A small quantity is obtained from the quicksilver ores of Idria, Austria, and a small quantity also from the quicksilver mines of Almaden and the Asturias, Spain. The Idria arsenic is chiefly used on the spot in the manufacture of colors, and the Spanish production is not large enough to be taken into account commercially. At one time a considerable supply was promised from a large deposit of arsenical pyrites at the Deloro mines in Canada, but from various causes this promise has not yet been fulfilled, and none was obtained during the last year from that source. A small quantity is furnished from time to time from Austrian Silesia, but the production there is intermittent.

In England arsenic is obtained as a side product from some of the Cornwall copper-tin mines; by working the waste heaps from some of the old copper ores; but chiefly from the mines of arsenical pyrites, the best known of which are the Levant Mine, in Cornwall, the Gawton and the Devon Great Consols, in Devon. A very complete and interesting account of the production of arsenic from these mines and the various processes by which it is produced in commercial form were given in Vol. II. of The Mineral Industry. The total production in Great Britain was 6170 tons in 1893 and 4830 tons in 1894. In Germany an output of 2906 metric tons of arsenic ore was reported in 1894 and of 1794 tons of various arsenic products in the same year. In 1895 the production of ore increased to 3497 tons. The Canadian output was 6.4 tons of white arsenic in 1894, but in 1895 none was reported. Besides at the Freiberg mines in Germany, arsenic is made at the Muldenhütten Works and also at the Blaufarbenwerke, at Schneeberge, with a small quantity only at the tin works at Altenberg.

The uses of arsenic are various, although the most important is in the manufacture of colors. Scheele's green is a compound composed chiefly of copper and arsenic. Schweinfurt green is also an arsenide of copper, and other colors are made of the same minerals in various proportions, the best known and most widely used being Paris green. It is also used in preserving hides and furs. It has been employed to some extent in agriculture, white arsenic having been tried both in this country and in England in a mixture with ordinary stable manure with beneficial results as a vermicide. Its use in killing injurious insects is well known, and the potato-bug pest in this country largely increased the consumption of Paris green. A considerable quantity has been used, especially in Australia, as a basis of a composition for dipping sheep. Other uses for arsenic are found in glass manufacture, while realgar is applied in making fireworks, as well as in the manufacture of colors. In making ordinary lead shot it is customary to mix arsenic with the lead in proportion of about 40 lbs. of commercial arsenic to 1 ton of lead. A small quantity finds use in medicine, and it has a part in several medical compounds. Popularly arsenic is best known as a poison. It is injurious to most animals, although hogs are not affected by it; taken in sufficient quantities it is fatal to human life, and its cheapness and comparative abundance commercially have led to its employment as a poison in many cases. The fact that it is used in manufactures of various kinds has also made accidental cases of poisoning frequent. As an instantaneous antidote in such cases may frequently be of service, we reproduce from Vol. II. of THE MINERAL INDUSTRY the following:

Cure for Arsenic Poisoning.—The simplest and best antidote for arsenic poisoning is freshly precipitated hydrated oxide of iron. This precipitate can be kept for some time under water in bottles, and a spoonful of it may be taken without the least inconvenience by any one who has been poisoned by arsenic. It is an immediate and absolute antidote. Arsenic sores may be washed with this oxide of iron. It is an effective antidote also with animals. This oxide of iron is prepared as follows:

	Parts.
Sulphate of iron (crystals)	280
Sulphuric acid	100
Nitric acid	35
Water	500

Dissolve the sulphate of iron in the water and sulphuric acid; add nitric acid, very gradually toward the last of the operation, until the liquor shows a clear red color, keeping the solution hot. Use a capacious vessel. Precipitate with ammonia until all the iron is precipitated; then filter and wash the filtrate well with water.

Prices.—There has recently been an extraordinary and rapid increase in the price of arsenic. For five or six years past commercial arsenic varied in price from 3¼ to 3⅝c. per lb., but toward the close of 1895 it began to rise very rapidly and in a few weeks reached a quotation of 7 to 7¼c. Since the close of the year it has still further increased to 9c. The production of last year has not been high, and there has been a moderate increase in the demand which has absorbed the small output of this product. The demand is still too small to justify the production of arsenic except as a by-product in obtaining some more valuable element.

Manufacture of White, Red, and Yellow Arsenic at Freiberg, Saxony.

By Albert Doerr.

The Muldenhütte Works, near Freiberg, produce white arsenic (As_2O_3) in powder and glass, yellow (As_2S_3) and red (As_2S_2) arsenical glasses, and metallic arsenic (As). The raw materials used are arsenical iron and copper pyrites, arsenical lead ores, and flue dust. The flue dust carries from 25% upward of arsenic; the pyrites and other ores carry about 10 to 40% As. The pyritous ores are by-products from the concentrating works.

Arsenious oxide, or white arsenic (As_2O_3), is produced from arsenical ores and from flue dust, and at the present time from flue dust almost entirely. The raw material is roasted in an ordinary English reverberatory calcining furnace called a sublimating furnace, which is externally square and with but two rabbling doors on each side. The hearth measures inside 4.40 meters in length and 3.20 meters in width. The roof is very low, not more than 18 in. above the hearth at

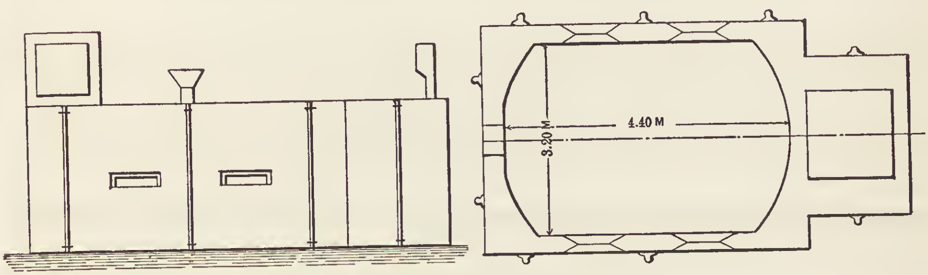

Fig. 1.—Reverberatory Calciner.

the ends. Coke fuel is used to produce a flame free from soot. Each furnace has, besides the ordinary underground condensing chambers (connected with the main chimney), another system about 100 meters in length above the ground for condensing the sublimated As_2O_3. Each furnace has a capacity of 3300 kgms. of pyrites or 2400 kgms. of flue dust in 24 hours. The time of roasting is about 8 hours for each charge of 1100 kgms. of pyrites or 800 kgms. of flue dust, and each furnace is charged three times in 24 hours. While the furnaces are being charged through funnels in the roof the As_2O_3 condensing chambers are shut off and the fumes are conducted into the underground chambers leading to the chimney. To thoroughly purify it the white arsenic is given a second sublimation in a furnace similar to the one used in the first operation. Fig. 1 shows the reverberatory calciner for white-arsenic production, giving an elevation of furnace and section. In the elevation will be seen on top of the furnace the flue for the As_2O_3, the hopper in the middle serving to charge the ores and the hopper at the end for feeding the coke.

White arsenical glass is produced by fusing the white arsenic (As_2O_3) at a temperature lower than that required for sublimation. The fusing is done in iron pots 0.47 meter deep and 0.59 meter wide. Each pot is covered with a cylindrical iron hat with a conical top. The hat is 1.41 meters high and 0.56 meter wide, the cone being but 0.14 meter in diameter at the narrowest part. To the top of the hat (at the cone) is attached an iron pipe through which the fumes are conducted to a flue and from thence to the chimney. The pipe is connected with the cone in such a manner that the escaping gases are visible. The gases should have a slow circulating motion, which denotes that the fusion is going properly. Each pot holds about 150 kgms. of white arsenic and stands 60 to 100, sometimes as high as 300 fusions. The fused glass adheres in layers from 2 to 4 cm. thick to the sides of the cylindrical hat. After cooling it is broken out with wooden hammers, and impure pieces (those containing iron or unaltered white arsenic) are returned for resublimation. Each charge, after a fusion of about 9 hours, produces about seven-eighths of its weight in glass. The pots are charged but once in 24 hours; 9 hours are required for the fusion and 15

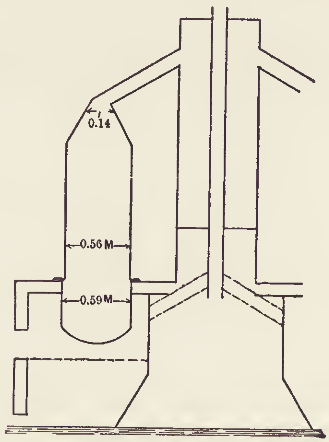

Fig. 2.—Furnace for White Glass.

hours to cool off the fused glass. Fig. 2 shows the furnace for white glass, as described above, of heavy sheet iron. Dotted lines lead from fireplace to chimney.

Yellow glass (As_2S_3), or orpiment, is made from a mixture of white arsenic and sulphur. The operation is the same as in the white-glass process, except that 25 parts sulphur are mixed with 1000 parts of white arsenic in the charge.

Red arsenical glass (As_2S_2 realgar) is a combination of arsenic and sulphur, which is not, however, identical with native realgar, but its composition resembles realgar. The furnaces used for producing this glass are called, in German, Rohrenofen, or pipe furnaces. Externally they are rectangular; internally they resemble more or less a locomotive fire box with parallel sides and an arched roof. Each furnace has 12 fireclay pipes, arranged in rows, 5 in the bottom, 4 in the middle, and 3 in the top. Each pipe is 1.4 meters long, 0.18 meter in diameter, and 0.017 meter thick. The pipes are placed horizontally. Each furnace has two fireplaces, the flames and hot gases circulating around all of the pipes. The pipes are open at the charging (rear) end, but after having been charged are closed with a fireclay plate firmly plastered on with ordinary clay. At the front end the pipes are closed, with the exception of a small round opening in the center, from which protrudes a very short neck cut off diagonally. To this neck is attached the shoe-shaped sheet-iron condenser. Each furnace receives three times in 24 hours a charge of 400 kgms. of ore, containing about 10 to 15% arsenic and 30 to 35% sulphur. After charging at a fairly low temperature the temperature is increased to a red heat and kept so for nearly 8 hours. The clay plates are then taken off the rear end of the pipes, the roasted ore drawn out into carts, a new charge given, and the fire again built up, but before the temperature has become very high the condensers into which the raw glass has been sublimated are taken off and others attached in their places. After cooling for perhaps 30 minutes the glass is knocked out of the condensers. It is partly fused, partly in powder form. The fused portion is ready for refining and the powder is returned for sublimation. The raw glass has to be refined,

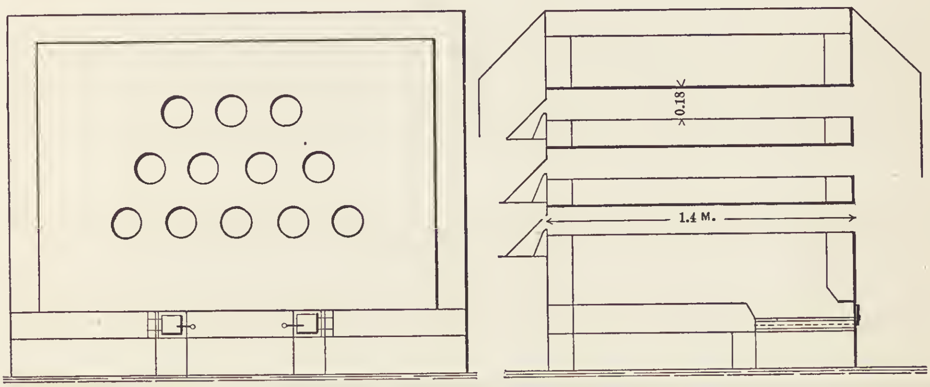

Fig. 3.—Pipe Furnace for Red Glass.

as it is uneven in both structure and color. By the addition of sulphur (added when refining) any desired color can be produced. Fig. 3 shows the pipe furnace for red glass, giving a front view of furnace and a section showing grates, pipes, and condensers.

The raw red glass is refined in small iron pots of 28 cm. diameter and 50 cm. depth. Each pot will hold 150 kgms. raw glass; each refining requires about 2 hours' time. To each pot of raw glass is added from 6 to 9 kgms. sulphur, according to amount needed. After refining, the finished red glass is tapped off at the bottom of the pot into iron molds or pans. The impurities in the raw glass form during the process of refining into a slag (consisting of pyrites, arsenic, sulphur, etc.), which is skimmed off and returned to the pipe furnaces. During the process of refining the fused glass in the pot is constantly stirred. A fairly high temperature is required to keep the glass fused. To test when the glass is finished a small iron rod is dipped into it, quickly withdrawn, and allowed to cool rapidly. If the glass is finished it is transparent and has a rich dark cherry-red color; if unfinished the color is either too dark or too light, and in both cases the glass is not clear. If too dark more arsenic is needed; if too light more sulphur must be added. Two workmen are necessary to every pipe furnace; one man is sufficient for the refining. Fig. 4 shows a section of the red-glass refining furnace described. The pot is in two pieces, cast iron; the small upright pipe leads to main flue-dust chambers.

Metallic arsenic is produced from pure arsenical pyrites finely powdered. The furnace used somewhat resembles the red-glass furnace, having similar pipes, called in German Kruege (jugs); they are smaller and shorter than those in the pipe furnaces, go but half way through the furnace, and are entirely closed at the rear end. The pipes in the metallic-arsenic furnace are 13 in number, arranged in two rows, 7 in the bottom, 6 in the top. Each furnace is really a double furnace, as two furnaces are always built back to back, one fireplace, extending from end to end of the furnace, being sufficient for both. Each

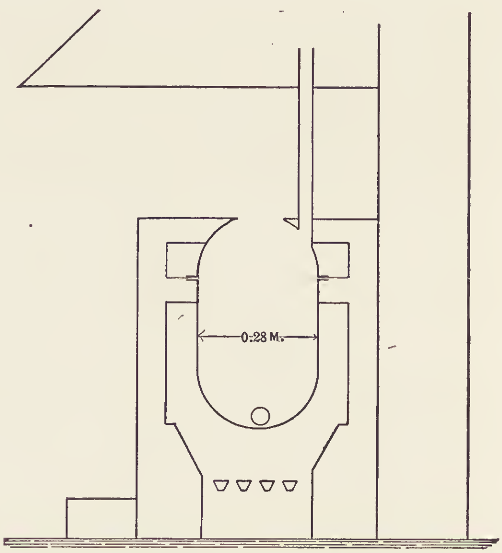

Fig. 4.—Refining Furnace for Red Glass.

jug is fitted with a cylindrical sheet-iron condenser to which is attached another condenser, made of fireclay, to catch the arsenic sulphides, small quantities of which are also sublimated with the metallic arsenic. After charging the furnaces are heated to a high temperature. In the beginning of the sublimation some arsenic sulphide and a small quantity of powdered amorphous arsenic are deposited in the clay condenser. The metallic arsenic condenses in the iron cylinders, in the hottest parts in beautiful crystals. The arsenic sulphide and amorphous arsenic are returned to the red-glass furnaces for resublimation there. Each furnace is charged with 350 kgms. of ore every 8 hours, and about 75 kgms. of metallic arsenic are produced from every charge. One workman is sufficient for each double furnace. Fig. 5 shows the furnace for metallic arsenic, giving a front view and section, showing arrangement of jugs, condensers, and fireplace.

At the Freiberg Works there are 6 sublimating furnaces for red glass, 1 refining pot for red glass, 3 metallic-arsenic furnaces (double), 2 sublimating furnaces for white arsenic, 10 sublimating pots for white glass, 8 sublimating pots for yellow glass, and 1 ball mill for powdering the finished red glass.

Freiberg is the principal arsenic producer in Germany. The greatest demand is for red glass, consequently this is produced in larger quantities than white arsenic. Some of the raw red glass manufactured in Freiberg is produced by a new and secret process. The raw glass is produced by fusing white arsenic and sulphur in small white-glass pots, and when finished is tapped off in a liquid. It is generally too dark in color and is refined with additions of arsenic in the usual manner.

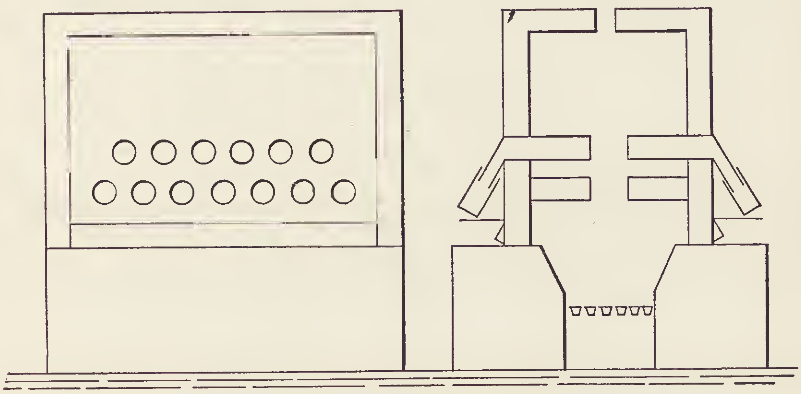

Fig. 5.—Furnace for Metallic Arsenic.

All the workmen employed around the arsenic furnaces suffer from inhaling the fumes and from the arsenic entering the system through the pores of the skin. The buildings in which the furnaces are placed should be as cool as possible. If arsenic settles on the skin while perspiring it quickly enters the pores and causes painful irritation and sores. One of the bad effects on the workmen seems to be that the joints of the bones become very loose; the ball and socket seems to wear away and become smaller. Precautions are taken to prevent the fumes from being inhaled by tying a sponge and cotton wool over the mouth and nostrils, but it is impossible to entirely prevent it.

The total production of arsenic in Germany in 1895 was about 3000 tons. Of this about 2000 tons was produced in Saxony (at Freiberg, at Schneeberg, and Altenberg). A large portion of the red glass produced goes to America.

PRODUCTION OF ARSENIC.

In Great Britain, where the production is chiefly of arsenious acid, or commercial arsenic, the production is variable, but does not upon the whole increase. In 1890 it was 7395 tons, valued at $303,635, and in the following year it fell to 6147 tons, valued at $292,965. In 1892 there was another considerable fall to 5196 tons, valued at $218,430, but in 1893 the production rose again to 6170 tons, valued at $288,470, this being very close to the figures of 1891. In

1894, however, there was another decrease and the production was only 4877 tons, valued at $243,070. The exact figures for 1895 have not yet been issued, but it is understood there was very little change from the preceding year. In 1894 there was produced also 3340 tons of arsenical pyrites, valued at $19,115.

In Germany the output is chiefly of arsenical glasses, the manufacture and preparation of which are described above. In that country the amount of arsenic products made during the five years ending with 1894 was as follows:

ARSENIC PRODUCTS IN GERMANY.

Year.	Prussia.		Saxony.		Totals.	
	Metric Tons.	Value.	Metric Tons.	Value.	Metric Tons.	Value.
1890	817	$41,108	1,342	$105,723	2,159	$146,831
1891	812	41,379	1,170	96,827	1,982	138,206
1892	592	22,739	1,075	86,388	1,667	109,127
1893	709	31,939	1,084	87,649	1,793	119,588
1894	1,147	57,377	1,229	108,511	2,376	165,888

The quantity produced from quicksilver ores in Spain is not reported; it is chiefly marketed in the form of colors, etc. The arsenic from the Idria quicksilver mines in Austria is chiefly marketed as realgar.

Some studies have recently been made in England on the influence of arsenic on steel, but though they have some scientific interest, they do not seem so far to be of practical importance.

ASBESTOS.

By Matthew Penhale.

Asbestos was well known and its properties understood by the ancients, but little or no practical use was made of it until a comparative recent period. It was regarded rather as a curiosity to be used for experiments or perhaps for scientific tricks, as they may be called, and to be preserved in cabinets as specimens than as a commercial product. In recent years its value as packing for joints, covering for pipes, fireproof material, and other purposes has been realized and production on a considerable scale has begun. For a considerable period the supply came almost entirely from Italy and from the island of Corsica, but the mines there falling under the control of a combination which attempted to increase the price to an almost prohibitory point, exploration in other parts of the world was stimulated.

The existence of asbestos in Canada has been known for nearly 50 years, and in 1851 Sir W. E. Logan, then director of the Geological Survey of the colony, published a paper on the deposits of this mineral in the Province of Quebec. Nothing was done to explore these deposits for nearly 30 years, and the first one of commercial importance was discovered in 1877 on the farm of Mr. Johnson, in the township of Thetford, Quebec. Samples of the mineral were sent to the United States and to Europe, and from Germany an offer was received of $80 per ton for all the asbestos that could be furnished equal in grade and quality to the sample. Mining was then actively begun, and prospecting through the district showed the existence of other deposits which have since been worked.

The Canadian asbestos is found in the range of serpentine rocks which extends across the Province of Quebec from the Vermont line to beyond the Chaudière River. Not all of this serpentine range contains asbestos, but no asbestos has yet been found outside of its limits. At present there are two principal groups of mines. In the Thetford district there are a number of mines, most of them situated close to the line of the Quebec Central Railway. In the Black Lake district there is also a group of mines near the same road, but most of them from one to two miles distant from the track. Outside of these two groups only two mines are worked. The Danville Mine, which is a large one, is situated near the Grand Trunk Railway between Richmond and Point Levis. There is a small mine near Ottawa, but its production at present is insignificant, and nearly all the ore shipped comes from the Thetford and Black Lake groups and from Danville.

The total shipments from the Quebec mines from the time they were first opened up to the close of 1894 amounted to 64,042 tons, valued at $4,895,087. In 1895 there were shipped from the Canadian mines 8275 tons, bringing the total shipments up to 72,317 tons. The value in 1895 is difficult to state, as prices varied more than for many years previously. Asbestos under present conditions in Canada cannot be very cheaply produced. The mining and preparation for market costs from $25 to $45 per ton, according to the mine and local conditions, and there is no doubt that some of it was sold last year for less than cost of production.

The shipments of Canadian asbestos for the six years ending with 1895 are shown in the following table, in tons of 2000 lbs. The figures for the years prior to 1890 can be found in the several volumes of THE MINERAL INDUSTRY:

SHIPMENTS OF CANADIAN ASBESTOS.

Year.	Tons.	Value.	Year.	Tons.	Value.	Year.	Tons.	Value.
1890	9,860	$1,360,240	1892	7,431	$990,878	1894	7,649	$535,430
1891	9,279	1,000,000	1893	5,539	581,595	1895	8,275	347,550

The details of the shipments in 1895 are here given:

SHIPMENTS OF CANADIAN ASBESTOS, 1895.

To Points in the United States.	Tons.	To Points in Europe.	Tons.
Baldwinsville, Mass	236	Genoa	30
Camden, N. J	350	Glasgow	256
Cincinnati, Ohio	12	Hamburg	717
Erie, Pa	1,020	Havre	188
Franklin, Pa	12	Liverpool	381
Lockland, Ohio	39	London	701
New York	2,354	Marseilles	50
		Montreal (for export)	491
Total to the United States	4,023	Rotterdam	720
Total to Europe	4,252	To other points	718
Total shipments	8,275	Total	4,252

The Canadian mines are generally well equipped with machinery for freeing the asbestos fiber from any rock which may adhere to it or be mixed with it and for shipping it to market in good shape. The methods of mining and preparations for market were very fully described in Vol. II. of THE MINERAL INDUSTRY. Before shipment the asbestos is carefully graded. The fall in price is shown by the fact that the current quotations loaded on cars at the mine in 1890–91 were $250 per ton for No. 1, $100 for No. 2, and $50 for No. 3; while in 1895 it was sold at times as low as $70 per ton for No. 1, $35@$40 for No. 2, and $25@$30 for No. 3. At present cost of production the industry will not stand a continuance of these prices. It must be remembered that not only is a great deal of care required in grading and preparation, but the mining for asbestos requires the removal of a large quantity of barren rock. In Black Lake, for instance, not over 2 tons of commercial asbestos is taken out to 100 tons of rock, and in Thetford the average is about the same. At the Danville Mine the proportion of good mineral is somewhat higher, and in some portion of the vein nearly 90% of the product is commercial asbestos; but this was a very exceptional case. Under these circumstances it can readily be seen that the cost is high; in fact, the disposition of the waste rock is getting to be a matter of some expense and difficulty at the older mines.

No new discoveries were made in Quebec during 1895 nor were any special improvements made in the dressing or preparation of the ore. The Danville Company's plant, which is of the latest type and contains the most improved machinery, is described as follows:

This mine was formerly the Jeffery asbestos mine, the product of which was known both in Europe and America for its whiteness and peculiar silk-like quality. Mr. Jeffery, the former proprietor, died some time ago, and the mine has since passed into the hands of a new company with abundant capital, the managers of which realized that a change in the methods of working was necessary in order to secure a larger output, which they believed the property was able to furnish. After testing and examining the deposit by blasting in various places and treating the resulting rock, they came to the conclusion that the mine could produce a larger amount than any other of the kind in Canada, the test showing from 25% up to as high as 90% of true asbestos fiber in the rock. The company's next step was to secure markets for the product, and it is understood that it has made contracts to furnish an amount as high as 5000 tons a year. To supply this it has been necessary to put up large reduction works, which are now completed. The main factory building is 160x70 ft. and five stories in height, solidly built of the best material, the posts being 12x12 in. set. 10 ft. apart, and everything in proportion, while the whole building is excellently lighted. The roof is flat and is covered with asbestos, and in building more attention has been paid to outside appearance and ornament than is customary in mine buildings. A second building is now being erected adjoining the first, 100x70 ft. in size. On the first floor of the larger building there are 6 rock crushers, 2 of 35 tons each with double jaws, and the other 4 of smaller size, the least being 7 tons. Next to the crushers are sets of Cornish rolls and a revolving picking table of great length. In addition to this machinery there are in the factory 12 cyclone pulverizers, a number of fan and exhaust blowers, revolving screens of all kinds, shaker screens and jiggers, all driven from the shafting. The main driving shaft is 5 in. in diameter. The whole plant is driven by an engine of 500 horse-power, which is placed in a separate house at one side of the main building with a battery of four large boilers which are of sufficient capacity to furnish more power if needed. The engine stands on a granite foundation and the smoke from the boilers will be carried off by a stack over 100 ft. high. To furnish water supply a pumping station has been placed on a creek near by, the water being pumped into a tank set in the sand and made of heavy timber. The company has established an office at Danville in charge of Mr. B. Marcuse, who is general manager in charge of all the work at the mines. In the mine also the company is making many improvements with the object of taking out mineral on a large scale. The whole plant is the largest ever erected in the Province of Quebec. Part of the machinery was furnished by Montreal houses and part of it from New York.

The production in the United States in 1895 amounted to 1010 short tons, 1000 tons of this coming from the mines of the Sall Mountain Asbestos Company, in White County, Ga. At this place a considerable deposit has been exposed, and the company has erected a plant from which the first shipments were made in 1894; production is increasing steadily. The quality of the Georgia asbestos is very similar to that of the Canadian mineral, and it is finding a ready market. Outside of this Georgia mine, the only production in the United States last year was 10 tons from a small mine in California, which is worked at irregular intervals.

Asbestos was discovered two or three years ago in Gallatin County, Mont., and some explorations made there seem to indicate that the mineral exists in sufficient quantity and of a quality to warrant working the deposit. It is, however, at present so remote from transportation facilities as to put its possible product out of the market until roads or a railroad make it accessible.

The development of the asbestos mine at Caspar Mountain, in Wyoming, has also been delayed by difficulties in transportation, and no production is reported from that mine or from any other in Wyoming.

Uses of Asbestos.—New uses for this mineral are continually being found and introduced. Its employment for packing in steam engines is one of the oldest and best known. Recently many applications have been devised in the way of preventing fire and introducing fireproof linings and partitions. For instance, asbestos paint, which is a pigment mixed with ground asbestos, has been extensively used in theaters and other public buildings. Asbestos in combination with paper and other substances is used to cover pipes and to protect stovepipes and other heated channels from contact with inflammable material. Asbestos paper has also been suggested for use in valuable books, but although paper of this kind has been made of very good quality, we are not aware that any has been used. Asbestos hangings and wall decorations are being used to a considerable extent in steamboat work and for similar purposes. Other new uses have also been suggested.

Fibrous Talc and Soapstone.

By C. H. Smyth, Jr.

In the massive form known as steatite, or soapstone, talc has had some application in the arts for many years. But the development and use of the fibrous variety, sometimes called agalite, are of recent date, being limited to a period of not more than 20 years. This modern industry is based entirely upon the talc deposits occurring in the towns of Edwards and Fowler, St. Lawrence County, N. Y., from 8 to 15 miles southeast of the village of Gouverneur.

In the published accounts of these deposits the talc is very generally described as constituting a vein in clearly defined granitic walls, while the country rock, in one instance at least, is said to be Trenton limestone. As to the genesis of the talc, its derivation from amphibole has been suggested, but the origin of the latter has not generally been referred to.

The talc district lies toward the northern edge of the area of crystalline rocks constituting the Adirondack region. The nearest paleozoic rocks, with the exception of small patches of Potsdam sandstone, lie many miles to the north and west, the talc district consisting wholly of pre-Cambrian crystalline rocks. Of the latter there are two prevailing types—gneiss, constituting extensive areas, and crystalline limestone, forming more limited belts stretching northeast and southwest. Within one of these limestone belts, beginning in Fowler and stretching across Edwards townships, are included all of the important talc deposits yet found. The mines are opened along a line parallel with the trend of the limestone belt, or in other words the so-called vein conforms to the strike of the inclosing rock. The "vein" varies in thickness from 2 to 20 ft., or even more, but sometimes pinches out almost entirely. The walls, instead of being granitic, are composed either of tremolite rock or of impure limestone, sometimes with intervening quartzose layer. While in actual mining practice it is generally easy to separate the talc from the wall, no very pronounced petrographic distinction exists between the two. The structure of the talc differs but slightly from that of the tremolite rock, and between them there is a complete gradation. The tremolite rock, furthermore, passes over into a tremolitic crystalline limestone and the latter into a pure marble. In short, there is a gradual transition from crystalline limestone into talc, and the latter is clearly shown by all of the evidence to be an integral part of the crystalline limestone formation.

The intimate association of talc and tremolite rock, with gradations between the two, points strongly to the derivation of the former from the latter, and this supposition is entirely supported by microscopic study of the rocks, as well as by the chemical composition and well-known relations of the two minerals. In fact, many specimens mined as talc contain a large percentage of tremolite, the process of alteration not having been completed.

On the basis of phenomena exhibited in the field, the process of talc formation may be sketched as follows: The crystalline limestone is a calcareous sedimentary formation which has been subjected to intense metamorphism. Certain layers of this formation, being rich in silica, magnesia, etc., have in the process of metamorphism formed tremolite rock instead of marble. Subsequently the tremolite (with which are associated other magnesian silicates, enstatite being particularly abundant), through the action of carbonated waters, probably under pressure and somewhat heated, has been more or less completely altered to talc. The alteration is most complete toward the southwestern end of the belt, where foliated talc largely replaces the fibrous variety. The former has more the normal properties of the mineral; the latter retains the tremolitic structure, showing more clearly its pseudomorphous origin. The talc is thus not a vein deposit resulting from the deposition of material in a fissure, but instead the altered portions of a bedded deposit. That the talc does not form a clearly defined layer or bed of uniform thickness and position is the necessary result of the irregular alteration of the tremolite, together with the effects of folding, slipping, and crushing.

On the supposition that the talc is formed by the process outlined, it seems probable that the deposits extend to such a depth that mining will be limited only by the increase of cost. Considering the thickness of the deposit and its considerable linear extent, it is evident that the supply is sufficient to meet all demands for some time to come. At present mining operations are chiefly in the hands of four companies, most of the mines being located at or near Talcville, in the town of Edwards. One large mine, that of the American Company, is situated near the southwestern end of the talc belt, some 2 miles south of Little York, in the town of Fowler. The bed worked at this point has an average thickness of about 14 ft. and is composed chiefly of massive and foliated talc, with only a little of the fibrous variety. The hanging wall consists of tremolite schist and impure crystalline limestone, separated from the talc by a thick layer of quartz. The foot wall is massive talc of rather impure quality, such as not to repay working. Below this the rocks are doubtless similar to those in the hanging, but they are not exposed. At the surface the bed dips 30 to 40° northward, but this increases with depth, becoming almost 90° at 100 ft. from the surface. Compressed-air drills and dynamite are used in the mine, which is lighted by electricity. The product of the mine is ground in a mill only a few rods distant and is then carted to the railroad at Gouverneur. The grinding plant has been described in Vol. II. of The Mineral Industry and may serve as a type of the mills which prepare the talc for the market. This plant labors under some disadvantage in having no water power and in being at a distance from the railroad. The latter difficulty might, however, be obviated by building a switch about 2 miles in length.

Numerous small openings have been made along the belt between the American location and the group of mines at Talcville, but most of these are now idle, and it is difficult to see how any of them can compete with the larger workings, which have many special advantages besides those naturally following from development on a larger scale. At Talcville most of the mining operations of the district are concentrated, furnishing the great bulk of the output. The product of these mines is of the highest quality, most of it being characterized by a pronounced fibrous structure. The talc is worked on two or more horizons, separated by a small but variable distance and entirely confined to the tremolitic portion of the crystalline limestone formation. The workable talc averages 15 or 16 ft. in thickness, but sometimes pinches down to 2 or 3 ft. In some mines it is separated by a "slip" into an upper and lower layer, the former having a bluish color and being of exceptionally fine quality. Both foot and hanging walls are composed of tremolite rock, which looks much like the talc itself, but is harder and more vitreous in luster. It sometimes shows a granular structure, and varies in color from white to pink or more rarely to dark gray. The adjacent crystalline limestone is sometimes an ophicalcite and contains contorted tremolitic layers. The entire formation, including the talc beds, dips northward at an angle of about 45°. From an eighth to a quarter of a mile north of the talc beds there is a prominent ridge of coarse massive gneiss. The relation of this rock to the limestone formation is not certain, but it may be intrusive. In this case it must cut off the talc, but this would probably occur at such a depth that it is not an important consideration from an economic standpoint.

The nature of the talc deposits is such as to demand only simple methods of mining. It is the custom to start at the outcrop and sink on the slope of the bed, drifting off laterally at convenient levels. The roof, as a rule, is very good and is supported by pillars of talc. Sometimes the presence of slips necessitates the introduction of some timbering, but seldom in any large quantity. Compressed-air drills are used and blasting is done with dynamite, which tears out the talc in large blocks requiring to be sledged. This is done in the mines before loading into skips which carry the talc to the dumps. Here it is carefully sorted and then shipped by rail to the mills.

On account of the thickness of the bed comparatively little of the material mined has to be rejected, and this fact, together with the good roof, little water, and limited depth of the mines, renders mining quite cheap. The great toughness of the large blocks blasted out, on the other hand, tends to raise the cost, as the element of sledging not only involves labor directly, but produces large quantities of fines which have to be handled with a fork. Furthermore, in the winter the fines often freeze to a solid mass during the transportation to the mills, thus greatly increasing the cost of unloading.

The location of the mines is decidedly advantageous. The openings are in a high ridge close to the Oswegatchie River, which has recently been paralleled by the Gouverneur & Oswegatchie Railroad. The site is such that from the time the talc reaches the mouth of the mine till it is delivered at the mill all transfers are aided by gravity, while the power for turning out the finished product from the mills is furnished by the river.

As mined the talc is white, greenish, bluish, or yellowish, most of it fibrous and of variable hardness, depending upon the completeness of alteration. Much of it is readily scratched by the finger nail, but other portions are too hard to receive any impression. In sorting, the harder portions, particularly if they carry quartz or other hard minerals, together with discolored pieces, are rejected. But even the best pieces of talc contain some "grit," often shown by the microscope to be quartz. It is doubtful, however, whether a moderate amount of such material is deleterious beyond the increased wear of mill machinery resulting from its presence.

The product of the mills is an impalpable powder, graded according to fineness and color. Extreme fineness and a pure blue-white color are the qualities sought, any tinge of yellow reducing the value. In so fine a powder it would seem as though the much-talked-of fibrous structure must have been pretty well destroyed. But the "felting" of the material in all attempts to bolt it, as well as its behavior in paper pulp, seem to indicate the contrary. All doubt upon this point is removed by examining the powdered talc under the microscope. It is seen to consist of minute fibrous particles of very irregular size and shape, usually elongated parallel to the fibers and often much frayed at the ends. An examination of this kind clearly shows that the fibrous structure is present on a minute scale, and accounts fully for the peculiar behavior of the material.

As the value of the talc is dependent upon its physical rather than its chemical properties, the latter are of importance only as they affect the former. The talc is more valuable than the original tremolite, not because it is a silicate of magnesium instead of magnesium and calcium, but because in losing calcium and taking up hydrogen in its place it has acquired a softness and pliability not possessed by the original mineral. Minor variations of composition, so long as they do not greatly change color or hardness of the talc, are of little or no importance in relation to its value. For this reason simple mechanical tests are more important than chemical analyses in determining the grade of the finished product.

An analysis of talc from the mines of the International Talc Company shows the following composition:

SiO_2	62.10
MgO	32.40
FeO	1.30
MnO	2.15
H_2O	2.05

So far as silica and magnesia are concerned, this corresponds closely with analyses of the mineral talc; but the water is rather low, while the amount of manganese is surprisingly large. It seems probable that analyses representing an average of the product of the mines would show a wider variation from the composition of true talc, often with more or less calcium present.

A conservative estimate of the product of the mines during 1895 places it at 40,000 tons, which is rather less than that of former years. This decrease in production is not to be ascribed to any falling off in the value of the material in its various applications or to anything like exhaustion of the supply, but rather to the depression prevailing in all branches of business. The price of the talc ranges from about $7 to $12 per ton, depending upon the grade, and it finds a sale not only in this country, but also in Europe. As heretofore, most of the product is used in the manufacture of paper, for which it is found to be much better than the clays formerly used. Its value depends upon the fibrous structure, in virtue of which 70 to 80% of the powder is retained by the paper pulp, as against 30 to 40% in the case of clay. In addition to various minor applications mentioned in previous volumes of THE MINERAL INDUSTRY, it is said to have been recently used in the manufacture of dynamite. As an absorbent and conveyer of the nitroglycerine it is claimed to be much superior to any other material.

Viewing the talc industry of this district as a whole, it may be said that the deposits now worked are sufficient to supply all demands for years to come, while it is possible that other deposits may be found, though efforts thus far made in this direction have been fruitless. At the present time there are no inducements to search for new fields, as the mines already opened are more than sufficient to supply present demands. None of the mines or mills is being crowded, and with existing plants the output could be largely increased at any time. In view of these facts, together with the natural advantages enjoyed by those already in the field, it is highly improbable that any new talc properties will be sought for or developed in the near future.

The following table shows the production of fibrous talc in the United States for the six years ending with 1895. The figures for the years previous to 1890 will be found in THE MINERAL INDUSTRY, Vols. I., II., and III.:

PRODUCTION OF FIBROUS TALC IN THE UNITED STATES.

(In tons of 2000 lbs.)

Year.	Quantity.	Value.		Year.	Quantity.	Value.	
		Total.	Per Ton.			Total.	Per Ton.
1890	41,354	$389,186	$9.41	1893	36,500	$337,625	$9.25
1891	53,054	493,068	9.28	1894	50,500	505,000	10.00
1892	41,925	472,485	11.27	1895	66,500	665,000	10.00

Soapstone.—Unlike fibrous talc, the massive variety, soapstone, is by no means an uncommon rock. It occurs in a great many localities, often in sufficient quantity and purity to repay working. Its ordinary association is with metamorphic rocks, in which it forms beds or pockets, and it is either a product of metamorphism or, doubtless much oftener, a result of the alteration of such a product or of a basic igneous rock.

Soapstone is extensively used in the manufacture of utensils exposed to high temperatures or to the action of corrosive liquids and gases. A smaller amount is ground and employed in the manufacture of paper, pigments, various pharmaceutical preparations and lubricants, and in the dressing of leather. As the industry is rather scattered, accurate figures in regard to production are not easy to obtain. An estimate of the total output for 1895 places it at about 21,000 tons, or in the neighborhood of one-half the amount of fibrous talc produced in the same period. The numerous uses of the soapstone in the solid form give it a higher value, weight for weight, than the fibrous talc. It so happens that the relation between prices and products of the two varieties is such as to bring their total values quite close together.

The production of soapstone in the United States for the six years ending with 1895 is found in the following table, in tons of 2000 lbs.:

SOAPSTONE PRODUCTION IN THE UNITED STATES.

Year.	Quantity.	Value.		Year.	Quantity.	Value.	
		Total.	Per Ton.			Total.	Per Ton.
1890	13,670	$252,309	$18.50	1893	20,100	$366,825	$13.50
1891	16,514	243,981	15.00	1894	21,044	401,892	19.09
1892	23,208	423,449	18.00	1895	18,885	361,353	19.13

A small quantity of soapstone is imported for special purposes; it comes chiefly from Germany and is usually imported in manufactured or finished form.

These imports form, however, an insignificant portion of the supply of the mineral.

Soapstone is found in many places in the United States, but is mined or quarried chiefly in Vermont, New Hampshire, New York, Pennsylvania, and North Carolina. The consumption is extending. In addition to the various uses named above, it is taken in increasing quantities every year for house construction in making laundry and bath tubs, hearthstones, and similar purposes.

Soapstone finely powdered is used in some of the so-called "water-proofing" compositions used for protecting stone and metal work against the weather. It adds materially to the efficiency of such pigments on account of its property of adhering tenaciously to the surfaces over which it is spread and to its resistance to moisture and changes of temperature.

ASPHALTUM.

By J. W. Howard.

Asphaltum and its compounds were fully treated in The Mineral Industry, Vols. II. and III. The first article, in Vol. II., described the properties, occurrence, analyses, tests, statistics, history, and importance of asphaltum and its compounds, both natural and artificial.

Although the asphalt-paving industry has been firmly established since 1854, when the material was first successfully used in Paris, asphaltum and its natural compounds form the basis of much other business besides paving. They were used in various ways previous to this century. Within the last 15 years large amounts of asphaltum are annually used in the preparation of insulation for electric cables and in connection with electricity in many other forms.

The volume of the asphalt industries of the world has become so great, employing more than $15,000,000 of capital and about 7000 men, that the value of statistics in connection with this substance depends upon their proper analysis. It is necessary to distinguish between asphaltum, which is a mineral pitch more or less pure, and the natural compounds of asphaltum, such as asphaltic limestone and asphaltic sandstone. Unfortunately nearly all of the tabulation of these minerals has been heretofore made so that it is almost impossible to tell how much of each has been produced. It is of little interest and no commercial value when asphaltum statistics have been added to those of asphaltic limestone. Thus a ton of asphaltum when mixed with sand, etc., at the place where employed for paving forms about 15% of the mixture, consequently a ton of asphaltum suffices to lay about 60 sq. yds. of pavement; whereas a ton of natural asphaltic limestone, called often rock asphalt, permits of no admixture of sand or other materials and will seldom lay more than 10 sq. yds. of pavement. Asphaltum when refined and made into an asphaltic cement by the addition of a little residuum oil or a maltha serves as the matrix or cementing mixture to hold together the sand, etc., which are the component parts of the paving mixture. But asphaltic limestone is used by crushing, powdering, heating, and laying it without changing the crude material.

The relative values for paving are evident when we consider the prices of these two materials, asphaltum at about $35 per ton when refined and ready for use and asphaltic limestone at about $16 per ton when delivered in Atlantic seaboard cities ready to be powdered, heated, and laid. The cost of sand being so small, the asphaltum has the decided advantage at the prices named for constructing pavements. For floors and a few other uses the asphaltic limestone is preferable. The paving industry absorbs fully 90% of the asphaltum used by the 54 companies in America and Europe. It is evident how important it is that an effort be made to tabulate the different natural asphalt compounds separately from asphaltum.

The reports and statistics from the custom houses at the ports of entry and from the different companies and others mining and dealing in asphaltum and its various compounds have during 1895 been unfortunately compiled as heretofore, and it does not seem wise to again publish them without analysis. Special care will be taken in the coming year to analyze as far as possible the past and future statistics of asphalt, maltha, and a few other allied bitumens, also asphaltic limestone, asphaltic sandstone, etc., and tabulate them so that these figures will prove of more practical value than heretofore. This can only be accomplished for the volume of THE MINERAL INDUSTRY succeeding this one.

The principal source from which asphalt is obtained is, as heretofore, from the asphalt lake on the island of Trinidad. A little has been imported from the small land deposits outside of the lake. Another important large deposit is in the State of Bermudez, Venezuela. Probably the deposits of California stand next. They are of two classes, those containing asphaltum and those containing asphaltic sandstone. Kentucky contains asphaltic sandstone, which, however, has not yet been proved to be of great value. The question of how to use it is discouraging, although the solution may be found in time. Texas supplies a soft asphaltic limestone from which an asphaltic gum is extracted of excellent quality for varnish and electric uses. The outcroppings of bituminous substances in Indian Territory are so scattered that practical mining of them has thus far proved unprofitable.

The quantities of asphaltum imported into the United States during 1895 were: From Trinidad, 58,058 long tons; from Bermudez, 3400 tons. The asphaltum mined and shipped from California was about 2800 tons. In addition to the above some glance pitch, or gilsonite, was mined in the United States and a little imported under the name of asphaltum. It is used for other purposes than paving, such as varnish and insulation. The Utah product of glance pitch almost controls the black-varnish market, the only other supply being a little found elsewhere and some exceedingly brilliant glance pitch imported as Egyptian and Assyrian asphalt. The Assyrian deposits have been worked since at least 550 B.C. One is about 60 miles from Bagdad and northeast of Palestine.

The asphaltic limestone of Utah seems so inaccessible that it is doubtful, even if the quality proves good, whether it will become a commercial success for many years. Similar material, found in Indian Territory and called there asphaltic lime rock, is very hard and of irregular formation. It does not seem to be homogeneous nor uniform. A large amount of money has been spent to develop the asphaltic sandstone and asphaltic limestone of Indian Territory, the result so far being failure. One or two quarries have been worked during 1895, and better results are hoped for, especially from the new quarries of asphaltic limestone.

Mexico has small outcroppings of maltha, asphalt, and glance pitch, but they are so small, widely scattered, and practically inaccessible that they cannot form the basis of anything but a very small industry. There is very little asphalt there, most of the material being maltha, which is soft and not suitable for paving, while it is not found in large enough quantities even for use as a flux to mix with the asphalts from the large sources of supply in California, Trinidad, Venezuela, and elsewhere. During 1895 a small shipment of 100 tons of Mexican maltha was imported into the United States under the name of asphalt, but it was so soft that it had to be brought in expensive barrels and cans, which fact, aside from its possible lack of value for paving, added so much expense to the material that it was not a practical article of commerce even for other purposes.

ASPHALT PAVEMENTS IN THE UNITED STATES.

According to *Paving and Municipal Engineering*, the total Trinidad lake asphalt pavement laid since about 1878 in the United States and in use on January 1, 1896, was 19,348,716 sq. yds., the equivalent of about 1335 miles of roadway of an average width of 26 ft. This was laid by about 48 paving companies and contractors, although two or three paving companies have laid a little more than half of it. Many pavements have been laid with other materials than the Trinidad lake asphalt. Without including the coal tar, vulcanite, and other imitations of asphalt pavement, the total amount of other asphalt pavements which have been laid is a little more than 1,200,000 sq. yds., of which about 900,000 sq. yds. were in use on the streets of the cities of the United States and Canada January 1, 1896. The largest part is that of European rock asphalt, technically described as "asphaltic limestone." The use of this, however, is diminishing, because it is probably more expensive for the contractors to lay than the mixtures composed of sand combined with Trinidad or other asphalt. The natural asphaltic sandstones of California have been extensively used there with fair results, where a firm, solid, even pavement is not demanded, as in the Eastern cities of the United States. The balance of the 900,000 sq. yds. of various asphalt pavements is composed of mixtures of sand with California asphalt, according to specifications somewhat similar to those used for laying Trinidad asphalt pavements; also pavements made of materials from Kentucky and Utah, as well as Trinidad lake asphalt pavements. The above statistics are given without reference to the comparative merits of the many kinds of asphalt pavements.

Asphalt and the Paving Question.—The paving question is one which attracts much attention and discussion, and which is growing in importance with the continual increase in the number of towns and cities in the United States which have passed or are passing beyond the dirt-road stage. The old-fashioned cobblestone pavement is now only regarded as a curiosity and a relic of the past, and even the stone-block pavement no longer finds favor except in streets where the traffic is composed of very heavy vehicles, or on sharp grades where a rough footing is necessary for the horses. On streets of residences and outside of the business sections of cities its accompanying noise, dust, and the greater difficulty of cleaning it have caused it to be considered generally undesirable, and it is gradually losing ground.

There are fashions in pavements as in everything else, and they change from time to time, often without regard to the real merits of the case; but in the long run the best generally succeeds. Some 25 years ago great things were expected of wood pavements, and many miles of streets in our larger cities were laid with the different forms which were then devised. In the Eastern cities, at least, the wood-block system did not prove satisfactory, and it has been generally condemned as costly in the first place, difficult to keep in repair, and not very durable. In the West it found more favor, but is not now in very much request for new work even there. At the present time the demand is for a hard, smooth, and even pavement which shall reduce the inevitable noise of street traffic to a minimum. The asphalt pavement meets these requirements, and the charge sometimes made that it lacks the further essential quality of durability has been supported only by quoting instances of failure where it had been put down on poorly made or improperly made foundations; a very important point with all pavements, and one often neglected, either through the ignorance or dishonesty of contractors or the inefficiency of supervising engineers.

At the present time brick pavements are being extensively laid in many Western towns, a circumstance explained by local conditions and by considerations of expense. In the cities of the East the use of asphalt is extending continually, and brick pavements are but little used. New York has spent and is spending a good deal of money in putting down asphalt on its uptown streets, and plans have been prepared for a large extension of this work. Fortunately the street department of the city is for the present under competent and intelligent direction, and the work is being well done.

In a question of this kind all the elements must be taken into account. The extraordinary extension of the use of the bicycle had much to do with the agitation for better country roads, and it is now very distinctly felt in the paving question. The demand for smooth and even pavements has been very much strengthened by the owners of wheels, and the increase in the use of asphalt in the cities has been partly due to this. This has been especially the case in New York. The introduction of the horseless carriage, which is a possibility of the near future, may also have an influence on the paving question.

Upon the whole, there is every probability that the demand for asphalt for paving purposes is going to increase materially. While the imports can readily be increased to almost any extent required, there will also be full opportunity to develop our own supplies.

BARYTES.

Barytes, or barium sulphate, is a mineral of frequent occurrence. It is often found in connection with lead and zinc deposits, forming the gangue of the metal-bearing vein. It occurs frequently also in pockets and occasionally in veins, usually in limestone. The barytes mined and sold is generally from the latter deposits, as that found in connection with metal-bearing veins is as a rule mixed with many impurities.

Barytes—commonly called heavy spar—occurs in many places in the United States. It is mined in Virginia, Missouri, New Jersey, Illinois, and other States, but the chief supply comes from Virginia in the East and Missouri in the West.

The following table shows the production, imports, and approximate consumption in the United States for five years ending with 1895. Statistics for the years previous to 1891 will be found in Vols. I., II., and III. of The Minerai Industry:

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

(In tons of 2000 lbs.)

Year.	Production.			Imports.			Consumption.	
	Quantity.	Value per Ton.	Value.	Quantity.	Value per Ton.	Value.	Quantity.	Value.
1891	21,069	$5.61	$118,363	7,412	$3.58	$26,546	28,481	$144,909
1892	28,476	5.00	142,380	4,667	4.88	22,837	33,143	165,217
1893	26,632	5.00	133,360	4,459	4.21	18,791	31,091	152,151
1894	23,758	4.00	95,032	2,720	5.80	15,826	26,478	110,858
1895	20,255	4.89	99,020	4,680	5.27	24,673	24,935	123,693

The production last year, as will be seen from the figures, showed a decrease of about 15% from that of 1894. This decrease was partly made up by an increase in the imports; nevertheless the total consumption shows a falling off of 1543 tons as compared with 1894 and of 6156 tons as compared with 1893. The depression in the industry which was noticed in 1894 continued to a considerable extent last year. There was, however, an increase in the value of the domestic product, although the average cost of the imports showed a small decrease.

Of the production last year very nearly half, or about 10,000 tons, was from Missouri, where the ore is usually sorted and picked at the mines and shipped to St. Louis for its final preparation. The greater part of the remaining half was from Virginia, but some supply was furnished from North Carolina and smaller quantities from New Jersey and Georgia.

Barytes is prepared for market by first roughly sorting the ore to free it from rock and other impurities and then crushing it. After crushing the barytes is usually boiled in diluted sulphuric acid, then washed to free it from the acid, and finally ground to a fine powder, in which form it comes to the market.

The imported barytes formerly commanded a somewhat higher price than that mined in the United States, chiefly because it was more carefully prepared and more finely and evenly ground than the native. Recently, however, there has been an improvement in this respect, and at present there is very little difference in the price.

The color of barytes varies from white to almost black, the best varieties being the white and the gray. The variation in the color is chifly due to impurities, generally to oxide of iron. Pure barytes ($BaSO_4$) should contain 65.7% oxide of barium and 35.3% sulphuric anhydride, but part of the barium is sometimes replaced by strontium and calcium. The impurities are usually iron oxide and silica, alumina, or clays of different kinds. The chief properties of the mineral are its high specific gravity and its insolubility in acids.

The chief use of barytes is as pigment; for this purpose it is mixed with other substances, usually with white lead. In this country its employment for this purpose, especially with white lead, is considered as an adulteration and is regarded as depreciating the value of the paint. In Europe its use is fully recognized, and for many purposes it is considered a useful and excellent addition. Its insolubility in acid will often render a mixture of barytes with white lead more elastic and less subject to discoloration than the pure white lead. It is believed also to give greater body to the paint and to resist the influence of the weather better than the white lead alone. A small quantity is used here in giving weight and body to certain kinds of paper, and some is sold for use in preparing canvas covers in which hams and other salt meats are packed for market, the canvas thus prepared resisting atmospheric influences and protecting the contents of the package better than that prepared in any other way.

BAUXITE.

By William M. Brewer.

The product of the bauxite mines in Cherokee County, Ala., during 1895 was nearly 14,000 tons, which is the largest for any year in the history of this industry. The production from the mines in Bartow County, Ga., was 4800 tons.

Year by year we are gaining greater knowledge of this mineral and its mode of occurrence, but since its first discovery in Georgia in 1889 and in Alabama in 1891 the number of the known deposits in Cherokee County, Ala., and in the Van's valley or Bobo district and the Cave Spring, in Floyd County, Ga., has not been increased. This shows that really no new discoveries had been made in the districts which were first prospected. But recently a new deposit was opened near Anniston, in Calhoun County, Ala., or, more properly speaking, an old discovery has been developed on land owned by the Alabama Mineral Land Company. This is called an old discovery because Mr. Ballard, an analytical chemist of Anniston, reported it in 1892 and claimed that it was the first made in the United States, since as early as in 1888 the ore was brought to him and he identified it. He then made a test in one of the charcoal furnaces of the Woodstock Iron Company as to its adaptability for furnace lining.

During 1895 there were no new discoveries of deposits of the mineral recorded. The last one was made in Walker County, Ga., on what is known as the Thurman property, in 1893. Some geologists consider it not improbable that discoveries will be made both to the northeast and southwest of the present known limits of the belt, but no efforts have been made to prove that this opinion is correct by actual prospecting. The opinion is based on the fact that the same geological formations in which the several deposits of bauxite have already been discovered extend to Bibb County, Ala., to the southwest and across northwestern Georgia and eastern Tennessee into Virginia to the northeast.

The only important incident in the industry during 1895 was the completion of the organization of the Georgia Bauxite Company, with Capt. A. E. Hunt, of the Pittsburg Reduction Works, as president. During 1894 this company leased for a term of years the bauxite deposits located on the Barnsley estate, in Bartow County, Ga. These deposits really belong to the Hermitage district, in which the first discovery of the mineral was made in Georgia in 1889. The county line dividing Floyd and Bartow crosses this district, dividing it almost equally. It was not until June, 1895, that this new organization commenced actual shipments of ore. Since then the shipments have been 4800 tons of washed and dried ore.

Until 1895 no effort was made by the shippers of bauxite to either wash or dry the ore by mechanical process. The method of drying was by scattering the crude ore as it came from the mine in open sheds covered with iron roofing. The first effort at mechanically drying was at Hermitage, by the Republic Mining and Manufacturing Company, in 1892 or 1893, when Mr. Hawkins, the superintendent, had a revolving furnace built in the old stock sheds of the Ridge Valley Furnace. This was intended for experiment and not for practical working, and for some reason the company did not at that time carry the experiments to completion, but continued to ship ore after being air dried. In the summer of 1893 Mr. Perry, the manager of the Southern Bauxite Company, operating the War Whoop Mine, in Cherokee County, Ala., constructed a drying plant of the revolving-cylinder type, through which all ore passes and is subjected to a high temperature. The Georgia Bauxite Company erected a Colby-Davis furnace which, it was expected, would leave the ore after treatment in a better condition for shipment than as prepared by either of the other companies, but it has been necessary to make several modifications in the plant as at first designed to attain the results desired. No bauxite ore has been washed except by this company, and this practice was only resorted to because the waste dumps at the mines were found to contain a large proportion of the high-grade bauxite which had been wasted when screens were used. The massive structure of most of the bauxite in the mine renders the use of a washer under ordinary circumstances unnecessary.

Besides the addition to the list of producing companies of the Georgia Bauxite Company, noted above, the Alabama Mineral Land Company is making arrangements to mine and ship bauxite from its property. The old companies which are now operating are the Southern Bauxite Company of Piedmont, Ala., and the Republic Mining and Manufacturing Company of Hermitage, Ala.

The average amount received for bauxite ore after deducting freight was about $3 per ton on cars at the mines. The cost of mining, drying, etc., varies, and no definite figures can be given.

The following table shows the production and imports of bauxite in the United States for the six years 1890–95, inclusive:

BAUXITE PRODUCTION AND IMPORTS IN THE UNITED STATES.

Year.	Production.				Imports.		Consumption.	
	Alabama.	Georgia.	Total.					
	Long Tons.	Long Tons.	Long Tons.	Value.	Long Tons.	Value.	Long Tons.	Value.
1890	....	1,850	1,850	$9,250	12,278	$46,137	14,128	$55,387
1891	600	3,300	3,900	19,500	8,021	46,252	11,921	65,752
1892	4,900	4,900	9,800	49,000	5,716	57,948	15,516	106,948
1893	7,063	3,965	11,028	55,205	5,103	28,217	16,131	83,422
1894	8,687	2,045	10,732	42,928	1,028	6,661	11,760	49,589
1895	14,000	4,800	18,800	56,400	5,797	34,782	24,597	91,182

No production was reported from Arkansas during 1895, and no steps were taken to develop the deposits there. The imported bauxite is used chiefly in the manufacture of alum.

BORAX.

So far as production is concerned no material change in the borax industry in the United States can be reported for 1895. There was a heavy reduction in the average price—from 7 to 5½c.—due to the change made in the duty on the imported product. The producers met this and slightly increased their output, showing their ability to hold the market in the face of foreign competition.

The following table gives the production of borax for the five years 1891–95, inclusive. For the years prior to 1891 the production and manufacture and uses can be found in THE MINERAL INDUSTRY, Vols. I., II., and III.:

BORAX PRODUCTION AND IMPORTS IN THE UNITED STATES.

Year.	Production.							Imports.	
	California. Pounds.	Nevada. Pounds.	Total Pounds	Metric Tons.	Value.			Pounds.	Value.
					Totals.	Per Lb.	Per Metric Ton.		
1891........	8,533,337	3,296,663	11,830,000	5,366	$887,250	7½c.	$165	760,232	$51,131
1892........	11,050,495	1,487,701	12,538,196	5,687	940,365	7½	165	705,635	39,850
1893........	7,999,562	1,199,438	9,199,000	4,173	689,925	7½	165	....	....
1894........	11,540,099	1,600,595	13,140,594	5,950	919,842	7	155	....	....
1895........	11,919,141	1,587,215	13,506,356	6,126	742,850	5½	121	....	....

The producing localities in 1895 were the Columbus and Rhodes marshes in Nevada, the Saline Valley marshes in California, and the Calico mines in California. In the Calico district the borate of lime is taken from a fissure vein; the workings have extended to a considerable depth and the deposits have so far proved enduring and of a favorable quality. Experience up to the present has proved that the production from these mines is putting the industry on a firmer basis than under the old plan of working the marsh deposits. The Calico district is the only place in the world where deep mining for borax is carried on. At the Stassfurt mines, in Germany, a small quantity is obtained, but the mining there is for other salts and the borax is only a by-product.

In the management of the industry no change has taken place. It remains almost entirely in the hands of a single producer, and there has been no domestic competition. At the present prices the margin of profit is too small to permit the working of any but the most favorably located and economically handled deposits, and the introduction of mineral from a new deposit worked on a small scale would be difficult, if not impossible. No new discoveries were reported in 1895 and no new developments were made. Mining was carried on steadily, with the results shown in the table; a moderate gain in output over 1895 and a total production which was the largest ever reported, though that of 1892 came very near it.

Borax finds many and varied uses. It is employed as a flux in welding metals, and is an important ingredient in the enamel used on iron ware and in various glazes for china, in which its property of forming fusible salts with many metallic oxides is of great service. It is used also in dyeing and is of service in the manufacture of many drugs and chemicals. It is employed in soap making, while its varied domestic uses are well known. These uses are constantly extending, and there is no prospect that the demand will diminish in the future. On the other hand, the supply is abundant, and the production can be increased without difficulty whenever the additional demand requires it. The sources already known will give a greater output than at present, and there are other deposits which can be developed when needed.

In the foreign production there have been no new developments. The chief sources of supply in Europe continue to be the hot springs of Tuscany, in Italy, and the salt mines of Stassfurt, in Germany. Of these the Italian springs are the more important, furnishing a large part of the European output.

In South America a large quantity of borax is obtained in Chile and Bolivia, chiefly from old lake beds, and recently considerable supplies have been obtained from the Argentine Republic, where it is collected from marshes in a way very similar to the operations carried on in the California and Nevada marshes. Nearly all the South American product is sent to Europe.

A considerable supply also comes to Europe from the deposits of Suzurlu, in Asia Minor, which have been worked since 1869 and which furnish a supply of about 8000 tons yearly. It is said that this supply can be increased considerably, but no detailed or complete account of these deposits has ever been given. The mineral is calcium borate.

For a number of years a supply of borax has been derived from Thibet. It is obtained from the alkaline basins or deserts of that region and is brought to Northern India. While this is the oldest source of supply of this material, very little is known definitely about the occurrence or extent of the deposits.

While the average price (5½c. per lb.) for 1895 is the lowest on record, it fell very nearly to the same level once before, in 1887, when the average was 5⅝c. The highest figure during the past 15 years was 14⅝c., in 1884. Since 1888 there have been very few fluctuations, as the market has been controlled by a single concern.

BROMINE.

The chief source of the bromine supply in the United States is in the mother liquor of a number of brine wells in the salt belt which extends from Western Pennsylvania through West Virginia and Ohio into Michigan. The manufacture is carried on at several points in the States named, the largest producers being in Ohio, though Pennsylvania and West Virginia also furnish a considerable quantity. In Michigan it is obtained only at a few wells in Midland County.

The foreign product is from the salt mines and works of Stassfurt, in Germany, which furnish the greater portion, though some bromine is also made at Leopoldschall.

A possible source of supply is found in sea water, in which bromine exists in appreciable quantities, but none of the commercial supply is from this source.

The following table shows the production of bromine in the United States for the five years 1891–95, inclusive. The statistics and other information for the years prior to 1891 can be found in The Mineral Industry, Vols. I., II., and III.:

PRODUCTION OF BROMINE IN THE UNITED STATES.

Year.	Michigan.	Ohio.	Pennsylvania.	West Virginia.	Totals.	Metric Tons.	Value.	
							Totals.	Per Pound.
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.			
1891	47,320	121,681	85,832	113,953	368,786	167	$73,757	20c.
1892	43,864	135,683	92,978	104,142	376,667	171	64,034	17
1893	42,565	113,575	111,403	80,852	348,399	158	87,100	25
1894	29,116	146,501	100,623	103,304	379,544	172	98,655	26
1895	30,280	152,360	104,647	107,567	394,854	179	102,662	26

The production in 1895 showed an increase of 15,310 lbs. over that of the preceding year. The industry is subject to few fluctuations, as will be seen by the table, and the changes in output have not been important for several years past. There has been very little change in prices also since 1892, when an agreement was made between the German and American producers. This is still in force, and the price in 1895 was about 26c. per lb., the same as in 1894.

The output at Stassfurt and Leopoldschall is about 660,000 lbs. yearly and has been maintained at about that level for several years. The total production last year was therefore about 1,050,000 lbs. of commercial bromine.

The increase in United States production last year was quite evenly distributed.

Of the total output Ohio furnished 38.6%; West Virginia, 27.2%; Pennsylvania, 26.5%; Michigan, 7.7%. In addition to the production given above a small quantity of crude bromides was made by the Midland Chemical Company, at Midland, Mich.

The chief use of bromine is in the preparation of the various bromide salts used in chemistry and medicine. In the manufacture of colors a small quantity is used, and some bromine is also applied as a disinfectant. The uses of the material do not extend very much, the result being shown in the nearly stationary production.

Reference has been made in previous volumes to the proposed use of bromine in place of chlorine in the extraction of gold from pyritic ores. The experiments made by L. D. Godshall and others in this direction were successful, but no application has been made on a commercial scale of the bromination process, on account of the higher cost of the chemical required.

During the past year, however, experiments have been carried on by several parties with reference to the use of bromine as an auxiliary in the cyanide process of gold extraction. In the process patented by Sulman & Teed cyanogen bromide is added in varying proportions to the dilute solution of potassium cyanide. In the Mulholland process bromine is added directly to the dilute solution. Experiments made by A. W. Warwick* and J. S. C. Wells† seem to indicate that the addition of bromine increases the rapidity of action of the solution and perhaps makes a higher rate of extraction possible. The question has been discussed by various writers and chemists,‡ but their experimental conclusions have not so far been supplemented by any demonstrations in practical mill work. It seems to be fairly well established, however, that the addition of bromine with certain ores is worth a trial.

In New Zealand in 1895 Dr. Gaze§ obtained patents covering the use of chloride of bromine as a solvent which can be used in obtaining gold from ores. The chloride is prepared by passing chlorine through bromine until the latter is volatilized and conducting the resulting gas through water, or by passing chlorine through bromine under water. It is stated that this process has proved successful in laboratory experiments, the chloride of bromine dissolving the gold without difficulty, but it has not yet been applied practically. Should any one of the processes referred to be introduced on a considerable scale it would cause an additional demand for bromine, but the amount required would not be very large.

The industry itself is not of sufficient importance to warrant much expense in experiment on new methods of production. It is not surprising, therefore, that no changes in processes or improvements in manufacture are reported.

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* *Engineering and Mining Journal*, June 29, 1895, p. 604.

† *Ibid.*, May 25, 1895, p. 482.

‡ See citations above; also *Ibid.*, April 20, 1895, p. 363; June 1, 1895, p. 510; June 8, 1895, p. 531.

§ *Ibid.*, May 11, 1895, p. 442; July 13, 1895, p. 27.

CEMENT.

Few changes have been reported in the cement industry of the United States during 1895. Some new works were started, while nearly all of the old operators remained in the business. The chief feature was a considerable increase in the production of Portland cement, while that of natural hydraulic cement showed a very slight decrease. The total consumption showed a gain over 1894, in common with nearly all the other materials of construction, but the greater part of this improvement in demand was met by an enlargement of the imports.

The following table shows the production and consumption of cement of all kinds in the United States for the five years ending with 1895. The statistics for the years previous to 1891 can be found in Vols. I., II., and III. of The Mineral Industry:

CEMENT PRODUCTION, IMPORTS, EXPORTS, AND CONSUMPTION IN THE UNITED STATES.

(In barrels of 300 lbs.)

Year.	Production.				Imports.		Exports.		Consumption.	
	Natural Hydraulic.	Portland.	Total Barrels.	Value.	Barrels.	Value.	Barrels	Value.	Barrels.	Value.
1891	....	....	8,222,792	$6,680,951	3,988,315	$4,411,330	97,124	$147,668	12,113,983	$10,944,613
1892	8,211,181	547,440	8,758,621	7,152,750	3,254,273	3,378,331	107,894	169,538	11,905,000	10,361,543
1893	7,445,950	673,989	8,119,939	6,063,131	3,565,932	3,470,169	112,520	174,663	11,573,451	9,358,737
1894	7,895,259	738,196	8,633,455	5,478,051	3,517,476	3,396,729	12,966	15,072	12,137,955	8,859,708
1895	7,694,053	998,745	8,692,798	6,027,374	3,996,527	3,873,123	11,927	13,895	12,676,798	9,931,572

As above noted, the production of Portland cement last year showed a very considerable gain, the increase being from the Ohio, the New York, the New Jersey, and the South Dakota districts. The amount produced in Pennsylvania, chiefly in the Lehigh Valley, showed very little change. While Portland cement finds favor with engineers and architects for some purposes, its manufacture has never been very extensive in this country, mainly owing to the large supply of good material which we possess for making natural cement and the consequent absence of the demand for artificial cements which has promoted their use in Europe. It must also be admitted that not enough use has been made in the United States of scientific methods for making artificial Portland cements of any desired quality as is done in Germany and even in England.

The following table shows the production of Portland cement in the United States for 1894 and 1895 by States:

PRODUCTION OF PORTLAND CEMENT IN THE UNITED STATES.

(In barrels of 400 lbs.)

States.	1894.			1895.		
	Barrels.	Value at Works.		Barrels.	Value at Works.	
		Total.	Per Bbl.		Total.	Per Bbl.
California	6,460	$20,400	$3.16	12,212	$32,566	$2.67
Colorado	9,000	28,000	3.11	....	....	....
New Jersey	87,038	152,100	1.75	135,000	236,250	1.75
New York	103,495	244,806	2.37	135,368	308,454	2.28
Ohio	72,220	168,572	2.33	117,706	225,235	1.91
Pennsylvania	272,941	454,218	1.66	272,048	457,584	1.68
South Dakota	41,325	91,350	2.21	61,725	130,000	2.11
Texas	18,750	50,000	2.67	15,000	40,000	2.67
Total barrels	611,229	$1,209,446	$1.98	749,059	$1,430,089	$1.91
Total metric tons	110,877	Per met. ton..	10.91	135,879	Per met. ton..	10.52

Notwithstanding the increase already referred to in other districts, the cement works of Eastern Pennsylvania supplied in 1895 about 35% of the total. New Jersey, New York, and Ohio together made about 50%, the remaining 10% coming from South Dakota, Texas, and California. The Colorado cement works reported no production in 1895.

The production of natural hydraulic cement, which forms more than nine-tenths of the total used in this country, was as follows by States in 1894 and 1895:

PRODUCTION OF NATURAL HYDRAULIC CEMENT IN THE UNITED STATES.

(In barrels of 300 lbs.)

States.	1894.			1895.		
	Barrels.	Value at Works.		Barrels.	Value at Works.	
		Total.	Per Bbl.		Total.	Per Bbl.
Illinois	196,266	$68,793	$0.35	216,010	$75,604	$0.35
Indiana and Kentucky	2,225,000	1,057,500	.47	1,701,023	597,091	.35
Kansas	171,000	115,750	.68	188,000	121,340	.65
Maryland	157,250	80,125	.57	144,450	74,993	.52
Minnesota	105,506	46,525	.44	90,687	37,291	.41
New York, Ulster County	2,659,601	1,755,337	.66	3,230,051	2,422,538	.75
New York, Onondaga County	273,827	141,159	.52	259,843	141,120	.54
New York, Schoharie County	32,735	25,830	.78	31,980	23,804	.74
New York, Erie County	988,272	637,570	.65	970,427	618,577	.64
Ohio	42,420	36,586	.86	39,401	36,024	.91
Pennsylvania	414,232	243,559	.57	400,998	233,713	.58
Virginia	3,500	3,000	.86	1,600	1,440	.90
West Virginia	32,000	19,000	.60	....	....	....
Wisconsin	512,157	225,194	.43	419,583	213,750	.51
Total barrels	7,813,766	$4,455,928	$0.57	7,694,053	$4,597,285	$0.58
Total metric tons	1,064,297	Per met. ton..	4.19	1,047,006	Per met. ton..	4.39

The total output in this table shows a slight decrease, which was somewhat unevenly distributed. By far the largest producer is the Ulster County or Rosendale district, in New York, which furnishes some 45% of the entire supply. The history of the manufacture of cement in this district was very fully given in THE MINERAL INDUSTRY, Vol. III.

THE CHEMICAL INDUSTRY.

THE chemical industry of the United States, though still in its infancy, is making such rapid progress that it is clearly destined within a brief period to become very important and may soon rival that of any of the European countries. The foundations for a successful chemical industry—fuel, salt, lime, and sulphur—exist here in quality and cheapness that are unsurpassed in any other country, and the technical chemical knowledge, which is as essential to a successful modern industry as is an abundant supply of raw material, is now also available, as is evidenced by the great progress recently made or impending in many departments of this industry. It is true that the rate of day wages in the United States is at least double that paid in European works, but it is no less true that in the chemical industry, as in nearly every other department of trade and manufacturing, the labor item in the cost of production is as low and often lower here than in any other country.

The most notable improvement in sulphuric-acid making here during the past year has been the adoption of simple devices by which the capacity of an existing plant has been very largely increased. Progress has also been made toward the solution of the problem involved in the fixation of the nitrogen of the atmosphere in ammonia, and in the economical manufacture of soda and several other chemicals by electrolysis. The alkali manufacture is, after sulphuric acid, the most important department of the chemical industry, and as it is making immense progress, it is of great interest to be able to show how it has grown. In Vol. II. of THE MINERAL INDUSTRY was given the development of the alkali industry in Europe and the technical details of the several processes that have been and are now being used both there and here.

A few more or less unsuccessful efforts were made before 1884 to make soda in the United States, but the birth of the industry here may be said to have commenced practically in 1884 with the manufacture of 11,000 metric tons of soda ash by the Solvay Process Company, at Syracuse, N. Y. This company was organized in September, 1882, with a capital of $300,000, and commenced the erection of works with an estimated capacity of 30 tons of soda ash a day, and in 1884 it commenced regular production. To-day its plant covers an investment of some $6,000,000 and has a capacity of 175,000 tons of soda ash alone at Syracuse. The improvements introduced from the very beginning increased the output beyond the estimated capacity when the works were planned, as is shown in the accompanying table of materials used and products turned out each year. This valuable table, contributed to THE MINERAL INDUSTRY by the courtesy of the company, is in itself almost a history of the alkali industry in the United States, for it covers probably nearly 90% of the entire output. In 1894 and 1895, when there were a number of other producers, the Solvay Process Company made about three-quarters of the entire output and is now building a large plant near Detroit, Mich.

MATERIALS CONSUMED BY AND PRODUCTS OF THE SOLVAY PROCESS WORKS, SYRACUSE, N. Y.
(In metric tons.)

	1884.		1885.		1886.		1887.		1888.		1889.	
	Tons.	Price	Tons.	Price	Tons.	Price	Tons.	Price	Tons.	Price	Tons.	Price
Materials used:												
Salt as brine	20,000	$1.25	28,000	$1.25	45,000	$1.25	58,000	$1.25	90,000	$1.12	99,000	$1.00
Limestone	21,000	1.25	29,000	1.25	47,000	1.25	60,000	1.25	100,000	1.25	124,350	1.00
Coal consumed	22,000	2.00	30,000	2.00	48,000	2.00	62,000	2.15	90,000	2.15	101,395	2.25
Coke	......	......	......	......	......	......	8,000	3.75	11,000	3.75	12,000	......
Ammonia as sulphate	440	69.00	520	70.00	615	68.00	680	66.00	920	66.00	990	66.00
Sulphuric acid	......	......	......	......	......	......	......	......	......	......	......	......
Bauxite	......	......	......	......	......	......	......	......	......	......	......	......
Products:												
Ammonia sulphate	......	......	......	......	......	......	......	......	......	......	......	......
Tar produced	......	......	......	......	......	......	......	......	......	......	......	......
Soda ash, 58%	11,000	40.00	15,000	35.00	24,000	32.00	34,700	28.50	50,700	26.25	54,500	26.35
Caustic	......	......	......	......	......	......	......	......	4,120	55.00	9,100	53.25
Bicarbonate	......	......	......	......	......	......	......	......	3,145	42.00	3,400	40.00
Crystals	......	......	......	......	......	......	......	......	......	......	......	......
Sulphate of soda	......	......	......	......	......	......	......	......	......	......	......	......
Crown filler ($CaSO_4$)	......	......	......	......	......	......	......	......	......	......	......	......
Oxide of alumina hydrate	......	......	......	......	......	......	......	......	......	......	......	......

	1890.		1891.		1892.		1893.		1894.		1895.	
	Tons.	Price	Tons.	Price	Tons.	Price	Tons.	Price	Tons.	Price	Tons.	Price
Materials used:												
Salt as brine	115,000	$1.00	125,000	$1.00	150,000	$1.00	160,000	$1.00	197,000	$1.00	215,000	$1.00
Limestone	153,110	1.00	189,800	1.00	209,840	1.00	199,070	1.00	240,000	1.00	270,000	1.00
Coal consumed	122,690	2.25	142,910	2.25	173,180	2.25	162,485	2.25	170,000	2.25	200,000	2.25
Coke	14,680	3.50	17,340	3.50	18,785	3.50	17,220	3.50	20,000	3.50	25,000	3.50
Ammonia as sulphate	1,260	66.00	1,400	70.00	1,670	70.00	1,600	65.00	1,790	64.00	1,800	65.00
Sulphuric acid	......	......	......	......	......	......	......	......	700	......	700	7.00
Bauxite	......	......	......	......	......	......	545	......	160	......	......	......
Products:												
Ammonia sulphate	......	......	......	......	75	65.00	130	65.00	135	65.00	135	65.00
Tar produced	......	......	......	......	276	8.00	420	8.00	415	8.00	420	8.00
Soda ash, 58%	65,870	27.54	70,990	30.50	82,000	33.60	85,000	32.00	104,600	23.50	120,000	23.00
Caustic	11,120	60.00	14,960	69.00	23,800	69.00	22,700	66.00	30,000	53.00	36,000	41.00
Bicarbonate	4,090	40.00	6,520	39.00	8,400	39.00	8,940	37.00	9,900	36.00	9,900	36.00
Crystals	......	......	......	......	......	......	......	......	430	40.00	430	40.00
Sulphate of soda	......	......	......	......	......	......	100	......	330	11.00	350	11.00
Crown filler ($CaSO_4$)	......	......	......	......	......	......	......	......	700	25.00	700	25.00
Oxide of alumina hydrate	......	......	......	......	......	......	70	66.00	100	66.00	......	......

All the alkali produced in the United States is made by the ammonia process, with the exception of a little made electrolytically by the Castner process at Saltville, Va., where this process has recently been introduced. Nevertheless the other works are all experimenting also with electrolytic methods. The Solvay Process Company's works at Syracuse enjoy the immense advantage of exchanging experiences with the European Solvay works. Any improvements made by any of these can be used by all the others, and no doubt to this aggregation of experience is due the wonderful progress that has been made both in increasing output and in reducing cost.

The Chemical Market During 1895.

Heavy Chemicals.—The course of the heavy chemical market during 1895 was regular and unexciting. Following the lines of general business improvement noted during the second half of 1894, the consumption showed signs of returning to normal proportions, and the production of the domestic article and the importations of foreign goods showed a corresponding increase. In this country the Solvay Process Company and in England Brunner, Mond & Co. and the United Alkali Company practically control the situation, so that after the episode of 1894—the sending to England of some lots of caustic soda—a truce was arranged and the various interests worked amicably in this country.

There really was no especially salient feature in the market here during 1895. Caustic soda opened at 2@2¼c. according to test. There was an improved business in point of volume, but lacking in elements of uncertainty or speculation. The weeks dragged on without appreciable change, but in the fall, owing to the understanding among makers, values stiffened and ruled steady, so that at the close of the year ruling prices were 2⅛@2¼c. per lb. for 70–74% and for 76% 10c. more per cwt. The same remarks apply to alkali. Prices declined during the course of the year, for on January 1, 1895, quotations were 90@95c., according to test and package. As low as 80c. per 100 lbs. was subsequently paid on a few large orders, but this could scarcely be called a fair market quotation. In the fall prices stiffened gradually, so that at the close of the year quotations were 90@97½c. according to test and package, though business was done at 85@90c. Late in December it was definitely announced that the differences between the English alkali makers had been arranged and an agreement signed.

The large decrease in the imports of sal soda noted in the statement given below shows how the decreased cost of the domestic article has brought it into more extended use. Prices opened at 70@75c. for domestic and 5c. higher for English. Gradually the price declined, and as low as 60@62½c. was paid for domestic. Our cousins across the water have not deemed it worth their while to compete with this price, and hence the falling off in imports.

Bleaching powder enjoys the advantage of having no competition from domestic sources. The English article is the favorite, due to its excellence, and the continental makes have a hard time of it in their endeavors to gain a foothold here. Owing to the general business improvement the imports of bleach were heavier in 1895 than in 1894 by about 20%. It is noteworthy, though scarcely to be wondered at, that the imports of the continental article for last year show a falling off of over 50% as compared with 1894.

Prices being regulated by the alkali "Union" naturally fluctuated but little, opening at 1.75@1.90c. for prime English brands and 1.50@1.65c. for continental. Prices stiffened and advanced slowly until at the close 1.90@1.95c. was the current spot price. Contracts for yearly supplies are made for a certain quantity, and prices are based on the current market quotations at the time of delivery, with the stipulation that they are are not to exceed a certain maximum figure. Such an arrangement is equitable to the contractor, for it eliminates the uncertain or speculative element. The lower the current price is the less the contractor pays. During December supplies grew scarcer owing to storms on the other side interfering with shipping operations, and as a consequence current market rates were 10 or 15 points higher than the maximum contract price. The principal consumer, the paper trade, was more active in 1895 than in 1894, and the bleaching-powder market showed a corresponding improvement.

Chlorate of potash also showed a marked increase in imports. Closing quotations were 8¾@9½c.

The following table shows the imports of chemicals for the five years ending with 1895:

IMPORTS OF CHEMICALS INTO THE UNITED STATES. (IN POUNDS.)

Year.	Nitrate of Soda.		Bicarbonate of Soda.		Caustic Soda.		Sal Soda and Ash.		Other Soda Salts.	
1891.....	219,712,640	$2,579.930	1,500,663	$26.936	68,154,226	$1,700,532	347,822,902	$4,509,611	16,226,334	$114,955
1892.....	213,456,320	2,933,174	1,466,595	25,874	54,384,120	1,309,500	361,648,637	4,698,379	40,954,822	284,853
1893.....	257,626,880	3,673,537	1,380,426	23,136	52,1[illegible]6,492	1,171,878	348,972,506	3,982,772	29,850,109	205,523
1894.....	219,824,646	3,189,084	....	....	46,554,322	919,197	321,300,874	2,665,838	17,667,314	132,385
1895.....	236,959,000	3,778,360	....	....	72,019,114	1,211,000	307,026,104	2,321,612	9,943,015	155,006

Year.	Nitrate of Potash.		Muriate of Potash.		Chlorate of Potash.		Chloride of Lime.	
1891.....	15,292,057	$469,591	78,144,810	$1,220,119	3,134,464	$363,795	108,880,831	$1,632,127
1892.....	13,012,087	382,771	70,227,971	1,098,267	3,568,751	365,326	100,888,561	1,962,084
1893.....	13,374,016	369,274	74,663,116	1,192,516	3,881,791	481,839	98,618,148	1,843,410
1894.....	9,375,950	249,842	101,597,074	1,540,081	4,599,969	573,154	96,256,251	1,697,038
1895.....	11,419,090	505,207	81,732,736	1,296,164	4,917,636	456,342	103,317,968	1,628,877

Soda Production in the United States.—The production of soda in the United States is increasing rapidly, and the output for 1895 was about 161,000 metric tons, counted as 58% ash. (It is a satisfaction to have one industry in which the greater part of the product is counted in metric tons.)

The great Solvay Works are preparing to increase capacity by 50% through their new Detroit works. The Mathieson Alkali Company at Saltville, Va., is also preparing to make a large output of ash and caustic during 1896, and is now working the Castner electrolytic process with excellent results. This company has a magnificent plant and will be an important factor in the market.

The neighborhood of Detroit, Mich., will shortly become the greatest alkali-producing center in the United States. The new Solvay works, the Michigan Alkali Works at Wyandotte, Church & Co. at Trenton, and two other projected works are all in the vicinity of Detroit. The Standard Oil Company also proposes to operate alkali works at Cleveland, Ohio.

There is every prospect that in a few years more the United States will not only make all the alkali required for domestic consumption, but it will before many years export to other markets. When our manufacturers have been able to meet a market price of 80c. per 100 lbs., as they did in 1895, it is evidence of what they can do, and the cost is constantly being reduced by increasing production and by utilizing waste by-products.

Nitrate of Soda.—There were no violent fluctuations in this market during 1895. The price opened at 1.95@2c. in January, and declined steadily, touching 1.60c. in May. From that time it slowly and steadily improved, going as high as 1.80c. It closed steady at 1.70c. The consumption showed a fair increase over the preceding year.

In a report issued in 1895 by the Treasury Department of Chile the production of nitrate for several years back is given as follows, in Spanish quintals, the quintal being equivalent to 90 lbs.: 1894, 23,778,413; 1893, 21,056,580; 1892, 17,478,000; 1891, 18,739,000; 1890, 23,373,000.

Messrs. Mortimer & Wisner, the well-known nitrate brokers of New York, estimate that the production during 1895 amounted to 1,270,000 tons, the largest ever known. Of this amount about 1,162,000 tons were shipped to Europe and about 108,000 tons to the United States. The production for 1896 promises to be even greater than in 1895, the low prices having caused an increased consumption in Europe, which is likely to continue.

The following statistics of nitrate have been compiled by Messrs. Mortimer & Wisner:

(1 bag = 220 lbs.)	1891.	1892.	1893. (*a*)	1894.	1895.
Imported into Atlantic ports from the west coast of South Africa from January 1 to January 1....Bags.	632,536	641,165	767,332	714,631	819,214
Imported from January 1 to January 1 from Europe....Bags.	18,802	5,862	16,712	....	4,300
Totals....Bags.	651,338	647,027	784,044	714,631	823,514
Stock in store and afloat December 31 in New York....Bags.	50,685	14,034	36,838	55,067	48,189
Stock in store and afloat December 31 in Boston..Bags.	900	420	3,000	1,300	....
Stock in store and afloat December 31 in Philadelphia....Bags.	....	....	....	....	150
Stock in store and afloat December 31 in Baltimore....Bags.	2,000	1,000	5,100	2,000	5,500
To arrive, actually sailed....Bags.	188,000	164,000	125,000	259,000	310,000
Visible supply to April 15....Bags.	241,685	179,454	169,938	317,367	363,839
Stock on hand January 1....Bags.	36,454	53,588	15,454	44,938	58,367
Deliveries December....Bags.	36,098	35,280	134,837	123,568	93,526
Total yearly deliveries....Bags.	634,207	685,158	754,560	701,202	828,042
Prices current December 31....Bags.	$2.07½	$2.15	$1.77½@1.80	$1.95@1.97½	$1.77½@1.80

(*a*) Included in the deliveries of 1893 are 9500 bags shipped to European ports.

Acids.—During the first half of 1895 the acid market was practically what it had been during the preceding year. The depression of 1893 and 1894 resulted in leaving considerable stocks in the hands of makers, and this in turn tended to make competition among them very lively and prices very low. During the second half of the year a marked improvement took place in the demand, and acid became scarcer than at any time since 1892. Prices naturally advanced, and by the time the contracts for 1896 delivery were ready to be signed values were higher than had been expected.

Prices opened in January as follows: Sulphuric, 60°, 60@70c.; 66°, 70@85c.; chamber acid, 50°, $5.75@$6.50 per ton; muriatic, 18°, 75@85c.; 20°, 80@85c.; nitric, 36°, 3.20@3.50c.; 40°, 3.90@4.35c.; 42°, 4.35@5c. These prices did not go much lower, though early in the summer they were "shaded" and obtained rather freely, 66° sulphuric selling in some instances at 65@70c. and chamber acid in large lots at $5.25@$5.50 per ton. Later on values advanced, and on December 31 they were: Sulphuric, 66°, 75@90c. per lb.; chamber acid, 50°, $6.50@$7 per ton; muriatic, 20°, 70@80c. per lb.; 22°, 80@90c.; nitric, 36°, 3.50@4c.; 40°, 4@4.50c.; 42°, 4.50@5c.; aqua fortis, ¼c. less per lb. than nitric of the same strength.

As compared with 1894, 1895 undoubtedly showed an increased consumption. The improvement in the business of consumers was general and more acid was used. The production also shows an increase over 1894. While there has not been a marked increase in the productive capacity of the plant of any one manufacturer, alterations and improvements were made by various others, which resulted in a greater aggregate capacity. The year was not altogether a profitable one, for business was not really good until the fall; but considering the "cutting" of the first half of 1895, manufacturers had no good reason to be dissatisfied.

Brimstone.—The course of the brimstone market during 1895 was uniformly steady and prices ruled low. On January 1 quotations for best unmixed seconds were $16@$16.25 and $1 less for thirds. On July 1 prices for seconds were the same, but thirds were higher, being quoted at only 50c. per ton less than seconds. On December 31 best unmixed seconds were held at $15.25@$15.37½ and thirds at 50c. less. All these quotations were for shipments. The price of brimstone on the spot or near by is always higher, as nobody buys that way unless he is in urgent need of supplies or else in small lots, and hence is expected to pay a higher sum. Again, a decrease in the available supply for prompt delivery puts up the price of spot, as was the case when, owing to the loss in the Mediterranean of a steamer having some brimstone for this country, prices advanced, and $17 for spot and near by was quoted. This lasted only as long as the shortage in the supply existed.

The shipments of brimstone from Sicily to the United States during 1895 were less than in 1894. We are enabled, through the courtesy of Messrs. Alfred S. Malcomson and Parsons & Pettit, the well-known brokers in brimstone, to give interesting and valuable statistics. Thus the exports from Sicily to the United States during 1895 were as follows: January, 5758 tons; February, 9675 tons; March, 7350 tons; April, 5900 tons; May, 3225 tons; June, 9675 tons; July, 7650 tons; August, 8613 tons; September, 11,485 tons; October, 7494 tons; November (estimated), 12,000 tons; December (estimated), 10,000 tons. Total for the year (estimated), 98,825 tons.

Stocks in Sicily were heavy during nearly all of 1895, to which fact must be attributed the uniformly low price of the year. In November, 1895, stocks were 216,000 tons, as against 193,000 tons in November, 1894, and 210,000 tons in November, 1893.

Some Japanese brimstone arrived at New York during the year, and while exact figures are wanting, it is safe to say that the total was under 10,000 tons.

The total imports into the United States during 1895 were 125,959 tons, compared with 124,467 tons for 1894. The greater amount for 1895 is due to the fact that in the receipts are included cargoes which sailed from Sicily in 1894.

The United States production in 1895 was confined to a small output from Cave Creek, Utah, and a few hundred tons produced in an experimental way in Louisiana. It is expected that the near future will see a substantial output from these and other domestic fields.

The German Chemical Industry.

By Dr. George Lunge.

A report on the German chemical industry should deal with two separate matters: firstly, with its extent and the profits realized; secondly, with the technical progress made during the period in question. Evidently the latter has always some influence upon the former, but hardly ever in a direct ratio; on the contrary, it happens not infrequently that during a period of great external prosperity manufacturers are too busy to occupy their time with improvements of old or experiments on new processes, while in times of diminished or vanishing profits necessity compels them to turn their attention to plans for cheapening the production, for increasing yields, and for introducing new articles. Still, it may be taken for granted that technical progress generally goes hand in hand with commercial prosperity.

Considering it in this light, the German chemical industry is still moving in an upward direction. As stated by Mr. Wenzel, the General Secretary of the German Association for the Protection of the Interests of Chemical Industry (from whose official report of September 20, 1895, I have taken the following statistics), the quantity of raw materials imported for chemical purposes into Germany (chiefly pyrites and nitrate of soda) in 1894 exceeded the importation of 1893 by 75,875 tons, while the importation of manufactured articles in 1894 decreased by 11,265 tons, and their pecuniary value by 2,400,000 marks. On the other hand, the exportation from Germany in 1894 exceeded that of 1893 in both respects; the raw materials (chiefly potash salts and common salt) by 27,908 tons; manufactured products (coal-tar colors, explosives, cyanide of potassium, alkaloids, etc.) by 17,933 tons. In spite of an extraordinary shrinkage of prices, the balance of trade in 1894 exceeded that of 1893 by 7,000,000 marks; the total value of exportations in the chemical line amounting to 33,000,000 marks more than that of importations.

Taking a general view of the German export trade, we find that in 1888 the value of the chemicals was 7.04% of the total exported; this proportion has steadily increased from year to year, and in 1894 it had reached 9.98% of the total.

The number of factories comprised in the "Berufsgenossenschaft" of the German chemical industries in 1894 showed an increase of 159, that of the men employed of 4342, that of the days worked of 1,302,600, that of the wages of 4,500,000 marks. The average amount of wages per annum in 1893 was 879.34, in 1894 885.04 marks. The dividends paid in 1894 by 91 chemical works carried on as limited liability companies, which publish their balance sheets, representing a share capital of 224,729,500 marks, amounted to 29,373,845 marks, or an average of 13.44%, being the highest average on record since the year 1882, when these statistics were commenced. This does not take into account the sums set apart for amortization, interest on mortgages, dividends on preferred stock, etc. Of the 91 companies comprised in the above list, 13 paid no dividend at all, 12 paid dividends up to 5%, 34 between 5 and 10%, 16 between 10 and 15%, and 16 upward of 15%.

It is unnecessary to say that the various branches of the chemical industry have a very unequal share in these profits. I shall quote the principal groups quite summarily. The works manufacturing scientific, pharmaceutical, photographic, and technical chemicals averaged a dividend of 11.93%, which is decidedly less than the average of the last ten years, owing to the decline of prices, in spite of increased sales. The manufacture of spirit of wine and products derived therefrom suffered a good deal from the excessive fluctuation of the price of raw spirits. The industries of tartaric, oxalic, and acetic acid seem to have been comparatively unremunerative. Mineral colors were improving, especially the manufacture of ultramarine, which, however, even now is carrying on a very hard struggle for existence. But the manufacture of coal-tar colors has been as remunerative as ever, the average of dividends, which in 1885 was 7.05%, now amounting to 23.13%. A number of valuable inventions have been made in German factories during the last year, and the above financial results very distinctly prove that the enormous sums spent by the German manufacturers of coal-tar colors upon chemists' salaries and laboratories are bearing excellent interest.

The manufacture of explosives in 1894 averaged a dividend of 17.37% ; this has only once been materially exceeded, 19.73% in 1890. The principal exportation was to South Africa ; in South America sharp competition was encountered from North American firms. In the lucifer-match industries the dividends of the corporations, working on a large scale, averaged 6.06%; but the smaller manufacturers, working under less favorable conditions, seem to have fared very badly. The prices were at a very low ebb, owing to the cheap Japanese ware inundating the East Asiatic market and forcing back the European produce into the home market.

In the manufacture of artificial fertilizers great complaints were made about insufficient dividends. In this branch of industry extremely low prices were ruling, partly owing to the sharp decline in the price of Florida phosphates, which told upon the market price of German superphosphate long before the effect of the cheapened raw material came into play. For all that the dividends in 1894 still averaged 6.69%. This is certainly less than at any time since 1888; but there seems to be no reason for much grumbling at such a dividend, especially when it is considered that in 1886 the dividends averaged only 2.27%.

We now come to the manufacture of heavy chemicals (acids and alkalies). Here the dividends of the companies which publish such averaged in 1894 9.23%, which is considerably in excess of any return during the last ten years, and probably also during any previous period. The official report frankly acknowledges that both soda and potash products commanded a large sale, and that at remunerative prices; only toward the end of the year it seemed as if there was a decline in both directions. Bleaching powder and hydrochloric acid kept well up; sulphuric acid suffered to some extent under the depression in the sale of superphosphates, but it was apparently recovering the lost ground. Potassium chloride and "Abraum" salts did very well, but this was not the case with some other potassium salts. As might be expected from the great development of the manufacture of modern explosives, especially smokeless powders, which are reducing the use of black powder, the demand for saltpeter is constantly receding. In the case of potashes, the carbonate made from potassium chloride is in sharp competition with that made from beet-root molasses; but a new factor is the manufacture of caustic potash by the electrolysis of potassium chloride, which in this case makes every competition from other quarters hopeless. (See later on.) A similar change, for the same reason, has already commenced in the manufacture of chlorates; the day does not seem to be far distant when it will not pay to make chlorates by any other than the electrolytical process. In the beginning of 1894 prussiate of potash paid very well, in consequence of the great demand for potassium cyanide, but in the course of the year the demand slackened, and as a number of new works had been started, the prices shrank to the lowest level on record.

I now leave Mr. Wenzel's statistics and turn to those which I have myself collected, principally for the forthcoming third volume of my *Sulphuric Acid and Alkali*, and which, of course, exclusively refer to the industries comprised under that title. In the year 1860, when I first came into contact with that group of chemical industries, Germany held only a modest place in the manufacture of chemicals in the world; in comparison with the British production Germany was nowhere, and she was, on the contrary, one of England's best customers for alkali and bleaching powder. About 1878, when I began to publish the first edition of my *Sulphuric Acid and Alkali*, the state of matters had greatly changed. At that period the larger German acid and alkali works had already emancipated themselves from a mere imitation of the French and English style of manufacturing, which had formerly prevailed. These imitations had been very incomplete and frequently very unfortunate, owing to the fact that there was at that period comparatively little known in any one country about the style of working in other countries. This is very different now, as everybody knows. At that period, however, the Germans had already begun to have ideas of their own in that field, and to investigate the conditions of chemical manufacturing in a more scientific way than their neighbors were accustomed to. They still imported foreign, especially English, inventions (as is quite natural and will of course be done to the end of time), but they did not do this any more in a mechanical way, making, on the contrary, important improvements and additions of their own. The Deacon chlorine process, for instance, was for the first time thoroughly worked out and put on its present level by the efforts of Hasenclever, at Stolberg; from the same place came the rational blende-roasting furnaces, the Thelen pan, and other inventions which afterward made their way to England and other countries. Other foreign inventions, as the Malétra shelf burners, the Glover towers, the mechanical salt-cake and black-ash furnaces, the Weldon chlorine process, were not merely introduced by all the larger German works, but they were worked with greater attention and economy than in their own homes.

Unfortunately no reliable statistics, in most cases no statistics at all, are obtainable concerning this earlier stage of the development of the German chemical industry. But so much is certain, that the amount of heavy chemicals made in Germany in 1878 must have been very much larger than that produced in 1860, and as far as quality is concerned, the chemicals "made in Germany" were then already at the top of the tree.

When speaking of the development of the industry of heavy chemicals in Germany, we certainly must not lose sight of the fact that this industry was to a certain extent protected by import duties. But that this is not of decisive importance is proved by the following facts. In 1873 the import duty on soda ash was lowered from 40 marks to 15 marks per ton. In spite of that the home manufacture of that article, as far as can be seen, did not at all decrease during the next few years, while that of caustic soda, which was protected to the amount of 60 marks per ton, did not increase to any great extent. In 1879 the duty on soda ash was raised to 25 marks per ton, that on caustic soda was lowered to 40 marks. This lowering of the duty, so far from causing a decrease in the home manufacture of caustic soda, was followed by a large increase in the production of German make and the total expulsion of English caustic soda from the German market. It is true that without a certain amount of protection the German alkali manufacture would have been nipped in the bud by the sharp blast of English competition. Without some such protection (which has never attained undue proportions) no headway could have been made against the enormous advantages enjoyed by the British chemical industry, viz., greater cheapness of raw materials, easier communication by land and sea, accumulated experience in old-established works, universal connections, and the possession of the field generally. But in the course of time, as the following statistics will show, all these advantages began to lose their power, the importation of English chemicals into Germany gradually but steadily declined, and for a number of years past Germany has been practically blotted out as one of the buyers of English heavy chemicals.

It is, however, worthy of remark that at the period of which we are now speaking, that is, before Germany had taken her proper place as a producer of heavy chemicals, that country had already proved its hold on the chemical market where not merely "the action of masses" and ordinary business capacities and facilities, but real scientific knowledge was concerned; and that although *no* protective duties existed in that line. Germany already possessed almost a monopoly of the manufacture of most scientific and many pharmaceutical and photographic chemicals; what is even more remarkable, it supplied Great Britain with the bulk of the alizarine and aniline colors consumed by its textile industry, although at that time the raw materials required for the manufacture of these articles were nearly all imported from England into Germany. The almost complete migration of the coal-tar color trade into Germany (and Switzerland) is all the more striking, as the first coal-tar colors were not discovered in Germany, but in England (certainly under the direct auspices of a German, A. W. Hofman), and as even the commercial production of alizarine, which had been first synthetically made in Germany, was discovered simultaneously in England by Perkin and in Germany by Gräbe, Liebermann and Caro. But these manufactures, where superior scientific skill is called for, have not taken anything like as much hold in England as in Germany, in spite of the immense natural and financial advantages possessed by the former country. Nobody has ever denied that this is mainly owing to the superior kind of chemistry instruction at the German universities. But it seems strange that the thousands of non-German students who have been at German universities have not brought about the establishment of chemical industries of the above-mentioned kind on a more extended scale after their return to their own countries. Nor has this been effected by the large number of German chemists who at one time were found abroad. Of course, there are some factories producing coal-tar colors in England, France, etc., but they sink into insignificance beside the huge works at Ludwigshafen, Höchst, Elberfeld, and other places in Germany.

Sulphuric Acid.—Let us now return to our proper subject, the development of the industry of heavy chemicals in Germany since 1878, from which year on more detailed statistics are available. Still, beginning with sulphuric acid, it must be complained that really reliable statistics are even now wanting. Up to 1881 the official returns refer only to "metallurgical" sulphuric acid, that is, that which is produced as a by-product in the smelting of copper and other metals. From then to 1886 the total production of sulphuric acid is included in the returns, and is calculated into acid of 60° B., except Nordhausen acid, which is separately quoted. But from 1887 the returns do not attempt any such reduction to a certain standard, and the official figures are merely mechanical additions of the returns of the single works, throwing acid of 60°, of 66°, and Nordhausen acid all into one pot. We therefore learn comparatively little from the official reports, and I will merely mention from them that in 1869 the metallurgical sulphuric acid produced is given as 135,106 tons, in 1882 the total acid as 286,953 tons, in 1890 as 460,081 tons.

Only for two years do we possess really trustworthy figures, worked out by a specially qualified authority, Mr. Hasenclever. For 1882 he estimates the total acid produced in Germany at 358,149 tons, calculated as 60° B.; for 1890 his figure is 627,392 tons of 60° B., which was obtained as follows:

	Tons.
From German pyrites	138,910
From Spanish pyrites	359,480
From zinc blende	75,313
From copper pyrites, etc.	43,689
From spent oxide of gas works	10,000
	627,392

Since 1890 the production of sulphuric acid must have largely increased, especially through the now generally effected utilization of the blende, of which in 1894 160,000 tons were worked for sulphuric acid in Germany. The German sulphuric-acid production is now more than twice as large as in 1882, and is probably between two-thirds and three-fourths of the British production.

Alkali.—Concerning alkali, including soda ash, crystals, caustic soda, and bicarbonate, but not including potashes, of which we take no notice here, the figures are more abundant and trustworthy than in that of sulphuric acid, and in this case the increase is far more startling. Taking for basis Hasenclever's figures in successive volumes of the *Chemische Industrie,* we find the German production of all sorts of alkali, reduced to the standard of 100% sodium carbonate, to be as follows:

Year.	Leblanc Process.	Ammonia Process.	Total Tons.
1877	......	......	42,500
1883	56,200	59.100	115,300
1890	30,000	165,000	195,000
1894	40,000	210,000	250,000

Hence the German alkali manufacture has attained *six* times the extent it possessed 17 years ago. In 1877 the German soda production was considered by

English alkali manufacturers as a "flea-bite." We cannot exactly tell what the English production may be now, for since 1887 the British Alkali Manufacturers' Association has ceased to publish any returns, and private inquiries have not been responded to. But it is perfectly evident that there cannot have been any notable increase since 1886, for we know at least the quantities of salt decomposed in Great Britain, which in 1886 amounted to 721,543 tons, in 1894 to 795,-901 tons. In 1886 there was produced in Great Britain 250,782 tons soda ash (48%), 182,379 tons crystals (21%), 153,884 tons caustic soda (60%), and 15,083 tons bicarbonate (38%). Reducing all this to 58%, that is, to 100% sodium carbonate, we obtain 432,733 tons of alkali manufactured in Great Britain in 1886. Assuming that the increase in 1894 corresponded to the increase in the quantity of salt decomposed, the production of alkali in 1894 would be abont 477,000 tons, which is not quite twice as much as the 250,000 tons "made in Germany." The flea-bite of 1877 and previous years had grown into a big wound.

Looking at the German chemical trade from another side, we receive the same impression of lively expansion and of emancipation from foreign supplies. In 1872 (the year in which my statistics commence) the importation of soda ash, crystals, caustic, and bicarbonate, reduced to terms of 100% of sodium carbonate, exceeded the exportation by 12,241 tons. This difference in favor of importation went on increasing during the next few years, evidently owing to the development of the industries of coal-tar colors and of fine chemicals, with which the manufacture of soda ash, needed as raw material for the above industries, could not as yet keep pace. The highest excess of importations over exportation was 27,500 tons, in 1876, and this figure kept nearly at the same height till 1879. Then the development of the alkali works, partly aided by the duties introduced in that year, began to tell by diminishing the importations year after year. In 1883 they still exceeded the exportation by 7917 tons; in 1884 there is already an excess of *exportations* of 3305 tons, and this grows steadily to 41,470 tons in 1892. During the last two years it has slightly diminished, but only to 40,089 tons.

Analyzing the figures a little more closely, we find the tide turning in favor of exportation from Germany in the case of soda ash in 1884, in that of soda crystals in 1886, in that of caustic soda in 1890. Bicarbonate (which plays a very insignificant part here) followed last, in 1894.

Exactly the same picture is presented by bleaching powder. In 1882 the importation exceeded the exportation by 5440 tons. In 1887 the tide begins to turn; in 1892 there is already and excess of exportations of 626 tons, and in 1894 this had grown to 2178 tons. Chlorate of potash (and soda) behave in just the same way. In 1885 Germany imported 731 tons and exported 94 tons; in 1890 there is an even balance, but in 1894 the importation is 661 tons against an exportation of 956 tons.

The principal customers for German heavy chemicals are Italy, Switzerland, Belgium, Holland, Denmark, Sweden; the United States took 4030 tons soda ash in 1893; 2120 tons in 1894. Even England has of late several times imported more alkali from Germany than she has exported to that country.

Of course these figures do not represent the whole increase of the manufacture in Germany, for the home consumption of all those articles has largely increased during the same period. But they afford by themselves sufficient proof of the flourishing condition of the German chemical trade, which also impressed every visitor of that department at the World's Fair in 1893.

I do not overlook the seamy side of that marvelous expansion of the manufacture of heavy chemicals in Germany, viz., the danger of overproduction and of the subsequent ruin of some, especially smaller factories. Some of the smaller alkali works have been actually stopped, but their big neighbors have been all the more enlarged. That there is as yet any real overproduction is not borne out by the steadily increasing dividends. It cannot be denied that the customs duties aid the alkali works in earning those dividends; but the German duties have nothing to do with the chemicals sent out of the country. Nor must it be forgotten that the existence of duties is nothing new in that line in Germany, and they were partly even higher at former times than now. The advantages accruing to German manufacturers from import duties are also counterbalanced by the extremely heavy charges for sick-funds and provisions for old age imposed by the German law, but unknown in every other country.

The next part of my task would be to follow up in detail the improvements in manufacturing to which at least part of the described splendid results must be traced. But here we are on more difficult ground. We must at once distinguish between two things: outwardly visible improvements of old and inventions of new processes, and internal economies in the already existing processes, produced by carefully looking after all details and keeping every process under strict chemical control. I am inclined to think that it is chiefly the second class of economies which has been the main cause of the success of the industry of heavy chemicals in Germany.

The most striking differences between German and English chemical works (such as these were a few years ago before the foundation of the United Alkali Company greatly restricted the opportunities for visiting British chemical works) were, firstly, the much greater cleanliness, and, secondly, the incomparably ampler laboratory accommodation and the far more numerous chemical staff of the former. Both the number of chemists and the salaries paid to them would have struck many British manufacturers as downright extravagance if compared to what they were accustomed to. But this apparent extravagance has in the long run proved to be a very profitable investment; and this no doubt equally holds good of the great cleanliness inculcated in all well-conducted German alkali works, at a time when some (certainly not all) of the most renowned British alkali works would have been styled "pig-styes" by irreverent visitors. At that time a good many British alkali makers honestly believed and frequently asserted that in their old-fashioned way they made larger profits and turned out much better stuff than those foreigners, with all their airs and graces. I am quite sure that most of them have now seen the mistake they then made in underrating the ways of their competitors, and probably a corresponding change has come over their works; but owing to the above-mentioned reason I cannot be sure to what extent this has been the case.

Improvements in Manufacture.—As far as the introduction of new or improved chemical processes is concerned, Germany enjoys no particular advantage over England, France, the United States, or other industrial countries. But it is worthy of notice what change has been wrought in that respect by the introduction of a German patent law in 1876. Until then there had been practically no protection for inventions in Germany. Theorists contended that it was both wrong and foolish to fetter trade by monopolies, granted in many cases not to the true inventor, but to somebody who understood how to suck other people's brains, and often for ideas which were considered as common property by those employed in that direction. "Practical men" frequently held that it was cheaper to avail one's self of processes made public by foreign patents than to pay royalties for patents taken at home; nor did they much care if this was called "robbery" by the foreign inventor, all the less as they risked themselves every day being robbed in a similar way by their neighbors.

No doubt there is something in these and other objections to patents, especially chemical patents, and a few small nations up to this day abstain from granting such; but the balance of advantages is largely the other way. There is no better proof for this than the fact that an immense increase has taken place in the number of really valuable chemical inventions in Germany precisely since the introduction of the patent law. Of course the German patent law is not perfect; neither is the American, or English, or French, or any other law which will ever be enacted, but a much worse law than the German one would be still preferable to no law at all. In Germany since 1886 inventions can be quietly and completely worked out and turned into a success, while before that time capitalists mostly considered it very foolish to invest money in pulling the chestnuts out of the fire for people who were only waiting to lay hold of any invention as soon as it was perfected, in the absence of any law securing protection for mental property.

This applies not merely to inventions made in the country itself, but also to those which are imported from abroad. By paying the inventor a certain royalty you acquire all his experience, and this generally costs much less than you would have to spend in attempting to work out all the details for yourself, merely with the help of a published patent specification. Of course there are instances to the contrary, but they are decidedly exceptions to the rule.

This lesson, which to American readers will appear as a truism, was formerly not appreciated in Germany (as it is not up to this day in Holland and Switzerland), but it was quickly taken up and profited by since 1876. I shall quote a few instances of this. Germany for many years has been the largest producer of basic steel by the process of Thomas & Gilchrist, the German royalties for which, while procuring a princely income for the English inventors, have been many times over recompensed by the advantages accruing to the German industry. Germany is also now the largest sugar-making country in the world, to a great extent owing to patented inventions, made in this instance by Germans.

As I have said before, in the industry of heavy chemicals it is not so much special apparatus or processes as specially careful work by which the German factories are distinguished. Beginning with sulphuric acid, the great majority of the works still hold by the old lead chambers, with their appurtenances of hand-worked pyrites kilns, Glover towers, and Gay-Lussac towers. Mechanical burners are not in much favor, not even for roasting blende, most of which is treated in Liebig-Eichhorn furnaces or the modification of these introduced by the Rhenania Chemical Company. Several works have introduced "plate towers;" but as I do not wish in this paper to write *in propria causa,* I abstain from going into any details on this matter. Attempts are being made by several inventors in the same direction, some of them going even further than myself by trying to abolish the lead chambers altogether. The same is pursued from another quarter; the synthesis of sulphuric anhydride from sulphur dioxide and air by means of contact substances (finely divided platinum) is stated to have attained such perfection and cheapness that at one or two works sulphuric anhydride is said to be employed for bringing ordinary chamber acid up to strength, instead of concentration by evaporation. At one factory, I was told, they were going to take down the chambers altogether; but I could not hear of any other works pursuing such a bold plan. The whole thing is still surrounded with a great amount of mystery and a corresponding amount of doubt, and it is hardly likely that the days of lead chambers are numbered.

I have already mentioned that a large amount of sulphuric acid is now produced in the treatment of zinc blende, about 160,000 tons having been worked in this way in 1894. It is expected that within a year or two the whole of the blende used in Germany will be treated in this way. This is a great step in doing away with the nuisance caused by the noxious gases from smelting works. Up to the present it seems to be still usual that the proprietors of the blende pay a certain sum to the chemical works for roasting the blende, the acid maker enjoying this premium over and above the value of the sulphur in the blende.

Sulphate of Soda.—The manufacture of saltcake (sulphate of soda) has not declined in Germany to the extent that might be expected from the preponderance of the ammonia-soda process. This proceeds from the fact that there is still a good sale of saltcake for glass making, and that the consumption of hydrochloric acid is still on the increase, which acid cannot as yet be economically produced by any other than the Leblanc process. Small quantities of hydrochloric acid are made from Strassfurt magnesium chloride, but the expectations formerly entertained by men like Weldon and Péchiney, that Stassfurt would become the purveyor of the world with its chlorine compounds, is quite as far from its realization as ever.

The production of hydrochloric acid from electrolytically made chlorine by means of steam and red-hot carbon, according to the patent of Lorenz, is an interesting sign of the direction which this industry may possibly take at some future period, but it is not likely to become an actual fact for the present.

In the manufacture of saltcake itself, mechanical furnaces are not very much in favor in Germany (they are losing ground even in England), for the very good reason that they are usually worked as open furnaces and thus cannot furnish hydrochloric acid of full strength. The condensation of the acid is now sometimes effected by plate towers, and several publications have been made on their efficiency for that purpose, but for the above-stated reason I will not dilate upon this.

It is easily understood why not much progress has lately been made in apparatus for the manufacture of Leblanc soda, both because this process has been thoroughly threshed out before and because nobody expects it will have a prolonged life. Since 1879, when I published the first edition of my *Sulphuric Acid and Alkali,* very many improvements in details have been made, as can be seen from the second edition of that book, but during the last few years the stream of inventions on this line has been very thin indeed. It is contended, and it may be easily believed, that since the combination of most British alkali works into one huge concern, by applying the joint experience of their best men, brought to one focus, many economies have been effected and the cost of production has been materially reduced. But in spite of that and of the artificial raising of the price of bleaching powder by syndicating it, the United Alkali Company did not pay any dividend on the ordinary shares in 1894. It is unnecessary to comment upon this fact, which strongly contrasts with the dividends paid by the German works.

Ammonia-Soda Process.—This is in a very different position indeed from the Leblanc process, as far as its future is concerned, which everybody assumes to be safe for an indefinite period. But the technical side of the ammonia process is equally worked out to such an extent that no great inventions in that direction seem to be imminent. The simple reactions of this process can be and actually are carried out by extremely different mechanical contrivances. The great bulk of the ammonia ash is made in the various works connected with the Solvay syndicate. In spite of the strict secrecy with which these works are surrounded, their style of work is sufficiently well known. The precipitation of the bicarbonate seems to be carried out in all of them by the Cogswell modification of the Solvay tower, that is, with the help of an internal cooling arrangement. In the other stages of the process the apparatus originally patented by Solvay, which is as complicated as it is ingenious, seems to have been everywhere replaced by much simpler apparatus. The greatest difficulty was formerly experienced in the apparently simple task of reducing the moist bicarbonate to dry soda ash. Solvay himself has taken out one patent after another for this purpose, and many other inventors have followed suit. Ultimately the task has been solved by an invention made at a Leblanc soda works and originally intended for boiling down Leblanc liquors and obtaining dry soda therefrom. This is the "Thelen pan," which is now found at most or all ammonia-soda works. If we consider the fact that at the Solvay works themselves they have abandoned the well-known apparatus, as it is shown in the patents, except the towers (all of which is now, after the expiration of the patents, public property), we shall not be surprised that the various ammonia-soda works not belonging to the Solvay syndicate mostly work with quite different apparatus, which they evidently prefer to Solvay's. A goodly number of such works outside the Solvay syndicate is in existence, but none of them has attained anything like the size of the Solvay factories, which enjoy unparalleled technical and commercial advantages through their working in harmony, and commanding together more than one-third of the soda-ash trade of the whole world. The ammonia ash has now also seriously invaded the stronghold of the Leblanc makers, viz., caustic soda, over which it has the advantage of allowing makers to obtain much more easily the highest degree of purity. But in that domain the most formidable rival will probably be the caustic soda produced in electrolysis.

The indefatigable attempts made by Solvay himself, as well as by other inventors, to combine the manufacture of chlorine with that of ammonia soda, seem to be doomed to remain fruitless. A great deal of noise had been made especially over

Mond's nickel chlorine process, and later on over his magnesia process for decomposing ammonium chloride into ammonia and chlorine. There is no doubt that Mond and his engineers have overcome the immense technical difficulties of these processes with the greatest ingenuity, and that at the works of his firm a certain quantity of bleaching powder is (or has been) regularly manufactured by the magnesia process. But nobody knows what that bleaching powder has really cost to make, and how much that cost will increase with the inevitable deterioration of the plant and of the magnesia "pills." It is significant that Mond's faithful partner, Solvay, has turned his attention to electrolysis, which seems to show that he has abandoned the hope of making the extraction of chlorine in the ammonia process a remunerative operation.

Natural soda, which had attracted much attention a few years ago, has again receded into the background. It would appear that at present the cost of carriage to the great markets of the world is still too high; personal motives of those controlling the various sources of natural soda may also have been active in retarding its utilization. But it seems unlikely that this great natural treasure will remain dormant for an indefinite time to come.

Chlorine.—In entering upon the industry of chlorine, we notice a remarkable change during the last few years. Until quite recently the manufacture of chlorine from hydrochloric acid or from calcium and magnesium chloride was one of the favorite hunting grounds of inventors. My forthcoming volume will chronicle a large number of inventions patented since the first edition, some of which have been actually worked out with great expenditure of ingenuity and of capital. Several of these processes looked very hopeful indeed; particularly those dealing with nitric acid as an oxidizer; also, for instance, the process of De Wilde and Reychler, which employs a mixture of manganese and magnesium salts; and various others. Of Mond's processes for making chlorine directly from ammonium chloride I have already spoken; these would have been available for making it as well from hydrochloric acid. Nor had the efforts ceased for making chlorine from magnesium chloride even after the economical failure of the beautiful but too complicated apparatus of Péchiney and Boulouvard. Some chlorine seems to have been actually turned out on a manufacturing scale from magnesium chloride at Strassfurt. Last, not least, the Deacon process had been so much improved in its details, and had received such an important development by Hasenclever's process for obtaining a stream of pure hydrochloric acid from impure roaster acid, that it seemed to be nearly perfect. In my opinion the Deacon process in its present shape is really the best of those which have proceeded beyond the experimental stage into that of application on a thorough working scale, although the great bulk of chlorine is still made by the old Weldon process.

Electrolytic Processes.—But there is a lion in the path of all the other chlorine processes, in the shape of electrolysis. I beg to be excused for again turning to my own book in order to illustrate the truly marvelous strides made in this direction. In the first edition the report on electrolytical processes occupied only a few lines, and this was at that time quite adequate to their intrinsic importance. In the volume now in the press they will occupy upward of a hundred pages, although most of the patents are only quoted in short abstracts. Only 4 patents are mentioned up to 1872; only 9 more up to and including 1884. But from 1885 onward a stream of patents rushes forth, swelling more and more from year to year, and the cry is still "they come." At the same time only a few inventors still risk the patent fees for other chlorine processes. Sauls, like F. Hurter, who as late as 1888 declared it almost absurd to entertain the notion of applying electricity in the chemical industry, have turned into Pauls, and now knock at the doors of the patent offices with electrolytical processes of their own. One big limited company after another is launched, and electrolytical shares are already important objects in the stock exchange.

I should not think of attempting in a short article like the present to give a synopsis of even the most important electrolytical soda and chlorine processes. I must content myself with pointing out that the prediction which I ventured to make in Vol. I. of THE MINERAL INDUSTRY (p. 63), concerning the development of the electrolytical processes for the manufacture of chlorine, at a time when their success was still doubted by very many otherwise well-informed people, has been decidedly borne out by the facts. It is true that only a small fraction of the bleaching powder in the market is as yet made by electrolysis, but it is now certain that the future of the chlorine industry belongs to this class of processes. As far as chlorates are concerned, the day seems to be already near at hand when electrolysis will have driven Liebig's time-honored processes entirely out of the field. Such a fate befell the manufacture of aluminum, exactly when its preparation by the old sodium process had been immensely advanced by the invention of much cheaper processes for producing metallic sodium by Castner and by Netto; but before these could be fairly got to work, the electrolytical aluminum made at Pittsburg and on a much larger scale at the falls of the Rhine had killed that made by the help of sodium. This is a very significant proof how electricity will help countries possessing no coals, but abundant water powers, like Switzerland and Sweden, in becoming manufacturers of heavy chemicals. North America possesses both coals and water power in quantities exceeding those of any other country, and already in 1892 I pointed to the great danger threatening the European chemical industry by the expansive power possessed by the United States through their unlimited command of those mighty agents in the field of electrolytical processes.

If we try to fix the present aspect of the matter, as far as I can make it out it would seem that so far only one or two German electrolytical chlorine works have emerged from the experimental stage, and are regularly supplying electrolytically manufactured bleaching powder to the market, while the chlorate market has long ago felt the influence of the Vollorbes works (Gall & Montlaur's process). The Griesheim works have added to their electrolytical plant near Frankfort, another much larger plant at Bitterfeld, where also another large works has been erected by a rival company, and it appears that the caustic potash made there from potassium chloride has driven all other caustic potash out of the market. Other works intended for the production of soda are in the course of erection in several countries. England had been lagging behind, not in the number of inventions, but in turning from mere experiments to the application of electrolytical processes on a real commercial scale. During the last few months the foundation of several large companies for that object seems to show that British enterprise has at length entered upon this field with a good will.

In surveying the domain of electrolytical processes for the decomposition of chlorides, we must not lose sight of the fact that by electrolysis we obtain 100 parts of bleaching powder for every 40 parts of caustic soda, and that soda-ash, crystals, etc., are nothing like as economically produced by this process as caustic soda. At present the world consumes at least five times as much alkali as bleaching powder. Hence if all the bleaching powder in the world was made by electricity, this would furnish only about one-tenth of the alkali needed in trade. As far as we can judge the other nine-tenths will be furnished mainly by the ammonia-soda process, but some share will in all probability be supplied in the future by natural soda, and there seems to be also room for other soda processes, which avoid some of the drawbacks and losses of the Leblanc process. It is worthy of observation that the special advantages enjoyed by Great Britain for the working of the Leblanc process, and which have led to its overpowering development in that country, do not exist to anything like the same extent for electrolysis on the one side or for ammonia-ash on the other side, as is evidenced by the course which events have taken.

Conclusion.—The outlook in the field of heavy chemicals is not very bright for the English industry. Already some years ago it lost one of its best customers when Germany not merely emancipated herself from English soda, but began to supply other former customers of England. Another big customer, Russia, has nearly succeeded in obtaining all its supply at home, and the very best customer, America, counts upon doing so at no distant period. British energy, technical skill, and capital will, of course, find other outlets; but the day has passed when they ruled the trade of the world, mostly by applying the "rule of thumb." That rule is very good in its way and it has achieved very much; but just as scientific warfare triumphed over mere pluck, dash, and prestige in 1886 and 1870, the peaceful strife of commerce and manufacture, most of all in the chemical line, requires the general staff of science to lead it on to victory, and this lesson must be learned by every nation which does not wish to fall behind in the great race.

Sulphate of Ammonia Recovery from Gas Producer.

At the chemical works of Brunner, Mond & Co., Northwich, England, there is in operation a plant for the simultaneous generation of producer gas and the manufacture of sulphate of ammonia from the nitrogen in coal. This plant is the invention of Dr. Mond, and so completely has the problem been worked out that not only is a maximum amount of ammonia obtained from the coal, but a producer gas of high calorific value is generated.

The experiments of Dr. Mond showed that the yield of ammonia in the producer was highest when the producer was worked as cool as was compatible with a good combustion of the fuel, and the most favorable results were obtained by introducing 2½ tons of steam into the producer for every ton of coal consumed. About 70% of the nitrogen contained in the coal is recovered, yielding 90 lbs. of sulphate of ammonia to the ton.

The gas producers are cylindrical in shape, 10 ft. diameter and 21 ft. high, and taper at the bottom. In the producer as used in practice about 24 tons of fuel are gasified every 24 hours. Toward the bottom of the producer casing the sides taper inward and end in a conical grate. This grate has a round opening in the center through which the ashes descend into a water lute. The upper portion of the producer has a cone and hopper for introducing the fuel, and underneath the cone is a bell-shaped casting about 7 ft. long which is kept partially filled with fuel. The casing of the producer consists of two wrought-iron shells; air saturated with steam is blown into the annular space between them, and after being thus distributed and heated passes through the conical grate into the fuel. The producer is kept filled up to the bottom of the bell-shaped casting. When fuel is introduced it is first of all distilled as in an ordinary gas retort inside the bell-shaped casting. The gases given off force their way downward through the hot fuel, and during their passage the tarry vapors become fixed and give no further trouble. The gas on being taken off from the producer at a temperature of 450 to 500° C. is made to pass up and down a series of wrought-iron pipes before going to the washers. These pipes are surrounded by annular casings, protected from the air by non-conducting material. The steam-saturated air coming forward to the producer passes through these annular casings and is heated there by the producer gases, and so a considerable amount of heat is returned to the producer. The producer lining lasts a long time and little clinker is made, on account of the low temperature at which it is worked.

After passing through these pipes the producer gas is led through a chamber which is partially filled with water. This water is beaten into spray by revolving beaters, and the spray washes the dust and soot from the gas. The gas is reduced in temperature in this chamber to about 100° C., and it is further loaded with water vapor from the spray; it is then passed through a leaden scrubber filled with perforated bricks. This chamber contains the sulphuric acid for absorbing the ammonia. In practice it is found best not to use pure acid, but to keep in circulation a fairly concentrated solution of sulphate of ammonia, say 36% strength, which contains about 2½% of free acid. At regular intervals a certain proportion of this solution is withdrawn and the sulphate of ammonia recovered, the free acid being pumped back. After the gas has passed through the chambers its temperature is as low as 80° C., and as it is not fully saturated with moisture no condensation takes place. The gas is then passed to a second scrubber constructed of wrought iron and filled with perforated wood blocks. In this it meets a current of cold water which condenses the steam, which heats the cold water to about 78° C. The gas is cooled to 50° C. in this chamber and passes from it ready to be consumed. The hot water in the chamber is pumped into a third scrubber of wrought iron, through which a current of cold air is forced. This air gets saturated with moisture, becomes heated to about 74° C., and is afterward forced back to the producer. The water leaves this third scrubber cold enough to be used again on the second scrubber. In this way about half the steam required in the producer is recovered from the gas.

The producer gas in a dry state contains by volume 17% CO_2, 11% CO, 27% hydrogen, 42½% nitrogen, 0.4% olefins, and 1.8% methane. The fuel used is a common kind of slack and contains 33½% of volatile matter, including water, 55% of non-volatile carbon, and 11½% of ash. At Brunner, Mond & Co.'s works 10 of these plants are now in use, and the average cost per ton of sulphate produced is about $21, the value of the gas being deducted from the cost of the coal.

Manufacture of Potash and Magnesia Salts at Stassfurt.

As by far the greater part of the world's supply of potash and magnesium salts is obtained from the abraum or refuse salts mined at Stassfurt, Prussia, a brief description of the methods of manufacture practiced there will be of interest. The abraum or crude salts consist chiefly of the minerals carnallite, sylvine, and kainite mixed with more or less rock salt and composed principally of the chlorides and sulphates of potash and magnesia. The greater part of the kainite mined is sold in crude state as fertilizer, only a small part being manufactured into concentrated salts. The chloride, sulphate, and carbonate of potash and the sulphate of magnesia are the four chief products manufactured from the crude salts.

I. *Preparation of Potassium Chloride.*—The method in general use depends upon the leaching action either of hot water or of a hot concentrated solution of magnesium chloride, which is obtained in enormous quantities at Stassfurt as a by-product. It consists of the following five operations: 1. Lixiviation of the abraum salts, which average 16% KCl, with barely sufficient hot water or magnesium chloride to dissolve the chlorides of potash and magnesia, but not the bulk of the common salt and magnesium sulphate. 2. Crystallizing the chloride of potassium by cooling to 70° C. 3. Evaporating and cooling the mother liquor down to 15° C. to produce a second yield of crystallized potassium chloride. 4. Concentrating and cooling the remaining mother liquor to obtain artificial carnallite (double chloride of potash and magnesia), which is then treated like the native salt. 5. Washing, drying, and packing the crystals of potassium chloride.

The hot solution (sp. gr. 1.3) obtained in the first operation is allowed to stand in the dissolving vessels to deposit clay and other suspended matter and is then passed into iron crystallizing tanks, in which, after cooling during 2 or 3 days, a mixture of potassium and sodium chloride crystallizes out. If the concentrated crude saline solution is largely diluted with water, the separation of sodium chloride is diminished and a crystallization of almost pure potassium chloride is effected. In order to obtain the potassium chloride still remaining in the mother liquor, the latter is evaporated down to such a concentration that the potassium chloride separates out almost entirely (as carnallite) and only 1% KCl is left in the solution. The artificial carnallite is dissolved in hot water, and as it cools a second crystallization of potassium chloride is obtained. The potassium chloride obtained from both crystallizations is washed with water at the ordinary temperature to remove magnesium chloride and some of the sodium chloride; it is dried in a calcining furnace or in kilns heated by steam. The mother liquor from the second crystallization and the washings containing potassium, sodium, and magnesium chlorides are used for dissolving the crude salt. The pans for evaporating the mother liquor in the manufacture of potassium chloride have three flame tubes, the middle one, through which the flame first passes, having double the section of the two side tubes. To facilitate the ready removal of the salt which separates out on the evaporation of the mother liquor, the bottom of the pan slopes toward the middle and the lowest portion is provided with a helix. By its rotation the salt, which has been deposited on the bottom of the pan, is conveniently removed.

By the above process 75 to 85% of the potassium chloride present in the crude salt is obtained; the rest is lost in the various residues. The proportion of potassium chloride remaining in the muddy settlings is often large, and the resulting clay product, which is calcined and sold as fertilizer, frequently contains as much as 18% of potassium chloride. If the loss in the manufacture be taken at 20%, then 625 kgms. of crude or abraum salt, containing 16% KCl, are required for the production of 100 kgms. potassium chloride of 80% purity. For the daily manipulation of 50 tons of raw salt a space of 350 cu. meters is needed for the crystallizing plant, or a total of 24,500 cu. meters for a daily output of 3500 tons. Potassium chloride of 80% purity is used in the manufacture of potash saltpeter, while for the preparation of potassium carbonate or potash a pure product, as free as possible from sodium chloride, is needed.

II. *Extraction of Magnesia and Glauber Salts.*—As by-products kieserite ($MgSO_4 + H_2O$) and sodium sulphate are obtained from the residues. The former is secured by dissolving out the sodium chloride and allowing the sparingly soluble kieserite to settle as a fine muddy deposit. This absorbs water and hardens in a few hours and is sold in blocks weighing 25 kgms. From a part of the kieserite pure magnesium sulphate, or bitter salt, is obtained by solution and crystallization.

The manufacture of Glauber salt (hydrated sodium sulphate) is at present carried on only in winter, although the contemplated introduction of freezing machines will make the manufacture possible at all times independent of the season. The process depends on the reciprocal decomposition of sodium chloride and magnesium sulphate in aqueous solutions at a low temperature. To this end the concentrated solution obtained by leaching the residues is cleared by settling and then exposed to cold in flat wooden troughs. The crystallization of Glauber salt is often effected in a single night. In this manner about 10,000 tons sulphate are produced yearly.

III. *Manufacture of Potassium Sulphate.*—Large quantities of potassium sulphate are prepared by means of sulphuric acid in a manner quite analogous to the first stages of the Leblanc soda process and with similar furnaces.

Potassium-magnesium sulphate is made from kainite ($MgSO_4,KCl + 3H_2O$) on a large scale by one of the following two processes. The first method consists in treating the kainite with a cold saturated solution of the kainite or magnesium sulphate at 80° C. and cooling the mixture, whereupon the potassium-magnesium sulphate crystallizes out. The second process is based upon heating the kainite with water or brine at a temperature of 120 to 150° under pressure. In this manner 3 tons of coarsely powdered kainite are decomposed in about 30 minutes and the potassium-magnesium sulphate is obtained as an exceedingly fine crystallized powder. The potassium-magnesium sulphate with 50% of potassium-sulphate and 3% of chloride is in great demand for both agricultural and manufacturing purposes, and this is perhaps the reason why its further treatment for pure potassium sulphate is not always carried out.

The utilization of the solutions of magnesium chloride, obtained in enormous quantities at Stassfurt, is still largely an unsolved problem. A small portion is evaporated down and the magnesium chloride after being calcined is sold; from a larger portion the 0.2% of bromine present is separated before it is allowed to run into the creeks. At present about one-third of the final leach liquor is thus treated, yielding annually over 300 tons of bromine and bromides.

IV. *Manufacture of Potassium Carbonate.*—The only process used on a large scale for the conversion of potassium chloride or sulphate into carbonate is an adaptation of the Leblanc soda process, first applied to the production of potash by Grueneberg in 1861. The following precautions have to be observed. In the black-ash process a high temperature must be carefully avoided. If the coal used for reduction is rich in nitrogen, potassium ferrocyanide is produced and must be separated from the carbonated salt by leaching and crystallization. Experiments to obtain potassium carbonate by the ammonia process have hitherto proved unsuccessful.

PRODUCTION OF CRUDE AND REFINED POTASH AND MAGNESIA SALTS IN GERMANY.

Year.	Crude Products.				Refined Products.			
	Kainite.		Other Potash Salts.		Glauber Salt.		Magnesium Chloride.	
	Metric Tons	Value.	Metric Tons	Value.	Metric Tons	Value.	Metric Tons	Value.
1890..........	361,827	$1,299,939	913,030	$2,826,199	68,716	$434,831	14,958	$37,453
1891..........	472,256	1,701,640	898,993	2,771,494	....	....	15,619	39,528
1892..........	549,445	1,955,717	802,630	2,532,169	73,988	502,750	14,386	50,828
1893..........	664,986	2,397,774	861,162	2,762,060	75,965	486,250	12,764	44,493
1894..........	727,234	2,574,805	916,339	2,988,403	66,309	392,640	17,422	50,913

Year.	Refined Products—*Continued.*							
	Magnesium Sulphate.		Potassium Chloride.		Potassium Sulphate.		Potassium-Magnesium Sulphate.	
	Metric Tons	Value.	Metric Tons	Value.	Metric Tons	Value.	Metric Tons	Value.
1890..........	26,376	$79,778	137,005	$4,433,685	31,126	$1,233,036	11,094	$214,629
1891..........	23,126	71,126	129,512	4,282,290	....	....	10,508	190,155
1892..........	23,879	84,008	123,962	4,106,579	22,968	931,750	11,593	228,172
1893..........	27,548	79,250	137,216	4,326,250	22.555	956,500	14,129	288,750
1894..........	28,628	88,814	149,775	4,722,049	23,281	958,736	14.150	274,694

The importance of the potash and magnesia industry can best be appreciated when it is considered that the chemical works in the Stassfurt district annually treat over a million tons of abraum salts and employ nearly 6000 men.

Manufacture of Potassium Cyanide.

By Titus Ulke.

Owing to the general adoption of the cyanide process in the recovery of gold from its ores and consequent enormous increase in the demand for potassium cyanide, great efforts are being directed toward cheapening the manufacture of this chemical. There are three sources of its production: (1) ferrocyanide of potassium, which forms the basis of all the present commercially successful methods, (2) sulphocyanides, and (3) cyanogen, obtained from the nitrogen of the atmosphere or from ammonia.

1. *Production of Potassium Cyanide from Ferrocyanide of Potash.*—Practically all the cyanide of commerce is made from the ferrocyanide and by simple fusion with the addition of alkaline carbonates, metallic sodium or sodium-lead alloy. For most technical and industrial purposes the cheaper and less easily decomposed

cyan-salt—a mixture of potassium and sodium cyanides, prepared by fusing together 8 parts of anhydrous potassium ferrocyanide and 2 parts of sodium carbonate—can be used to advantage instead of the pure potassium cyanide. The 98% cyanide is prepared in the main as follows: The yellow ferrocyanide is dried, pulverized, and thoroughly mixed with potassium carbonate, which is added to lower the melting point of the charge. The mixture is charged into the so-called flange pot—an iron crucible which retains the residue formed, but permits the fused cyanide to flow out through an opening in its bottom into a receiving vessel. The flange pots are arranged in a battery and are heated by a coke fire in square crucible furnaces. According to Liebig the following reaction takes place: $K_4FeCy_6 = 4KCy + FeC_2 + 2N$. When the fusion is complete (*i.e.*, when no more nitrogen escapes) the residue is taken out and the flange pot recharged. The separation of the KCN and K_2CO_3 can be effected by means of alcohol or acetone. The residue consists principally of iron carbide and potash, together with some undecomposed ferrocyanide and only a little potassium cyanide in the best modification of the above process, as the following analysis shows: KCN, 0.89%; K_4FeCy_6, 3.55%; K_2CO_3, 28.60%. Balance chiefly FeC_2 and metallic iron.

In this connection it may be interesting to call attention to a new and improved method for the quantitative determination of potassium cyanide in the iron residue of cyanide manufacture, discovered by Dr. C. Bruehl, of Perth Amboy, N. J. This novel method avoids the errors due to the presence of ferrocyanide and certain other compounds, to which attention has been called by Clennell (*Chemical News*, Vol. LXXII., p. 227) and Conroy (*Journal Society of Chemical Industry*, Jan. 31, 1896, p. 12). The usual method of determining the cyanide contents of these residues by leaching with water is erroneous, owing to the accompanying unavoidable formation of new compounds and decomposition products. In the attempt to overcome these difficulties Dr. Bruehl discovered that acetone dissolved KCN, while not acting upon potassium carbonate and ferrocyanide, and based his analytical method upon this fact. In order to prove the accuracy of the new method, a mixture containing 0.2 gm. KCN, 0.5 gm. K_4FeCy_6, and 1 gm. K_2CO_3 was leached with acetone, and the resulting leach liquor containing the cyanide diluted with water and titrated with 1 : 10 normal silver solution. The soluble portion of the residue was now leached out with water, diluted up to 250 c.c., and one half of this solution taken for the K_4FeCy_6 determination by means of potassium permanganate, while the other half was used for the potassium-carbonate determination. Three analyses gave the following very satisfactory results:

No.	KCN.	K_4FeCy_6.	K_2CO_3.
1	0.1998	0.4993	1.0016
2	0.2003	0.4997	0.9995
3	0.1997	0.5004	0.9998

In the analyses of the iron residue a perfectly fresh sample was secured, to avoid the decomposition of the cyanide by the atmosphere. It was taken from a flange pot which had furnished the best cyanide output and which had only been slightly cooled, and placed in an air-tight receptacle. Ten gms. of the sample were treated in a rubber-stoppered Erlenmayer flask with acetone for 12 hours, filtered and washed, until a drop of the filtrate showed no cloudiness with silver nitrate. The filtrate was then diluted and titrated with 1 : 10 normal silver solution, the number of c.c. $AgNO_3$ being calculated to their equivalent in KCN. Two determinations from the same material gave 0.88 and 0.89% KCN. The residue on the filter was thoroughly extracted with hot water and diluted to 1 liter. Five hundred c.c. of this solution were acidified with dilute sulphuric acid and titrated with 1 : 10 $KMnO_4$, whereby 3.55% of K_4FeCy_6 was found. To 200 c.c. of the liter solution, corresponding to 1 gm. of the original sample, barium chloride was added. The carbonic acid in the precipitated barium carbonate was calculated to K_2CO_3, and thus 28.6% of potassium carbonate was found present.

In the treatment of the iron-carbide residue on a large scale somewhat different results are obtained, owing (1) to the length of time that the residues are stored and (2) to their decomposition and alteration. Proof of this fact is seen in the smell of ammonia noticed during the leaching and is due to the formation of salts of formic acid. Furthermore, in consequence of the presence of iron, ferrocyanide is produced, and the cyanide is acted upon by the carbonic acid of the air, forming carbonate of potash. That the potash extracted always shows a higher percentage in ferrocyanide than the iron residue samples is due, according to Dr. Bruehl, to the fact that the formate of potash produced also reacts upon the reagent permanganate.

The accumulated residues are pulverized, spread on sieves, placed in cast-iron vats, and leached with hot water. The leach liquor is concentrated by evaporation and the resulting solid mass calcined to secure potassium carbonate. This is again utilized in the first fusion for cyanide. The refined potassium cyanide obtained by the above process contains 98 to 99% KCN. It is sold at about 50c. per lb. in cases of 112 lbs., whereas 67% cyanide sells at 37c., while the cost of the chief raw material, prime ferrocyanide of potash, is about 20 to 22c. per lb. The lower the price of the latter the lower the cost of the cyanide, of course. Now, although the process of making ferrocyanide—by fusing together potassium carbonate and iron borings with subsequent addition of animal matter—seems to have reached its highest efficiency, it still involves considerable loss. For this reason many attempts have been made to prepare potassium cyanide otherwise than through the prussiate compound, with the result of developing the following interesting process.

2. *Preparation of Potassium Cyanide from Sulphocyanides.*—Commercial ammonium sulphocyanide, costing about 25c. per lb., is now manufactured on a large scale by a modification of Gelis' process. It consists in agitating calcium or magnesium hydrate, water, ammonia, and carbon bisulphide in a closed steam-jacketed iron vessel at 100° C. The reaction occurring, $CS_2 + 4NH_3 = NH_4CNS + (NH_4)_2S$, is said to take from 2 to 6 hours. The product, after distilling off any excess of free ammonia, is filtered from the lime, etc., and carbon dioxide is blown through the liquor in any suitable apparatus such as the Chance carbonators. This drives off H_2S, at the same time precipitating the lime of the

calcium hydrosulphide as calcium carbonate, while the calcium sulphocyanide remains in solution and may be utilized as desired.

The conversion of the sulphocyanide to cyanide is accomplished by withdrawing the sulphur from the sulphocyanide, either by reduction (by means of some suitable metal) or by oxidation to sulphuric acid. Although Playfair claims to have secured 70% of cyanide by using zinc as a reducing agent, neither his process nor any of the others based upon the above facts has as yet proven commercially successful.

3. *The Production of Cyanide from Air or Ammonia.*—The discovery by Dawes in 1835 of potassium cyanide as an efflorescence near the boshes of certain iron furnaces first indicated that cyanide could be made directly and without the intermediate use of cyanogen compounds. Since then a great many processes have been patented, all based essentially upon conducting nitrogen, or in later processes ammonia gas, over a heated mixture of coke and potash (or barium oxide) and the recovery of the resulting cyanide by distillation or lixiviation.

As Conroy has stated (*Chemical Industry*, Vol. XV., No. 1), the temperature of formation of cyanide by all of these methods is so extremely high as to make the success of any of them very doubtful. Especially is this the case when ammonia is used, since this gas decomposes rapidly at the temperature employed. Castner in 1894 patented a process in which metallic sodium is allowed to flow downward over heated coke, while a stream of ammonia gas passes upward through the mass. The reaction $2NH_3 + C_2 + 2Na = 2NaCN + 3H_2$ is said to take place at a much lower temperature than in the cases cited above, so that the loss by volatilization and dissociation is considerably diminished. In concluding this review of the cyanide manufacture, we see that none of the other methods proposed is as yet able to compete with the old yellow-prussiate process.

During the year 1895 a number of patents for the manufacture of potassium cyanide were taken out in Great Britain. Among these the following are noted:

J. B. Readman (No. 6621) Edinburgh, Scotland; making cyanides by heating electrically carbonaceous matter and carbonate of barium in presence of nitrogen.

A. E. Hetherington, F. Hurter, and E. K. Muspratt (No. 5832), Wednes, England; manufacture of cyanide of sodium or potassium by heating ferrocyanide of sodium or potassium with an alloy of lead with sodium or potassium.

William Mackey and J. F. Hutchinson (Nos. 6925 and 18,792), Glasgow, Scotland; producing cyanides by subjecting alkaline carbonates and carbonaceous matter to the action of a blast in a blast furnace, and then producing ammonia by subjecting the products of the process to the action of steam.

One United States patent is noted; it is No. 543,643, issued to Hamilton Y. Castner, the process consisting in producing an amide by decomposing anhydrous ammonia in the presence of an alkali metal and then converting the amide into a cyanide by decomposing it in the presence of heated carbon.

Among contributions to the literature of the subject may be noted a paper by Dr. Francis Wyatt* on the "Fixation of Atmospheric Nitrogen and the Manufacture of Cyanides and Ammonia," in which the subject is very carefully treated.

* *Engineering and Mining Journal*, Aug. 10, 1895, pp. 124, 125.

Production of Zinc Vitriol from the Zinc-Lead Ores of the Harz.

By Bruno Kerl.

The Rammelsberg deposit near Goslar, in the Harz, occurs in Orthoceras schists (Goslar schists) of the Lower Devonian, and consists of an intimate mixture of gold and silver bearing pyrite, chalcopyrite, blende, and galena,* with gangue chiefly of heavy spar and imbedded country rock (schist). At the edge of the ore deposit the country rock itself is impregnated with metallic sulphides and then bears the name "kniest." Owing to the intimate mixture of the barite and zinc blende with the other sulphides nothing but a simple mechanical preparation of the ore is attempted, this consisting merely of a sorting according to the predominant mineral (copper ore, lead ore, mixed or copper-lead ore, pyritous ore, etc.). Each kind of ore is again sorted according to the size of the pieces into stufferze (pieces of 8 kg. weight), bergkern (pieces the size of the fist), waschkern (egg-size pieces), graupel (pieces from the size of strawberries to hazelnuts), and schlieg (or fines). The copper ore is separated according to its copper contents into three kinds, No. 1, No. 2, and No. 3; the lead ore into pure sulphide and that with much heavy spar (grauerze). The average composition of the Rammelsberg ores is as follows, analyses Nos. 1 to 5 being according to Bräuning:

	1. Copper Ore No. 1.	2. Copper Ore No. 2.	3. Copper Ore No. 3.	4. Mixed Ore.	5. Pyritous Ore.	6. Lead Ore, Stufferze.	7. Lead Ore, Schlieg.
Au	0.00011	0.00009	0.00008	0.00016	0.00006	...	...
Ag	0.017	0.011	0.007	0.017	0.008	0.016	0.013
Cu	17.66	0.64	4.68	4.52	1.01	0.31	0.68
Pb	3.70	2.41	1.77	9.98	6.65	11.66	9.75
Bi	Trace.	Trace.	Trace.	Trace.	Trace.	...	...
Fe	23.02	30.37	33.52	12.41	24.51	5.29	6.79
Zn	9.55	5.82	4.89	21.45	15.45	19.63	16.10
Mn	0.82	1.39	1.57	1.36	2.37	...	...
Ni	0.05	0.05	0.05	0.12	0.08	...	...
Co	?	0.05	0.07				
S	32.11	38.22	40.43	23.65	32.96	17.40	15.90
As	0.12	0.21	0.25	0.11	0.15	...	...
Sb	0.18	0.14	0.12	0.26	0.18	...	...
SiO_2	3.37	3 21	3.87	4.79	4.46	...	...
Al_2O_3	1.72	3.11	1.80	2.54	3.11	...	...
$CaCo_3$	1.16	2.05	3.72	2.57	4.32	...	...
$MgCo_3$	0.40	0.80	1.08	0.99	0.84	...	...
$BaSO_4$	5.61	2.18	1.17	14.79	3.50	...	...

Besides the above constituents the ores contain other elements which are concentrated in certain by-products of the metallurgical processes—*e.g.*, mercury (in the selenium-bearing slime from the sulphuric-acid chambers), cadmium in the flue dust, furnace scaffoldings, and the zinc-vitriol mother liquor), thallium† (in the crude sulphur, flue dust, zinc-vitriol mother liquor, and in the green flame from the throat of the smelting furnaces), etc.

* Literature: *Zeitschr. f. d. Preussische Berg- Hütten- und Salinenwesen*, Bd. 30, Heft I. u. III. (Köhler); *Berg- und Hüttenm. Zeitung*, 1888, p. 208 (Babu); 1864, p. 369; 1893, p. 105 (Wimmer); 1893, p. 137 (Neuburg); 1893, p. 309 (Klockmann); 1894, p. 219 (Vogt); A. von Groddeck, *Abrissder Geognosie des Harzes*, 2 Aufl. Clausthaul, Grosse; E. Häscher, *Das Bergwerk im Rammelsberg bei Goslar*, 40 Seiten und zuri Grubenrisse, Harzburg, Stotte, 1888; O. Hoppe, *Die Bergwerke, Aufbereitungs Anstalten und Hütten im Ober- und Unterharz*, 2 Aufl. Clausthal, Grosse.

† *Journ. f. prak. Chemie*, pp. 105, 343; Dingler's *Polyt. Journ.*, pp. 175, 186, 243, 244; *Ann. d. Chem. u. Pharm.*, pp. 108, 133.

Of the ores thus described the copper, mixed, and pyritous ores (the mixed ores predominating so that the average tenor of all ores does not exceed 5% copper) are sent for reduction* to the Okerhütte, at Oker, and the lead ores to the Herzog Julius and Frau Sophienhütte, lying on either side of Goslar.

At the Okerhütte all the ores (copper, mixed, etc.) are roasted according to the size of the pieces and their sulphur contents in shaft furnaces (kilns), pyrites burners, and three-hearth "muffelfortschaufelungsöfen" (Hasenclever furnaces), the gases being utilized for sulphuric-acid fabrication. The mixed ores are then roasted a second time in heaps under sheds, after which they are smelted in five-tuyère blast furnaces (sumpf schachtöfen) with about 15% kniest and 60 to 70% ore and matte concentration slags. The copper ores are smelted to matte containing 30 to 35% copper, and the mixed ores to base bullion (werkblei) and matte containing 22 to 25% copper. The matte is roasted in the furnaces of the sulphuric-acid department for the utilization of its sulphur contents, and is then concentrated in reverberatory furnaces to a product (spurstein) containing 60 to 65% copper, which is again roasted in covered heaps and smelted to black copper in blast furnaces (spur schachtöfen). The black copper is refined in reverberatory furnaces, where the arsenic, antimony, and bismuth are eliminated and cast into plates (the metal containing about 98.5% copper and 0.12% silver—for example, 98.509% copper, 0.111% silver and gold, 0.039% lead, 0.096% bismuth, 0.454% arsenic, 0.350% antimony, 0.030% iron, 0.041% nickel, and 0.003% insoluble matter) which serve as anodes in the production of electrolytic copper, the latter product containing 99.9937% copper, 0.0050% silver, 0.0008% antimony, 0.0024% oxygen, and a trace of iron. The matte produced in smelting the copper ores and slags with 0.5% lead, as much as 1% copper, and 0.001% silver are run down by an oxidizing smelting (verblasen) in blast-reverberatory furnaces (gebläseflammöfen) to a speissy black copper (königskupfer) which is granulated, the granules containing on an average 92.636% copper, 0.405% silver and gold, 0.337% lead, 0.464% bismuth, 2.152% arsenic, 2.950% antimony, 0.157% iron, and 0.245% nickel. The granulated copper is treated with hot dilute sulphuric acid with admission of air, whereby silver and gold bearing slime and copper sulphate are produced. The base bullion resulting from the smelting of the nickel ores, together with that from the Herzog Julius and Frau Sophienhütte is desilverized by zinc† after a previous liquation, and renfied by means of steam, the refined desilverized lead containing 0.0006% silver, 0.001% copper, 0.050% bismuth, 0.007% antimony, and traces of iron, nickel, and cobalt. The rich zinc crusts, slimes from the copper-sulphate production and electrolytic refining vats, are collected in lead by smelting in a blast furnace (hochofen), and the bullion (reichblei) is oxidized on a German cupellation hearth. The gold and silver bullion (blicksilber), containing about 92% silver and 0.85% gold, is refined in a muffle (silberfeinbrennen) and is parted in porcelain kettles by means of concentrated sulphuric acid. The gold

* Wimmer, *Ueber den Rammelsberger Bergbau*, and Bräuning, *Ueber die Okerschen Hüttenwerke;* Siegemann, *Ueber die Herzog Julius und Frau Sophienhütte*, 35 pp., Hanover, 1895; Kerl, *Die Rammelsberger Hüttenprozesse am Communion-Unterharze*, 2 Aufl.; Bräuning, "Die Unterharzer Hüttenprozesse," in *Ztsch. f. d. Preuss. Berg- Hütten- und Salinenwesen*, Bd. 25, pp. 13–69; *Mittheilungen über den Communion Unterharzer Bergbane und Hüttenbetrieb für den VI. Allgemeinen Deutscher Bergmannstag.*

† Recently aluminum and magnesium bearing zinc have been used instead of pure zinc, *B. u. H. Ztg.*, 1890, pp. 249, 429; 1891, p. 123; 1893, pp. 21, 258; 1894, pp. 37, 299; 1895, p. 321.

after repeated boiling with acid assays 986.5 fine, and the silver precipitated by copper from the sulphate solution 997.5 fine.

About 24,000 tons of ore, together with kniest, are smelted annually at the Okerhütte, the products being about 75 kg. gold, 7500 kg. silver, 5000 tons lead, 900 tons electrolytic copper, 1800 tons copper vitriol, and 20,000 tons of 50° B. sulphuric acid.

At the Herzog Julius and Frau Sophienhütte is treated the zinc-lead ore (consisting of about 27% zinc blende, 11.5% galena, 1.5% copper pyrites, 1.4% pyrites, and 46% barytes, calc spar, and clay shale), about 90% of which is stufferze and bergkern and the remainder fines, the whole averaging 10% lead, 18% zinc, 5% iron, 0.3% copper, 0.013 to 0.016% silver, and 13 to 16% sulphur. The combined sulphides (galena blende, chalcopyrite, and pyrite) constitute about 50% of the mass of the ore, the other half consisting chiefly of heavy spar with a little calc spar in the coarse ore, and chiefly of schist (country rock) in the fine. The stufferze and bergkern are richer in zinc blende than the waschkern, graupel, and schlieg. Since the sampling of heaps of ore of such different size is uncertain, the ore is taken by the works from the mine at a fixed price per ton.

With regard to the choice of reduction process, it is to be borne in mind that the complex character of the ore and its poverty in lead exclude reverberatory smelting (roast-reaction process) and the precipitation process (decomposition of the galena by iron) in shaft furnaces, and consequently only the roast-reduction process is offered. Since the zinc blende has a disastrous influence upon the separation of the lead and silver and the formation of a good slag, and also interrupts the furnace campaign by the formation of crusts and scaffolds, the plan is adopted to convert the zinc in the roasting so far as possible into sulphate—a commercial product—which can be leached out with water, leaving thereby an easily smeltible ore.

As to the choice of a roasting process for ore of the above description, the shaft furnace is not adapted on account of the high cost of installation and operation, non-availability of the gases for sulphuric-acid fabrication on account of their low sulphur contents, and danger of converting the zinc sulphate into insoluble zinc oxide, making a bad smelting product. The reverberatory furnace requires much fuel and labor, a costly commination of the ore, and renders the gases unavailable for sulphuric-acid making on account of the admixture of the products of combustion, also injuring the vegetation of the surrounding country unless the gases are dispersed by exceedingly high chimneys or neutralized by some more or less costly method. Experiments with roasting stalls did not give a uniform roasting on account of the cooling effect of the walls, while they were slow, and the workmen in turning the grates were badly affected by dust containing sulphate. Under these circumstances there remained only the process of heap roasting. This has also its drawbacks, as for instance the imperfect roasting, and on that account the repetition required to make a smelting ore, long duration (which, however, favors the formation of zinc sulphate), and the development of sulphurous acid in the open air. On the other hand, very little labor is necessary, and little fuel, while the winning of zinc vitriol and sulphur is made possible. The abundant quantity of stufferze for building the heaps and the high sulphur contents of the ore make a long maintenance of heat in the roast heaps possible if the latter are built sufficiently large.

In building a roast heap a foundation of slag and clay is first tamped down, upon which is laid a thin sheet of dry, fine ore; on this layer (30 to 40 cm. high) is placed a rectangular bed of cordwood (40 to 50 cm. high, or 35 to 40 cu. meters) and fagots, the sides of the bed being 10 to 12 meters long, so arranged that the sticks form air channels or flues. Upon this bed are placed, one over the other, 250 tons of stufferze, 100 tons bergkern, 14 tons graupel, and 20 tons schlieg, so that the heap of 400 tons of ore is arranged in the form of a truncated pyramid 200 meters high, the base covering 11.5 meters square and the upper surface 4 meters square, the sloping sides being 4.5 meters long. After covering the sides with a thick layer of sifted ore from a previous roasting the wood is kindled from the windward side. This must burn up in 24 to 36 hours in order that the sheet of ore lying above it may be ignited uniformly, after which the oxidation of the sulphur maintains the requisite roasting temperature.

Since with the proportionately large heap and the size of the pieces of ore which compose it the air cannot penetrate everywhere, a part of the sulphur of the pyrites is merely volatilized and condenses near the cool upper surface, beginning to show about 3 or 4 weeks after the burning of the wood. As soon as the layer of schlieg is saturated to a depth of about 20 cm., 30 semi-spherical colanders, 30 cm. in diameter and 20 cm. deep, are tamped in in rows, and in these up to about the end of the third month liquid sulphur collects. This is from time to time ladled into moistened wooden vessels and carried to the sulphur refinery common to the two works, where it is melted in cast-iron kettles, the impurities (particles of ore, etc.) being brought to the surface by stirring and skimmed off, after which the purified sulphur is tapped off from the bottom, melted again in small kettles, and poured into damp wooden molds in stick form (stangen). The yearly production of crude sulphur amounts to 12 or 13 tons, from which 81 to 82% stick sulphur is obtained. The sulphur winning from the heap may be affected unfavorably by meteorological conditions—for example, long rains, cold weather, etc.—and protection against the weather is provided if necessary by planks placed edgeways at the sides of the upper surface and a roof or cover of loose plank resting on these. With the cessation of the sulphur vapor the sulphurous acid fumes escaping from the heap also cease after about three months, but the latter are still developed in the interior and are consumed in the formation of sulphates. Eight or 9 months after the burning of the wood the cooling of the heap and entire cessation of fumes indicate the ending of the roasting, and the heap is then broken down by means of picks and the loosened material is raked over to separate the fines (rostkein), which forms the leaching product, from the coarse pieces (klümpen). The former arises especially from the rich pyritous pieces, which are decomposed in consequence of the more abundant formation of sulphates. The still incompletely roasted lumps are broken up with long hammers and subjected to a second roasting on a bed of wood in heaps of about 10 meters width, 15 to 25 meters length, and 3 meters height, consisting of 500 tons and more. These heaps are built under sheds and no covering of fine roasted ore is put upon them. They are so built in order that they may not be cooled down by rains and atmospheric exposure, the low sulphur contents of the material furnishing but little heat, and also to guard against leaching out of zinc vitriol. The second roasting lasts 6 to 8 weeks, the third 3 to 6 weeks. After each the fines are separated, until at last the lumps still remaining contain less than 5% sulphur (thrice-roasted ore for the smelting). The fines from the second and third roasting are poorer in sulphates (containing 15 and 12% respectively) than the fine from the first (which contains 20 to 25%), being richer in heavy spar, of which the lumps do not crumble in the first roasting, and also in oxides, which are formed from the sulphates in the second and third heaps in the absence of a covering of fine ore. Richest of all in sulphates is the covering of the first heap, which contains from 50 to 60%. In the fines almost half of the zinc is converted into a sulphate soluble in water, existing together with iron sulphate, and it follows that the solutions derived from the last roastings are purer than those from the first. In roasting 100 tons of raw ore an average of 13.9 cu. meters of brushwood (fagots) and 212 pieces of cordwood are required.

The leaching of the roasted ore was formerly carried out in two rows of vats, 5.50x1.80x0.53 meters, arranged in terrace form and stirred by hand with wooden paddles, but in 1888, in order to quicken and cheapen the process, wrought-iron barrels, 1 meter in diameter and 1.4 meters long, revolving mechanically, were introduced. These barrels have horizontal ribs on their inner sides, which serve to strengthen them and also to agitate the pulp. The barrel is filled from a hopper holding the amount of the charge—viz., 1.2 tons—provided with a gate at the bottom through which the pulp runs directly into the opening of the barrel. The barrel is filled with warm weak solution and closed, after which it is revolved for 20 minutes, 20 times per minute, by gearing driven from the main line shaft. After the solution is completed the barrel is thrown out of gear and turned by a crank until the opening comes uppermost. The pulp is then allowed to stand until the coarsest has settled, when the liquor, 35 to 40° B., is drawn off through a tap and carried through a movable launder into a masonry conduit. The barrel is again filled three-quarters full with warm weak solution and rotated, the second solution, 20 to 25° B., being drawn off in the same manner as the first and mixed with it, so that the whole has a strength of about 30° B. and will be free from danger of crystallization of the salts in solution. The liquor, which clears itself somewhat in the masonry conduits, is drawn into a deep settling basin. After the barrel residue has been treated a third and fourth time with warm water and the solutions, respectively 10 to 15° B. and 7 to 10° B. strong, have been drawn off, it is conducted into the weak-solution basin, whence it is pumped to the barrels for treating fresh ore, and the contents of the barrel (leached ore) are discharged into a car beneath it.

For the most complete separation of the iron from the crude solution* (the so-called schieren der lange) it is heated to 80 to 90° C. for 20 or 24 hours in lead pans (schierpfanne) supported on iron plates 4 meters long, 3 meters wide, and 0.62 meter deep (72 cu. meters capacity), whereby basic ferric sulphate, together with sulphate of lime and other insoluble salts, are separated. The liquor is then drawn off through a tap in the lower part of the pan or by means of a siphon into lead-lined wooden vats (schierkasten) of 7 cu. meters capacity to settle the precipitated salts, the clear liquor being tapped out into a basin, whence it is pumped into lead-lined iron pans (siedepfanne) of the same

* An attempt has been made to separate the iron by means of chloride of lime. This, however, proved too costly and besides formed zinc chloride, which does not crystallize out and is lost in the mother liquor.

size as the schierpfanne, where it undergoes concentration. The vaporized water is replaced by solution of 30° B. until at the end of about 36 hours a concentration of 47 to 50° B. is attained. The hot concentrated liquor (gaarlange) is then run into lead-lined wooden vats (kühlschiffen) for crystallization; these have sloping bottoms, the vats being 1.75 meters broad, 7 meters long, 0.61 meter deep in the middle, and 0.43 meter at the sides, with a capacity of 6.62 cu. meters. After 6 or 7 days the zinc vitriol has crystallized out in rhombic prisms, when the mother liquor* is tapped out through a hole in the bottom into a reservoir, whence it is added to the concentrating pans until its tenor in foreign salts (iron and copper sulphates) becomes too high. The zinc-vitriol crystals are shoveled into cars and carried to the drying room, where they are emptied upon a sloping platform (pritschen), whence the mother liquor drains away. The vitriol (when chemically pure, $ZnSO_4 + 7H_2O$, with 28.24% ZnO, 27.87% SO_3, and 43.89% H_2O) is composed with slight variation as follows: ZnO, 27%; MnO, 0.50%; FeO, 0.05%; SO_3, 27.95%; H_2O, 44%; total, 99.50%. The 0.50% unaccounted for consists among other things of about 0.05% cadmium oxide and 0.01% cobalt and nickel protoxide. The vitriol is shipped in sacks or in bulk and the larger part goes to the manufacturers of white paint.† Other uses are as a mordaunt in calico printing, for varnish manufacture, and the preparation of zinc compounds for disinfectants, preservatives, and medicinal purposes.

In order to save transportation on the vitriol richest in water a portion of the latter is eliminated by calcination, in which the crystals are melted in their water of crystallization in a copper kettle 1 meter deep and 1.18 meters in diameter, without, however, allowing the solution to come to the boiling point, in which case zinc sulphate would stick to the sides of the kettle. As soon as the charge has become fluid it is skimmed and transferred by means of a copper ladle into a trough, through which it is conveyed to a vat with sloping sides, where it is

* As previously mentioned, the mother liquor contained thallium up to 0.05%, which, according to Bausen (*Ann. Chem. Pharm.*, pp. 108, 133), may be obtained by precipitating copper, cadmium, and thallium with zinc, washing the precipitate in a filter of woolen cloth, dissolving the cadmium and thallium in dilute sulphuric acid, and precipitating chloride of thallium by means of chlorhydric acid or iodide of thallium by iodide of potassium. Metallic thallium can then be obtained from the washed and dried precipitate by fusion with cyanide of potassium, the metal being bluish-white, lustrous, and very flexible, so that it may be bent like tin, and next to the alkali metals is the softest of metals, being scratched by lead and the finger-nail. It is of 11.8 to 11.9 sp. gr., not very drawable, but slightly elastic and of less tensile strength than lead. Its chloride imparts a green coloration to the flame and a millionth of a gram may be recognized by its intense green spectral line. The properties of thallium before the blow pipe are described in detail in *B. u. H. Zeitung*, 1881, p. 189. As to uses for the metal Lamy (in Dingler's *Poly. Journ.*, pp. 76, 181) has declared that in glass potassium oxide may be replaced by thallium oxide, making a product of great refractory power, which may be used for optical purposes and imitations of precious stones. Paper saturated with thallium protoxide becomes brown in an atmosphere of ozone, whence it may be used for ozonometric determinations (*Journ. f. prak. Chemie*, pp. 95, 311).

†The white-paint manufacturers, for example at Schweinfurth, in Bavaria, and Schöningen, in Brunswick, use a good deal of zinc sulphate in the manufacture of lithophone, a white paint prepared by precipitating zinc sulphide and barium sulphate from a mixture of solutions of zinc sulphate and barium sulphide, the precipitate being washed, dried, and calcined. According to another process, that of Cowley (*Chem. News*, 1891, pp. 63, 68), equal quantities of zinc-sulphate and barium-sulphide solutions are mixed and ½ to 1% of freshly prepared magnesia and finely pulverized salt are added to the precipitate before filtration; to the dried precipitate 3% of ammonium chloride is added and the whole is then glowed. Color prepared in this manner does not darken on exposure to the sunlight. While white lead (basic lead carbonate) is well adapted as paint for outdoor surfaces, zinc white is of little durability when exposed to the air, since the zinc oxide is converted to carbonate, which becomes crystalline and contracts, scales off, and is carried away by rain and wind. Zinc white is used advantageously, however, for interiors on account of its shining white color and non-alteration when exposed to sulphureted hydrogen, although it does not possess the covering power of white lead.

stirred with a wooden paddle for 2 or 3 hours, or until it sets. The calcined vitriol, with about 40% water, has lost about an equal amount. Crystalline zinc vitriol ($ZnSO_4 + 7H_2O$) is converted at 30° C. into $ZnSO_4 + 6H_2O$ and at 100° C. into $ZnSO_4 + H_2O$, and when quite free from water contains 50.52% zinc oxide and 49.68% SO_3, its sp. gr. being 3.4. The yearly production of the works is 3000 to 3300 tons of crystallized zinc vitriol and 200 to 250 tons of calcined.*

The fine ore freed to a large extent of zinc by the leaching process is collected in sumps and there washed with the water condensed from the engines; in this way a solution still containing a little zinc is obtained, which is used for the lixiviation of the fresh ore in the revolving barrels. The coarser part of the leached ore is dried in a reverberatory furnace similar to a "fortschaufelungsofen," and the fine slime upon a covering of iron plates on the fire box. This ore, which contains from 14 to 15% lead, is mixed with the lump ore from the third roasting, which on account of the greater proportion of heavy spar seldom has more than 8% lead, and turned over to the smelting furnaces. The furnace charge consists of 50 to 60% fine leached ore and 50 to 40% lump ore, to which is added 20 to 30% of slag from previous runs and about 25% of slag rich in iron from the Oker works. The furnaces (sumpföfen) are 6 meters high, 1.05 meters diameter at the tuyère level, 1.40 meters diameter at about 1.25 meters above the tuyères, and 1.20 meters diameter at the top. They have five tuyères and are run with a blast of 30 to 32 mm. mercury.

The annual production of base bullion is 4000 to 4500 tons, which is sent to the Okerhütte for desilverization. The amount of roasted ore put through a furnace in 24 hours is 10 tons, or 14 to 15 tons of charge, from which is produced 12.5 to 13% base bullion with a consumption of 22% of the weight of the ore, or about 15% of the charge in fuel (coke). The elimination of the still large zinc contents of the charge necessitates a very basic slag† (a singulo-silicate) which contains with 12 to 13% silica 20% sulphides and ½ to ¾% lead. The flue dust collected from the dust canals nearest the throat of the furnaces is in part returned to the smelting furnaces and in part utilized in the covering of the first roasting heaps. The dust richer in zinc which is collected further in the canals is treated with dilute sulphuric acid of 20° B. in lead-lined wooden vats and the liquor boiled down for zinc vitriol. As soon as it attains a concentration to 40 to 42° B. a black substance sometimes suddenly precipitates from the clear liquor at a concentration of not over 46° B., while the normal degree of concentration

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* Zinc vitriol for the manufacture of white paint is also made at the Lautenthal Works in the Upper Harz in desilverizing the base bullion by zinc. The zinc crust resulting is converted by steam into rich lead and silver holding zinc oxide, which latter is treated with dilute sulphuric acid in lead-lined wooden vats, whereby the silver contents are separated in the residual slime. Since the vitriol for lithophone fabrication must not be too acid, the liquor is neutralized with zinc dust. Iron protoxide is more highly oxidized through the addition of fused saltpeter and manganese binoxide. A reliable method for the analysis of zinc vitriol is given by Professor Knorre in Dummer's *Illustrirte Lexicon der Verfalschungen*, Leipzig, 1887, p. 991.

A recent publication concerning the Upper Harz which can be recommended is the following: *Das Berg- und Hüttenwesen des Oberharzes, Unter Mitwirkung einer Auzahl Fachgenossen aus Aulass des VI.* Allgemeinen Deutschen Bergmannstages in Hannover herausgegeben, von H. Banitza, Oberbergrath, F. Klockmann, Dr. Phil Professor, A. Lengemann, Bergrath, und A. Sympfer, Bergrath; Verlag von Ferdinand Enke in Stuttgart. 1895.

† In the sixteenth century lead slags in the Lower Harz were poured into cast-iron molds and pressed into balls. Such, according to Pufahl in *B. u. H. Ztg.*, 1881, p. 446, contained SiO_2, 8.22%; FeO, 39.28%; BaO, 11.67%; MnO, 3.73%; CaO, 3.50%; MgO, 1.14%; K_2O, 0.60%; Na_2O, 0.59%; Al_2O_3, 7.10%; ZnS, 22.34%; CuS, 1.36%; PbS, 0.70%; FeS, 0.28%; As and Sb, trace.

for crystallization is 50° B. According to Hampe (*Chem. Ztg.*, 1890, No. 105) this black substance consists of cuprous sulphide (Cu_2S) formed by the action of hyposulphide of zinc (zinc thiosulphate), which comes from the flue dust, upon the sulphate of copper in solution. The zinc thiosulphate in the flue dust is formed by the action of sulphurous acid in the furnace gases upon zinc sulphide mechanically carried over in the presence of moisture ($2ZnS + 3SO_2 = 2ZnS_2O_3 + S$), while the sulphur set free may combine directly with zinc sulphide, which arises through absorption of sulphurous acid of the furnace gases by zinc oxide in the flue dust ($ZnSO_3 + S = ZnS_2O_3$).

Note by the Translator.—The new leaching department of the Juliushütte at the time of a recent visit (1893) was equipped with 10 barrels, arranged in 2 rows of 5 each. The lixiviant for fresh charges of ore was the weak solution from the third and fourth agitation of previous charges. When used with the fresh ore this was heated to about 50° C. Each barrel treated 2 charges of ore per 24 hours, wherefore the capacity of the plant was about 48 metric tons (or 53 tons of 2000 lbs.) per 24 hours. The concentration and crystallization department consisted of 2 schierpfannen, 2 siedepfannen, 10 precipitating vats, and 11 crystallization vats. The leaching department employed 2 men charging barrels, 2 boys attending to barrels, and 2 men handling residue—*i.e.*, 4 men and 2 boys per shift, which did not include the engine-man. The crystallization department employed 4 men per 24 hours. The zinc-sulphate plant at the Sophienhütte was a counterpart of that at the Juliushütte.

CHROMIUM.

Chrome ore as it is commonly known and found in nature is a combination of chromite or sesquioxide of chromium (Cr_2O_3) with iron oxide, and usually with considerable quantities of magnesia, alumina, and silica. The value of any deposit of this mineral depends entirely upon the amount of chromite which it contains, and generally an ore to be of commercial use must carry at least 50%. The usual occurrence of chrome ore is in connection with the serpentine rocks; as generally met with the ore occurs in masses with a granular crystalline structure. The sp. gr. of chromite varies from 4.1 to 4.7.

In the United States the first deposits of chrome ore worked were in Maryland, in the Black Hills as they are locally called, not far from the city of Baltimore. A deposit of chrome ore was also for some time worked in Lancaster County, Pa. Both of these deposits have been practically worked out and have not been operated for several years, the supply—or at least that part which was obtained in this country—having been derived from the mines in California. In that State chrome ore is found over an extensive range. There are large deposits in Siskiyou and Del Norte counties, in the northern part of the State, but these do not complete the list, since other deposits are known to exist in the counties bordering on San Francisco Bay, to the southeast in Shasta, Fresno, and Solano counties, and also in Southern California among the foothills in San Luis Obispo County. Only a small portion of the California ores runs over 50% in chromite; the greater part of them are of comparatively low grade, from 40 to 45%, and they also carry a considerable portion of silica, which is an impurity particularly objectionable to the manufacturers who purchase and use the ore. The probability is that the industry will not improve until plants are established for concentrating the ore, bringing it up to a high grade, and freeing it from the earthy impurities before shipment; and such plants would involve a considerable expenditure which is hardly warranted by the present extent of the demand.

The greater part of the world's supply of chrome ore comes from Russia and Turkey. Previous to 1877 the Russian ores commanded the market These ores, which are found in the Ural Mountains and in the Caucasus, are as a rule comparatively rich, running from 53 to 55% chromite. In 1877 large deposits of chrome ore were found near Smyrna, in Asiatic Turkey, this ore being soft and granular in its structure, easily mined, not far from a shipping port, running from

55 to 58% chromite, and comparatively free from silica. All these circumstances combined to bring the Turkish ores prominently into the market and to induce their development on a large scale. A considerable quantity of these ores comes to this country.

The uses of chrome ore in the chemical industry are fully described in the following pages. The principal consumers in this country are the Baltimore Chrome Works, the Philadelphia Chrome Works, and the Chrome Steel Works in Brooklyn. In Europe the chief consumers are the Moscow Chrome Works in Russia, the Silesian Chrome Works in Germany, the United Alkali Company in England, John & James White and Stevenson, Carlisle & Co. in Scotland.

The following table shows the production and the consumption of chrome ores in the United States for the five years ending with 1895. For the years previous to 1891 the statistics will be found in Vols. I., II., and III. of THE MINERAL INDUSTRY:

PRODUCTION AND IMPORTS OF CHROME ORE IN THE UNITED STATES.

(In tons of 2240 lbs.)

Year.	Production.			Imports.			Consumption.	
	Quantity.	Value per Ton.	Value.	Quantity.	Value per Ton.	Value.	Quantity.	Value.
1891..........	1,372	$15.00	$20,580	4,560	$23.85	$108,764	5,932	$129,344
1892..........	1,650	10.00	16,500	4,930	11.27	55,589	6,580	72,089
1893..........	1,629	9.84	16,000	6,354	9.23	58,629	7,983	74,629
1894..........	2,653	13.23	35,125	3,886	9.87	38,364	6,539	73,489
1895..........	1,740	9.75	16,965	5,230	15.84	82,845	6,970	99,810

Owing to the absence of any system of reports or any statistics of the mining industry in Turkey it is impossible to give exact figures for the production of chrome ore in that country. As the annual consumption of chrome ore in the world is estimated to reach from 75,000 to 80,000 tons, it is believed that the Turkish mines supply fully one-half of this amount.

CHROME ORE IN QUEBEC.

BY MATTHEW PENHALE.

CHROME ore was first discovered near Black Lake, in the Province of Quebec, accidentally. A boy picking berries found a piece of the ore in the fall of 1893 and carried it home, but it was not until the spring of 1894 that it was seen by the writer, who at once determined its value. Further examination revealed an outcrop of considerable extent, and assays of samples showed that the ore contained from 50 to 55% chromite. The announcement of this discovery caused considerable excitement in the district, and several outcrops were located by prospectors, many men leaving the asbestos mines in the neighborhood for this purpose. Work was carried on at first entirely on the outcrops, the ore in which was almost completely free from waste rock. Before this had proceeded very far the Coleraine Mining Company of Montreal, which owned most of the property where the ore was found, ordered all work by outsiders stopped and gave notice that it would only permit mining on its land either on shares or on royalty. This announcement stopped prospecting and a great deal of the work that had been started, but a few who had good pockets of ore accepted the company's terms. From the outcrop first found over 600 tons were taken out, and about 800 tons from another near by. In 1894 a total of 915 tons of chrome ore was shipped from Black Lake, all of it going to the United States—Philadelphia, Baltimore, and Pittsburg. In the same year another discovery was made near Little Lake St. Francis, the outcrops, in one place especially, being large. This was low grade, not running over 40% of chromite, so that a market was not so easily found, although 440 tons were sent to Great Britain.

Experience has shown the Canadian producers that the low-grade ore is of comparatively little value, but that any ore carrying 50% chromite or over will find a ready market, either in the United States or Great Britain, the price at present averaging about $26 per ton f.o.b. cars at station nearest the mine, for 50% ore.

In 1895 the mining in the Black Lake district increased not only on the original discovery, but on other locations in the district. Most of these were outside of the Coleraine Mining Company's property, and as a general thing the owners of the land readily agreed to leases at a royalty varying from $3 to $5 per ton, according to the quality of the ore. So far no deep mining has been done, and the ore taken out has been generally from pockets, but when one group of these gives out another is usually found close by. These pockets occur in serpentine and are not far from the asbestos mines which are found in the same rock, but no asbestos has been discovered in connection with the chrome. The pockets worked have been found in a very bare and rocky country of irregular surface, and the great difficulty heretofore has been the absence of roads through the section, which was not supposed to be of any particular value. Very little systematic mining has been done, many of those engaged in the business being almost entirely ignorant of mining and none of them having any considerable capital. All the ore taken out has been from pits or open workings, and the actual cost of mining has varied from 50c. to $3 per ton, according to location. Undoubtedly a larger quantity of ore could be taken out in the district at a very reasonable cost should the work be done systematically and on a considerable scale.

Notwithstanding the primitive nature of the industry, the shipments from Black Lake, which as above noted were 915 tons in 1894, increased to 2837 tons in 1895. The shipments included 2396 tons of high-grade ore, of which 870 tons went to Philadelphia, 725 tons to Baltimore, 810 tons to Pittsburg, and 54 tons to Nova Scotia. This ore brought an average of $26 per ton on the cars. The remaining shipments included 441 tons of low-grade ore, all of which went to Great Britain, but brought a much lower price—about $15 per ton on the cars. The low-grade ore would be very much improved by crushing and concentrating up to a higher grade, and it is now proposed to put in a plant for this purpose at Lake St. Francis should the deposit be found apparently permanent. At present there is no certainty of this. There is no doubt that a large quantity of chrome ore exists and that a flourishing industry can be built up in the Black Lake district.

The Occurrence of Chromite in Austria.

By R. Helmhacker.

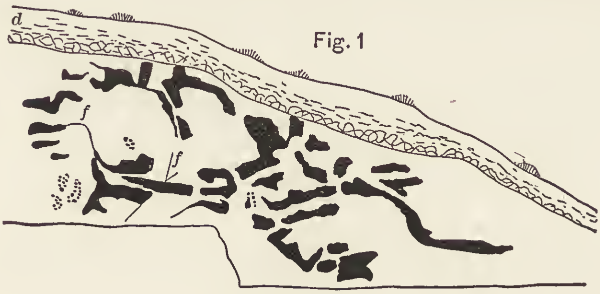
The occurrence of chromite or chrome ore is noted only in serpentine rock deposits or in olivine rock from which some serpentine bodies derive by decomposition. Though these rocks occur in large quantities in Austria, there are but few places where that ore is to be abundantly found. In Moravia, west of the town of Kroman, there is a large area consisting of thin bedded gneiss, granulitic gneiss, and mica-schist gneiss intruded by an immense mass of olivine rock decomposed superficially into serpentine. The olivine rock area has undergone a deep erosion by the little river Tihlavka, flowing now on the bottom of a valley bordered by rocks. In some gulches near Hrubshitz and Biskaupka the olivine rock contains either small impregnations or minute bunches, also small groups of minute undeveloped octahedric crystals of chrome ore. The quantities are too limited to be of use. In the valley of the Mour River, in Upper Styria, cutting across the Tauern range of the Austrian Alps, there appears on both banks of the river an immense area of eruptive olivine rock. The well-banked gneiss of the range is intruded by a gigantic mass of olivine rock decomposed on this outcrop into serpentine rock. In the valleys ending on both sides in the main valley of the Mour River the olivine incloses here and there, particularly in the Gulsen hill near Kraubath, small bunches of chrome ore or small irregular impregnations and stringers of ore, arranged in such an irregular manner that no rule can be laid down for tracing the ore bodies. In some places, particularly on the right side of the main valley, the working consists of an open cut with an inclined plane to conduct the tubs filled with ore to the bottom of the gulch. Some ore is mixed with waste and requires crushing and concentrating to raise the average to at least 50% of chromic oxide. The open cut is worked intermittently as the demand requires.

In the Banat, Hungary, is an extensive area of serpentine on and near the left bank of the Danube River. Here the chromite impregnating the serpentine is found in several places in bunches with very little waste. The ore has been worked either as the demand required or for shipping to chemical factories. Though there are open cuts at Ogradina, Dubova, and Plavishevitza, besides another near Tsoritza and Eibenthal claimed by three mining companies, the ore bodies are but slightly exploited. The ores can be shipped by water from Dreukova, on the left shore of the Danube, but roads must be built from the deposits to the landing pier.

Among the Austrian provinces Bosnia now takes the first rank in the production of chromic iron ore. In this province chrome iron ore is found in connection with serpentine in a belt extending from Banjaluka and Varesh to the Servian frontier. The ore is most abundant in this belt near Dubostitza, where deposits of commercial importance are found over an area of about 19 km. in length by 6 km. in width. This mining district is intersected by the valleys of three small rivers which empty in the Krivaia, a stream which forms the northern border of the mining district and which is a right-hand affluent of the Bosna River, a tributary of the Save River and the Danube. The series of mines and outcrops are known under the following names: In the valley of the Dubostica, at Machkovatz and Rudine; in the Tribia valley, at Boria, Laushevatz, Rujica, Torina, Blatatz, and Pobilie; in the Krivaia valley, at Breznitza, Prisieke, Arko, and Vozucha.

The chromite is disseminated through the serpentine in small stringers or larger bunches, all of irregular form. It has been necessary to build roads to the several deposits to connect them with the Bosna River Railway. Besides these

Fig. 1



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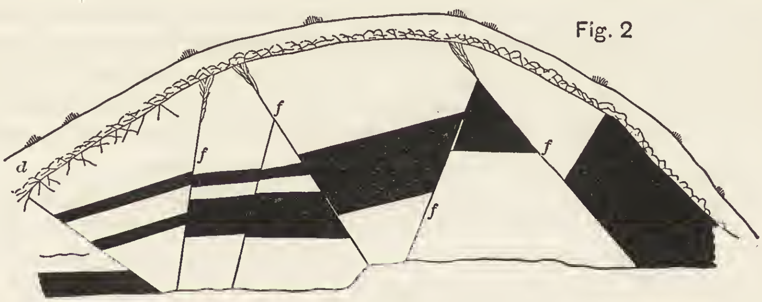
SECTION OF CUT AT RAKOVATZ.

deposits met with in the serpentine, bowlders of ore are found at the Boria planina. The ore is exploited mostly by open-air cuts. The accompanying figures show the vertical working breast of two open cuts sketched by Schönbucher and Syrovátka. The first, at Rakovatz, shows the occurrence of bunches and stringers, varying in their thickness; the second, at Breznitza, represents a layer-like body of ore with several faults. In both these sketches the chrome ore is shown by black patches; the lines *f f* are faults; *d d*, decomposed rock and drift. A great part of this

Fig. 2



Scale 1:200

SECTION OF CUT AT BREZNITZA.

ore is mined in large lumps that need but hand picking. The ore contains from 49 to 54% chromic oxide (Cr_2O_3). But part of the ores consists of a coarse-grained mixture with serpentine which is crushed wet by a stamp mill and in a rock breaker. The ore and the waste are separated in sluices moved by a 30 horse-power water wheel to which the water is conveyed by a ditch 1140 meters long. The value of the ore depends on the proportion of Cr_2O_3, as the chemical factories pay only for the chromite, and to render the ore fit for their use it must yield at least 50% of this chromic oxide. The use of lower-grade ore in manufacturing chromates was found to require too expensive processes. Ores carrying less than 50% of chromic oxide cannot be handled and shipped to compete with those coming from Asia Minor.

The following analyses have been made by Patera and the English chemical factories, 1 from 12 samples of hand-picked ores, 2 from 6 samples of crushed and separated ores that showed the following chemical character:

	1.	2.
Cr_2O_3	59.2–50.2	43.0–49.0
FeO	33.0–17.2	30.5–21.2
Al_2O_3	5.3–13.0	6.5–16.0
MgO	1.1–12.7	1.5– 9.8
CaO	1.8	3.2
SiO_2	1.0–13.0	1.5– 4.0

The production of chrome ore in Bosnia was 1296 tons in 1892, 965 tons in 1893, and 1808 tons in 1894.

The Analysis of Chrome Ores.

By J. T. Donald.

The determination of the percentage of chromic-sesquioxide in chromite presents no technical difficulty to the analytical chemist. At the same time, it is a piece of work calling for considerable care and patience, owing to the fact that the mineral is by no means easily decomposed. Until very recently, if not now indeed, the standard method of decomposition has been by ignition of the very finely ground ore for one hour with a mixture of calcined magnesia and caustic soda. This method, fully described in Vol. II. of The Mineral Industry, gives very satisfactory results. The principal objection is the length of time required for the ignition, while the rapidity with which caustic soda absorbs moisture renders it an undesirable ingredient in a mixture. Moreover, it not infrequently happens that a little of the ore escapes decomposition.

The comparatively recent introduction into commerce of sodium peroxide supplies a reagent which rapidly decomposes chromite and presents no inconvenience in the matter of handling. The use of this reagent in the analysis of chrome ore has recently been investigated by Dr. S. Rideal and S. Rosenblum, who have recorded their results.*

The writer has lately tested the method described by these chemists and finds it a great improvement over the magnesia method, while it gives results that agree very closely with those obtained by that method when both are applied to the same sample. The process followed by the writer is as follows: One-half gm. of the finely ground ore is intimately mixed in a nickel crucible with 6 gms. of sodium peroxide. The crucible is placed over a Bunsen lamp and heated to a moderately high temperature until the whole of the sodium peroxide is fused; the flame is then lowered and regulated so that the peroxide is kept freely liquid

* *Journal of the Society of Chemical Industry*, December, 1895.

for 5 minutes. The heat is then withdrawn, and as soon as a crust forms on the contents of the crucible another gm. of peroxide is added, the heat again applied, and the mass kept freely liquid for another 5 minutes. The crucible and contents are allowed to cool and are then placed in a suitable vessel, and about 150 or 200 c.c. of cold water added. The melt rapidly dissolves, the crucible is rinsed and removed, and the bulk of liquid is brought up to 300 or 350 c.c. This is then boiled for 10 minutes to decompose any sodium peroxide that may remain, the solution is filtered, and an excess of sulphuric acid added; then an excess of ammonium ferrous sulphate added to the warm solution, which is finally titrated back with a standard solution of potassium bichromate.

The following data from my laboratory work book will make clear the details of the process. One-half gm. of ore was fused with the quantity of sodium peroxide and for the time above mentioned. To the boiled solution containing excess of sulphuric acid was added 5 gms. of ammonium ferrous sulphate (Merck) containing 14.633% iron. To titrate back 12.2 c.c. of potassium bichromate (1 c.c. = 0.01367 gm. iron) were required. Then 0.7316, the amount of iron in the 5 gms. of ferrous salt —0.1667, the amount represented by the bichromate used in titration, leaves the amount of iron oxidized by the chrome sesquioxide; therefore this weight of iron $+\frac{153}{336}$ gives 2574 as the weight of chromic sesquioxide, and since the quantity of ore employed was $\frac{1}{2}$ gm., the ore contains 51.48% Cr_2O_3.

It will be noted that a nickel crucible is used for the fusion of the chromite with the sodium peroxide. Rideal and Rosenblum state that "a nickel crucible, though considerably attacked, will last for a long time provided it is not exposed to a very high temperature. We have tried platinum, silver, and porcelain crucibles, but with unsatisfactory results." They also state that the nickel oxide found in the melt as a result of the attack upon the crucible should be filtered off before sulphuric acid is added to the aqueous solution, otherwise the nickel, by forming nickel ferrocyanide, obscures the end reaction in the titrating. Certainly the nickel crucible is attacked, but I do not find that the presence of the nickel interferes to any serious extent with the titration. Undoubtedly filtration is preferable, yet with care very accurate results can be obtained without it and the time required somewhat lessened. The boiling of the aqueous solution of the melt before the addition of sulphuric acid is a matter of importance, for frequently the sodium peroxide is not entirely decomposed in the fusion, and if sulphuric acid is added in the presence of sodium peroxide, hydrogen peroxide is formed and this will reduce the chromite and of course introduce error. Boiling the aqueous solution under the conditions already mentioned suffices to fully decompose any peroxide of sodium it may contain.

For this, as for any other process, it is of course desirable that the chromite be finely ground in an agate mortar, yet it is one of the advantages of the process under discussion that it will give a perfect decomposition even when the ore is not quite as finely ground as is absolutely necessary in the magnesia method.

In a still more recent communication* Mr. E. W. Saniter, who proposed the peroxide method, gives details of the latest development of his method by which an analysis of chromite may be completed in three-quarters of an hour. The

* *Journal of the Society of Chemical Industry*, March, 1896.

writer can testify to most satisfactory results being obtained by closely adhering to Saniter's directions, which follow: "Three gms. sodium peroxide and 0.5 gm. chrome ore are weighed into the capsule and thoroughly mixed. The capsule is now held by means of tongs in a good hot Bunsen flame. As soon as the mass begins to melt a circular motion is given to the capsule to prevent the chrome ore from settling to the bottom. The fusion and shaking must be continued for about 3 minutes, when the ore will be completely decomposed. The temperature should be just short of visible red. This will give a very liquid melt. When the capsule has cooled it is placed in a large porcelain basin and cold water is put into it, which causes the melt to dissolve rapidly, the basin being required to catch any 'spits,' which would otherwise be lost. The capsule and dish are now rinsed into a large beaker, the capsule is again half filled with water which is heated to boiling, and is thoroughly 'couched' and rinsed out. The whole is diluted to about 300 c.c. with hot water and made pink with permanganate of potash. One hundred c.c. of dilute hydrochloric acid (1 and 1) are now gradually added and the solution boiled till clear, when 150 c.c. of hot water are added and boiling continued for 10 minutes, by which time all the chlorine is driven off. The solution, about 500 c.c. in volume, after cooling is titrated with ferrous sulphate and bichromate of potash in the usual manner. In this quantity of solution the nickel salts from the capsule do not interfere with the sharpness of the final point of the titration."

The Manufacture of Chromates.

By S. Peacock.

Bichromates of potash and soda are so largely used in various industrial processes that the following description of the manufacturing methods involved will be interesting both to the chemical technologist and to the commercial world. There has been little published up to this time on the details of chromate manufacture, but the author of this sketch assisted in the preparation some years since of a paper which was published in *Drugs, Oils and Paints*, of Philadelphia. From that paper the various technical computations are repeated here.

The statements of fact in this article are taken from actual factory experience in one of the few bichromate-manufacturing plants now in operation. The experience of the author is further supplemented by the aid and counsel of two European technologists especially trained in the art. In all the computations and tables of results, actual averages of long-continued operations on a factory scale alone are taken. The results are not those of special tests or trial runs, but the averages of regular routine factory operations.

SALTS OF CHROMIUM DESCRIBED.

In the following remarks on chromium salts only the best authorities on points of chemical technology are accepted. The text is confined to those salts of interest to the commercial and the industrial world.

Chromate of Potash.—A neutral salt; crystals lemon-yellow, transparent, rhombic-prism order; soluble; 100 parts of water take up 80 parts of the salt at 100° C. and 60 parts at 15° C.

Bichromate of Potash.—Acid salt; crystals red, transparent, and of triclinic order; soluble; 100 parts of water dissolve 5 parts of the salt at 0° C., 8.5 parts at 10° C., 29.2 parts at 40° C., 73 parts at 73° C., and 102 parts at 100° C.

Chromate of Soda.—A neutral efflorescent salt, similar in many particulars to its corresponding potash salt. It is less soluble than the acid soda salt.

Bichromate of Soda.—An acid deliquescent salt, blood-red in color and very soluble. Forms crystals, but the high degree of deliquescence nullifies this property from a commercial view. It is soluble in 100 parts of water in the following proportions: At 0° C., 107 parts; at 15° C., 109 parts; at 30° C., 127 parts; at 80° C., 143 parts; at 100° C., 163 parts; at 139° C., 210 parts.

In all these salts the alkali acts merely as a carrier for the chromic acid. As the bichromate carries relatively the greater quantity of chromic acid, it is this form which is most used in the arts. Free chromic acid is so unstable and so violent in its action that its use as such in most industrial processes is impracticable.

Chromic Acid.—Deep blood-red, needle-shaped crystals, deliquescent and very soluble. It readily parts with its oxygen; forms with metallic oxides various colored salts. It is these two properties which chiefly mark the commercial importance of this acid.

MANUFACTURING PROCESS—MATERIALS.

The manufacture of bichromates is still surrounded by a host of secret methods, even to the extent of using locked scales which the process manager alone adjusts and specially graduated thermometers and hydrometers. It is not at all difficult to manufacture these salts, but the process must be properly carried out through every step, or at the end of the process failure will assume most surprising proportions. It is not unusual for new plants, though working with fairly skilled men but without a proper balancing of men and machinery, to turn out finished crystal at something like 50c. per pound. A properly managed plant to-day can probably manufacture bichromate of potash under 8c. per pound.

This industry has the usual long list of patented processes trailing after it, very few of which are of the slightest importance and not a few simply absurd and betraying a woeful lack of knowledge of the business. The cheapness of production depends much upon the factory procedure—that is, on the works manager. By a judicious adjustment of men and apparatus the productive capacity of the plant may be greatly advanced.

The materials used in the manufacture of chromates are chrome ore, alkaline salts, caustic lime, and fuel. Sulphuric acid is also used, but in such a relatively small quantity as to be neglected at this stage. Approximately, to every 100 lbs. of chrome ore, 100 lbs. of alkaline carbonate and sulphate, 125 lbs. of caustic lime, and 250 lbs. of soft coal are required. This statement is rather crude and is placed here merely to indicate the importance of locating a factory with regard to transportation facilities. More complete data will be found further on.

Chrome Ore.—This ore is widely distributed on the earth's surface, but is generally of low grade—less than 45% sesquioxide of chromium (Cr_2O_3). For manufacturing purposes the ore should not contain less than 46% chromic oxide, and even then is mixed with an ore of higher grade and in such small quantities that the average percentage of the mixture shall fall little below 50. The importance of this is very plain. A given quantity of low-grade ore will be almost as expensive to work as the same quantity of high-grade ore, and will give proportionately less return in finished crystal. An ordinary reverberatory furnace will handle 2400 lbs. of chrome ore in 24 hours, and the grade of the ore has little effect upon the capacity.

Ores from the Pacific slope are generally hard and flinty and of a grayish color in the lump. The content of chromic oxide ranges from 35 to 48 and 50%. They are sometimes high in silica, which causes a loss of alkali in the calcination process. Low-grade California ores have been successfully concentrated up to 55 and 56%. The chrome ores of the United States Atlantic coast range are chiefly in the form of black sand and are commonly very low grade. A deposit at Bare Hills, Md., proved an exception to this rule, and was the cause of starting the bichromate industry in this country. The deposit is now exhausted.

The Asiatic ores vary in hardness and color; they range from 48 to 56% and are generally desirable from their low silica. Australasian ores are generally more friable than the usual chrome ore and are reddish in color. They are frequently of high grade. The Canadian ores resemble those of Asia in general characteristics.

The following table of analyses indicates the average composition of the different chrome ores:

ANALYSES OF CHROME ORES.

From—	Cr_2O_3.	FeO.	Al_2O_3.	SiO_2.	MgO.	CaO.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Turkish (Asia)........	55.04	11.57	10.81	3.80	16.10	1.13
Turkish (Asia)........	51.80	24.72	13.90	2.05	7.81	0.41
New Caledonia........	55.54	14.50	15.43	1.30	12.85	0.80
California............	42.40	12.28	20.23	5.69	16.52	1.40
California............	42.45	14.83	16.75	6.48	16.42	1.21
Canada...............	50.65	13.93	12.70	3.35	15.04	....

For manufacturing purposes the ore is pulverized to a fineness of about 80 mesh. In this condition the color is uniformly of a brownish nature; the higher the grade the more distinct the color, but as the grade lowers the color becomes more uneven and frequently darker. At about 30% chromic oxide the color becomes a nondescript drab. These color marks are so distinct that an experienced man can closely approximate the grade of an ore by abrading the surface, or knowing the grade in use can closely judge the fineness of pulverization with the unaided eye.

Alkaline Salts.—Potash, or soda if the soda salt is desired, is used in the form of carbonate and sulphate. With the former alone a higher degree of oxidation is obtained, thus realizing more from the ore as well as increasing the productive capacity of the plant. On the other hand, carbonates are much more expensive than sulphates, and with a thorough knowledge of the manufacturing cost of each factory item the works manager can easily determine which is the cheaper salt to use. In factory practice a certain quantity of sulphate is made as a by-product. This is either converted into carbonate by means of a supplementary plant or is mixed in certain definite proportions with the carbonate used. The most economical procedure will be guided wholly by local conditions and the alkali market. In some processes the chlorides are used, but by means of an auxiliary process and not in the furnacing operation.

Caustic Lime.—The lime should be finely ground to facilitate rapid slaking. This is necessary only as an aid to a thorough intermixture of the ingredients of the batch for furnacing. As a matter of fact, the water has to be expelled in the furnace and causes a determinable loss of fuel. The lime should be free of silica and of magnesia so far as possible—at least not made from a magnesian limestone.

Fuel.—The fuel will depend upon local conditions, but a good bituminous coal does good service. It should be as free of sulphur as possible, and frequent tests should be made to keep it under control. A specially designed gas furnace gave good results in an experimental test, but lacks confirmation by long factory working.

MANUFACTURING PROCESS—PLANT.

Tersely stated, chromates are manufactured by pulverizing chrome ore, mixing the same with a certain proportion of alkaline salts and caustic lime, and roasting the mixture in a reverberatory furnace. The calcined mass is leached with hot water, the resulting liquors concentrated to a certain point, half the alkali removed with sulphuric acid, and the acid liquors decanted into lead-lined vessels for crystallization. It is a simple process enough, but is somewhat confined in its routine—in other words, it is very easy to miss a link in the chain, with all the attendant consequences of the usual broken link.

The Reverberatory Furnace.—The most important single factor in the apparatus is the furnace, which is constructed to supply a greater quantity of oxygen to the roasting floor than in the usual reverberatory. There are many types of oxidizing furnaces, but the most effective in the writer's experience is one of rather moderate dimensions, capable of calcining about 2800 lbs. of chrome ore per day of 24 hours. The dimensions are practically as follows: Furnace walls, 12 in.; roasting floor, 10 by 20 ft.; fire box, 3 ft. 6 in. by 7 ft.; air inlet, 4 in. by 9 in.; drop flue, 4 ft. 6 in. by 7 ft.; floor of roasting beds to be laid dry and grouted. The roasting floor is divided into two beds; the bed next the fire box is called the "drawing" bed, the other the "charging" bed. The "batch" for roasting is first charged into the charging bed, and 4 hours later is shifted into the drawing bed by means of slice bars. After 4 hours in the latter it is drawn through the furnace door, the next batch shifted over, etc. The bridge wall extends but 18 in. above the roasting floor. The furnace is best cased in with iron plates and is braced with the usual cross bars and tie rods. Flues are fitted with dampers subject to control, and the stack should be sufficient to consume freely something above 2½ tons of bituminous coal daily.

The other apparatus scarcely requires individual mention. The ore must be pulverized to a fineness passing a screen of 80 meshes to the inch and must be used perfectly dry. There are several mills adapted to this purpose. The leaching vats are simple iron boxes fitted with false bottoms. The mixing machine is not unlike a fertilizer mixer, and any method of evaporation may be used. The lead-lined crystallizing vessels are preferably about 5 ft. deep by 5 ft. wide and 12 ft. long. They should be arranged in batteries of 20 or more, as it is important to keep the temperature as even as possible in contiguous vessels. The crystallizing room should be arranged to withstand sudden changes of temperature.

The arrangement of the various machines and engines is a very important factor in a bichromate factory. The labor of handling materials and expense of pumping liquors may become a very considerable item in the cost price. The furnace work must be continuous, and each furnace must be supplied with a full complement of drawing hoes, slice bars, fire bars, etc. The efficiency of each furnace is usually posted daily in the furnace room, that the men may check their work.

MANUFACTURING PROCESS—MANIPULATION.

In describing the manipulation it is necessary to go into rather minute details. Commencing with the mixture, the procedure is given herewith through each step in the process until the crude materials become the finished crystal.

Mixing the Materials.—The pulverized chrome ore, alkali, and lime must be very intimately mixed together to facilitate oxidation. The object of the calcination stage is to convert the chromic oxide (Cr_2O_3) into chromic acid ($2CrO_3$). But as the oxygen supplied to the reverberatory effects the oxidation, an equivalent alkali must be within the immediate chemical arena of the chromic acid thus formed, that the union of the acid and base may form a stable salt. This may not be an absolutely true statement of the actual reaction which occurs, but suffices to suggest the necessity of an intimate intermixture of the ore and alkali. The lime is present to prevent a fusion; it also performs other useful functions and forms insoluble chromates. The object, therefore, of the calcination stage is to convert as much as possible of the chromic *oxide* in the ore into chromic *acid*. This conversion of the oxide into the acid is called oxidation—that is, the objective is a high oxidation percentage.

The mixing is done in several ways, but the best practice seems to sanction the use of the alkali in solution, the quantity of water used being just sufficient to form hydrates of the alkali and free lime. In the United States a common practice is to combine all three of the ingredients at the same time, but in Europe the lime and alkali are treated first and the pulverized ore added to the first mixture. The object of the latter method is to prevent balling of the pulverized ore, and to some extent this is an advantage, but the greater cost of the handling more than compensates for any advantage in the oxidation percentages.

The Furnacing Operation.—This is the most important step in the process. If the work is poorly done and the percentage of oxidation low the loss is irreparable. For example, suppose an oxidation of only 60%; to recover the remaining 40% will require an entire rehandling with a material less than half as valuable as in the first operation—in effect, working an ore at 20% chromic oxide. The labor cost and the loss of alkali in the furnace would remain the same in both cases. With ore free of cost it is very doubtful if a percentage as low as 30 could be profitably worked. The importance of thorough furnace work is recognized in all works by granting special privileges to the furnace-men, and they are held to a strict accountability. Bulletin boards at each furnace detail the routine even down to quarter hours, and individual orders are frequently posted.

The mixture, or "batch" as it is called in factory parlance, is first charged into the charging bed, where it is heated to a dull red and the moisture expelled. Immediately after the batch is charged it is spread evenly over the furnace floor and allowed to lie for 30 minutes; thenceforward until it is withdrawn from the furnace it is ridged or furrowed thoroughly and completely every 20 minutes. The object of this ridging is to expose fresh surfaces to the oxidizing atmosphere of the furnace. When the batch is drawn from the furnace it should show no evidences of fusion and should fall into the barrow without a metallic sound. Either of these two properties indicates bad work or bad mixtures and will work havoc with the cost sheet. A suitable cooling floor must be provided, where the batches remain until they are quite cold, or at least show no heat color.

When cold the batch will, if properly made, show a rich black exterior free from a tinge of brown, which latter marks a badly worked batch. The characteristics vary somewhat, depending much on the process in use and the proportions of the ingredients. The trained factory-man soon learns to detect good and bad work under all the different processes. In the average reverberatory furnace as outlined heretofore, the batch as charged into the furnace will weigh from 1000 to 1500 lbs. and 700 to 1000 lbs. when drawn. With bituminous coal of good quality 650 lbs. will be required per batch. There can be no hard-and-fast rules governing batches and furnacing periods; the object is to get as much work out of a given plant as possible without sacrificing quality. Forcing in factory work is a crime second only to neglect.

Leaching the Furnaced Material.—The greater part of the chromates in the "batch" are soluble in water, and the next step in the process is to leach the batches. This is simple enough, but may be made very costly in many ways. If the furnaced material is not almost totally exhausted by repeated washings, a very considerable quantity of the valuable chromates is lost in the worthless waste; on the other hand, a too free use of water will cause a very heavy evaporation cost, as all the liquors must be evaporated to a sp. gr. of 1.35. Years of practice and experiment have fixed the best method on the lines of the "cascade" lixiviation plan. The material is open and sufficiently porous to admit of this method, provided the batches have been properly compounded and furnaced.

The leaching vats may be of free dimensions, but factory convenience would dictate such dimensions as to comfortably meet the output. The layer of material in the vat should not greatly exceed 3 ft. in depth; a convenient size to take 17 batches, as indicated previously, would be 10 ft. square by a depth of 5 ft. Four to five of these vats are arranged in series, with pump and pipe lines so adjusted that the contents of any one vat may be pumped into itself or into any other vat in the series, or to the storage tanks. The vats are fitted with a false bottom filtering arrangement similar to that of an ordinary vacuum filter. As soon as the vat is charged with furnaced material, liquor from the vat filled on the previous day is pumped on until the material is freely submerged. In this manner the liquors of each vat are changed from a weaker to a stronger vat until the vat most nearly exhausted is reached, and this is treated with hot water. The washing is continued until the weakest vat liquors register 0 on a Twaddel hydrometer.

Treatment of the Liquors.—The average strength (specific gravity) of the vat liquors depends upon the mixture used and the excellence of the furnacing and leaching processes. The higher the average the lower the evaporation cost. These liquors contain the neutral chromate in solution. The further object to be attained is to convert the chromates into bichromates and to obtain the latter in such form as to suit commercial conveniences. Bichromate of potash is invariably crystallized out, while the corresponding soda salt is usually evaporated to a cake. The treatment of the liquors is somewhat different and is best mentioned separately.

With potash chromates the vat liquors are concentrated to a sp. gr. of 1.35 and are immediately transferred to a settling tank, in which the hot liquor is treated with sufficient sulphuric acid to rob the chromate of half its potash. The solution has now changed from a deep yellow to a blood-red color. After settling for 20 minutes the clear supernatant liquor is run off to the crystallizing vessels. As run into the crystallizers the liquor should have a sp. gr. of about 1.3 and a temperature of about 168° F. As soon as the crystallizer is filled it should be covered with loose board covers to prevent a too rapid loss of heat. The sulphuric acid required averages about 1200 lbs. at 1.71 sp. gr. to each 1000 gals. of neutral liquors. The crystallizers remain at rest for about 19 days in winter and 22 days in summer, when the liquors (called mother liquors) show a sp. gr. of about 1.175 and a temperature of 59 to 60° F. The mother liquor is now run off to a storage tank and the crystals removed from the sides of the vessel, washed and dried. The smaller crystals are usually returned to the process, together with the accumulations on the bottoms of the crystallizers.

With soda chromates a different process is followed, owing to the fact that bichromate of soda is much more soluble than the corresponding potash salt. In some cases the bichromate is crystallized out of solution, but the usual practice is to manufacture in the form of a fused cake, as this latter form is fairly stable, with reasonable precaution against moisture. For the manufacture of crystal the separation is effected at practically the same point the cake solution goes to its final evaporating pan; for the cake the evaporation is continued until the water is expelled. The neutral liquors are concentrated to 1.3 sp. gr. and treated with sulphuric acid as described in the manufacture of the potash salt. After settling for a full hour the supernatant liquor, now bichromate, is run into an evaporator and concentrated to 1.6 sp. gr., when it is again settled and removed to another evaporator and concentrated to 1.8 sp. gr. After a thorough settling the liquor is removed to direct heat-evaporating pans and brought to the consistency of treacle, after which it is finally fused in light sheet-iron pans, or by any convenient method effecting the same purpose. As soon as cool the cake should be ground and packed in casks lined with waxed paper.

MIXTURES FOR FURNACING.

An important function in the manufacture of bichromates is the proper compounding of the mixtures to be used in the furnace. If the lime is deficient the batch will fuse and the oxidation will be low; if the alkali is deficient loss will result not only in a low oxidation, but also in the formation of insoluble chromates which are largely lost in the waste. In fact, a proper proportioning of the different ingredients is one of the tests of a works manager's fitness for his position. He needs to aid him in this work daily routine tests of materials and finished products. The mixtures depend upon the materials used, the grade of the ore, and the quantity of by-products it is necessary to work up. Experimental tests alone seem to determine the best proportions. In mixtures the alkali is used either wholly as carbonates, sulphates, or a combination of the two. As a bichromate plant turns out considerable quantities of sulphates as a by-product, their utilization is one of the problems of the manufacturing process.

Mixtures with Carbonate of Potash Alone.—This is the most expensive alkali used in bichromate manufacture, and its chief advantages are a high degree of oxidation and a relatively rich furnaced material. The following results are averages of repeated tests on an actual factory basis:

MIXTURES WITH THE POTASH WHOLLY AS CARBONATE.

No.	Country.	Materials in Pounds.			Ratio.	
		Chrome Ore.	Potassic Carbonate.	Burned Lime.	Cr_2O_3.	K_2O.
1	United States....	100 of 50%	67 of 66%	95	100	88
2	United States....	100 " 49	89 " 66	115	100	120
3	Scotland	100 " 51	86 " 66	94	100	111
4	Scotland	100 " 51	63 " 68	69	100	84
5	Germany........	100 " 50	90 " 66	97	100	119
6	Russia	100 " 52	88 " 68	93	100	111

The above mixtures gave the following oxidation percentages in the furnaced batch, all the figures based on the total chromic oxide (Cr_2O_3) in the furnaced batch:

OXIDATION PERCENTAGES.

No.	Total Cr_2O_3 in Batch.	Percentage of Total Cr_2O_3 in the Batch as—			
		Soluble Chromate.	Insoluble Chromate.	Chromite.	Undecomposed Ore.
1	20.60	82.28	11.75	4.95	1.02
2	16.10	90.10	1.76	5.54	2.60
3	21.05	85.42	1.02	10.55	3.01
4	21.59	82.27	4.38	10.79	2.56
5	17.08	87.03	1.89	7.02	4.06
6	21.12	83.98	1.12	9.81	5.09

The theoretical quantity of potassic oxide (K_2O) required for 100 lbs. of chromic oxide is 123 lbs. Practice demonstrates that the full theoretical quantity cannot be used to advantage.

In converting the neutral liquors into bichromate half the potash becomes sulphate, which is a by-product in the process. A small plant to convert this salt into carbonate is part of the usual equipment of a bichromate factory, but the sulphate may be used directly in the mixture. The following results give the indicated efficiency of such mixtures:

MIXTURES WITH POTASH BOTH AS CARBONATE AND SULPHATE.

No.	Materials in Pounds.			Potash (K_2O) as—	
	Cr_2O_3.	K_2O.	CaO.	Carbonate.	Sulphate.
1	100	86.5	250	17%	83%
2	100	104.0	222	54	46
3	100	117.5	315	46	54
4	100	98.5	240	60	40

The oxidation percentages of the above mixtures were:

OXIDATION PERCENTAGES.

No.	Total Cr_2O_3 in Batch.	Percentage of Total Cr_2O_3 in the Batch as—			
		Soluble Chromate.	Insoluble Chromate.	Chromite.	Undecomposed Ore.
1	15.2	65.51	18.43	12.74	3.32
2	17.3	82.54	6.47	9.19	1.80
3	15.7	85.74	5.45	6.86	1.95
4	16.8	84.87	6.67	7.42	1.04

There remains the tests with sulphate alone, which would make a very cheap furnace mixture if reasonable oxidation percentages could be maintained.

MIXTURES WITH THE POTASH WHOLLY AS SULPHATE.

	1.	2.
	Pounds.	Pounds.
Chromic oxide in the mixture	100.00	100.00
Potassic oxide as sulphate of potash	76.00	74.50
Calcic oxide as freshly burned lime	255.00	252.00
	Per Cent.	Per Cent.
Total chromic oxide in furnaced material	16.02	16.00
Percentage of total chromic oxide in the furnaced material as—		
Soluble chromates	63.53	65.26
Insoluble chromates	20.80	19.66
Chromite	14.01	13.17
Undecomposed ore	1.66	1.91

The terms used in the above tabulations may cause some confusion to those not versed in the factory practice of this industry. The total chromic oxide in the furnaced material is shown, because it is important to have this as high as possible. A total of 12% and one of 18% would show that for the same labor and fuel cost of furnacing the latter produces 50% more valuable products. It must be understood that this chromic oxide in the furnaced material does not really exist as chromic *oxide*, but as chromic *acid*. Chromic oxide is taken as a basis of computation merely for purposes of convenient comparison. After the total chromic oxide in the furnaced material is computed the different forms in which it occurs are also computed in the same terms, but stated as percentages of the original total. Thus the percentage of soluble chromates shows that of *all* the chromic oxide in the material this percentage is in a form for direct use for the manufacture of bichromates; the insoluble chromates indicate those forms which would be equally useful as the soluble but for the fact that the leaching process fails to extract them from the material; the chromites indicate those forms which the furnacing process has failed to oxidize and which are consequently useless and just so much loss; undecomposed ore shows the proportion which has passed through the furnace practically unchanged. Of the four different forms the first alone is wholly available; the second form may be recovered in part by supplementary processes, such as treating the material in the leaching vats with a hot solution of sulphate of potash.

The mixtures for the manufacture of bichromate of soda are similar to those for the potash salt. The following table gives a fair estimate of the results from different mixtures:

MIXTURES FOR THE MANUFACTURE OF BICHROMATE OF SODA.

	With the Soda Salt as—		
	Carbonate.	Carbonate and Sulphate.	Sulphate.
	Pounds.	Pounds.	Pounds.
Chromic oxide	100	100	100
Sodic oxide (Na_2O)	94	87	72
Burned lime	180	242	286
	Per Cent.	Per Cent.	Per Cent.
Total chromic oxide in the batch	19.60	16.70	15.50
Percentage of total as soluble chromates	91.88	75.30	50.23
Percentage of total as insoluble chromates	4.18	15.31	31.12
Percentage of total as chromite	3.24	8.56	16.77
Percentage of total as undecomposed ore	0.70	0.83	1.88

In the second illustration, in which both sulphate and carbonate were used, the relative proportions were 42% of the sodic oxide as carbonate and 58% as sulphate.

BY-PRODUCTS.

The only important by-products in the manufacture of bichromates are the sulphates of the alkalies formed by the conversion of the neutral liquors into acid liquors and the mother liquors from the crystallizing vessels.

Alkaline Sulphates.—Both of the sulphates are so tinged with the characteristic chrome-yellow color that they are suitable for few technical uses. They are sometimes converted into carbonates by the Leblanc process and again used in the furnaces. A common practice in some factories is to add these sulphates to the regular mixtures in such proportions as to exactly exhaust the supply. The average analysis of the potash salt is as follows:

	Per Cent.
Potassic sulphate	54.64
Potassic chromate	3.91
Potassic chloride	0.08
Calcic sulphate	12.38
Calcic oxide	2.12
Insoluble matter	0.38
Moisture	26.49

Mother Liquors.—The problem of recovering the valuable salts in the mother liquors is not at all difficult. Much will depend on the process in operation. These liquors are sometimes used in the freshly filled leaching vats, and with much purpose should the mixture in use have a high insoluble percentage. The mother liquors may easily be freed of sulphates by neutralizing with lime, evaporation, and salting out the impurities. The analysis of these liquors is fairly indicated by the following table:

COMPOSITION OF MOTHER LIQUORS.

	Winter.		Summer.	
	1.	2.	1.	2.
Specific gravity	1.198	1.170	1.185	1.195
Temperature (degs. F.)	57	58	78	76
Total solids per liter (grams)	293.6	233.9	287.5	271.4
Total solids as—	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Bichromate potash	17.37	14.06	26.89	23.64
Potassic sulphate	52.35	51.02	42.47	44.41
Sodic sulphate	20.23	25.66	22.39	24.17
Sodium chloride	8.73	7.28	6.24	6.57
Free acid	1.32	1.98	2.01	1.21

PROCESS LOSSES.

The unavoidable process losses are few in number, as with careful attention the manufacture of bichromates is a very exact business. There are two sources of loss which are to a certain extent unavoidable, and these are the loss of potash, or soda, in the furnacing operation, and the loss of chromic acid and alkalies in the vat waste. The loss in the furnace is due to volatilization and the gradual disintegration of the brickwork of the furnace itself. It ranges from 13 to 16% on the total consumption. An important loss is the valuable material carried away in the vat waste. A thousand pounds of furnaced material makes about 1250 to 1500 lbs. of waste, depending on whether carbonates or sulphates were used. The following analyses give a statement of a well-washed waste from both processes:

	With Carbonate.	With Sulphate.
	Per Cent.	Per Cent.
Soluble chromates computed as Cr_2O_3......	0.16	0.17
Insoluble chromates computed as Cr_2O_3....	0.55	0.68
Potash computed as K_2O....................	0.34	0.38

The only remedy against excessive losses from these sources is the time-honored "eternal vigilance." Some loss is practically unavoidable, but it may be kept within reasonable bounds.

COST OF MANUFACTURE.

The cost of manufacturing is governed largely by prices of materials and the fitness of the plant. The data given herewith are based on fictitious prices of the materials used in the manufacture, which may at any time be converted into current prices. These fictitious prices are:

	Per Ton of 2000 Lbs.
Chrome ore at 50%...	$24.50
Carbonate of potash...	90 00
Burned lime...	4.00
Bituminous coal...	3.20
Sulphuric acid at 60° B...	10.80

The following statement of costs is taken from actual working results in the United States, and is somewhat high, as the plant used was far from being an economical one. The figures are for bichromate of potash both by the carbonate and the sulphate mixtures:

COST OF MANUFACTURING 100 LBS. OF BICHROMATE OF POTASH.

Items.	Carbonate.	Sulphate.
Chromic iron ore....................................	$1.41	$1.85
Potash....................................	3.15	1.68
Lime....................................	.31	.49
Coal....................................	.68	.88
Sulphuric acid, 60° B....................................	.32	.34
Wages....................................	1.21	1.53
Interest, etc....................................	.43	.57
Supervision and maintenance....................................	1.28	1.32
Totals....................................	$8.79	$8.66

About 35% of the wages cost is wholly on account of the furnacing, which also is responsible for 65% of the fuel cost. There is no doubt but that with present prices of materials the above total would be cut nearly if not quite $2. The proportions are of such a nature that ready comparison may be made with current prices or with any particularly special facilities. The writer's factory experience brought him into contact with all sides of the business, and the process books were part of the regular daily service. The figures and statements in this paper are based on sources of information not accessible to any one not intimately concerned with the daily routine of the business.

The following table shows the course of prices of bichromate of potash for 51 years:

PRICES OF BICHROMATE OF POTASH IN THE UNITED STATES, 1845–95.

Year.	Cents per Pound.	Year.	Cents per Pound.	Year.	Cents per Pound.	Year.	Cents per Pound.
1845	19⅞	1858	20¾	1871	16⅝	1884	11⅛
1846	18¾	1859	19	1872	20 11/16	1885	10
1847	17½	1860	20¾	1873	20 9/16	1886	9⅞
1848	16⅜	1861	20¾	1874	18⅛	1887	10
1849	20¾	1862	20⅜	1875	18 5/16	1888	10½
1850	22⅝	1863	23⅛	1876	15⅝	1889	11⅜
1851	17	1864	26¼	1877	13	1890	10½
1852	15⅝	1865	25½	1878	12 7/16	1891	9 13/16
1853	15	1866	23⅞	1879	12 7/16	1892	10½
1854	15 1/16	1867	19⅜	1880	13⅞	1893	10½
1855	14 11/16	1868	18⅝	1881	15⅜	1894	10½
1856	16½	1869	16⅞	1882	15½	1895	10½
1857	18¾	1870	14⅛	1883	14 9/16		

The even course of these prices is the most remarkable feature of the table. In the past 12 years the extreme variation in prices of bichromate has been 1½c. per lb., and for four years the average has not changed.

CLAY.

The clay industry is a branch of the mineral industry which presents a great diversity of products, and is carried on in so many places and under so many forms that it is extremely difficult to estimate its actual value and the amount of its products. With certain branches of the industry, such as kaolin or china clay and refractory clays, it is possible to secure fairly full returns, but the digging and working of ordinary clay for brick making and other purposes is carried on all over the country, in many places on a very small scale and in a desultory way as demand may require. From many of the smaller producers it is impossible to obtain statistical returns.

In the previous volumes of The Mineral Industry the technology of the clay industry has been very fully treated, and in Vol. II. analyses were given of a large number of clays from different places.

The clays of commercial value may be divided into three general classes: The china clays, the refractory clays, and the ordinary brick clays.

China Clays (*Kaolin, etc.*).—The total production of kaolin in 1895 amounted to 30,910 short tons (28,035 metric tons), valued at $258,431. The most important deposits worked are in New Jersey and Ohio, and the largest manufacturing interests are located in their vicinity in those States. In addition to the kaolin obtained in this country, a considerable quantity of the finer kinds of clay is imported for special work.

Kaolin deposits are found in many other States. Alabama, Georgia, Florida, and Tennessee possess such clays, some of them reported to be of excellent quality. They are also found in the East in Massachusetts, Pennsylvania, and Virginia, in the West in Arkansas, Colorado, and Arizona, and in the Northwest in Wisconsin and Iowa.

Refractory Clays.—The production of refractory clays is a large one, amounting in 1895 to 3,750,000 short tons, of an estimated value of $4,500,000. Here again Ohio and New Jersey are the chief producers. The composition and treatment of refractory clays are treated in the following pages.

Brick Clays.—The production and actual value of these clays it is impossible to state even approximately. They are very seldom sold as clay; always in finished form as brick, tile, etc. The total value of these products has been very variously estimated; probably from $65,000,000 to $70,000,000 in 1895 would not be far from the mark.

The locations chosen for this industry depend chiefly on three points, the presence of suitable deposits of clay being, of course, the most important, though supplies of fuel and nearness to a market with cheap transportation are also essential. Among the chief brick-making districts in the East are the country along the Hudson River from Haverstraw nearly up to Poughkeepsie in New York; along the Hackensack River in New Jersey; and in the neighborhood of Philadelphia, in Eastern Pennsylvania. The Hudson River clays are much valued, and the brick made from them are a standard quality in the trade.

A branch of this industry which is growing rapidly is the manufacture of paving brick, or shale brick as they are sometimes called. This has found place chiefly in the West, where brick pavements have been put down in many cities. In the East, where stone is usually cheaper and more accessible, they have been but little used. The manufacture has, however, been established at Catskill, N. Y., the chief material used being a clay shale from near Cairo, N. Y.

For railroad ballast in the West, where stone or gravel is not readily obtained, burned clay has been used with success on a number of roads. It was first introduced for this purpose by the Chicago, Burlington & Quincy Railroad Company upon some of its lines in Iowa, and has since been used on other roads. The clay is burned or baked in kilns built for the purpose and is broken up into lumps of suitable size.

Tennessee Clays.—According to Mr. Lucius P. Brown, all varieties of clay except true kaolin (kaolinite) are known to exist in Tennessee in workable amounts. In the eastern division of the State the coal-measure clays and shales are pretty extensively used. Besides these, clays resulting from the decomposition of the Knox dolomite and accompanying formations are important, and at Cleveland a considerable factory has been established upon a bed of this sort.

In the middle division of the State clays resulting from the weathering of Silurian and Lower Carboniferous rocks and Lower Carboniferous shales are used for making paving and building brick and terra cotta. In this connection a fact of interest is that in a neighborhood pottery in Hickman County coarse ware used to be made from a bed of clay resulting from the decomposition of Niagara rocks which were glazed with a slip containing manganese, the manganese mine for this purpose being the first opened in the United States. Of course only a few hundred pounds per year were used.

That portion of the State lying west of the Tennessee River is the richest in clay resources. Here, besides the coarser sorts of clays, very fine stoneware clays, burning to a hard body of a good color, are abundant, and deposits of good ball clay occur. Close search may reveal beds of fine sedimentary kaolin in the Tertiary rocks. The stoneware and ball clays mentioned above are believed to be of Cretaceous age. Good sands are also abundant, and a peculiar sand deposit containing a very small amount of alumina, which might be used as a substitute for ground flint.

Feldspar.—The total production of feldspar in the United States in 1895 was 22,195 long tons (22,550 metric tons), valued at $104,082. This showed an increase of 3491 tons over 1894; there was a larger proportionate increase in the value, the average price obtained showing an improvement. Feldspar finds its chief use in the chinaware and pottery manufactures.

Refractory Clays and Firebrick.

By Charles Ferry.

The term refractory refers to all those substances which, when subjected to an intense white heat, show no tendency to soften or fuse. The comparative refractory property of different materials or their mixtures may be determined by noting the respective temperatures at which these physical changes take place. But when we speak of refractory material it does not include all mineral substances and metals, for the term has limitations and comprises only those substances which remain intact at a continued white heat. As yet the line has not been definitely drawn between refractory and non-refractory substances. The chief bases of all the common refractory materials of commerce are pure silica, silicate of alumina (kaolinite), or combinations of these two compounds. We find examples of each and their mixtures in all the various grades of fireclay, firesand, kaolin, and their calcined products, of which firebrick is the most prominent. There are three principal varieties of fireclay—flint fireclay, rock fireclay, and plastic or sedimentary fireclay. From a chemical standpoint they are quite similar, but physically they are different. The flint and rock clays are both very hard and occur in a rock formation. They possess almost no plasticity unless very thoroughly pulverized and moistened with water; then most of these clays will manifest only a sparing amount of "stickiness."

Plastic or sedimentary fireclays, so largely produced in the northern part of the State of New Jersey, occur in the beds in a moist and completely disintegrated state. These clays are stratified and can be readily mined with pick and shovel. Of the plastic variety there are upward of 100 grades, classified according to their chemical composition, but as distinguished by the eye they may be referred to under the general heads white, blue, red stopped, sandy blue, and sagger clays (dark varieties), etc.

It is a very easy matter to distinguish the rock and flint clays from the plastic clays by a general physical examination. The classification of fireclays may be most successfully conducted by the assistance of chemical analysis. Resorting to color, feeling, or taste of fireclays is not reliable as a sure means of determining their absolute value. In the New Jersey deposits we find the very sandy varieties of clay, and also those containing as much as 40% of alumina—a little more than enough of that constituent to form pure kaolinite.

In a chemical examination of fireclay after each substance had been determined analytically, the results are interpreted and rearranged as follow:

	Per Cent.
Silica combined	45.25
Alumina	38.91
Water combined	12.21
Iron sesquioxide	0.37
Lime	0.12
Magnesia	0.08
Potassium oxide	0.73
Sodium oxide	None
Quartz (sand)	2.62

These refractories are composed of, first, kaolinite, quartz, accidental impurities, and moisture; then if we reduce these component parts into their elementary substances we find kaolinite contains combined silica, alumina, and combined water, and the fluxing impurities, consisting of lime, magnesia, protoxide and sesquioxide of iron, sodium and potassium oxides, sulphuric acid, phosphoric acid.

From the physical condition of the mass as a whole and of each constituent, coupled with their actual chemical composition, it is possible to determine their value or adaptability to any class of work. There is no code of rules which will tell the clay miner the absolute worth of any specimen of fireclay. The exact fitness of a given refractory material depends as largely upon the physical and chemical conditions to which it is to be exposed as upon its chemical composition. This shows the vital importance of a careful and intelligent classification of refractories and also their proper application.

While there is almost an infinite number of refractories with respect to chemical composition and physical nature, each becomes identified with some specific work where this or that grade of clay, sand, or kaolin acts efficiently by virtue of properties peculiar to itself. Difficulties are sure to arise if these refractories are not assigned each to its proper place and work. The complaint that a certain grade of clay does not give adequate results is not a positive proof that the material is a poor refractory mass. Accurate and reliable judgment in their application is one of the chief problems with which fireclay miners and manufacturers have to battle, and their inability to solve them correctly is the cause of most of their failures.

Roughly, then, the points to be observed before the proper disposition of refractories can be made are an exhaustive study, first, of their composition from their chemical analysis; second, their physical condition with respect to plasticity, including presence or absence of crystalline nature, and coarseness of grain. The last condition referred to—coarseness of grain—as related to the sedimentary variety of fireclay, depends almost entirely upon the quantity of anhydrous silica (quartz) present and the size of its crystals.

So far as I am able to learn from extensive investigation along these lines in the laboratory and in practice, these general laws are equally applicable to all refractory bodies—at least to all those which have either or both kaolinite and quartz as their principal constituents. There are certain other varieties of native refractories to which I have not alluded—magnesite, bauxite, etc.—but as their consumption is rather limited where actual heat-resisting power is the all-important property, I will not enter into their discussion.

Referring again to the physical condition of fireclay and its relation to the manufacture of firebrick, I would like to recall some of the advantages of a plastic clay. There are general principles in regard to the properties of plastic fireclays and methods for manipulating them which are demonstrated to every practical brickmaker through his daily factory experiences, and can be applied with safety in the manufacture of firebrick. In considering the best process for making firebrick, it is well to be governed largely by such practical knowledge, and adopt that method in which every virtue of the raw material is brought out in producing those necessary features of toughness and homogeneity of structure which good firebrick should possess.

There are so many different styles of brick machines that it is not a difficult matter to convert any refractory mixture into brick, therefore the expense necessary for working the mixture to a particular degree of fineness, or tempering and pugging it to a given state of softness before it is made into brick, has become a matter of choice to the manufacturer. Just here lies a point of serious impor-

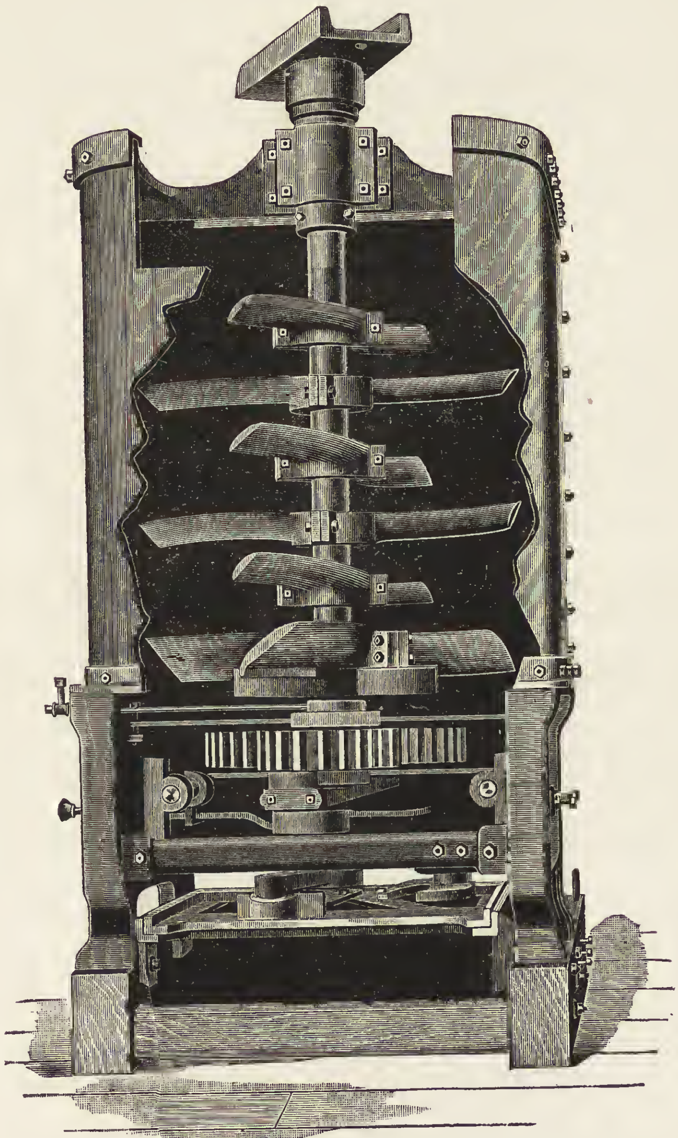


FIG. 1.—PUG MILL.

tance to those who make irebrick from fireclays which do not possess more than a trace of plasticity. Afew illustrations and a pinch of theory will serve to demonstrate this point .nd also to prove the value of its consideration in practice.

There are high grades of plastic fireclays which are practically free from all fluxing impurities such as lime, magnesia, oxide of iron, and the fixed alkalies, and are composed of quartz, hydro-silicate of alumina, kaolinite, and water of constitution. Plasticity of such sedimentary fireclays usually increases directly as their percentages of hydro-silicate of alumina and inversely as their percentages of quartz present. Suppose, for instance, we have a number of different samples of plastic fireclay, varying widely in chemical composition with respect to quartz and hydrous silicate of alumina, and from each of them we make a green brick. If these are burned properly in the kiln, annealed, and cooled, then examined in regard to their toughness, we will find that the brick made from the fireclay containing the least quartz and the most hydrous silicate of alumina is by far the toughest, while brick which carries the most quartz and the least hydrous silicate of alumina will be the most friable and possibly soggy.

It is true that bricks made from an extremely fat clay, consisting of little else but hydrous silicate of alumina, usually shrink so seriously in the kiln as to cause cracking. But this does not weaken the theory that the hydrous silicate of alumina not only gives the sedimentary fireclays most of their plasticity, but when burned in the kiln imparts a decided bond to the calcined product. In many instances the manufacturer depends upon the fluxing impurites for giving to the brick this hardening and toughening effect. But there is a great difference between a hard and a tough firebrick. The fact is only too familiar to iron manufacturers who have tested numerous grades of firebrick and have observed this tendency of some to chip off and waste away, not resulting so much from inferior refractory property as apparently due to the inability of the brick to expand and contract suddenly. The grains of clay in such brick are not held together by traces of fusible silicates and not by kaolinite to any extent. The iron manufacturer knows the tough firebrick which "burns evenly" in his furnace—the brick which has assumed its strength and ability to expand and contract suddenly without disintegration by virtue of that double bond received principally from the plasticity of its mixture, and reënforced by the trace of fluxing impurities.

Again, when a green firebrick is burned in the kiln usually its cubic contents are more or less reduced. If this shrinkage factor is too great the brick is liable to become checked and cracked in the operation. The shrinkage of clay is due to one or more of the following physical and chemical changes: loss of moisture; loss of water; partial fusion.

Shrinkage of clays and clay mixtures due to the loss of moisture, or water only mechanically associated with them, takes place from the time the mass is molded until it has been thoroughly "water-smoked" in the kiln.

Shrinkage of clay or clay mixtures due to the loss of water of constitution is effected from the moment the brick has been relieved of all its moisture until it has become completely anhydrous.

Shrinkage due to partial fusion and solidification is that change that takes place in the molecular and crystalline structure of the clay after it has been subjected to a very intense white heat. This form of clay shrinkage does not seem to associate itself with or in any way become dependent upon either the water of constitution or the moisture of the clay. This factor is most apparent in the impure plastic clays, and sometimes a very material allowance must be afforded when the brick molds and press boxes are made, to provide for this extra shrinkage in addition to the water and moisture shrinkages of the clay. Complete fusion means the operation of melting or rendering fluid by heat without the aid of a solvent. Partial fusion, then, is the act of so softening a substance by heat that its crystalline nature, if it has any, is destroyed and its molecules blended together into oneness—that is, vitrifaction in the same sense that the word is now used. "Softening" is a word which applies very fittingly here, because this shrinkage depends upon the degree of softness of the particles of clay when they are under the influence of heat. As fireclays do not vitrify in the kiln, but are usually taken out in a porous condition, it would seem as though this factor had little to do with the firebrick manufacturer's work. On the contrary, however, a firebrick does shrink very materially after having been thoroughly calcined, and still retains its porous nature.

This contraction of the body is "shrinkage due to partial fusion," and while the effect is not perceptible to the eye in a burned firebrick, still it is only the very being of that physical change known as vitrifaction. There are two principal conditions which control shrinkage due to partial fusion—chemical composition of the refractory and degree of heat to which it is exposed. Frequently those who are manipulating refractory clays take from their kilns soft or underburned firebrick which are white, soggy, and entirely unfit for all commercial use. As a means of utilizing this product, an effort is made to reburn them where they will be exposed to the direct and severest heat of the kiln.

The firebrick made from the purest clays, if not successfully burned in the first kiln treatment, cannot be combined perfectly by reignition. The soggy, dead firebrick that has been burned the second time usually does not show any marked improvement over its previous condition. While these results condemn the efficiency of such a method for reproducing sound brick from the under-burned soft brick, still, negatively it always speaks well for the purity of the clay. If in such treatment brick manifests this obstinacy and utterly refuses to be influenced by a second burn, it is usually a sure indication that the accidental impurities run low in the clays of which it is composed.

Experience teaches that in order to make a superior firebrick from plastic clays which are really destitute of any appreciable amount of fluxing impurities and are combined by virtue of the effect of the white heat of the kiln upon the hydrous kaolinite present, the process of burning must be continuous and uninterrupted. The green brick should be "water-smoked" and the heat increased gradually until a complete ignition has been effected. Again, it is easy to illustrate the similar effects which are obtained in relation to "shrinkage due to partial fusion" of a brick, first, by change in the chemical composition, and, second, by very intense heat.

Take, for example, a plastic firebrick mixture and burn it in the usual way in the kiln. The product obtained is porous and possesses but little fusion shrinkage. For the first experiment we will add to the firebrick mixture 5 to 6% of lime, then burn a brick of this composition in the customary manner. When the ware is taken from the kiln it will be seen that the brick has been vitrified and its dimensions very materially reduced. For the second experiment we will put one of these firebrick, without the lime, into the throat of a reheater iron furnace, where the heat is exceedingly intense, much more so than in the kiln. The result will be that the molecules of anhydrous kaolinite and quartz will succumb to this treatment and soften just enough to bring about the same solidification of these particles which was accomplished in the kiln in the first experiment. In both instances this shrinkage is due to only a trace of fusion, but a vast difference in temperature is required on account of a wide variation in actual refractory property of each brick.

In considering the processes for manufacturing firebrick it is well to bear in mind the two distinct classes of work which are carried on in the factory: Production of special shapes or hand-made brick and production of the regular stock shapes.

The most important feature of a firebrick mixture to the molder is that it should have sufficient plasticity to be manipulated successfully. It is easy to see why this condition of the mixture should be considered and amply provided for if the molder is expected to accomplish his work economically. Briefly, the method for producing a "hand-made" brick is to roll a ball of the mixture large enough to fill the wooden mold, and to throw it down into the mold with all the force possible. The excess of clay is cut off with a wire, the exposed surface of brick smoothed off with a stick, and then the brick is dumped. If the mixture is "short," or only sparingly plastic, it is difficult to form the ball of clay and impossible to throw it into the mold without a large part of the stock flying in all directions. In addition to the requisite amount of plasticity, the different clays which constitute the mixture should be evenly distributed throughout the mass.

Thus we see it is absolutely necessary that the process for preparing these clay mixtures, designed for hand work, should be one eminently fitted for producing from the mixture its maximum amount of plasticity.

There are three general processes for manufacturing firebrick: The soft-mud process, the semi-dry or stiff-mud process, and the dry process.

If a clay mixture has plasticity it is sure to be developed if thoroughly disintegrated and soaked—two important features in the soft-mud process. When we bear these points in mind, it is evident that brick mixtures prepared by these methods are in the most perfect conditions for hand molding. The brick mixtures usually consist of two or more varieties of refractory materials, and for the soft-mud process they are first ground to any degree of fineness desired, then transferred to a large square pit in small consecutive layers, each of which contains all these different ingredients, introduced in the proper proportion by bulk. There may be seven layers in the pit when full, each of which represents a complete mixture in itself, but these layers may have their materials arranged in the form of sub-layers distinct from one another.

The contents of the pit are thoroughly soaked with water and allowed to stand for 24 hours. From the pit the mixture is shoveled into a vertical pug mill, which is no more than a large square box with a vertical shaft running through it from top to bottom, provided with 24 or more heavy flat knives extending out horizontally and as long as the mill will admit. The knives are so adjusted as not only to mix and soften the wet clays, but to force them down and out through a small hole on one side of the bottom of the mill. The machine is shown in Fig. 1.

The mixture as it is taken from the pug mill (Fig. 1) is ready for the hand molder, or it may be transferred to the soft-mud brick machine, one type of which is represented in Fig. 2. This machine repugs the mixture and produces rough, unfinished brick. Wooden brick molds (Fig. 3) are fed into the machine on one side and issue from the other filled with the clay mixture. The bricks, in a very soft and rough condition, are dumped upon boards and transferred to a rack, where they are allowed to remain until quite stiff. When they have become so sound that it is difficult to make a decided impression upon them with the finger, they are pressed into regular and perfect shapes in the hand machine illustrated in Fig. 4. As they are taken from the press they are placed on brick cars and run into a dryer, consisting of hot tunnels, where they are relieved of most of their mois-

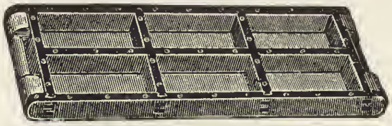


Fig. 3.—Brick Mold.

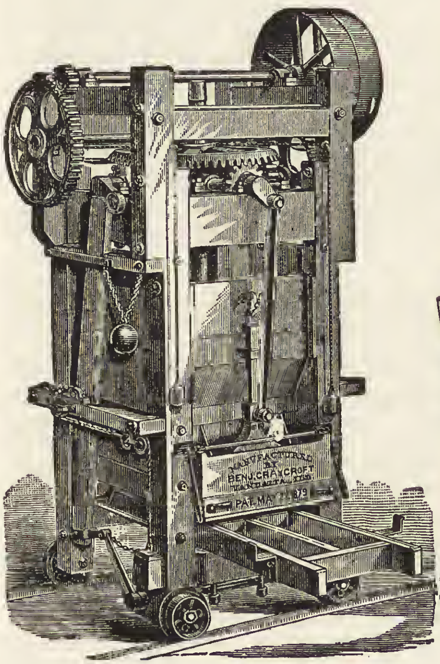


Fig. 2.—Brick-making Machine.

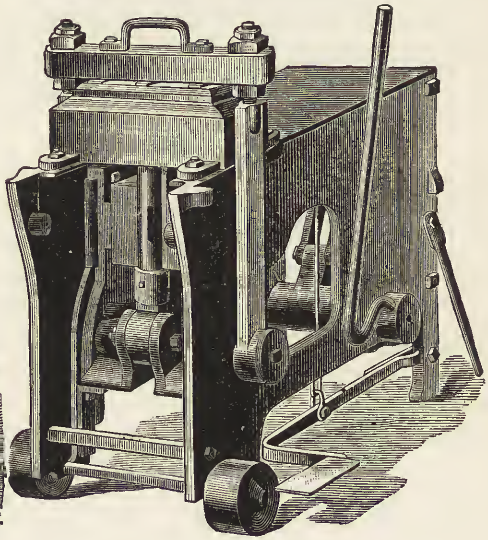


Fig. 4.—Hand Press.

ture. There is a continuous circulation of dry hot air passing through these tunnels, and as the cars are sent into the dryer in the opposite direction, it is always the purpose of the brick maker to have one end of his dryer discharging dry green brick and the other continually receiving wet brick.

There is also the semi-dry or stiff-mud process for making firebrick. The chief point in which it differs from the previous method is in the quantity of water added to the clay mixture. All the refractories in the mixture are disintegrated and mixed dry, then transferred to a horizontal pug mill, where only enough water is added to temper the clay sufficiently to bring out its cohesive and plastic properties without making it soft. When the mixture is treated in this way the bricks can be piled six high without becoming seriously deformed and can be pressed directly as they come from the machine. This method of procedure avoids the necessity of brick racks when the product as it issues from the machine has to be left to stiffen before being pressed. The brick made by the stiff-mud process which have been re-pressed probably dry quicker and safer than the soft-mud brick, on account of the smaller quantity of water in them. As this is one continuous and uninterrupted series of treatments, the raw material can be handled by machinery through all its stages of development till it is ready for the kiln.

In the dry process the clay is not softened to any extent, but the raw material pressed into perfectly shaped brick by one operation of the machine, depending upon the natural moisture in the clay or a small percentage added by the application of steam to bind the particles of the green brick together. It is easy to see that the products of such a machine would possess the most dense and compact structure of any firebrick made, and the only bond the material could have would be that cohesion of propinquity and the pressure which puts these grains into their relative positions. In other words, the plasticity of any fireclay is able to impart to the green or burned ware no more than half its strength if the bricks are made by this process. The only effective binding power of the dry-pressed brick is brought about by the fusible silicates, and it will be remembered that superior refractories should contain these substances only in limited quantities.

There are several different varieties of firebrick kilns, many of which are patented, but all may be classified under one of the three general heads: the up-draught kiln, the down-draught kiln, and the continuous kiln.

There is still considerable discussion over the comparative merits of the up-draught and down-draught kilns, but it is enough to say that both are used for burning refractory brick with excellent results. It is easy to grasp the principle of each, and therefore a few words in relation to each will be quite sufficient.

Fig. 5 represents an up-draught kiln, the fire holes being shown below the charging hole above, through which the green bricks are passed when the kiln is filled. The peculiar feature about the up-draught kiln is that the hot gases pass into the bottom from the fire holes, and after becoming distributed throughout the lower part of the kiln go on upward, thence directly out through the chimney.

Referring to Fig. 6, which shows a section of a down-draught kiln, it will be noticed that after the gases go into the kiln they are conducted through flues arranged around the sides to the top of the kiln, then downward through the wares into flues in the bottom of the kiln, which are connected with an outside chimney.

The continuous kiln, as shown in Fig. 7, is built with a series of connecting chambers in which bricks are set ready to be burned; each of these chambers might be considered as a kiln by itself. After a given number or all of these chambers are filled the first in the series is fired and the wares burned to a finish. During this operation the radiating or exhausted heat, instead of passing directly into the open air and thus being wasted, is drawn horizontally through the next adjacent chamber of brick and is utilized in drying and partially calcining green wares. When the continuous kiln is in full operation the entire work of setting, burning, cooling, and discharging is made perpetual, but the heat which escapes from any individual chamber is sure to be caught and made to do work in the next compartment of brick.

The chemical composition of fireclays in general consists in varying proportions

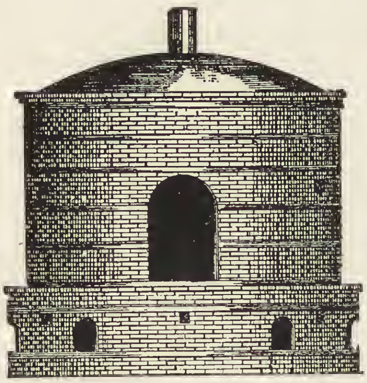


FIG. 5.—UP-DRAUGHT KILN.

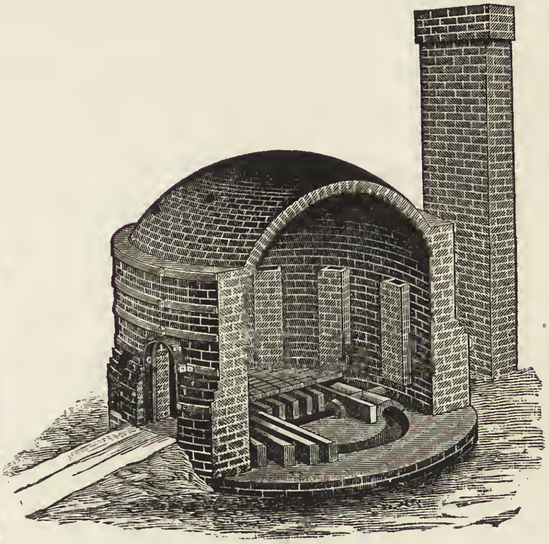


FIG. 6.—DOWN-DRAUGHT KILN.

of kaolinite, quartz, and water of constitution. Kaolinite is a normal silicate of alumina, $Al_2O_3,2SO_2,4H_2O$. Quartz (sand) is pure anhydrous silica. Water of constitution is the water which is chemically combined or a part of the clay itself. In other words, clay may be "bone dry" and to all appearances free from water, but if examined will be found to contain from 2 to 12% of water.

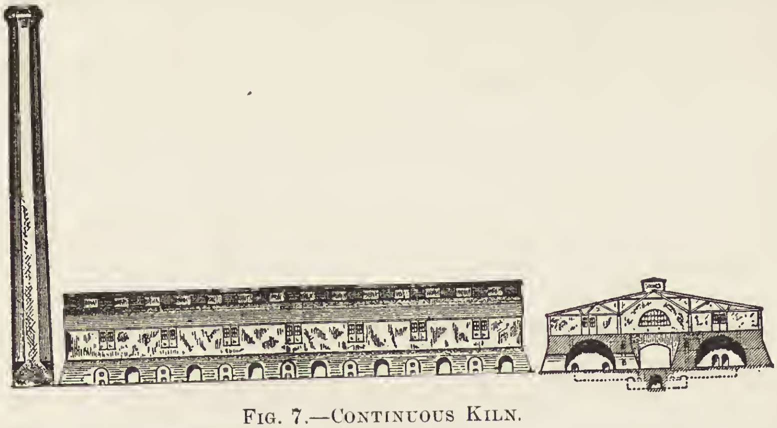


FIG. 7.—CONTINUOUS KILN.

If an analysis is made of fireclay it is customary to determine the total amount of alumina and silica present; but the second substance, silica, while it is all separated from the clay by chemical manipulation and weighed in the same condition, namely, as anhydrous silica, yet exists in the raw clay in two distinct states, hydrous (combined) silica and anhydrous (uncombined) silica. The first substance mentioned, hydrous (combined) silica, is united chemically with the alumina of the clay, and the anhydrous (uncombined) silica remains free so far as any chemical bond is concerned. It can be readily explained and understood that kaolinite is the combination of the hydrous (combined) silica with all the alumina of the clay. Therefore the composition of a theoretically pure fireclay is: Kaolinite-hydrous combined silica and alumina; quartz sand-anhydrous uncombined silica; water of constitution.

There are places where firebrick are used which call for the most siliceous brick that can be made. On the other hand, there are furnaces which have to be lined with firebrick, but when in operation contain gases and substances which unite directly with silica, forming fusible silicates. As a result of these changes, high-silica brick of the best grade may be destroyed in a comparatively short time.

So far we have been discussing theoretically pure fireclay and its proper application, but practically speaking there is no such thing. Every natural fireclay contains, besides kaolinite, quartz, and water of constitution, at least traces of one or more of the following-named accidental impurities: Titanium, iron, lime, magnesia, alkalies (potassium and sodium), and possibly sulphur. For determining the ability of a given specimen of firebrick to resist a clear hot flame, the nearest approach to freedom from all of these impurities, save the first and last, is the best index and surest guide. Iron, lime, magnesia, and the alkalies at an intense heat unite with the silica of the clay, if they have not already combined to form fusible silicates which reduce the refractory property of the material.

The temperature at which the change takes place is not the same with all of these impurities. Iron does not unite with silica at as low heat as sodium and potassium compounds. Lime and magnesia do not combine with silica as readily as the alkalies, but as a general rule these bases—iron, magnesia, lime, and the fixed alkalies—have an affinity for the silica of a firebrick which will be satisfied at extreme temperatures. These bases may already exist in the form of silicates.

Take a pure fireclay and mix it with a definite amount of lime, say 4 to 5%, then make from it a quantity of firebrick. If the brick are subjected to a sufficiently high heat to effect a union between the silica of the brick and the lime, we will find that the lime has not taken up only a limited amount of silica, but has united with and distributed itself evenly throughout the entire mass of silica in the brick. Here silica acts as an acid in combining with bases to form salts or silicates. These impurities, however, play an important part in the physical character of the brick if properly treated in the kiln, besides having a very close relation to its refractory property.

To come back to the advantages of a high siliceous refractory material, by reason of its chemical composition alone a high-silica brick cannot be made to withstand the action of the hot volatile substances so often contained in the gases which come in direct contact with the brick. At the same time, for much work there is a large demand for high-silica bricks, because it has been proved that they give the best service.

In closing, it may be said that if the refractories of the present age have not proved adequate in service, the fault does not exist in their qualities, but rather in our improper application of them.

COAL.

The production of coal in the United States in 1895 reached a total of 195,-761,332 short tons (or 177,595,679 metric tons), the largest amount ever reported in a single year. The increase over 1894 was no less than 25,885,551 tons, or 15.2%, while as compared with 1892, the year which had previously shown the greatest output, there was a gain of 15,449,828 tons, or 8.5%.

In the coal produced in 1895 there is included 58,362,985 short tons of anthracite and 137,398,317 tons of bituminous coal. The anthracite was almost wholly from the Pennsylvania mines, only 236,640 tons, or 0.4% of the total, coming from Arkansas and Colorado.

This increase in coal production reflected almost with accuracy the industrial position of the country. During the two years of depression in the iron and other manufacturing interests the output of coal diminished almost as rapidly as the demand, but in 1895 the revival of business called for a larger production, and the coal operators were only too eager to respond. The coal mined in the United States is almost all consumed within our own borders, the exports being less than 2% of the total, so that there is no large outlet for a surplus production.

The general tendency in coal mining in this country has been to keep just a little—sometimes more than a little—ahead of the demand. The opening of new fields has been aided by the construction of railroads anxious for traffic, and has been carried on at a rate which has kept prices always low and established a sharp competition for all the trade. The average price of bituminous coal at the mines in 1895 was $0.91 per short ton, and of anthracite $1.51; the average for the entire coal output being $1.21 per ton. The return obtained for the anthracite was 5c. per ton less than in 1894, while that for the bituminous was 3c. per ton greater.

That the supply of coal in the United States is practically inexhaustible is generally conceded, and we have not yet, except in the anthracite fields and a few of the bituminous fields, come to the point where it is necessary to husband our resources. Low prices have furnished a strong incentive to economy in operating, but wasteful methods of mining and handling are still the rule, and a very large portion of the coal is either left in the mines or goes into the waste dumps and culm heaps. The saving of a portion of this waste rather than the opening of new mines should be the object of coal operators.

Almost the only improvement recently introduced, or now being introduced, into the coal mines is the washing of coal, and where the character of the coal makes it possible, the conversion of the slack into coke. This has been tried at several mines in the South with excellent results.

One consideration, which may have had its effect with a few long-headed men, but to which the great body of coal operators have given no thought as yet, is the possibility that the not remote future may see a radical change in our methods. It is not improbable that the actual transportation of fuel may decrease very much, or even be entirely done away with, and that the fuel may be converted into gas or electricity in plants erected at the mines and transmitted to the points where heat and power are required by pipe lines or wires. A suggestion of this is found in the plans now under discussion at Boston, where a company is seeking legislative authority for the establishment of a central plant or plants from which fuel gas may be furnished to a number of towns and cities; while at the same time the by-products of the distillation of coal may be utilized in chemical works placed in close connection therewith.

The accompanying table shows in detail, by States, the production of coal and coke in the United States for the years 1894 and 1895.

It will be seen that the increase in coal production was not evenly distributed. Pennsylvania continued to be by far the leading State as a coal producer, furnishing not only nearly all the anthracite, but 38% of the bituminous coal; that is, in all, over 56% of the entire output. The percentage of increase was also greater than the average. Ohio and West Virginia made notable gains, as did also Indiana and Alabama. In Iowa, where the manufacturing demand is not a large factor, the coal production showed only a moderate gain. In Illinois it was nearly stationary, showing the effect which the competition of Ohio, Indiana, and West Virginia coal has had in the markets to which the coal from this State chiefly goes.

In Vol. III. of The Mineral Industry the conditions under which a large part of the bituminous coal mined is marketed were described. It cannot be said that these conditions changed materially during 1895, though the situation was somewhat relieved by the increased demand for coal. Notwithstanding this competition continued very sharp and was aided, as heretofore, by the railroads upon which the different coal fields depend for transportation and by which they are controlled. Some of the results are shown by the changes expressed in the table and by the comparative increases and decreases. The extension in the sales of West Virginia coal at tidewater continued, and there were also some gains in the Western markets. The hold gained by this coal during the great strike of 1894 has not been lost, and it now enters into sharp competition with the Indiana and Illinois and to some extent with the Ohio coals also at many important points. The Kanawha district, in the same State, is also competing actively for the Mississippi River trade with the Pittsburg coal, and in 1895 it was again favored by the dry season and the difficulties of navigation in the Ohio, which prevented shipments from Pittsburg for months at a time and left the markets open to its competitor.

TOTAL PRODUCTION OF COAL AND COKE IN THE UNITED STATES.

(In tons of 2000 lbs.)

COAL.

States.	1894. Tons.	1894. Value. Totals.	1894. Value. Per Ton.	1895. Tons.	1895. Value. Totals.	1895. Value. Per Ton.
Bituminous:						
Alabama	4,381,295	$3,943,165	$0.90	5,680,410	$5,680,270	$0.90
Arkansas	*a*672,866	799,919	1.20	797,424	1,993,569	2.50
California	94,754	236,885	2.50	80,115	240,345	3.00
Colorado	2,862,994	3,521,483	1.23	3,449,000	4,242,270	1.23
Georgia	354,111	300,994	.85	414,310	364,593	.88
Illinois	*a*17,113,576	15,402,218	.90	*a*17,735,864	16,316,995	.92
Indiana	*a*3,065,394	2,973,432	.97	*a*4,312,084	4,096,480	.95
Indian Territory	1,072,542	1,662,440	1.55	1,228,440	1,904,082	1.55
Iowa	*a*3,776,373	4,720,466	1.25	*a*3,995,836	5,076,434	1.27
Kansas	2,701,191	3,241,439	1.20	3,190,843	3,590,141	1.13
Kentucky	2,967,195	2,521,615	.85	3,207,770	2,726,605	.85
Maryland	3,101,082	2,729,744	.88	3,479,499	3,061,959	.88
Missouri	*a*2,383,322	2,740,820	1.15	*a*2,283,081	2,625,543	1.15
Montana	688,780	1,377,560	2.00	1,104,854	2,300,300	2.08
New Mexico	323,721	485,581	1.50	367,442	551,162	1.50
North Carolina	13,150	20,514	1.56	15,386	24,771	1.57
North Dakota	65,000	81,500	1.10	79,850	99,475	1.25
Ohio	11,902,678	10,117,276	.85	13,926,133	12,254,997	.87
Oregon	42,509	95,645	2.25	65,918	240,081	3.64
Pennsylvania	41,867,188	29,307,033	.70	51,813,112	36,787,310	.71
Tennessee	2,589,664	2,019,938	.78	2,319,720	1,809,382	.78
Texas	469,904	1,000,895	2.13	499,668	1,064,293	2.13
Utah	453,601	635,041	1.40	530,713	769,533	1.44
Virginia	925,837	694,378	.75	1,083,229	812,421	.75
West Virginia	*a*10,559,926	7,401,948	.70	12,355,113	8,895,681	.70
Washington	1,183,660	2,840,784	2.40	1,184,619	4,738,476	4.00
Wyoming	2,224,135	2,869,134	1.29	2,197,914	3,077,080	1.40
Other States	8,000	17,120	2.13	....	....	....
Total bituminous { Short tons	117,865,348	$103,758,967	$0.88	137,398,347	$125,344,248	$0.91
Total bituminous { Metric tons	106,903,871	....	.97	124,627,141	....	1.01
Anthracite:						
Arkansas	50,994	$178,479	$3.50	103,247	$309,741	$3.00
Colorado	131,034	366,897	2.80	133,393	373,500	2.80
Pennsylvania	51,828,405	80,334,028	1.55	58,126,345	89,265,458	1.54
Total anthracite { Short tons	52,010,433	$80,879,404	$1.56	58,362,985	$89,948,699	$1.54
Total anthracite { Metric tons	47,183,345	....	1.76	52,965,538	....	1.70
Grand total coal { Short tons	169,875,781	184,638,371	$1.09	195,761,332	215,292,947	$1.10
Grand total coal { Metric tons	154,211,308	....	1.20	177,595,679	....	1.21

COKE.

States.	1894. Tons.	1894. Value. Totals.	1894. Value. Per Ton.	1895. Tons.	1895. Value. Totals.	1895. Value. Per Ton.
Alabama	924,002	$1,524,603	$1.65	1,232,242	$2,094,811	$1.70
Colorado	283,945	562,211	1.98	310,950	621,900	2.00
Georgia	86,000	136,740	1.50	90,620	144,086	1.58
Illinois	2,400	3,960	1.65	3,200	5,280	1.65
Indiana	4,500	7,785	1.73	4,760	8,330	1.75
Indian Territory	7,131	16,900	2.37	7,000	16,590	2.38
Kansas	7,500	14,850	1.98	8,350	16,700	2.00
Kentucky	27,715	44,067	1.59	25,453	40,725	1.60
Montana	30,000	86,100	2.87	61,378	506,417	8.25
New Mexico	6,706	15,490	2.31	1,309	3,024	2.31
Ohio	15,000	23,850	1.59	17,150	27,905	1.59
Pennsylvania	5,561,476	7,952,910	1.43	6,355,813	9,088,813	1.44
Tennessee	316,358	477,700	1.51	371,740	557,610	1.52
Utah	29,286	64,429	2.20	34,265	75,383	2.20
Virginia	117,800	174,344	1.48	137,826	203,982	1.49
West Virginia	1,067,157	1,526,034	1.43	1,248,574	1,785,461	1.43
Washington	4,294	14,213	3.31	7,318	43,918	6.00
Wyoming	4,025	8,372	2.08	9,000	18,000	2.00
Total coke	8,495,295	$12,654,558	$1.49	9,927,348	$15,258,935	$1.54

(*a*) Fiscal year.

The changes in most of the other States call for little remark. The most notable, perhaps, is the slight decrease shown on the Pacific Coast.

The following table shows the total production by States for the five years ending with 1895:

UNITED STATES PRODUCTION OF COAL, 1891–95. (IN SHORT TONS.)

Year.	Alabama.	Arkansas	California.	Colorado.	Georgia.	Illinois.	Indiana.	Indian Territory	Iowa.	Kansas.
1891......	4,759,781	542,379	93,301	3,512,632	171,000	15,660,698	2,973,474	1,091,032	3.825,495	2,753,724
1892......	5,314,227	739,300	131,431	3,771,234	165,000	17,862,276	4,494,811	1,004,765	3,820,000	2,794,000
1893......	5,170,042	740,000	75,000	3,946,232	372,191	19,949,564	*a*4,583,000	1,229,562	*a*3,790,000	2,881,930
1894......	4,381,295	*a*723,860	94,754	2,994,028	354,111	*a*17,113,576	*a*3,065,394	1,072,542	*a*3,776,373	2,701,191
1895......	5,680,410	900,671	80,115	3,582,393	414,310	17,735,864	4,312,084	1,228,440	3,995,836	3,190,843

Year.	Kentucky	Maryland	Michigan	Missouri.	Montana.	New Mexico.	North Carolina.	North Dakota.	Ohio.	Oregon.
1891......	2,916,069	3,820,239	80,307	2,650,018	541,861	462,328	....	....	14,616,209	51,826
1892......	3,020,050	3,036,283	70,000	3,017,285	648,701	434,291	....	....	14,599,908	34,720
1893......	3,302,250	3,327,749	22,072	*a*3,190,442	783,300	457,085	17,000	*b*125,000	14,828,097	41,478
1894......	2,967,195	3,101,082	....	*a*2,383,322	688,780	323,721	13,157	*b*65,000	11,902,678	42,509
1895......	3,207,770	3,479,499	....	2,283,081	1,104,854	367,442	15,386	79,850	13,926,133	65,918

Year.	Pennsylvania.		Tennessee.	Texas.	Utah.	Virginia	West Virginia.	Washington.	Wyoming	Other States.	Totals.
	Bituminous.	Anthracite.									
1891..	42,788,490	50,665,431	2,703,319	172,100	371,045	736,399	8,155,201	1,056,249	2,327,841	....	169,543,948
1892..	46,576,576	52.472,504	2,413,678	300,000	363,020	800,000	8,710,878	1,000,000	2,454,449	....	180,311,504
1893..	43,421,898	47,179,563	1,857,432	322,745	421,400	842,933	*a*9,838,011	1,211,550	2,243,401	....	176,180,927
1894..	41,867,188	51,828,405	2,589,664	469,904	453,601	925,837	*a*10,559,926	1,183,660	2,224,135	8,000	169,875,781
1895..	51,813,112	58,126,345	2,319,720	499,668	530,713	1,083,229	12,355,113	1,184,619	2,197,914	....	195,761,332

(*a*) Fiscal year. (*b*) Estimated.

As already noted, the imports and exports of coal in the United States affect the production very slightly; those for the five years ending with 1895 are shown in the following tables:

IMPORTS OF COAL AND COKE INTO THE UNITED STATES.

Year.	Coal.					Coke.		
	Anthracite.	Bituminous.	Totals.			Short Tons.	Metric Tons	Value.
	Short Tons.	Short Tons.	Short Tons.	Metric Tons	Value.			
1891..........	16,676	1,525,972	1,542,648	1,399,490	....	50,753	46,043	$223,184
1892	....	1,144,499	1,144,499	1,038,290	$3,747,140	24,482	22,210	86,350
1893..........	....	1,108,538	1,108,538	1,005,933	3,620,368	33,165	30,080	99,683
1894....	....	1,244,330	1,244,330	1,128,156	3,829,807	29,137	26,427	70,358
1895..........	....	1,226,386	1,226,386	1,351,845	3,637,085	....	....	....

EXPORTS OF COAL—DOMESTIC PRODUCTION.

Year.	Anthracite.		Bituminous.		Totals.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1891............	967,181	$4,062,160	1,807,202	$5,710,758	2,774,383	$9,772,918
1892............	851,639	3,722,903	1,645,686	4,999,289	2,497,325	8,722,192
1893............	1,334,287	6,241,007	2,324,591	6,009,801	3,658,878	12,250,808
1894............	1,440,625	6,359,021	2,195,716	4,970,270	3,636,341	9,995,362
1895............	1,470,710	5,937,130	2,211,983	4,816,847	3,682,693	10,753,977

In order to secure a completed statement, we add to the foregoing tables an additional one, in which are shown the production, imports, exports, and the approximate consumption for the five years ending with 1895:

COAL PRODUCTION AND CONSUMPTION IN THE UNITED STATES. (IN SHORT TONS.)

Year.	Production.	Imports.	Total Supply.	Exports.	Consumption.	
					Short Tons.	Metric Tons.
1891	169,543,948	1,542,648	171,086,596	3,774,383	167,312,213	151,785,640
1892	180,311,504	1,144,499	181,456,003	2,497,325	178,958,678	162,351,313
1893	176,180,927	1,108,538	177,289,465	3,658,878	173,630,587	157,517,669
1894	169,875,781	1,244,330	171,120,111	3,636,341	167,483,770	151,941,276
1895	195,761,332	1,226,386	196,987,718	3,682,693	193,305,025	175,366,319

The mining statistics of cost, labor, etc., are given in a separate article entitled "Labor, Wages, and Accidents in Mining" in another part of this volume.

COAL PRODUCTION OF THE WORLD.

In the table below are collected the statements of production of the different nations of the world for the five years ending with 1895. The figures are given from the official returns, except that in the Australasian colonies, Austria-Hungary, India, Italy, Japan, and Sweden we have estimated the production for 1895:

COAL PRODUCTION OF THE WORLD. (IN METRIC TONS.)

Year.	Africa	Australasia.					Austria-Hungary	Belgium.	Canada.		France.	Germany.
		New South Wales.	New Zealand.	Queensland.	Tasmania	Victoria.			Alberta, British Columbia	N. Brunsw'k, Nova Scotia.		
1891..	156,603	4,102,940	679,562	275,949	43,952	29,625	28,822,439	19,675,664	1,195,665	2,077,605	26,024,893	94,252,278
1892..	250,000	3,841,842	684,155	269,354	36,243	30,445	29,225,004	19,583,173	1,006,721	1,974,059	26,178,073	92,544,050
1893..	300,000	3,330,939	691.548	268,260	43,893	93,202	26,548,604	19,407,251	925,298	2,556,085	25,738,073	95,476,208
1894..	600,000	3,730,829	745,000	275,036	31,052	174,407	26,905,490	20,534,501	1,327,259	2,168,340	27,416,905	101,485,857
1895..	700,000	3,500,000	760,000	275,000	33,000	200,000	27,250,000	20,414,849	1,403,911	1,782,732	28,236,039	103,876,813

Year.	India.	Italy.	Japan.	Russia.	Spain.	Sweden	United Kingdom.	United States.	All Other Countries.	Totals.
1891..	2,366,067	289,286	3,226,975	6,233,025	1,320,139	198,033	188,465,340	153,810,270	1,854,690	535,101,000
1892..	2,578,299	295,713	3,199,763	6,325,020	1,461,196	199,380	184,713,640	163,657 988	1,500,000	539,554,118
1893..	2,570,332	317,249	3,328,879	6,560,320	1,531,810	199,933	166,971,440	159,919,176	1,500,000	518,456,180
1894..	2,620,910	271,294	3,500,000	7,498,000	1,659,264	213,634	188,277,525	154,211,308	1,600,000	545,246,611
1895..	2,650,000	250,000	3,650,000	7,551,180	1,774,560	205,000	194,350,604	177,595,679	1,750,000	578,209,367

Great Britain continues to lead as a coal producer, though a few years more of such progress as was shown in 1895 will put the United States in the first place. Germany, whose output has been growing gradually but very steadily, holds the third place. and is far in advance of any other nation. The three countries mentioned furnish about 82% of the world's supply of coal.

Great Britain continues to be the great exporting nation, sending abroad yearly from 17 to 20% of her entire output. Germany exports comparatively little, using nearly all her own product and importing some from Austria. No other European nation mines enough for its own use, and all are importers to some extent.

The coal production of France increases slowly and does not quite supply all the home demand, some coal being imported from England, though, on the other hand, some is exported to Belgium. The last-named country is now apparently working its coal measures to the fullest possible extent, and little or no increase is to be looked for in the future; a gradual decrease is rather to be expected. In Austria-Hungary the production does not vary greatly, as the demand increases slowly. The Russian production grows moderately, though the consumption of fuel is constantly increasing. In a large section of Southeastern Russia, most of which is a long distance from the coal-mining districts, crude petroleum and the heavy refuse from the distillation of petroleum are coming into very general use as fuel, as they can be obtained in many places more cheaply than coal. In European Russia there is room for a great expansion in coal mining, and in Siberia there are valuable coal fields which have hardly been touched as yet, but which will doubtless be developed when they obtain railroad transportation. Coal has also been discovered recently in Russian Turkestan, and work has been begun on the deposits, which are not far from the Trans-Caspian Railroad.

In the East there have been few changes. The Japanese coal trade was to some extent interfered with by the war with China, but mining is increasing and the coal continues to be pushed in the Eastern markets, where it is proving a strong competitor of the Australian and English coals. Some cargoes of Japanese coal have even found their way to San Francisco. Now that the island of Formosa has passed under Japanese rule, it is probable that its great coal deposits will be developed.

The coal production of Australia decreased slightly, owing to the depression in business and in the manufacturing industry which prevailed in the colonies. In New South Wales, which is the chief exporter, the decrease was partly due to the competition of Japanese coal and to the extension of coal mining in several of the islands of the Indian Archipelago which have been customers for Australian coal.

COKE.

The increase of the coke production of the United States in 1895, which, as shown in the table, amounted to 9,927,348 tons, a gain of 1,432,053 tons, or 16.9%, over the previous year, was the consequence of the improvement in the iron trade, which is the chief customer for coke. The most notable event in the coke trade has been the reaction against the control of the Connellsville coke region in Pennsylvania by a single interest, and the consequent increase in the demand for West Virginia coke, and the establishment of plants in other districts which is now in progress.

There is a marked tendency also at present toward the adoption of by-product coke ovens of some of the various types, as both coke makers and iron makers are realizing that this is necessary if we are to continue to hold our own with our competitors. The progress made so far is comparatively small, but there is so large a number of new plants planned and begun that the disappearance of the old wasteful beehive oven seems certain. A full account of the various types of by-product ovens will be found in another part of this volume.

The Anthracite Coal Market in 1895.

In many ways the year 1895 was a remarkable one for the anthracite coal trade. It was remarkable for the things done which ought not to have been done, and also for the things left undone which ought to have been done; in the first half it was remarkable for the number of meetings of presidents and sales agents; in the second half for the total absence of such gatherings, and throughout the twelve months for the numerous plans suggested, all of which were remarkably unacceptable to the majority. The year was also remarkable for the poor showing made by producers in general and for the fact that even greater disaster was averted.

Probably there is not another industry involving the very existence of many thousands of people and a product that runs beyond the $100,000,000 mark which has been managed with such an apparent disregard for sound business principles. It has been said that the ability shown in managing the great coal corporations has been about of the grade necessary to conduct a country store, though this is probably an exaggeration. It has seemed to some officials that if they could manage to sell a certain number of tons of coal per month, they had done all that was required of them. To others, that if the traffic statements of their particular roads showed certain figures, they had been equal to the situation. Still others have considered that if the stock of their companies was quoted on the Stock Exchange at a certain figure—generally far above its intrinsic worth—a great and praiseworthy feat of financiering had been accomplished. It would thus seem that this trade lacks men who can demonstrate the ability to rise superior to the relative pettiness of the present; that is, men who can grasp the situation and whose vision can take in more than two degrees of the business horizon. This is not, after all, to be taken as derogatory. Great geniuses are rare, and it takes genius—or at least the ability to work—to master all of the intricacies and perplexing details of the trade as it stands to-day.

Anthracite coal occupies a position that is in many respects unique. Competition, which is the life of every normal trade, seems to be death to the anthracite industry. The productive capacity of the collieries is about 50% in excess of the present consumption. An unsold block of only 100,000 tons of coal can affect and has affected detrimentally the sale of twenty-five times that quantity. The ordinary laws of demand and supply cannot, in the strict economic sense, prevail in this market without entailing heavy losses—losses, we may add, which can be of particular benefit to no one person or interest, though of great injury to many thousands.

On the other hand, there is no other industry, save a few controlled by "trusts," which can be so closely regulated. The production of anthracite coal is in few hands and can be curtailed without difficulty, so that the danger of overproduction can be minimized. This fact in a measure offsets the difference set forth in the preceding paragraph.

The actual cost of producing coal naturally varies in different regions and in different mines. Anthracite has to be "prepared"—that is, broken into certain sizes. The difference in the actual cost of preparing these sizes is seldom the difference in the actual selling prices. "Stove" coal may sell at $3.50 per ton f.o.b. and "broken" at $3. But if a breaker turns out very much $3.50 stove, there will also be too much $2 buckwheat and more than enough worthless culm. This much is known to each producer—that is, the cost per ton ; but prominent operators confess that they can only guess at the proper amount of each size which they should prepare in order to profit most by the demand. In other words, an accurate knowledge of the actual requirements of the market, based upon detailed statistics, is wanting, and tends further to aggravate the inherent instability of prices.

If the operators of all the collieries were operators only the situation would be, after all, comparatively simple. Unfortunately, the great coal-mining companies are also great coal-carrying railroads. There is always a struggle between the two great interests. The Delaware, Lackawanna & Western can apparently make money where the Lehigh Valley cannot. Both, let us say, get the same price for their product, and we will assume that the coal itself costs both companies the same. The profit, then, is probably in the transportation. The great trouble is that the double nature of the business permits at any time a juggling arrangement, by which whatever profit or loss there is may be made to appear in the mining or transportation account as the exigencies of the company—or the stock market—may require.

In 1894 there was a sort of combination, a "gentlemen's agreement," which was as near a trust as the anthracite interests could go and keep out of the law courts. Words and promises were broken, and it was shown that such "understandings" availed nothing. The year, in spite of them, was not profitable. In 1895, after June, there was no understanding whatever, and the year was also a poor one. It seems a repetition of an unfortunate alternative. With or without "percentages" and agreed "restrictions" the anthracite men have been unable to make a good showing.

The Market During 1895.—The previous year, 1894, had seen the trade approach dangerously near to utter demoralization, but in December the presidents of the various companies seemed to realize their peril; they held meetings, made suggestions and promises, and appointed a committee of three, consisting of Messrs. Torrey, of the Delaware & Hudson, Henderson, of the Philadelphia & Reading, and Sayre, of the Lehigh Valley, to collect data relative to the outputs and percentages of all the companies for several years previously. So much was expected of these gentlemen that the *Engineering and Mining Journal* christened them the "Salvation Committee," and 1895 really opened better than there had been reason to expect two months before. The "circular"—that is, the f.o.b. prices which the companies had agreed to maintain—was $3.60 for stove, $3.45 for egg and chestnut, and $3.35 for broken, and the sales agents recommended that the production for January be restricted to 2,300,000 tons, or 45% of the June, 1894, tonnage. The market, as usual at that time of the year, was dull for "new" business, and though the companies made some effort to maintain the circular, a pernicious practice of "stretching" old or cheap-priced orders for favored customers soon caused prices to sag, and coal could be bought for 25c. below the "official" figures. Shipments for the month amounted to 3,063,535 tons, exceeding by over 750,000 tons the amount "recommended" by the sales agents and by 375,514 tons the output of January, 1894.

For February the output agreed upon was 2,045,000 tons, or 40% of the June tonnage. The January circular was left unchanged. The "Salvation Committee" continued its labors, for the various companies wanted to establish new "allotments of production," or the percentage of the total tonnage which each transportation company was entitled to. The effect of the excessive output of January was manifest in the weakness of prices, which were really about 30c. below the circular. Some "rusty" and "stock" coal, stove and egg, sold for $3 a ton f.o.b., and though not really a fair basis of values for the better grades of coal, it tended still further to unsettle prices. A cold snap, which should have strengthened them had the companies adhered to the 40% restriction agreed upon, served only as an excuse for heavy mining, and the months production was 3,133,246 tons, as against 2,344,511 tons for February, 1894, and 2,045,000 tons, the amount "recommended" by the sales agents as being in their opinion what the market would take safely. It began to look as if in spite of the disastrous experience of 1894 the wholesale anthracite coal trade had not learned wisdom.

For March the circular was left "unchanged," which was wise considering that actual prices were 30c. below it, and the output was agreed on at 3,067,415 tons, or 60% of the June tonnage. Though March is a good coal-using month, prices continued to weaken. The companies did not adhere strictly to the circular, but they did not sell as cheaply as it was said at the time. However, the prices sagged, and from $3.30 for stove declined until $3 was paid at the close of the month. The "Salvation Committee" completed its compilation of statistics and submitted them to the General Committee. A new committee, consisting of Messrs. Henderson, of the Reading, Torrey, of the Delaware & Hudson, Sayre, of the Lehigh Valley, Joyce, of the Pennsylvania Railroad, and Maxwell, of the Jersey Central, was appointed to submit new "percentages" based on the "Salvation Committee's" figures.

March shipments amounted to 3,761,665 tons, as against the 3,067,495 tons "recommended" and 2,565,061 tons in March, 1894. The result was that the sales agents met, advised a restriction to 50% of June's output, or only 2,550,000 tons, and again left prices unchanged. Actual prices on April 1 were $3@$3.15 for stove and $2.85@$3 for broken egg and chestnut. The presidents held a meeting on April 5, instructed the sales agents to advance f.o.b. prices to $3.50 for stove and $3.35 for the other sizes, less the usual commission of 15c., and discussed the matter of percentages, but could not reach a decision, and so a committee to make suggestions was appointed, consisting of Messrs. Wilbur, of the Lehigh Valley, Roberts, of the Pennsylvania, Olyphant, of the Delaware & Hudson, Sloane, of the Delaware, Lackawanna & Western, and Harris, of the Philadelphia & Reading. The latter, however, could agree to nothing without consulting the receivers, and it developed later that the policy of the Reading was "21% and not a ton less." All negotiations came to an abrupt end on account of this stand. The April output was 3,139,122 tons, as against the "recommendation" of 2,550,000 tons and 2,799,307 tons in April, 1894.

May opened badly, in the nature of things. The demand was very light, and though prices were still supposed to be upheld, in view of the presidents' orders, a few sales of stove coal at $3 on board took place. The sales agents, in the absence of percentages, had been unable to agree on the precise amount to be mined during the month, but after several meetings the representative of the independent operators in a fit of inspiration suggested that every producer should close down entirely three consecutive days each week. This was adopted and the various interests agreed to try to maintain prices at $3.35 for stove and $3.20 for the other sizes. Then one of the most senseless of all the senseless actions of the anthracite interests occurred. In spite of the unsettled feeling, the lack of demand, and the inability to agree on a working plan to save the trade from demoralization, in spite of the fact that a radical restriction—half-time—had been agreed upon, the various operators rushed the production to such an extent that notwithstanding the three days' suspension per week, shipments during the week ending May 18 were 817,523 tons, or at a rate at which, had the various interests worked continuously, would mean more than 85,000,000 tons a year. Of course, no producer could maintain the degree of efficiency necessary to achieve such a vast total, but it showed how great the productive capacity of the collieries was and how much in excess of any demand that is likely to arise for many years to come. Although working on half-time during the month, the May production was nevertheless 3,788,946 tons, a decrease of nearly 100,000 tons as compared with 1894, to be sure, but still far too much for the market. Of course, at the next meeting the sales agents could only recommend again the three-days-per-week suspension and leave prices "unchanged" at $3.35 for stove and $3.20 for the other sizes. Actual selling prices were unsettled and stove could be bought for $3, though buyers very wisely decided that as prices were weak and showed a declining tendency there was no especial inducement to buy ahead. The June shipments aggregated 3,777,644 tons, and the sales agents held several meetings in reference to the course of action for July. Everybody seemed more or less weary of the farce, and all such attempts were abandoned. The trade was thenceforth to be governed by ordinary market conditions, and with the aid of Providence it was hoped to avert bankruptcy.

Early in July the Delaware, Lackawanna & Western, for "good and sufficient reasons," declined to furnish to the Bureau of Anthracite Statistics the figures of its shipments, and the trade had the still greater disadvantage of working without knowing how the general production was running. Shipments for the six months ending June 30, 1895, were 20,674,905 tons, against 19,398,020 tons for the first half of 1894.

Naturally prices continued to sag and in July sales of stove coal were made at $2.75 on board. This was for good grades—not "fancy"—of coal, and "stock" coal was sold for even less. In August coal still sold on the basis of $2.75 for stove, and many rumors of $2.50 were heard. Probably some sales were made at less than $2.75, but as many transactions took place at more than $2.75 we give that figure as a fair quotation. In Boston one of the most prominent companies sold stove coal at $2.90 below bridges. The market was very dull, and neither buyers nor sellers were anxious to trade, the former because there was no profit at that figure and the latter because it was thought that prices might decline still further.

With the approach of the fall prices began to stiffen. September opened with some stove selling at $2.75 f.o.b. and closed at $3.20@$3.30. There was an almost unprecedentedly severe drought in some of the regions, which made unavoidable a marked restriction of the output. The West was bare of stocks and shipments thither caused a scarcity of cars, which still further aggravated the situation, so that little coal, comparatively, came to tidewater. Dealers at this time, foreseeing trouble, began to send in their orders at around $3 and $3.25, and the first thing the trade knew prices were advanced to $3.75 and then to $4. The latter advance did not really obtain. A few dealers who were absolutely without coal in their yards and could not get deliveries on their old orders were forced to pay such figures for small cargoes for immediate delivery. But with the ending of the drought and the consequent increased output prices again declined, so that very few sellers disposed of any $4 coal to speak of, and few even at $3.75. We know from the returns made by certain companies to certain independent operators, whose product is bought on the basis of 60% of the tidewater price, that these companies received only from $3.10 to $3.20 for coal sold, at a time when $4 was supposed to obtain. In other words, the advance came too late and lasted too short a time, for as soon as Western shipments were sufficiently heavy to preclude the danger of a shortage there, values declined slowly but surely, and by December 1 coal was selling at $3.60 for stove, $3.35 for chestnut, $3.25 for egg, and $3 for broken. The market closed with a demand governed exclusively by the thermometer. Quotations on the last day of the year were: Stove, $3.35@$3.50; chestnut, $3.10@$3.25; egg, $3.15@$3.30; broken, $3@$3.10; all net on board.

General Observations.—It will be seen from the foregoing that the past year must have been an unprofitable one for all producers. It has been stated that the only operators who made money were A. S. Van Wickle & Co., who had a contract with the Pennsylvania Railroad, by which the latter company agreed to buy the entire output of one colliery operated by the firm at a price which we understand to be $2.35 per ton at the mine. The contract was signed at the time when the "Pennsy" feared that the meteoric McLeod would "gobble up" all the tonnage of the collieries in the region. The colliery in question worked on full time the year through.

Primarily, the unprofitable year is doubtless due to the absence of an *entente cordiale* among the anthracite interests. The Reading, that old mother of combinations, has been blamed for its refusal to accept less than 21% for its allotment. It declined to submit the matter to arbitration, and not being compelled to pay interest, as it was in the hands of receivers, it presented its ultimatum and calmly proceeded to mine as much as it pleased. This question of allotments is in itself such a complicated matter that it is impossible to offer plans. It approaches, too, dangerously near an illegal affair. It is well enough to allot fixed percentage to each coal transportation company, but, after all, none has ever adhered to its allotment, and the Pennsylvania has always declined to enter into any agreement to restrict, formal or informal. However, the lack of even this understanding, half binding only though it was, rendered futile all efforts at a concerted restriction. And unrestricted production wrought havoc.

Though all interests suffered, some were worse sufferers than others. Briefly stated, we may say that those sellers who disposed of the least $2.75 stove suffered the least. And the selling of coal at the August figures was a matter of individual temperament more than of anything else. When the Lehigh Valley sold stove coal at $2.75 on board, it meant that operators along its line received $1.65 per ton on cars at the mines. The cost of mining, royalties, etc., differ so much in the various regions and collieries that no estimate of value in calculating losses or profits can be given. The companies admit that profits were small. Some of the independent operators, who certainly can mine as cheaply as and, oftener than not, more cheaply than the companies, claim that they actually lost money.

The amount of dead work performed by the companies which make the best apparent showing was small. The stockholders may receive a report which is not so poor in view of the circumstances; but it is not specified therein, in the item of expenditures, that the amount of development work was really inadequate to the future needs of the collieries, and that this will have to be made up sooner or later —probably the former. Colliery superintendents and district inspectors have assured us that the amount of such development work and the preparation of the collieries in order to insure a continued normal output was last year considerably below that for previous seasons. Therefore, when stockholders a year or two hence read under the head of "Expenditures" that the amount expended in 1896 for "colliery improvements" greatly exceeds that spent during 1895, they will know that they are simply paying back debts. In other words, the ill effects of the past year will be felt for many moons to come.

Throughout the year buyers bought ahead less than usual. In the unsettled condition of the market they felt, not illogically, that there was no telling just how low prices might go. This created a chronic light demand, and accumulations of stock seemed to so frighten certain sellers that every possible inducement and opportunity was offered to buyers to place their orders. There can be no objection to reasonable prices. We should condemn $5 coal as extortionate; but there is decided objection to sales at a loss where there is little real need for it. The stockholders of the various companies have invested many millions of dollars in an industry which affords a means of livelihood to hundreds of thousands of people. It is only reasonable that they should have a fair return for their investment, and for this reason, while opposing anything that savors of trusts or combinations as illegal and immoral, we would wish to see the anthracite companies so managed as to yield fair profits. It is practically impossible for anthracite coal to go unduly high; but it may go unduly low. While it may have been impossible in midsummer to obtain $3.25 per ton for coal, why did the companies bid so eagerly on yearly contracts for schools and other public institutions at prices at which there could be little or no profit and which could serve but to unsettle still further an already overweak market? It is the stockholders of the great coal corporations who should ask this and other pertinent questions. And they should insist upon categoric answers.

Production.—The shipments of anthracite coal were not published after July, the condition of the trade and accusations of breaches of faith and of misuse of the information leading the different companies to withhold the figures. After the close of 1895 the question of an agreement was taken up, and after long discussion an arrangement was made in February giving to each company a proportion of the total tonnage for 1896 and providing for a regulation of the amount of output. In connection with the meetings at which this agreement was adopted, statements of the production of anthracite coal for 1894 and 1895 and its division among the different companies were prepared. The table below shows these statistics and also the division agreed upon for 1896:

SHIPMENTS OF ANTHRACITE COAL, IN TONS OF 2240 LBS.

Company.	1894.		1895.		1896.
	Shipments.	Proportion.	Shipments.	Proportion.	Allotment.
	Tons.	Per Cent.	Tons.	Per Cent.	Per Cent.
Philadelphia & Reading	8,286,518	20.02	9,905,059	21.47	20.50
Lehigh Valley	6,423,914	15.52	7,360,454	15.81	15.65
New Jersey Central	4,846,909	11.71	5,388,194	11.57	11.70
Delaware, Lackawanna & Western	5,997,585	14.49	6,129,260	13.16	13.35
Delaware & Hudson	3,994,251	9.65	4,347,843	9.34	9.60
Pennsylvania Railroad	4,726,875	11.42	5,025,645	10.79	11.40
Pennsylvania Coal Company	1,705,317	4.12	1,746,832	3.75	4.00
Erie Railroad	1,668,065	4.03	1,820,038	3.91	4.00
New York, Ontario & Western	1,370,049	3.31	1,424,407	3.03	3.20
New York, Susquehanna & Western	740,903	1.79	1,492,244	3.06	3.10
Coxe Brothers & Co	1,630,813	3.94	1,905,784	4.11	3.50
Totals	41,391,198	100.00	46,545,670	100.00	100.00

The increase in shipments shown in 1895 was 5,154,472 tons, or 12.5%, over the preceding year. These figures establish the "record" of the yearly production, as the heaviest shipments in any previous year were 43,089,536 tons in 1893. It must be remembered that the above figures show only the amount of coal carried by the transportation companies. To estimate the actual production 7% of the total shipments should be added, to cover the amount of coal consumed in and about the mines and breakers, and also that which was used for household purposes by persons living near enough to the breakers to buy their fuel supplies there. Some authorities have placed this item of "coal used in and about the collieries" as high as 11%, which is beyond doubt excessive. Some years ago thorough investigation showed that the amount so used was only slightly in excess of 6%, and since then it has grown smaller, if anything. Moreover, the greater the production the smaller is the percentage consumed by the collieries themselves. Adding this 7% to the shipments, we find that the production of anthracite coal during 1895 amounted to the enormous total of 49,803,867 long tons, the heaviest yearly output in the history of the anthracite trade.

Apropos of this, it is interesting to remember that only about one-third of the coal mined is available for consumption. That is, the waste resulting from culm and the "pillars" left in the mines to uphold the roof is about twice as great as the quantity actually consumed. It is therefore evident that the anthracite coal reserves of Pennsylvania were decreased in 1895 by approximately 139,411,591 long tons.

The Local Coal Markets.

The condition of affairs in the principal local coal and coke markets and distributing points in 1895 is shown in the articles following.

BUFFALO.

The annexed figures give some idea of the trade in anthracite and bituminous coal and coke in Buffalo for 1895. In 1842 only 900 tons of anthracite coal were reported as being received; in 1852, 23,000 tons; in 1862, 132,500 tons; in 1872, 521,000 tons; in 1882, 1,623,000 tons; and in 1892, 4,804,700 tons. Fifty years thus showed progress and material wealth.

During 1895 a large trade was done in anthracite coal at a very small profit. A distinguishing feature of this market is the total lack of coöperation among dealers to maintain prices. Coal has been sold to private families who ordered five tons or more at a profit of only 10c. per net ton. Poor families, however, ordering from half to one ton at a time, were, as a rule, charged full circular rates.

All the coal is sold from the trestles, as the facilities prevent the expense of keeping coal yards, and anybody who can hire a horse and wagon becomes a dealer in coal; therefore there is no necessity now, as far as making money goes, to lay in stocks when coal is cheap in the spring and hold for higher prices the next fall and winter. From the end of October the anthracite coal schedule of prices was fairly well maintained on small orders, and some concessions allowed on large ones.

With regard to bituminous coal, all contracts made during the year were at extremely low figures. Coal was abundant; there was no "famine" at any time—supply generally far exceeding the demand. With run-of-mine coal at $1.40 per net ton on track at Buffalo, dealers say that electricity will have sharp competition in the race for cheap fuel and light.

The supply of cars at times while navigation was open was scarce for anthracite coal. Apparently no difficulty was experienced in the bituminous regions on this account. The anthracite coal brought to Buffalo comes by five lines of railroads: the Delaware, Lackawanna & Western in 1895 brought 25%; the Erie, 23%; New York Central, 18%; Lehigh Valley, 23%; Western New York & Pennsylvania, 9%. There are 7 shipping docks and coal pockets at the port of Buffalo; total average shipping capacity daily, 25,000 tons; average capacity of the pockets daily, 36,800 tons. Outside the city limits at Cheektowaga is the stocking coal trestle of the Delaware, Lackawanna & Western, with a capacity of over 100,000 tons storage. At the same place the Lehigh has its trestles and stocking plant of 175,000 tons storage capacity, with a shipping capacity of 3000 tons daily, and has a transfer trestle for loading box cars with a capacity of 100 cars daily. At the same point the Erie has a stocking plant with average daily capacity of 1100 tons and storage capacity of 100,000 tons. The Reading has in the city a large trestle and pocket for the convenience of the retail trade in connection with their docks, with a capacity of 2000 tons. The Buffalo, Rochester & Pittsburg has terminals fronting on the Blackwell Canal, with a water frontage of 1100 feet; also a town delivery yard, with a plant for loading and coaling vessels, used by Messrs. Coxe Bros. & Co.

The imports of bituminous coal into Buffalo in 1882 were only 65,000 net tons and in 1893 2,896,614 net tons—the highest figures on record. In 1892 the amount fell to 2,280,470 net tons, while in 1895 the estimate was 2,350,000 tons.

The coke trade of Buffalo during 1895 was very large in consequence of the increase of manufacturers using this product. Coke is cheaper at Buffalo than at Chicago and Philadelphia through the low railroad freights. Crushed coke is being largely introduced for family use. It is claimed that it lasts longer than a similar quantity of anthracite coal and is $1 per ton cheaper, besides being a clean, smokeless fuel.

The course of anthracite coal prices at Buffalo during 1895 is shown below:

LIST PRICES OF ANTHRACITE COAL AT BUFFALO IN 1895.

Date.	Per Long Ton, f.o.b. Buffalo.		Per Long Ton, on Cars at Buffalo or Suspension Bridge.			Per Short Ton, at Retail in City Limits.		
	Grate.	Stove, Egg and Chestnut.	Grate.	Stove, Egg and Chestnut.	Pea.	Grate.	Stove, Egg and Chestnut.	Pea.
January 1	$4.70	$4.95	$4.40	$4.65	$3.75	$5.00	$5.25	$3.75
May 3	4.05	4.20	3.75	3.90	3.00	4.40	4.50	3.75
September 15	3.85	3.80	3.35	3.50	3.00	3.75	4.00	3.50
October 1	4.30	4.55	4.00	4.25	3.00	4.50	4.75	4.00
October 24	4.45	4.70	4.15	4.40	3.00	4.75	5.00	3.50

The price of ordinary bituminous coal in 1895 in Buffalo ranged from $1.15 per ton for slack to $2.50 for screened lump. These prices were for short tons (2000 lbs.) in car lots on track, delivered at most convenient siding to factories, vessels, etc. No. 1 cannel sold at $4.25 per ton and Briar Hill lump at $6 per ton. The price of coke varied from $2.85 to $3.75 per short ton.

The statistics collected by William Thurstone, Secretary of the Merchants' Exchange of Buffalo, show that the coal trade of Buffalo has been as follows for five years, in tons of 2000 lbs.:

	1891.	1892.	1893.	1894.	1895.
Receipts:					
Anthracite by canal	....	54,760	70,546	42,130	12,382
Anthracite by rail	4,507,804	4,750,000	4,700,000	4,230,000	4,000,000
Bituminous by rail	2,428,084	2,652,441	2,921,614	2,305,470	2,350,000
Total receipts	6,935,888	7,457,201	7,692,160	6,577,600	6,362,382
Shipments:					
Bituminous by canal	34,060	29,316	19,336	8,840	4,289
Anthracite by lake	2,358,895	2,822,330	2,681,173	2,475,255	2,620,768
Bituminous by lake	7,000	30,000	22,500	10,000	22,000
Total shipments	2,399,955	2,881,646	2,723,009	2,494,095	2,687,057

Vessel owners did an excellent season's business in 1895 despite the dull opening. High freights, with plenty of grain, ore, coal, etc., to carry, were the features of the last part of the year 1895. The coal rate from Buffalo to Chicago opened at about 30c. per net ton, advancing gradually to 50c. the middle of June; advanced again to 65c. the first week in September, and later in the month to 70@75c.; and from October 1 to the close, 90c. Duluth freights on coal ruled low; opened at 15c., advanced to 20@25c., and from the middle of August 30c. was paid. Freights to other ports followed suit relatively.

Of the 2,620,768 net tons of anthracite coal shipped by lake from Buffalo during 1895, about 938,000 tons went to Chicago, 610,000 tons to Milwaukee, 85,000 tons to Toledo, 6000 tons to Detroit, 16,000 tons to Bay City, 9000 tons to Kenosha, 25,000 tons to Saginaw, 28,000 tons to Racine, 32,000 tons to Green Bay, 198,000 tons to Duluth, 270,000 tons to Superior, 43,000 tons to Gladstone, 30,-

000 tons to Manitowoc, 8000 tons to Sault Ste. Marie, 5000 tons to Sheboygan, 6500 tons to Washburn, 3000 tons to St. Clair, 3000 tons to Port Huron, 10,000 tons to Lake Linden, 14,500 tons to Fort William, 10,000 tons to Ashland, 17,000 tons to Hancock, 1700 tons to Houghton, 2000 tons each to Grand Haven, Menominee, Cheboygan, Marine City, and Michigan City, and the balance to Canadian and other ports too numerous to specify, varying from 25 to 1000 tons per cargo. The rates of freights to principal ports were as follows from Buffalo: 30@95c. to Chicago, 30@85c. to Milwaukee, 15@30c. to Duluth, Superior, and Lake Superior ports, 30@85c. to Green Bay, 25@50c. to Toledo and Bay City, 20@40c. to Detroit, 40c.@$1 to Racine, 35@70c. to Saginaw.

Natural gas continued to be extensively used for family purposes in the city. The supply is obtained from the fields of Pennsylvania, the wells in Canada, 20 miles away, and from the numerous wells just outside the city line east. This fact accounts for the decreased consumption of coal, which should show an increase in accord with the increased population.

A coal dealers' protective association was formed in the fall in consequence of the demoralization of the trade by cutting of prices, giving short weight, etc., so as to protect their interests as well as those of the consumer.

CHICAGO.

The year 1895 in Chicago brought no profit to the coal dealer, and it showed the lowest prices on coal that had ever been known in this market. Almost through the entire year the railroads centering in the city were carrying on a war of rates. The lines bringing soft coal from Ohio, Indiana, and Illinois points battled fiercely among themselves for the privilege of carrying coal, and it was never before so cheaply brought to Chicago. The railroads running west to the Missouri River fought over the hard-coal traffic, and it is said that rates of $1 per ton were made by one of the roads to get the business. On the other hand, vessels for carrying coal on the lakes were in such demand for the haulage of iron ores from Michigan and Minnesota points that it was almost impossible for coal shippers from Buffalo and other ports to get the boats, the profit being so much higher in carrying iron ore. In consequence shippers had to pay a very high rate to get anthracite coal to the Chicago market.

The month of January brought with it but little improvement in the coal trade over the closing month of 1894, and the following months up to and through August bettered the situation but little. Quotations in January on anthracite coal stood at about $5; this held until June, when there was an utter collapse in prices and the market went to pieces. Dealers apparently abandoned all thought of profit, as may be seen from the following. In July bids to furnish the city of Chicago with 82,000 tons of anthracite coal were received. A great many firms tried for this business and all bid low. One firm offered to supply the coal at $4.45 delivered, and at that price it represented a saving of 70c. per ton to the city over the 1894 figure. Bids were also opened for supplying the city with bituminous coal, and they ran from $1.97 to $3.80, according to specification, and in every case there was a large decrease in price from 1894.

Contention for the limited business outside of the city contracts was great, and in most cases the consumers undoubtedly got the best of the deal. Toward the end of August some improvement was observed, and the remaining months of the year showed up fairly well, November and December business being the best that dealers had seen in a long time.

Throughout the entire year there was no lack of either hard or soft coal in the yards and on the docks of the city. Rumors of short supplies were circulated frequently, but there was really no cause for them.

Navigation opened on the lakes a couple of weeks later in 1895 than it did in 1894, but it kept up a couple of weeks longer at the close of 1895. Bituminous coal was shipped to Chicago in great quantities, speculators running up a large tonnage during the worst time of cutting rates among the railroads. Receipts of soft coal were also greatly augmented by the fact that the mines of Ohio, Indiana, and Illinois were all working for a large output, and as there were no strikes of any importance a great tonnage was shipped to this and other markets. The actual consumption of soft coal for 1895 was much larger than in the preceding year, chiefly through the marked increase in manufacturing and other industries. There was but little profit in the business, however, prices having been low through the year, owing to the large supplies and sharp competition.

The closing price of hard coal for the year was about $5 per ton, though there was nothing to indicate firmness, and possibly $4.75 would be nearer the actual wholesale price. The year on the whole furnished but little satisfaction to the coal dealer.

PITTSBURG.

The Pittsburg river coal trade is something very uncertain, having to depend entirely on the weather. In some years there have been coal shipments every month in the year; this, however, is something that does not take place very often. In 1895 the coal runs were made in January, March, April, and November, with a total shipment of 45,003,000 bushels. In the last week in December another rise came, which took out 11,000,000 bushels more. In this case the rush to get out tows was so great that a number of boats were wrecked and 500,000 bushels of coal were lost. The December rise did not last long, and some 14,000,000 bushels were left loaded on boats which could not get away.

The table of shipments for 14 years given below will furnish a fair view of the situation. The highest shipment in that time was in 1888, which reached 109,902,000 bushels; this shows what the coal trade will do for Pittsburg when the system of locks and dams on the Ohio River is completed. The lowest amount shipped was 55,432,000 bushels in 1884. The coal run in November, 1895, was probably the most disastrous on record. Owners in their anxiety to meet the wants of their customers in the West and South started the tows before there was a sufficient stage of water; the result was that coal and other property was lost, variously estimated at $75,000 to $100,000. Between low water in the Ohio and miners' strikes the river coal operators had a year of trouble, accompanied with heavy losses and very hard work.

The river shipments from Pittsburg for 14 years past have been as follows, in tons of 2000 lbs.:

Year.	Cincinnati.	Louisville.	Totals.	Year.	Cincinnati.	Louisville.	Totals.
1882	1,378,480	1,467,260	2,845,640	1889	1,214,400	1,515,800	2,730,200
1883	1,261,320	2,258,48C	3,519,800	1890	1,304,640	2,042,160	3,346,800
1884	985,240	1,232,040	2,217,280	1891	1,125,000	1,931,600	3,056,600
1885	1,303,600	1,693,360	2,996,960	1892	973,560	1,519,960	2,523,520
1886	1,329,160	1,537,406	2,866,568	1893	879,950	1,617,840	2,497,790
1887	830,800	1,438,920	2,269,720	1894	1,139,920	1,383,280	2,523,200
1888	2,053,560	2,340,520	4,394,080	1895	896,240	1,343,880	2,240,120

To find a similar state of affairs we must go back to the great "coal famine" of 1879, when coal in Cincinnati went up to 40c. a bushel.

CONNELLSVILLE COKE.

The growth of the coke trade of Western Pennsylvania was unprecedented notwithstanding the strikes and the scarcity of water; at certain periods there was a large growth of production, and with sufficient cars to carry it away the production would have been larger still. The number of ovens in the coke region was 17,937 at the end of 1895; there were 16,190 in blast and 1747 ovens idle. The January production was 540,521 tons; shipments during the same time, 536,945 tons. In March production reached 783,197 tons, with shipments amounting to 809,898 tons; in this month's shipment there was 26,701 tons of stock coke used. During April, May, June, and July production fell off largely owing to strikes, scarcity of cars and of water. In August the revival of the iron trade caused a big demand; production was 717,294 tons, shipments 763,643 tons, stock coke being again used. In September and October business fell off about 100,000 tons.

November, however, beat all records with production amounting to 800,714 tons and shipments of 47,680 car loads, or 863,484 tons. The total result for the year 1895 was as follows: Production, 7,305,273 tons; shipments, 413,960 car loads, or 7,538,549 tons. Thus the year's shipments included 233,276 tons of the stock coke on hand at the beginning of the year.

Prices.—Prices opened in January at $1 f.o.b. at ovens for a ton of 2000 lbs. and remained nominally at that figure for some time, although there were reports of sales below that figure. Later the demand was such that prices advanced to $1.35. In November a further advance of the price to $2 was discussed. The closing quotations per ton were: Furnace, $1.60; foundry, $2; crushed, all sizes, $2.65 per ton of 2000 lbs. f.o.b. cars at ovens.

Freight per ton from the Connellsville region (which includes any part of it) to the principal points of consumption was as follows: To Pittsburg, $0.65; to Mahoning and Shenango Valleys, $1.29; to Wheeling, W. Va., $1.20; to Cleveland, Ohio, $1.56; to Buffalo, N. Y., $2; to Detroit, Mich., $2.40; to Cincinnati, Ohio, $2.55; to Toledo, Ohio, $2.40; to Louisville, Ky., $3.10; to Chicago, Ill., $2.65; to St. Louis, Mo., $3.30; to East St. Louis, $3.15; to Baltimore, $3.15; to Boston, $3.50.

Late in the year the H. C. Frick Coke Company acquired several large plants and mines, giving that company practical control of the greater part of the output of the Connellsville region. The increase in prices noted above and a further increase to $2 made in January, 1896, resulted in the diversion of some large contracts to the Pocahontas region in West Virginia.

Evolution of the Anthracite Coal Trade.

As the industrial activity and, one might almost say, the degree of civilization of a country is, to a certain extent, measured by its per caput consumption of coal, so also can we forecast the future of nations when we know the cost at which they can produce coal and deliver it at the seaboard—at least until the time when, if ever, coal is displaced from its position as the chief source of power and artificial heat and light. Moreover, the coal trade of the great industrial nations, being the largest and most economically conducted branch of mineral production, offers in its past growth and the conditions under which this has been accomplished the best object lesson from which to draw inspiration for the future conduct of this and of all other industries developing under more or less analogous conditions.

The anthracite fields of Pennsylvania, covering a coal-bearing area of only 484 sq. miles (125,655 hectares), constitute unquestionably the most valuable coal property of equal size on the face of the globe. With two unimportant exceptions, these are the nearest coal fields to the great tidewater markets on the eastern coast of the United States, and this fact, together with the small area of the fields and the limited quantity of this admirable and unique fuel, has occasioned their unrivaled development in output, which has grown within a brief three-quarters of a century to an annual amount of nearly 53,000,000 metric tons, worth at the mines no less than $90,000,000 and at the place of consumption probably $265,000,000.

The history of this marvelous growth of an industry originated within the memory of men now living and based on a limited supply of a commodity essential to the industrial life of the most enterprising and progressive people the world has ever seen, has presented many instructive lessons in political economy, as well as a few in mining, to which attention is here directed.

While true anthracite coal was known in other countries long before its discovery in Pennsylvania about 1768, yet the difficulty with which it is ignited had always rendered it less popular than soft coal and retarded the opening of mines for its production. The war with Great Britain in 1812, closing our ports to the entry of foreign and sea borne Virginia coals, created a coal famine in our coast cities and turned attention to the anthracite deposits of Pennsylvania, which were the nearest sources of supply and were accessible by more or less navigable streams—a very important matter in those roadless days of difficult transportation. The urgent need of fuel overcame the many objections at first raised to the use of anthracite and caused the opening of the mines near Mauch Chunk, an event which may be said to have given birth to the anthracite coal trade in 1820, though it is true small mines had been worked intermittently for a number of years before this in both the Wyoming and the Schuylkill regions for the supply of the local wants of blacksmiths and others.

Since the coal beds outcropped high on the hillsides, these early mines were opened by drifts in the coal and were worked in an irregular and altogether unskillful manner by the farmers. As the demand increased, men who had gained experience in Europe or in other parts of the United States made the mining of anthracite in this small way their regular occupation, and gradually, as the output increased, better roads were made from the mines to the towns or the shipping places on the rivers and better facilities for handling the coal were installed.

With the adoption of each improvement the cost of producing coal diminished, while on the other hand the capital required to open mines and to go into the coal business increased. The inevitable results were "hard times and unprofitable business" for the less advantageously situated and equipped mines and the concentration of the business into comparatively fewer and stronger hands.

The transportation of the coal to market had always been a very important consideration. From the time in 1793 when the old Lehigh Coal Mine Company made a special appropriation of £10 ($26.67) to build a road 9 miles in length from its mines to the Lehigh River at Mauch Chunk, and when the contractor who got $4 a ton for hauling the coal over this road lost money at the job, the burning question in the coal trade has been that of transportation to market. In those "good old days" coal was worth $1 to $2 a ton at the mines and $10 to $20 in the market, the transportation amounting to about 90% of the market price, while to-day it is only 35 to 40% of the market value of the coal.

The hauling of coal 100 miles in wagons over rough roads was quickly found to be commercially impossible, and the navigation of such rough and rapid streams as the Lehigh, in which four out of every five boats were wrecked before reaching market, was too precarious and costly. Canals were then built, but as they were frozen up for the five months in the year in which the demand for coal was greatest and were frequently interrupted in summer by floods in the rivers destroying dams or washing away the banks, railroads were built to supplement them and have finally supplanted them almost altogether.

The transportation troubles of the coal operators by no means ended with the advent of the railroad. On the contrary, like the frogs who elected a stork for king and were devoured by their own creation, they found themselves now at the mercy of the roads. Operators whose output of coal was large or who had special influence with the managers of the roads secured exceptional "tolls" or rates of freight which placed them at a great advantage in the market over their less favored rivals. The weaker concerns were thus in dull times forced to close their mines, and the road on which they had shipped lost traffic if the favored shipper were on a rival road. To prevent this the road would make advances to the needy operator to tide him over difficulties assumed to be temporary, and when he finally succumbed, to save its advances the road purchased the colliery, usually indirectly in the name of a subsidiary coal-mining company. Thus in one way or another, either by being controlled, if not built, by capitalists largely interested in the coal fields, by special rates to favored operators, or by financial interests, direct or indirect, in the coal-mining business, the roads became involved in the mining of the coal, and very naturally this still further intensified the discrimination against the "independent operator," whose fight for existence thus became more and more hopeless. Moreover, the amount of capital required to open and equip an anthracite mine on a scale which would permit of its economical working has from the very first been steadily increasing, and is now so enormous that few can command it, and those who can would not risk the investment unless able to control transportation rates, at least as advantageous as those enjoyed by the most favored operators or by those controlled by the road itself.

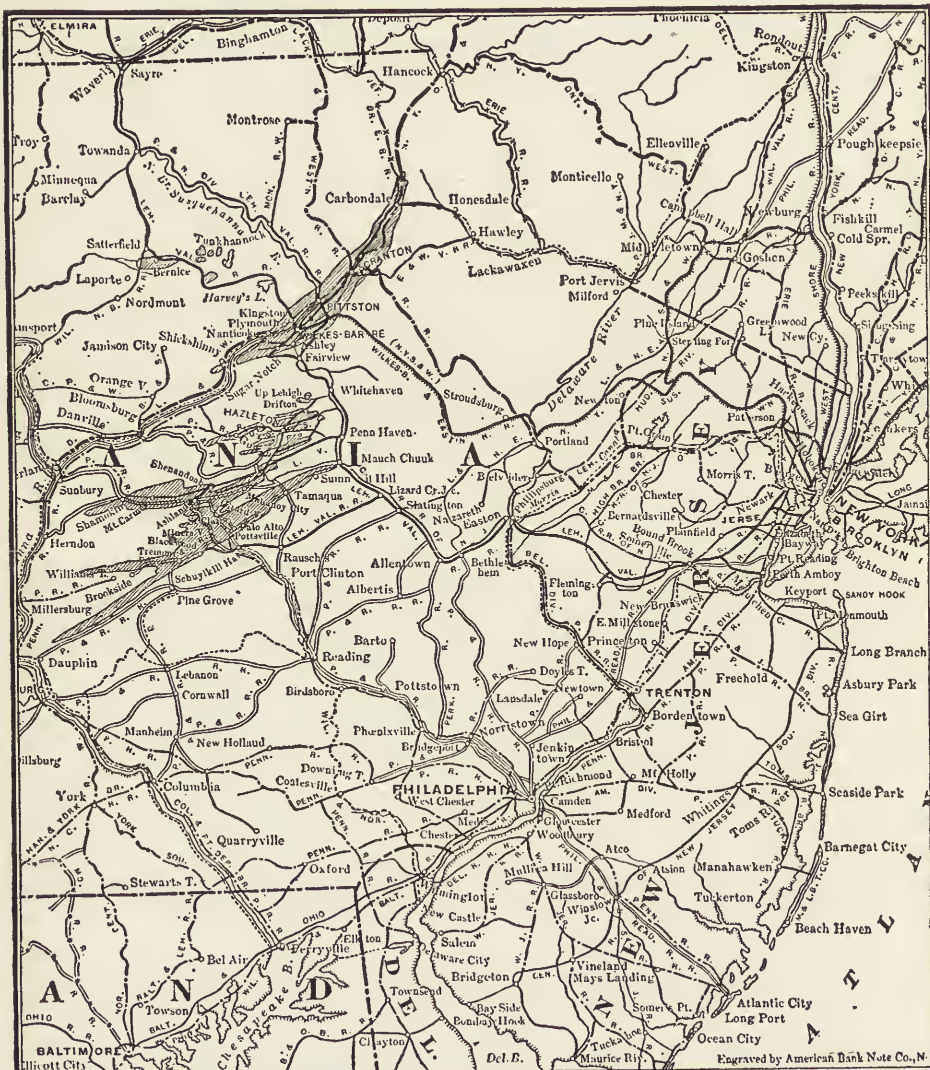
Thus the segregation of the industry into the hands of the transporter has gone relentlessly forward until the struggle for existence of the "independent operator" or mine owner in the anthracite fields of Pennsylvania is practically over and the race is almost extinct. The struggle is now between the "coal roads," and the immutable law is still working out its inevitable solution in the survival of the "fittest," which in this industrial age means that which can supply the market at the lowest cost—or, in this case apparently, that which has in preëminent degree the ability to borrow money.

The history of the evolution of the anthracite trade shows the path of the most remarkable and brilliant progress that the industrial world has ever seen strewn with financial wrecks at every turn. The victors of yesterday are the victims of to-morrow as the inexorable law works out its fulfillment, and the hardships of the struggle and the natural complaints of the great majority as they go under in the fight give a somber and depressing tone to the history of glorious achievements. It is not necessary to enter at length into the struggles and triumphs over appalling difficulties which have characterized the growth of the trade. It is sufficient to take a bird's-eye view of them, citing briefly contemporary evidence concerning those important features which have become dim when viewed from the distance of a half or even a quarter of a century.

THE ANTHRACITE FIELDS OF PENNSYLVANIA.

The accompanying map shows the geographical distribution of these several basins and the roads by which they are connected with New York and Philadelphia. Though the surface of the Lehigh and a portion of the Schuylkill regions is rough and desolate, the beautiful and fertile Wyoming Valley presents from end to end a landscape of surpassing loveliness.

Geologically, these several detached basins are but the small remains of what was at one time a large and probably a continuous coal field; but the crumpling or folding of the strata, both rock and coal, depressed portions of the field in narrow and deep troughs, in which the soft beds of coal were protected from destruction by solid ramparts or walls formed by the uptilted underlying hard sandstones and conglomerates of the coal measures, and these coal beds are merely the salvage from the wreck of a great coal field. Some of these basins scarcely exceed a few hundred yards in width, but extend in cases to an equal depth, and have yielded from the few large beds remaining many millions of tons of coal. Even the narrowest of these troughs is rarely a simple syncline, but is itself composed of two or more subsidiary syncline folds. The area underlaid by the lowest workable coal bed in the three great divisions of the fields, or "regions," as they are popularly called, as determined by the Geological Survey of Pennsylvania, is as follows: The northern or Wyoming field, 176 sq. miles (45,584 hectares); the middle or Lehigh field, composed of several small basins, 45 sq. miles (11,655 hectares); and the southern or Schuylkill field, 263 sq. miles (68,117 hectares); or in all but 484 sq. miles (125,356 hectares). Each of these basins contains several workable beds—some indeed have six or eight such beds, some of which attain a great thickness. While the same beds have been identified in the several basins and the thick and thin strata usually occur in the same order in these, the individual beds are by no means of equal thickness throughout. In fact, the thickness may vary greatly, and the bed may even split up and form two or more strata separated by heavy rock strata in different parts of a single basin.



THE RAILROAD OUTLETS OF THE ANTHRACITE COAL REGIONS.

When speaking of the enormous waste of coal in mining, the quantity of coal originally in the anthracite fields and that still obtainable and the duration of the supply will be discussed.

THE DISCOVERY OF ANTHRACITE.

It was in the Wyoming Valley that anthracite was first discovered on this continent and its combustible properties made known. According to an article in the *Memoirs of the Historical Society of Pennsylvania,* the adaptation of this newly observed substance to the purposes of fuel was discovered previous to 1768, when it was first used by one Obadiah Gore, a blacksmith, some three years previous to the laying out of the borough of Wilkesbarre, and as early as 1775 a cargo of this coal was sent down the Susquehanna River in boats, or "arks," as they were termed, to the arsenal at Carlisle, and this was undoubtedly the first recorded shipment to market of anthracite coal. Afterward Judge Fell, of Wilkesbarre, first burned anthracite in a grate in 1808 and taught the people in that vicinity how to make grates in which to burn the coal.

In the Schuylkill region anthracite appears to have first been noticed about 1790 by the persons settled near the present site of Pottsville. But there must have been some supposition on the subject at an earlier date, for on a map of Pennsylvania published in 1770 coal is noted as extending from the head waters of the Schuylkill Creek westward to the Swatara and to the "Wilderness of Saint Anthony."

The Lehigh region coal was first discovered in 1791 at the point where it was subsequently worked as the famous Summit Hill mines, operated as an open quarry for many years and finally abandoned in 1847, after having yielded some 2,000,000 tons of coal.

In the first volume of the above-mentioned memoirs is "A brief account of the discovery of anthracite coal on the Lehigh," from the pen of T. C. James, M.D., who with a friend in 1808 was conducted to the place by one Philip Ginter, who was the original discoverer. At that time, 17 years after its discovery, no work had been done beyond sinking a few well-like pits in the coal. The slowness with which the industry developed at that period was undoubtedly due to the abundance of wood and charcoal, the great trouble found in burning anthracite, the inaccessibility of the place at which the coal had been found, and the total absence of roads in that rough and rocky mountainous region. The Lehigh Coal Mining Company had been organized in 1793, two years after its discovery, to mine this coal. It purchased 10,000 acres of land, and as a first step appropriated "£10 ($26.67)" to build a road from the mine to the Lehigh River near Mauch Chunk, and endeavored to get coal over this road on wagons and down the Lehigh River in boats to market, and it appears one William Turnbull in 1806 actually delivered in Philadelphia an ark load of coal from these mines. This was undoubtedly the first shipment of anthracite to the seaboard. The coal was sold to the water works, but was not found manageable. Having failed in this attempt to market the coal, attention was directed to the improvement of the Lehigh River, but no mining was done. "In December, 1807,* the company gave a lease upon one of the coal veins to Rowland and Butland for 21 years, with the privilege of digging iron ore and coal gratis for the manufacture of iron." Nothing was done under this lease, and "in December, 1813, the company made a lease for 10 years of their lands to Messrs. Miner,

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* *History of the Lehigh Coal & Navigation Company,* published in 1840.

Cist, and Robinson. . . . The whole consideration for this lease was to be the annual introduction into market of 10,000 bushels of coal for the benefit of the lessees. Five ark loads of coal were dispatched by these gentlemen from the landing at Mauch Chunk, two of which reached Philadelphia, the others having been wrecked in their passage. Four dollars per ton were paid to a contractor for the hauling of this coal from the mines to the landing over the road above referred to, and the contractor lost money. The principal part of the coal which arrived at Philadelphia was purchased at $21 per ton by White and Hazard, who were then manufacturing wire at the Falls of Schuylkill. But even this price did not remunerate the owners for their losses and expenses in getting the coal to market, and they were consequently compelled to abandon the prosecution of the business."

In a communication made by the above-mentioned Mr. Charles Miner to a committee of the Pennsylvania State Senate, under the chairmanship of S. R. Packer, in 1833, he gave the following interesting account of this memorable effort to inaugurate the anthracite trade:

"Commerce being suspended with England and the coasting trade interrupted by British cruisers, so that neither foreign nor Virginia coal could be procured, fuel of all sorts, and especially coal for manufacturing purposes, rose in Philadelphia to very high prices. Jacob Cist, of Wilkesbarre, my intimate and much-lamented friend, had derived from his father a few shares of the Lehigh Coal Company's stock. Sitting by a glowing anthracite fire one evening in his parlor, conversation turned to the Lehigh coal, and we resolved to make an examination of the mines at Mauch Chunk and the Lehigh River, to satisfy ourselves whether it would be practicable to convey coal from thence by the stream to Philadelphia. Mr. Robinson, a mutual friend, active as a man of business, united with us in the enterprise. Toward the close of 1813 we visited Mauch Chunk, examined the mines, made all the inquiries suggested by prudence respecting the navigation of the Lehigh, and made up our minds to hazard the experiment if a sufficiently liberal arrangement could be made with the company. Our propositions were met with the utmost promptitude and liberality. A lease was obtained giving us liberty for 10 years to take what coal we pleased, and to use what lumber we could find and might need on their tract of 10,000 acres of land; the only consideration exacted being that we should work the mines, and every year take to the city a small quantity of coal—the coal to remain our own.

"On Tuesday, August 9 (1814), I being absent and there being a freshet in the river, Mr. Cist started off my first ark, 65 ft. long, 14 ft. wide, with 24 tons of coal. The ark, after many mishaps, arrived in Philadelphia on Sunday morning, August 14. From Mauch Chunk to Philadelphia, on the route sailed by the ark, is 124 miles.

"Expenses of the passage and hands down and returning, $28.27; wages, including three pilots, $47.50—$75.77; ark (cost high from inconvenience of building), $130; raising 24 tons coal from the mine, $24; hauling 9 miles to landing, at $4 a ton, $96; loading into ark, $5; total, $330.77. So that in the first experiment the coal cost us about $14 a ton in the city.

"I have been somewhat minute in giving these details, because this ark was the pioneer and led off the coal trade by the Lehigh to Philadelphia, now so extensive and important. This effort of ours might be regarded as the acorn from which has sprung the mighty oak of the Lehigh Coal & Navigation Company.

"But while we pushed forward our labors at the mine—hauling coal, building arks, etc.—we had the greater difficulty to overcome of inducing the public to use our coal when brought to their doors, much as it was needed. We published handbills in English and German, stating the mode of burning the coal in grates, smiths' fires, and stoves. Numerous certificates were obtained and printed from blacksmiths and others who had successfully used the anthracite. Mr. Cist formed the model of a coal stove and got a number cast. Together we went to several houses in the city and prevailed on the masters to allow us to kindle fires of anthracite in their grates, erected to burn Liverpool coal. We attended at blacksmiths' shops and persuaded some to alter the "too-iron" so that they might burn the Lehigh coal, and sometimes we were obliged to bribe the journeymen to try the experiment fairly, so averse were they to learning the use of a new sort of fuel so different from what they had been accustomed to. Great as were our united exertions, necessity accomplished more for us than our own labors. Charcoal advanced in price and was difficult to get. Manufacturers were forced to try the experiment of using the anthracite, and every day's experience convinced them and those who witnessed the fires of the great value of this coal. We sent down a considerable number of arks, three out of four of which stove and sunk by the way. Much had been taught us by experience, but at a heavy cost, by the operations of 1814–15. Peace came and found us in the midst of our enterprise. Philadelphia was now opened to foreign commerce, and the coasting trade was resumed. Liverpool and Richmond coal came in abundantly, and the hard-kindling anthracite fell to a price far below the cost of shipment. I need hardly add the business was abandoned."

The pioneers of the anthracite trade were not altogether disheartened by these repeated failures. Quoting again from the *History of the Lehigh Coal & Navigation Company*: "In December, 1817, Josiah White and Erskine Hazard, being desirous of supplying their (wire) works with anthracite coal, and finding they could not obtain it as cheaply from the Schuylkill region as they were led to believe it could be procured from the Lehigh, determined that Josiah White should visit the Lehigh mines and river and obtain the necessary information on the subject. In this visit he was joined by George F. A. Hauto. Upon their return and making a favorable report, it was ascertained that the lease on the mining property was forfeited by non user, and that the law, the last of six which had been passed for the improvement of the navigation of the river, had just expired by its own limitation. Under these circumstances the Lehigh Coal Mine Company became completely dispirited and executed a lease to Messrs. White, Hauto, and Hazard for 20 years of their whole property, on the conditions that after a given time for preparation they should deliver for their own benefit at least 40,000 bushels of coal annually in Philadelphia and the districts and should pay, upon demand, one ear of corn as an annual rent for the property.

"Having obtained the lease, these gentlemen applied to the Legislature for an act to authorize them to improve the navigation of the Lehigh, stating in their petition their object of getting coal to market, and that they had a plan for the cheap improvement of river navigation which they hoped would serve as a model for the improvement of many other streams in the State. Their project was considered chimerical, the improvement of the Lehigh particularly being deemed impracticable, from the failure of the various companies which had undertaken it under previous laws, one of which had the privilege of raising money by lottery. The act of March 20, 1818, however, gave these gentlemen the opportunity of 'ruining themselves,' as many members of the Legislature predicted would be the result of their undertaking. The various powers applied for, and which were granted in the act, embraced the whole scope of tried and untried methods of effecting the object of getting 'a navigation downward once in three days for boats loaded with 100 bbls., or 10 tons,' with the reservation on the part of the Legislature of the right to compel the adoption of a complete slackwater navigation from Easton to Stoddartsville should they not deem the mode of navigation adopted by the undertakers sufficient for the wants of the country.

"Messrs. White and Hazard, having leveled the river from Stoddartsville to Easton in the month of April, 1818, with instruments borrowed of the Delaware & Schuylkill Canal Company (the only instruments at that time to be met with in Philadelphia), and having also taken the levels from the river to the coal mines, to ascertain that a road could be constructed altogether on a descending grade from the coal to the navigation, and having ascertained from the concurrent testimony of persons residing in the neighborhood that the water in the river never fell, in the dryest seasons, below a certain mark in a rock at the Lausanne Landing, were satisfied that there would always be a sufficiency of water in the river to give the depth and width of water required by the law if the water were confined by wing dams and channel walls in its passage over the 'riffles' from pool to pool. This plan was therefore decided upon for the improvement of the navigation, as well as the use of flat-bottomed boats, to be constructed for each voyage from the timber lands which were purchased for this purpose on the upper section of the Lehigh. Rafts were sent during freshets from Lausanne downward, but no raft had ever come from above that point. From Mauch Chunk to Easton the fall was 364 ft., making the whole fall from Stoddartsville to Easton 1274 ft.

"There was then no knowledge that there were in each location continuous strata of coal for many miles in extent in each direction from these two points. Indeed, the old Coal Mine Company for some years offered a bonus of $200 to any one who should discover coal on their lands nearer to the Lehigh than the Summit mines, but without its being claimed. The use of the coal from these locations was confined to the forge fires of the neighboring blacksmiths and the bar-room stoves of the taverns along the road. Wood was almost the only fuel used in Philadelphia, and that and bituminous coal supplied the fireplaces of New York and Eastern cities. The only canals in Pennsylvania at that time in navigable order were one of about 2 miles in length, at York Haven, on the Susquehanna, and one made by Josiah White, at the Falls of Schuylkill, with two locks and a canal 300 or 400 yards long.

"It was under these circumstances that the Legislature of 1818 granted the privileges of the 'Act to improve the navigation of the River Lehigh' to Josiah White, George F. A. Hauto, and Erskine Hazard. The next step of the pioneers was to raise the necessary capital for carrying on the work. They proposed to create a company to improve the navigation and work the coal mines. The stock of this company was subscribed for on the condition that a committee should proceed to the Lehigh and satisfy themselves that the actual state of affairs corresponded with the representation of them. The committee repaired to Mauch Chunk, visited the coal mines, and then built a bateau at Lausanne, in which they descended the Lehigh and made their observations. They came to the conclusion, and so reported, that the improvement of the navigation was perfectly practicable, and that it would not exceed the cost of $50,000, as estimated, but that the making of a good road to the mines was utterly impossible; 'for,' added one of them, 'to give you an idea of the country over which the road is to pass, I need only tell you that I considered it quite an easement when the wheels of my carriage struck a stump instead of a stone.' This report, of course, voided the subscription to the joint stock.

"It very soon appeared that there was great diversity of opinion relative to the value of the two objects. Some were willing to join in the improvement of the navigation, but had no faith in the value of the coal or that a market could ever be found for it among a population accustomed wholly to the use of wood. On the other hand, some were of the opinion that the navigation would never pay the interest of its cost, while the coal business would prove profitable. This gave rise to the separation of the two interests; and proposals were issued for raising a capital of $50,000, on the terms that those who furnished the money should have all the profits accruing from the navigation up to 25%, all profits beyond that to go to White, Hauto, and Hazard, who also retained the exclusive management of the concern. The amount was subscribed and the company formed under the title of the Lehigh Navigation Company on August 10, 1818. The work was immediately commenced, the managers taking up their quarters in a boat upon the Lehigh, which moved downward as the work of constructing the wing dams progressed. The hands employed had similar accommodations.

"On October 21, 1818, the Lehigh Coal Company was formed, for the purpose of making a road from the river to the mines and of bringing coal to market by the new navigation. The capital subscribed to this company was $55,000, and was taken on the same plan with that of the Navigation Company; but the managers were to be entitled to all the profits above 20%, they conveying the lease of the Coal Mine Company's land and also several other tracts of land which they had purchased to trustees for the benefit of the association. The road which now for 7 miles constitutes the grading of the railroad to the Summit mines was laid out in the fall of 1818 and finished in 1819. This is believed to have been the first road ever laid out by an instrument on the principle of dividing the whole descent into the whole distance as regularly as the ground would admit of and to have no undulation. It was intended for a railroad as soon as the business would warrant the expense of placing rails upon it. A pair of horses would bring down from 4 to 6 tons upon it in two wagons.

"Everything was thus making satisfactory advances toward the accomplishment of the object, when, late in the season of 1818, the water in the river fell by an unparalleled drought, as was believed, fully 12 in. below the mark shown by the inhabitants as the lowest point to which the river ever sunk. Here was a difficulty totally unanticipated and one which required a very essential alteration in the plan. Nature did not furnish enough water by the regular flow of the river to keep the channels at the proper depth, owing to the very great fall in the river and the consequent rapidity of its motion. It became necessary to accumulate water by artificial means and let it off at stated periods, and let the boats pass down with the long wave thus formed which filled up the channels.

"This was effected by constructing dams in the neighborhood of Mauch Chunk, in which were placed sluice gates of a peculiar construction, invented for the purpose by Josiah White, by means of which the water could be retained in the pool above until required for use. When the dam became full and the water had run over it long enough for the river below the dam to acquire the depth of the ordinary flow of the river, the sluice gates were let down, and the boats, which were lying in the pools above, passed down with the artificial flood. About 12 of these dams and sluices were made in 1819, and with what work had been done in making wing dams absorbed the capital of the company (which on the first plan of improvement would have been adequate) before the whole of the dams were completely protected from ice freshets. They were, however, so far completed as to prove, in the fall of that year, that they were capable of producing the required depth of water from Mauch Chunk to Easton. In the spring of 1820 the ice severely injured several of the unprotected dams and carried away some of the sluice gates. This situation of things, of course, gave rise to many difficulties. It was necessary that more money should be raised or the work must be abandoned. A difficulty also arose among the managers themselves, which resulted in White and Hazard making an arrangement with Hauto for his interest in the concern on March 7, 1820. On April 21 following the Lehigh Coal Company and the Lehigh Navigation Company agreed to amalgamate their interests and to unite themselves into one company, under the title of the Lehigh Navigation & Coal Company, provided the additional sum of $20,000 was subscribed to the stock by a given date. Of this sum nearly three-fifths were subscribed by White and Hazard. With this aid the navigation was repaired and 365 tons of coal were sent to Philadelphia as the first fruits of the concern! This quantity of coal completely stocked the market and was with difficulty disposed of in the year 1820. It will be recollected that no anthracite coal came to market from any other source than the Lehigh before 1825 as a regular business.

"The money capital of the concern was soon found to require an increase. In 1822 the capital stock of the company was increased by new subscriptions amounting to $83,950, and 2240 tons of coal were sent to market.

"The boats used on this descending navigation consisted of square boxes, or arks, from 16 to 18 ft. wide and 20 to 25 ft. long. At first two of these were joined together by hinges, to allow them to bend up and down in passing the dams and sluices, and as the men became accustomed to the work and the channels were straightened and improved as experience dictated, the number of sections in each boat was increased till at last their whole length reached 180 ft. They were steered with long oars, like a raft. Machinery was devised for jointing and putting together the planks of which these boats were made, and the hands became so expert that five men would put one of the sections together and launch it in 45 minutes. Boats of this description were used on the Lehigh till the end of 1831, when the Delaware division of the Pennsylvania Canal was partially finished. In the last year 40,966 tons were sent down, which required so many boats to be built that if they had all been joined in one length they would have extended more than 13 miles. These boats made but one trip, and were then broken up in the city and the planks sold for lumber, the spikes, hinges, and other iron work being returned to Mauch Chunk by land, a distance of 80 miles. The hands employed in running these boats walked back for two or three years, when rough wagons were placed upon the road by some of the tavern keepers to carry them at reduced fares.

"The descending navigation by artificial freshets on the Lehigh is the first on record which was used as a permanent thing, though it is stated that in the expedition in 1779, under General Sullivan, Gen. James Clinton successfully made use of the expedient to extricate his division of the army from some difficulty on the east branch of the Susquehanna by erecting a temporary dam across the outlet of Otsego Lake, which accumulated water enough to float them when let off and carry them down the river. . . .

"In 1823 5823 tons of coal were sent to market, of which about 1000 tons remained unsold in the following spring, there being still a great prejudice against the domestic use of coal. This prejudice was, however, on the wane, and very soon after this time became nearly extinct. . . .

"It became evident that the business on the Lehigh could not be extended as fast as the demand for coal increased, while it was necessary to build a new boat for each load of coal. Besides, the forests were now beginning to feel the waste of timber (more than 400 acres a year being cut off), and showed plainly enough that they would soon disappear in consequence of the increased demand upon them; while at the same time the Schuylkill coal region had an uninterrupted slackwater navigation, which would accommodate boats in their passage up as well as down, and of course admitted any extension of the coal trade that might be deemed advisable. It should also be mentioned that almost the whole of the shares of the stock of the old Coal Mine Company had been purchased, so that the mines had become nearly the sole property of the Lehigh Coal & Navigation Company. These shares represented fiftieth parts of the whole property, and the purchase of them commenced at $150 per share; the last was purchased for $2000 after the slackwater navigation had been made. Under all these circumstances, it was concluded that the time had arrived for changing the navigation of the Lehigh into a slackwater navigation. The acting managers, who resided at Mauch Chunk, formed a plan for a steamboat navigation, with locks 130 ft. long and 30 ft. wide, which would accommodate a steamboat carrying 150 tons of coal. These locks were of a peculiar construction, adapted to river navigation. The gates operated upon the same principle with the sluice gates in the dams for making artificial freshets, and were raised or let down by the application or removal of a hydrostatic pressure below them. The first mile below Mauch Chunk was arranged for this kind of navigation. The locks proved to be perfectly effective and could be filled or emptied, notwithstanding their magnitude, in three minutes, or about half the time of the ordinary lock. Had this plan been adopted, there can be no doubt the transportation of coal upon it could have been effected at an expense not exceeding 4 mills per ton per mile, and the same steamboat could proceed (when the Delaware & Raritan Canal was done) to New York, Albany, Providence, etc., without transshipment.

"The large quantity of coal which had been brought to market and sold in the previous year produced a profit which brought the semi-annual dividend fully up to 3% on January 1, 1826, and placed all the stock of the company upon an equality from that time forward. In the previous years the dividend account stood as follows: January 1, 1822, the first dividend made was confined to the preferred subscribers, who then received 3% on their subscription of $50,000 and the same dividend regularly afterward. July, 1822, gave the original subscribers 1%, and from that time they regularly received 3%, except in July, 1824, when the dividend to them was omitted. On the stock allotted to White and Hazard a dividend of 1% was made in January, 1824, and of 2½% in January, 1825. These were the only dividends in which they participated previous to the one which equalized the stock.

"In 1826 there were 31,280 tons of coal sent down the Lehigh. The business was now becoming so large that it was difficult to keep the turnpike to the mines in good working order without coating it with stone, and it was determined that the best economy would be to convert it into a railroad. The only railroad in the United States in 1826 was the Quincy Railroad, about 3 miles in length, made in the fall of 1826. There had previously been a short wooden railroad, not plated with iron, at Leiper's stone quarry, of about three-quarters of a mile in length, but this was worn out and not in use. The railroad from Mauch Chunk to the Summit mines was commenced in January and completely in operation in May, 1827. It is 9 miles in length and has a descent all the way from the Summit mines to the river. The road is continued beyond the summit about three-fourths of a mile and descends into the mines west of the summit about 60 ft. With this exception the whole transportation of the coal upon it is done by gravity, the empty wagons being returned to the mines by mules, which ride down with the coal. This also was an arrangement made at the suggestion of Josiah White, entirely novel in its character, and enabled the mules to make two and a half trips to the summit and back, thus traveling about 40 miles each day."

THE SWITCHBACK OR GRAVITY RAILROAD.

An inclined plane with stationary engines and hoisting machinery was afterward built on the side of Mount Pisgah, and at a later date the Nesquehoning Mountain was pierced by a tunnel and the mines reached by locomotives—the gravity roads being then relegated to the use of excursion parties, by whom the region became known as the "Switzerland of America."

Rogers' *Geology of Pennsylvania* (1858) thus describes the operation of the old switchback or gravity road:

"It consists of two independently planted single-track railroads; one for conveying the loaded trains from the mines to Mauch Chunk, the other the empty trains back from Mauch Chunk to the mines. Their routes, though somewhat different, intersect each other. The coal cars at the remote part of the line, after receiving their freight of coal, previously picked and screened near the mines, convey it by force of gravity alone, upon a gently inclined railway track, along the immediate valley of Panther Creek to the foot of Plane No. 2. Here they are coupled into sets of three and hoisted rapidly by ample stationary power to the summit of the plane. This plane has a length of 618.75 meters (2030 ft.) and vertical lift of 76.20 meters (250 ft.). Collected at the summit of No. 2, they are allowed to run by gravity, under proper checks, to the foot of Plane No. 1, losing a little of the elevation they had gained. At No. 1 they receive a lift of 114.30 meters (375 ft.) over a plane 742.50 meters (2436 ft.) long. They are now at the summit level between Panther Creek Valley and Mauch Chunk. From this point their course to Mauch Chunk is unobstructed, and they now start upon their journey over what is called the loaded track. They are made up into trains, not embracing more than 16 cars in each train, controlled by a brakeman, who sits aloft, holding a rope to which the brake handle of each car is attached by a shorter cord, and who is thus enabled effectually to bridle the whole; and they are sent on their journey by a push from the shoulders of two or three men. Starting off with a smooth and gentle motion, they soon acquire a rapid speed, which occasionally requires the brakeman to rein them in. The terminus of the loaded track has an elevation of about 60.96 meters (200 ft.) above the pool or slackwater of the Lehigh at Mauch Chunk, and this descent is overcome by the contrivance of a series of shoots or inclined troughs. The total descent from the summit at the head of Panther Creek Plane No. 2 to the surface of the water at Mauch Chunk, where the canal boats receive the coal, is 288.34 meters (946 ft.). From the summit of the loaded track to its lower terminus the length is 13.67 kilometers ($8\frac{1}{2}$ miles).

"Having discharged their freight, the now empty coal cars are conveyed, still by gravity, to the foot of the first lifting plane of the empty or return track. This plane ascends along the east spur of Mount Pisgah, an outlying terminating synclinal knob of Sharp Mountain. The perpendicular lift to the summit of the back track at the head of this plane is 251.46 meters (825 ft.). The cars are pushed up the plane by an ingeniously contrived pushing car or truck, connected with an endless chain, or rather a broad band of tough plate iron, propelled by a stationary engine at the summit. The safety car, as it is called, rests at the bottom of the plane below the level of the track in a deep, long trench or pit, and the empty cars, in requisite number, are shoved over it. At a signal given the endless band is set in motion and the safety car drawn out of the pit to the rear of the empty train, which thus begins its journey toward the summit. The speed of the ascending train at Mount Pisgah is usually 112.78 meters (370 ft.) per minute. From the summit of the empty track the empty cars descend along the south flank of Sharp Mountain, a distance of a little more than 9.65 kilometers (6 miles), to the foot of Mount Jefferson. There they are lifted by another inclined plane, No. 2 of the empty track, a height of 140.82 meters (462 ft.), at a speed of about 225.55 meters (740 ft.) per minute, the plane having a length of 630.94 meters (2070 ft.). From the head of the Mount Jefferson Plane the empty gravity track is continued to the village of Summit Hill, a distance of nearly 1.6 kilometers (1 mile). The rest of the journey to the mines is made by what is called the back track, which setting off from Summit Hill runs by two branches or separate routes into the valley of Panther Creek."

The opening of the Lehigh coal fields was due to the enterprise, indomitable energy, and brilliant engineering genius of Josiah White and his constant associate Erskine Hazard. It was Josiah White who built the first canals in this country and invented the sluice gate for their locks. It was he who built the first jetty or wingwall improvement for river navigation, and who first used "flushing," "splashing," or "booming," by movable dams or sluices, as a means of improving river navigation where the regular flow of water was insufficient to furnish the necessary depth. Josiah White was the first to divide the entire elevation to be overcome into a road of uniform grade, the first to build a gravity or self-acting road, and the first to propose a ship railway, on which he planned to carry the canal boats from the headwaters of the Lehigh near White Haven, in tanks, over the mountain and down into the Susquehanna canal and river near Wilkesbarre, in the Wyoming Valley.

The enormous difficulties under which the Lehigh coal trade was inaugurated, and which he successfully overcame by brilliant and original devices, entitle Josiah White to be ranked among the very ablest engineers of any country and of all time.

THE SCHUYLKILL REGION.

The Schuylkill region, in the early days included with the Lehigh in "the first coal field," though much more accessible than the Lehigh, commenced its coal trade several years later. According to a statement of the Pottsville Board of Trade,* the coal shipments from that district were commenced about 1800, when Mr. William Morris, who owned a large tract of land in the neighborhood of Port Carbon, procured a quantity of coal and took it to Philadelphia, but he was unable, with all his exertions, to bring it into notice. This was the first coal to go to Philadelphia from the Schuylkill region. In 1812 Col. George Shoemaker, of Pottsville, hauled 9 wagon loads of coal from his land on the Norwegian Creek, the site afterward owned by the North American Coal Company, and known as the Centerville mines, but he was not well received in Philadelphia, being, indeed, called no less than impostor for trying to foist stone upon the people, under pretense that it was coal. He did at length succeed in selling 2 of his wagon loads, for the cost of transportation, to Messrs. Mellon & Bishop for their iron rolling mill in Delaware County, but was obliged to give the other 7 loads away, and had some difficulty in finding persons willing to take it.

Mr. John White, who became interested in Schuylkill coal lands in 1822, thus described the first methods used in mining: "The coal and water were raised in buckets with a windlass by perpendicular shafts sunk in the vein. In 1823 horse gins and inclined planes laid on the bottom slate were introduced. The method of mining by drifts, driven horizontally from the water level into the coal seams, was first employed in the Pennsylvania coal fields in 1827, on the suggestion of some English miners who had come there in that or the previous year." Colonel Krebs, a member of the Packer Senate Committee, contributed the following statistics: "In 1831 coal was sold during the early part of the year in Philadelphia as low as $4.50 per ton, delivered. In the fall and winter it rose to $8

* Packer's Senate Report, 1834.

and $10. The same winter coal sold in New York as high as from $14 to $16 per ton. In 1832 the average price in Philadelphia was about $6.50 per ton, and in New York about $8.50 per ton. During the present year (1833) coal has been sold in Philadelphia by the boat or cargo at $4 to $4.25 per ton. The average price in New York this year has been about $5.50 for Lackawanna. The average value of coal, delivered at Philadelphia, by the cargo or large quantity may be stated at $4.25 per ton, and in New York at about $6, the difference being the cost of freight between the two places. The boats now built carry about 45 tons and perform a trip to Philadelphia and back in 10 or 12 days. The usual rate of wages paid to miners is from $6 to $7 per week. The cost of mining seems to be very similar in all the coal districts. Coal rent or coal lease varies from 25 to 40c. per ton, according to the goodness of the bed, the quality of the coal, and convenience to the navigation. Two dollars per ton may be taken as about the average price of coal delivered into boats at the Pottsville (Schuylkill) landings. From thence to Philadelphia the usual freight is $1.25 and the toll $1. These are averages. This makes the coal at Philadelphia cost $4.25 per ton.

"The operation of getting coal consists of mining or quarrying the coal in the mine. It is then broken into a size convenient for handling, then placed in the gangway, and is then hauled out to the bank, where it is screened and cleaned and reloaded into the railroad wagons. These wagons are then sent down the main railroad to the landings at the navigation. The coal is then let fall through the bottom into the canal boat. It is estimated that the coal trade the present year (1833) has given employment to 6000 miners, laborers, and boatmen. If we state the value of the coal when delivered at the seaboard at an average price of $5 per ton, it will give the sum of $2,500,000 as a capital created by the labor of those engaged in sending 500,000 tons of coal to market."

The Schuylkill field was opened to trade by the Schuylkill Navigation Company, incorporated as a common carrier without mining and trading privileges. The construction of the Schuylkill Canal was commenced in 1815 and completed, 108 miles in length, in 1818, at a cost of $2,966,480, but coal does not appear in the annual reports of the company as a separate item until 1825, when 5806 tons were carried and yielded a revenue of $9700 to the company out of a total receipt of $15,776. In 1826 the coal carried amounted to 16,835 tons, and in 1830 no less than 89,984 tons, or more than twice as much as went down the Lehigh, which commenced its regular trade in 1820—an event attributed to the fact that the Schuylkill field was worked by individual operators and independent companies, while the Lehigh mines were controlled by the transporting company.

THE WYOMING REGION.

The Wyoming or northern coal fields being accessible by the North Branch of the Susquehanna River, coal was shipped down this stream continuously from 1775, when the first shipment of anthracite is recorded. In 1807 Abijah Smith & Co. shipped 55 tons from near Plymouth in this field to Columbia, Pa., and continued thereafter until about 1828 to ship 400 to 500 tons a year to market, some of it going to New York, where they received from $12 to $15 a ton for it.

The navigation of the river by boats or arks, which ran down the stream and were broken up at their destination, the lumber being sold, was, however, very dangerous, and a large proportion of these boats was wrecked on their way down. The Pennsylvania or North Branch Canal was built from Sunbury, on the Susquehanna, to overcome these difficulties, and in 1833 was being extended up the Wyoming Valley to the mouth of the Lackawanna River. It was subsequently extended up the Susquehanna into New York State, the plan being to connect with the Eric Canal and the great lakes. The portion up the North Branch of the Susquehanna was later on allowed to go into disrepair and was acquired in the interest of the Lehigh Valley Railroad, much of which line is laid on the grading for the canal.

The opening of the Schuylkill and the western end of the Wyoming fields was easy compared with that of the Lehigh and of the Lackawanna, or eastern end of the Wyoming field. This last was accomplished by the Delaware & Hudson Canal Company in 1829 on the bold lines first conceived in 1822 by Maurice and John Wurts, engineers who deserve the gratitude of the country. They proposed in 1822 to construct a railroad and canal from the coal beds on the Lackawanna to the Hudson River, and on April 7, 1823, obtained from the State of New York a perpetual charter with mining privileges for the Delaware & Hudson Canal; further acts were obtained in 1825. The engineers of the company, Mr. Benjamin Wright, Col. J. L. Sullivan, and their assistant, Mr. Mills, made surveys for this road and canal in 1824, and published in that year a very hopeful report, in which they estimated the cost of delivering coal in New York, exclusive of tolls, at $2.64½ per ton, a figure which has since been reached, though not in the way estimated.

This road from the Lackawanna mines and river to Honesdale, on the Lackawaxen River, a distance of 16 miles, crossed the Moosick Mountains 800 ft. above the Lackawanna and had eight inclined planes, five ascending planes worked by stationary steam engines and three descending planes acting by gravity. A canal was built from Honesdale to Rondout, on the Hudson or North River, 107 miles. This whole work, road and canal, 123 miles, was completed in 1829 at a cost of $2,305,599, and during that year 7000 tons of coal were sent to market over it, and in 1830 42,000 tons. The items of cost of delivering coal at New York, as given in the engineers' report above referred to, are interesting as showing the conditions existing and wages ruling in 1824. They were as follows:

Estimate of the expense of delivering coal from the Lackawaxen mines by the proprosed Delaware & Hudson Canal:

Quarrying now 25c. per ton, but as the excavation will become deeper, assume	$0.37½
Hauling, the distance from 4 to 5 miles, on a turnpike road, a 5-horse team will perform two trips per day with a load of 3 tons (according to experience in Pennsylvania). The daily expense of the team will be as follows:	
5 bushels of oats, usual price 25c., say 37½c	1.87½
16 lbs. hay for each horse is 80 lbs. per day for the team, the usual price $5 to $7 per ton, say $10	.36
Shoeing $1 per month each horse, is for the team $60 per annum, per day	.20
Driver	.75
Loading	.50
The team will labor but 300 days, and the keeping for 65 days must be assessed on the working days, each day	.48
Thus the hauling of 6 tons will be	4.16½
Per ton	.69½
The use of a railway will diminish the expense probably one-half.	
Loading coal into canal boats, per ton	.10

The length of the canal is 117 miles. A boat carrying 50 tons will go to the Hudson and return to the mines in 10 days; her expenses will be as follows:

3 men* 10 days @ 75c.	$22.50
2 horses 10 days @ 50c.	10.00
Expense of keeping horses 65 days, to be assessed on the working days, is 22c. per day, or per trip	2.20
Shoeing, $1 per month each horse, is 8c. per day	.80
For 30 tons	$35.50
Per ton	1.18

The canal boats may navigate the Hudson. A steamboat of 50 horse-power will tow 10 of them, and if double manned will perform the trip to New York and back in 2 days; the distance, 100 miles. Estimate of her expenses:

1 captain @ $30 per month, or $1.16 per day	$2.32
1 mate @ $25 per month, or 96c. per day	1.92
2 pilots @ $30 each, or $1.16 per day	4.64
2 engineers @ $30 each, or $1.16 per day	4.64
2 firemen @ $25 each, or 96c. per day	3.84
6 ordinary hands @ $12 each, or 47c. per day	5.64
1 steward @ $15, or 58c. per day	1.16
1 cook @ $12, or 47c. per day	.94
Provisions 2 days @ $6 per day	12.00
Coal, 6 tons per trip @ $3.60 per day	21.60
For 300 tons	$58.70
Per ton	.19½
Discharging the boats, per ton	.10
Cost of the coal delivered in New York (exclusive of tolls) is	2.64½

Or less than 9½c. per bushel.

* One man, a boy, and a horse are usually deemed sufficient to conduct a boat of 25 tons.

In this estimate of $2.64½ as the cost to the company of a ton of coal delivered in New York, it is of interest to note that the expenses of mining and loading the coal into boats at the point of shipment amount to $1.17 per ton.

The engineers further say: "No assessment is made upon the cost of the coal for the purpose of keeping the canal in repair and incidental expenses of management; for as the trade of an extensive country must pass through it, it may be safely assumed that the profits from other business than the coal trade will be more than adequate to supply a fund for this purpose." The expectations of these engineers, though long unfulfilled, were in the end realized. The annual report of the Delaware & Hudson Canal Company for 1877 speaks of what had been done up to that time in these assuring words: "Under these powers and privileges [legislative acts of the States of New York and Pennsylvania and the credit of the State of New York in 1827 and 1829 for an aggregate of $800,000] the corporation has within the past 54 years secured an immense property, constructed a canal 173.81 kilometers (108 miles) in length, operated hundreds of miles of railway, marketed 37,000,000 tons of coal, and divided among its shareholders more than $39,000,000."

OVERPRODUCTION AND UNPROFITABLE BUSINESS.

There appears to have been from the very first an abundance of coal available in the anthracite fields. Indeed, the capacity of the mines opened was always several times as great as was required to supply the normal demand. This cause brought about the same effect in those days of small beginnings as it does now. The more enterprising miners, or "operators," as the mine owners have long been called in the coal regions, who had best equipped their mines and improved the roads to market and who commanded more abundant capital could undersell their less progressive or less fortunate neighbors, and consequently many of the mines were worked only when the demand was large or were altogether abandoned when the competition rendered them unprofitable. Nevertheless the number of collieries became very great, though the output of each and the capital invested were quite small.

In 1833 there were no less than 92 collieries in the Schuylkill and Lehigh regions (no coal had been shipped from the Hazleton or Beaver Meadow fields), which produced a total of 429,933 tons, or an average of only 4673 tons each, while the average value of each colliery, "including working capital, utensils, horses, mules, etc.," was but $4000, or a total of $368,000. As little as $1000 was considered sufficient to open a mine and do a moderate amount of business at that time, and $10,000 sufficed for "a respectable business," including value of land, opening mines, boats, working capital, etc. In 1833, according to contemporary testimony, an amount of from $1 to $4 per ton of coal shipped was considered a sufficient capital for the coal business, exclusive of the amount required to carry stocks of coal in the chief markets, which all admitted was an efficient factor in increasing the consumption of coal and steadying prices.

While these amounts now appear ridiculously small, it was then difficult for private individuals to command them, and recourse was had to partnerships and to joint-stock companies, which had already come into favor, as they enabled operators and speculators in coal lands and town sites to raise capital with greater ease. The result of this movement was the introduction of much larger amounts of capital in the mining business and the adoption, already before 1833, of many improvements at the mines and a greatly increased output from each colliery. This so intensified the hardships of the small operators that frequent complaints were made to the Legislature against the incorporation of joint-stock mining companies which, through their large means, were rendering worthless the investments of individuals, and which it was asserted were transferring the profits of the business from those who lived and spent them in the district to alien or absentee stockholders living in the cities and even in other States, etc.

In answer to these bitter complaints and petitions, the Senate of Pennsylvania appointed in 1833 a committee, under the chairmanship of Mr. S. R. Packer, "to investigate the present state of the coal trade within this Commonwealth and the history of mining operations generally, with a view to ascertain the effect of incorporated companies (with mining and trading privileges) on the progress of the business and the improvement and prosperity of the country, and to inquire what further legislative provisions are necessary to protect, facilitate, and encourage this branch of industry."

The Packer report was published in 1834 and is an extremely instructive and able document. It constitutes, in fact, a very complete history of the evolution of the bituminous and anthracite coal trade up to that date, and to it we are indebted for much of our early knowledge of this industry.

A general summary of the capital invested in the industry at that period (1833) in the Schuylkill district is given as follows:

Railroads, laterals, and canals in the Schuylkill and Lehigh coal fields and the (60 miles) Delaware Division of the Pennsylvania Canal, aggregate 377 miles	$7,211,606
2354 railway cars @ $70	164,780
980 boats @ $500	490,000
92 collieries, including working capital, utensils, horses, mules, etc., @ $4000 each	368,000
100,000 acres of land @ $40 per acre	4,000,000
	$12,234,387

Total coal produced in the district in 1833, 429,933 tons.

Figures which give a good idea of the condition mining had attained at that period under individual operators and joint-stock mining companies. The committee gave the following estimate of the value of improvements and property connected with and consequent upon the anthracite coal trade of Pennsylvania in the three great coal fields in 1833:

Railroads and canals, including parts of the State canals, 489 miles	$9,750,937
Collieries, boats, cars, etc	1,270,280
Capital invested in coal lands	4,300,000
Mining capital	480,000
Value of towns in the coal field	3,375,000
Total	$19,176,217

The conclusions of the Packer committee on the questions submitted to it, and of which it had evidently made diligent study, are of great interest as indicating at that early day in the history of joint-stock mining companies the tendency or direction in the evolution of the coal trade.

With regard to "the effect of incorporated companies having mining and trading privileges on the progress of business and the improvement and prosperity of this country," the committee says "they have generally been beneficial. They have been mainly instrumental in introducing the use of anthracite coal, and . . . have contributed largely to furnish a constant and regular supply, by which the demand for coal has been increased and the community accommodated at a fair and reasonable price." After dilating upon the advantages of widely diffused operations and the dangers of "consolidation or monopoly of trade," which, however, it did not deem imminent, the committee deprecated "too much legislation" as being "more to be dreaded than the entire want of it," and with the exception of protesting against the State giving incorporated mining companies "the control of a canal or railroad, with power to lock up at pleasure the resources of a whole valley or community," the committee found everything commendable and recommended that "natural liberty and human action be no further restrained by legislative enactment than is consistent with or indispensable to the purposes of civil society and republican government."

THE EFFECT OF INFLATION AND DEPRECIATED MONEY ON THE COAL TRADE.

The progress of the anthracite trade after this abortive effort to stay, by legislative enactment, the operation of the natural law of the survival of the fittest, continued uninterrupted, as is shown by a reference to the accompanying tables of production and prices. There were the usual complaints of unprofitable business that are the accompaniment of progress in every industry, and the number of small mines steadily decreased and the average output of a colliery increased. Incorporated companies more and more absorbed the business, and the mining-transportation companies, in hard times particularly, more and more firmly controlled the markets and pushed their so-called "independent" rivals to the wall.

During the civil war labor was scarce and wages and coal extremely dear, profits were abnormally large, and new collieries were opened everywhere. The vast expenditures of the Government in a depreciated currency and the numberless opportunities to make money, honestly or dishonestly, out of the Government greatly demoralized the whole community, and the undesirable effects were long seen in the anthracite coal trade.

The settling down from the inflation of depreciated money and extravagant expenditures to the solid basis necessary for a permanent business prosperity brought about strikes and combinations of laborers and of capitalists, which were chronicled and carefully studied by the present writer in the annual editorial reviews of the coal trade in the *Engineering and Mining Journal,* 1875 to 1878. In the light of subsequent events, it will be admitted that these reviews constitute a valuable contribution to the history of this great industry. The following are extracts from the review of the trade for 1876. They show the condition of the industry at perhaps its most critical period:

"The year just closed has been one of the most eventful, as well as one of the most disastrous, in the history of our coal trade. The general revival of business which so many have been expecting and predicting for three years past, but which in our annual review of the coal trade a year ago we stated could scarcely be expected for some time to come, has not been realized, and the situation has been still further aggravated by the unhappy complications arising out of the presidential election. The clouds of adversity which have hung over the coal trade for the past three years are gradually lifting in the West, though to all appearances the storm has not yet passed in the East, nor will it, we fear, without still further increasing the number of wrecks which already mark its progress.

"Since the autumn of 1873 the whole business of the country has been settling down to a lower, more solid, and more honest basis. The great natural resources of the country and the prodigious energy and hopefulness of our people tended to postpone the day of reckoning for the extravagance, wastefulness, and dishonesty which grew out of the lavish expenditures of our civil war. The reaction or reform which set in three years ago has gained one position after another—whether in business or government—though it has necessarily brought with it great disappointments, sad revelations, and much suffering and want among our laboring classes. Powerful combinations among special classes of labor or in special branches of trade postponed for a time the inevitable decline in wages or profits; but no one industry can hold out against a general reaction such as that we are passing through. The coal trade is one of the most notable instances of this. During the war, with coal commanding the most extravagant prices, and with a scarcity of labor, the workmen, by their trades unions, were enabled to enforce higher wages than were obtained in other industries, and they continued to demand and receive these long after coal had ceased to command remunerative rates. To regulate an unprofitable trade and to gain that strength by union of forces which was necessary to compete successfully with the miners' unions, the great anthracite coal combination was formed. The policy of this remarkable 'trade union' was to increase the price of coal to such a point as would leave a fair profit to the mining and transporting companies. Incidentally, the wages of the workmen, which were abnormally high, were reduced somewhat, though only after a severe struggle, in which the united strength of the companies barely gave success. Even after this reduction, miners' wages were much higher than those of any other class of labor.

"The success of the combination in reducing wages and advancing the price of coal was so exceedingly satisfactory for the time that it was encouraged to continue a policy exactly similar to that of the miners, and in both cases the final results were alike. The extra high wages demanded by the miners brought about such an influx of laborers from other fields that there was not work for them all more than five or six months in the year; yet they pretended that it was their right to demand such wages that five months' work would suffice to maintain them in idleness—enforced idleness, it may be—for the remaining seven months. The companies united to put up the price of coal in order to be able to pay these exorbitant rates to the miners (it is so much easier to get the disorganized public to pay 50c. per ton more for their coal than get the organized miners to accept 10c. per ton less for their labor) and to provide for large dividend and interest accounts. The result in this case was a price that restricted consumption and invited competition from bituminous coal, and the mines, which were opened with a capacity of nearly twice the maximum market demand, had to stand idle more than one-half the time, thus necessarily increasing the cost of getting the coal and making it still more difficult to 'live' at any prices that could be obtained for it. The consumption of anthracite steadily decreased under this policy, and the temptation of high prices, combined with the pressing financial needs of some of the companies, finally proved stronger than the bond of mutual interest which held them together. This effort to control the production and cost of anthracite was abandoned in August last, since which time the other extreme has been adopted, and considerable coal has been sold at public auction at the lowest prices ever obtained in this market, and at a decline of from $2 to $2.50 per ton from the combination rates.

"From a programme price of $5.18 per ton to an average auction price of $2.91 per ton was a shock that tried the strongest constitutions, and for a time quite stunned some of the companies; but when subsequent sales indicated a decline rather than an advance from these prices, it was seen that the measure of economy in the production and handling of coal that had formerly been considered as the utmost possible limit must now find a stricter interpretation, or sudden and sure destruction awaited the companies. Wages at the mines and on the roads were reduced without opposition from the men; in some cases salaries were reduced also, and many dear, superfluous necessities were dispensed with.

"By these means the cost of getting and marketing coal was no doubt largely reduced, but the fact nevertheless remains that the prices obtained since the rupture of the combination have been ruinous to the large companies, and sufficient to prevent actual loss at only a small number of the most advantageously situated and best-managed collieries. If, as claimed by the heads of the great companies, the combination prices were only sufficient to provide for the interest and moderate dividend account of the companies, it must be very evident where the present prices will lead to. The longest purse and the best credit cannot long supply such a drain.

"That the companies' statement to which we have alluded is not without foundation, we estimate, from the best authorities obtainable, that the capital stock, bonds, and other forms of indebtedness of the coal and coal transportation companies, and of the companies whose bonds they have indorsed or whose properties they have leased (the rental being considered as the equivalent of interest on bonds), amount to nearly, if not quite, $550,000,000, which at 7% would require an annual net profit of $38,500,000 on the business done. Since these roads do other business than carrying coal, it would not be fair to charge the whole of this amount to this one item, yet it must earn by far the larger part of it. It will not be excessive to estimate a net profit of $30,000,000 from the mining and transportation of anthracite (say $1.60 per ton on the basis of the production of the past year) as necessary to provide 7% interest on the capital now invested, directly or indirectly, by the mining and transporting companies in this industry. In the olden times (and we are rapidly approaching that basis for estimating) 25c. a ton formed a very fair profit on coal mining. The net profits on transporting coal a distance of about 160 miles can scarcely exceed, in ordinary times, ¼c. a ton a mile, or 40c. for the entire distance. Where, then, is the balance to come from, or what will be the effect upon the coal trade generally and on the securities of our great coal companies in particular if it be not obtained? The solution of these conundrums has been the most important question in the trade for several years past, and it will certainly be the most prominent one during the coming season.

"It is a very simple matter to point out that there is too much capital invested in the anthracite trade, or to indicate that the purchasing of vast quantities of high-priced coal lands 50 or 100 years before they are wanted or can be used, and the leasing of large areas of undeveloped coal property at enormous minima rentals, as well as the ambitious design of seeking to control various outside industries, through onerous leases or guarantees of bonds, form elements of a suicidal policy, which, however fascinating and popular while business is brisk and prices are increasing, is a very 'Dead Sea apple,' turning to dust, bitterness, and disappointment when the inevitable reaction sets in and values decline. It is easy to point out these unpopular truths and yet recognize the enormous value of anthracite coal lands; for doubtless these, when available for immediate exploitation, are worth much more than $1000 or $1200 an acre, which at present are considered high prices. The difficulty is not that our coal companies have purchased worthless property, but that they have purchased and leased at these high prices much more than they can possibly use or require for many years to come, and the interest account will overwhelm them. They are like misers who have hoarded gold, and now in this struggle for existence they are sinking under the load of their accumulated treasures.

"Great facility in acquiring money, whether it be by earning it or by borrowing, invariably produces extravagant habits in companies as in individuals. Even where the management is strictly honest (and, unfortunately, there have been instances of the contrary even in the coal trade) the period of large expenditures is never marked by rigid economy. In the case under review, extravagant prices were paid for lands, for machinery, for all classes of supplies, and for labor. The abundance of money which was circulated during and after the war made the whole nation extravagant, and enabled nearly every industry to exact enormous profits from the spendthrift public.

"The great financial panic of 1873, though by no means the initial step in the reaction, was so sudden a bursting of the bubble of inflation, and so loath were our hopeful, successful people to believe in the end of the pleasant condition of things that had for years existed, that few could realize the extent and duration of the reaction which was then setting in. The coal trade would naturally have been one of the first industries to feel the effects of the suspension of general manufacturing and the curtailment of the demand for iron, and the prices of bituminous coal quickly showed this. The anthracite trade, however, was then controlled so effectually by the late coal combination that prices were not only maintained, but even increased, through 1874 and 1875, and but slightly reduced in 1876. The steady decline of consumption under this treatment was plausibly accounted for by other causes than the high prices, but the steady increase in the consumption of bituminous coal, while that of anthracite was diminishing, showed clearly that it was due to the policy governing the latter industry.

"It must not for a moment be supposed that the coal combination was originated or conducted as a heartless and extortionate monopoly. Like every oppressive tyranny, whether in trade, in politics, or in religion, it had a most laudable origin. For several years previous to 1872 the market had been overstocked with coal, and prices had declined to such a figure that the great majority of individual operators were ruined; but as the transportation yielded a fair profit, the railroad companies encouraged this large output. As the mine owners failed, the output of their collieries ceased and the transportation companies suffered. To provide against this contingency, money was loaned needy operators to enable them to continue producing, and of course it was always hoped and expected that business would revive and become profitable. There was a limit to the amounts individual coal operators could borrow in those days—just as there is in the case of their successors to-day—and when that limit was attained the creditor transportation company had to buy in the colliery to save (?) itself.

"The miners, combined in a rich and powerful union, resisted all reductions in wages by long-continued and expensive strikes. They had the divided operators at their mercy, and demanded such exorbitant wages as largely contributed to the ruin of their employers and to the later organization of the coal combination.

"The combination of the men to obtain exorbitant prices for their labor and to control production by means of total 'suspensions' of work resulted in the introduction into the coal fields of far more men than the trade could give full employment to, and consequently to enforced idleness during a portion of the year. It increased the cost and therefore the selling price of coal; retarded the natural increase in its consumption; ruined the independent operators; and eventually built up a combination of the large companies that has overthrown the union. The men who had long been receiving a rate of wages higher than that in any other industry in reality earned less than if they had secured the more constant employment which a lower rate of wages would have brought. Yet the unions were not without their advantages. They secured for the miners rights and privileges they would not have obtained while disorganized, and not the least of these advantages was the enactment of the mine ventilation law in Pennsylvania—a measure which has proved to be of great benefit to all parties.

"Union among the laboring classes seems to be necessary, in the present condition of society, for their protection and for the attainment of their rights. The danger is in the natural instinct—natural to employers as well as employed—to use their strength for tyrannical and oppressive ends. The miners' excesses brought about the reaction that destroyed the unions; the combination's excesses were the cause of its downfall. The influence of the combination on the coal trade in arbitrarily increasing the selling price of coal has already been noticed; it exercised, however, other and even more important influences, some of which were beneficial, others injurious. It regulated and steadied the price of coal, so that contracts could be made by manufacturers with assurance as to the cost of so important an item as fuel, and it kept the price moderate throughout the long strike of 1875, when, had it not been for its action, the most violent and injurious fluctuations might have been expected. By its strength it insured the supply of the market notwithstanding strikes, and enabled furnaces and manufacturers to dispense with the large stocks they had previously been obliged to carry to provide against sudden strikes. It was, in its early days especially, conducted with great moderation and justice, and is probably as favorable an instance of trade combination as can be cited. During and after the panic of 1873 and 1874 it stood between the coal trade and that ruinous condition of affairs which has now overtaken it. This was undoubtedly a great, an inestimable benefit to those engaged in the trade at that time; but since it merely postponed for a season the inevitable day of reckoning, and in so far retarded the settlement of values to that lower plane which they have necessarily to reach before the revival or upward course can commence, it is at least doubtful whether this temporary postponement was an advantage to the country at large or even to this industry.

"It seems indeed a hard and ungenerous thing to say, but it is nevertheless a sentiment widely indorsed by shrewd and far-seeing business men, that it would have been a positive advantage to the country and to every industry had the weak and embarrassed members failed in a general collapse three years ago, rather than have tided over from year to year, increasing their indebtedness, disturbing trade, and retarding the revival of a sound and healthy business on the new plane of values. The coal combination more than any other interest opposed and retarded, without being able to overcome, the new order of things. It prevented a decline in wages in the coal regions, which was and is an absolute necessity, and yet it did not benefit the miners, for in keeping up wages it increased the number of men, and at the same time diminished the amount of work to be done. It maintained an extravagant basis of values in the cost of conducting the business of this great industry, which is the inevitable concomitant of ability to command high prices. It postponed the evil day until now, when we might confidently look for the initiation of a general business revival, we are confronted with a condition of things which nips as with a sharp frost the slowly opening bud of returning confidence, and sets back the spring time which must precede the harvest of active trade. The hollowness of the apparent prosperity secured by this abnormal stimulant is shown in the present financial condition of the members of the combination.

THE FIRST ENGLISH COAL COMBINATION.

"There are no novel features of trade or of coal combinations, for the same story has been repeated over and over again during the past 200 years. The great anthracite coal combination did not spring fully developed from the fertile brain of its originator, like Minerva from the brain of Jove; it was a very human child, the offspring of accidents and expedients; it was constantly being amended, modified, extended; and yet, though this was the product of the very highest class of intellect, one is struck by the sameness of the story as we peruse the history of former efforts in the same direction. Take, for example, the old English coal combinations:

ANCIENT COAL COMBINATIONS.

"Coal appears to have been mined in England in the days of the Roman occupation of the island, but probably the earliest authentic specific record of coal being mined is in 1180. As early as 1665 the annual production was between 500,000 and 600,000 tons. This quantity seems to have overstocked the market, and on April 27, 1665, there was held a meeting of the coal dealers at Newcastle, when an agreement was signed by 22 coal owners that they would mine no more coal till the large stocks then on hand were disposed of; and 25 coal owners signed an agreement at the same time 'for raising the price to 13s. per caldron' (53 cwt.). About 100 years later, in 1771, we learn there was formed a combination among the coal owners who shipped their coal by the three rivers, the Tyne, the Wear, and the Tees, to raise the price of coal to consumers by restricting the quantity supplied. This combination, known as 'the limitation of the vend,' lasted, with but a few temporary interruptions, until 1845. 'A committee appointed from among the coal owners held its meetings regularly in Newcastle, and fixed the price at which coal of various qualities might be sold when sea borne for consumption within the kingdom.' They also assigned the quantity of coal which, during the space of a fortnight following each 'issue,' or order, individual collieries might ship.

"Upon opening a colliery, the first thing to be determined was the 'basis,' or rank, which that colliery was to take. The Coal Trade Committee appointed one referee and the coal owner another. These men, taking into account the extent of the coal field secured, the size of the pits, the number of steam engines employed, and other matters which indicated the amount of capital, fixed the proportionate quantity which the colliery would be permitted to furnish toward the general supply. This system necessarily led to various schemes for securing the largest possible 'basis.' The proprietors burdened themselves in various ways, as by securing a royalty extending over five to ten times the surface which they intended to work; as by sinking pits at great cost which they had no idea of using; as by building twice the number of cottages which they required for the colliers and by wasteful expenditure in every direction.

"This Newcastle committee met twenty-six times in the year, and according to the prices in London determined the quantity which might be issued during the following fortnight. The restrictions enforced by the 'limitation of the vend' did not apply to coal shipped to foreign parts. The consequence of this was that coal was frequently sold to foreign markets 40% under the prices in the London market, and English coal could sometimes be purchased in St. Petersburg at half the price of the same coal in the river Thames.

"The competition of the coal from the Midland counties seems to have broken down this plan of 'regulating trade,' and though various attempts were afterward made to maintain combinations of this kind, they all failed in the same manner. There is no general combination regulating either production or price of coal in Great Britain at the present time. Our combination was more enlightened and shorter lived than the old prototype above alluded to, but the spirit and the tendency of all such organizations are sufficiently alike to be able to predict with great certainty the final result in every case.

"One of the most notable features of our combination was the effort to bring the producer and consumer together, and thus save the commissions and expenses of 'middle-men.' Unquestionably this has, theoretically, many advantages. It seems as though the middle interest should be entirely superfluous, and if 20 or 30c. a ton could thus be saved it would be a very important consideration. Experience has shown, however, that there are great difficulties in dispensing with these factors. The salaried agents of the companies are never quite as successful salesmen as those who depend directly on the quantity sold for their income. Moreover, consumers, as a rule, have very little knowledge of the qualities of the various coals and are influenced to a great extent by what their coal agent tells them; and instances are not wanting where these ready reasoners, who have a special coal to sell, have been able to make 'the worse appear the better cause.' Then, again, consumers prefer dealing with individuals to buying from companies, and in many ways the large company is at a disadvantage in getting business. While the individual operators cannot afford to carry on the details of retailing or of the general trade in coal, they find it cheaper and more satisfactory to confine their attention to the one department of production, and leave to the middle interest the business of disposing of the product. The advantages which, theoretically, are to be gained by bringing the producer and consumer together are not generally realized in practice, though there can be no question but that the policy of the great companies having retail yards in the large cities has been very advantageous.

"The Reading Coal & Iron Company greatly reduced the retail price of coal in Philadelphia by establishing yards there, and the Pennyslvania Coal Company has long acted as a very just and reasonable governor to the retail prices in New York by offering its coal direct to consumers at moderate prices. Some of the other companies have also done good service by establishing yards in this and most of our other large cities. There must necessarily be a limit somewhere to the ramifications which it is prudent to allow a business to assume, for there is a limit beyond which the ability and talents of a man (and there must be one man at the head), however great or brilliant he may be, become so diffused and diluted, as it were, that the business is not as perfectly managed as if each department were entirely independent of the others. It is still an open question just where this limit should be placed, but the indications point to a reduction rather than an extension of the ramifications of a business, though this is due, in part at least, to the present limited financial resources of those engaged in this industry.

"No more notable event has occurred in the coal trade during the year, or indeed during its history, than the arraignment and conviction of the members of the Ancient Order of Hibernians, commonly known as the Molly Maguires. The history of this infamous band of assassins shows how, without even the incentives of revenge or of gain, they deliberately murdered inoffensive citizens against whom some of the members of the society had some petty grievance; how they terrorized over the entire mining districts of Pennsylvania until no man's life or property was secure from their nefarious acts. That numerous members of this band escaped punishment for so many years was due to the difficulty of convicting in the face of easily manufactured alibis and, humiliating as it is to admit it, owing to political influence. . . .

"It is to Mr. Franklin B. Gowen, president of the Reading Railroad, that the credit of exterminating this gang is principally due, and no citizen of the State has ever done his country a greater or more worthy service than that performed by him. The courage, ability, and perseverance Mr. Gowen has shown in this matter have given him the highest possible claims on the gratitude and honor of his countrymen everywhere, and particularly of those interested in the production of coal, the miners and owners of mines, and his name will be forever identified with this great service. . . .

"When a private mine owner fails his mine is either abandoned—when its production ceases—or it is sold out at a low price, and the new owner, having less capital in the business, can produce coal cheaper than his predecessor. On the other hand, experience shows that when a railroad company fails it simply goes into the hands of a receiver and works on untrammeled by interest or dividend charges. So long as its business covers running expenses it can afford to run, and therefore forms the most dangerous competitor for companies that have the interest to pay on their indebtedness, and whose stockholders clamor for dividends. No one will deny that the price of coal should be such as to make a liberal return on the investment necessary for the legitimate prosecution of the business. Mining investments are always attended with more or less risk, and they should be and usually are more remunerative than those of any other class. . . .

"The present actual cost of mining and the extent of the reduction which has been made during the year may be seen by an inspection of the following statement, which gives the exact figures as taken from the books of three collieries in Schuylkill County, designated A, B, and C:

COST OF MINING COAL—PER TON OF 2240 LBS.

	November, 1876.			November, 1875.		
	A	B	C	A	B	C
Mining contract account	$0.493	$0.118	$0.151	$1.024	$0.392	$0.266
Mining labor account	.071	.147	.224	.389	.197	.284
Outside labor account	.152	.128	.128	.267	.198	.189
Breaker labor account	.240	.193	.189	.304	.241	.216
Inside supply account	.192	.166	.131	.241	.273	.070
Outside supply account	.062	.123	.048	.029	.075	.168
Breaker supply account	....	....	....	.020	.015	.009
Improvement account	....	.221	.224	....	.141	.178
Cost per ton on cars, exclusive of royalty, interest, etc.	$1.210	$1.096	$1.085	$2.274	$1.532	$1.380

"Reduction in cost of mining varies, then, from 30c. to $1.05 per ton. If we add to the above figures the ground rents or royalties, which amount to, say, 25c.

per ton, and the 'lateral tolls' which the operator pays, and which amount to from 21 to 52c. per ton (both items being practically unchanged in the two years), adding the freight to South Amboy, say $1.12 to $1.50 per ton, we get the actual cost at South Amboy (without profit to the operator or interest on investment), $3.30 to $3.63 per ton, while the present selling price varies according to size from $3.25 to $3.75 per ton, or an average of about actual cost. It is claimed, however, that several of the Schuylkill collieries put their coal in the cars at a cost of from 66 to 80c. per ton, or 40 to 50c. per ton less than in the cases cited. There are also collieries in the Lehigh region that can put coal in the cars at, say, 70c. per ton, exclusive of royalty; but in many of these cases the low figures are secured probably only by a partial or total suspension of the dead work, which should be kept constantly in progress in every well-managed colliery.

"Since wages and some other items in cost will perhaps be further reduced, it is probable that the present prices, which provide little or nothing for interest or profit, may yet become remunerative. And it also shows that for some time to come there is little prospect of any great advance in prices. . . ."

In the review for the year 1877 the following paragraphs occur, and as they point out some of the features which were characteristic of this critical period in the trade, they are here reproduced:

"The anthracite fields, from their nearness to the great cities, the centers of finance, and from their limited areas, have always been the seat of speculation and feverish activity. Since their first discovery there have never been wanting enthusiastic pioneers who looked at the future of the coal trade through the magnifying glasses of their own oversanguine temperaments and projected schemes, either chimerical or suited to a condition of things far in advance of their times. The anthracite fields are still studded with the wrecks of such ambitous projects, and the trade, unduly stimulated by the infectious enthusiasm of these always great, though often unpractical men, has suffered from a species of intermittent fever, in which the feverish activity of 'good times'—when large amounts of capital were being invested—was followed by the chill of 'hard times,' when, the investment period having ceased, those who had been discounting the future at too favorable a rate were called upon to settle.

"These features of the trade are not original with nor confined to the Pennsylvania anthracite region, but have accompanied the growth of every great industry in every country. A period of prosperity leads to inflation, overinvestment, and overproduction, and is followed by one of shrinkage in values, losses, and collapse of fortunes. It requires for a return of confidence on the part of capital and for an equalization of demand and productive capacity a period longer in proportion to the extravagance of the previous inflation and to the amount of the resulting losses.

"The coal trade in this country has passed through a number of such revivals and relapses—some of the latter more disastrous in proportion to the extent of the trade and of the capital invested than is that through which we have been struggling for the past year or two.

"It is needless to enter into a history of the causes of the last inflation and overinvestment in the coal trade. It had its origin along with that of the inflation to every other department of industry and every species of values in the limitless expenditures and excesses of our civil war. The important questions now are as to when the natural growth of consumption will overtake our productive capacity and when the amount of trade will be such that, while maintaining low prices, moderate profits on the business done will give fair returns on the capital invested.

"The amount of capital now depending upon the anthracite trade for profit is so enormous that it seems impossible that any probable increase in the amount of the business for many years to come could pay a fair return upon it. Unquestionably much of the money thus invested in coal lands and railroads more or less remote from the coal fields has been permanently sunk and must be written off from the books. The process by which this injudiciously invested money finally disappears as a charge on the trade is bankruptcy—always a painful, but sometimes a necessary remedy for the ills of overinvestment. The necessities of manufacturing industry throughout this country require the supply of cheap fuel, and nature has provided, in our magnificent deposits of coal, the means of meeting this requirement. High prices for coal would be ruinous to the growth, if not to the very existence of some of these industries, and would at the same time retard and obstruct the growth of the coal trade itself. It is necessary, therefore, that any permanent improvement in the business of the companies engaged in it must come from an increase in the quantity of coal marketed rather than in any large increase in the prices.

"It is true that the immediate necessities of some of the companies engaged in the trade are such that a moderate price for coal will not meet their obligations, but that which would do this would permanently cripple the trade, while it would provide but a temporary relief, at the expense of future health, to the companies themselves. . . .

"The coal trade is a most sensitive barometer, which feels and records the slightest changes in the general business of the country. Thus it improved rapidly with the returning confidence and revival which showed itself in the autumn of 1876, and it was at once depressed by the complications connected with the presidential election, which were not settled until March.

"In common with all other business, it has been injuriously affected by the effort to depreciate the money of the country, in making the silver dollar of 412½ grains a legal tender for large amounts, and by the lack of confidence resulting from the revelations of the dishonesty so common in the management of our financial, railroad, insurance, and other institutions throughout the country. Had it not been for these causes, the abundant crops, the wonderful productiveness of our gold and silver mines, and the natural elasticity and hopefulness of our people would have carried the whole business of the country much further on the road to renewed prosperity than we now find it. Nevertheless the country has passed through the darkest days of this financial crisis and has now entered fairly upon the upward road. The coal trade is almost the last industry to feel this revival, and there is no concealing the fact that it has still impending over it financial failures of enormous proportions.

"The combination withstood the storm of 1873, and the exceptional ability of the managers of the great coal companies has enabled them to still maintain a bold front—though not quite an unbroken one—against the shrinkage which has so greatly reduced the inflated proportions of other forms of overinvestment. Whether their heroic struggles and partial success in resisting a necessary shrinkage have been a benefit to the trade is very doubtful; for it is certain that if relieved of some of the load which was unwisely assumed while under the influence of the inflation stimulant, the companies would be better able to contend with the new order of things."

LATER ATTEMPTS AT COMBINATION.

The events which have transpired in the coal trade since the above reviews were written, 20 years ago, have not only confirmed the correctness of the analysis then made and the conclusions arrived at, but they leave, in fact, little to add even to-day. Most of the great coal roads have since then, at one time or another, stopped paying dividends, and many of them have been in the hands of receivers and some of them have been "reorganized" several times and are to-day in a very unsatisfactory financial condition.

The financial necessities of some of the roads and the danger to the others should one be forced to cut deep into the market have brought them together, as we have seen, from time to time in various kinds of agreement. Thus the combination of 1873 sought to control only the shipments of coal to "competitive points" on the seaboard, while that of 1874 made several changes to meet difficulties that had come into view. "Season prices," which were always made lower than monthly schedules in order to induce early buying and thus make deliveries more uniform throughout the year, had given opportunities for underhand business which practically nullified the orders of the board of control. The combination of 1874 therefore decreed that season prices should not be more than 30c. per ton below the average of monthly prices through the year, and that no commissions should be allowed on them, while those on monthly sales were limited to 15c. per ton. All season contracts had also to be submitted to and approved by the board of control.

This method of control proving inefficient, yearly contracts were altogether prohibited in the combination of 1875, and the auction sales of the Delaware, Lackawanna & Western Railroad Company were also discontinued. The commission of 15c. per ton on sales of 25,000 tons was made 2 to 3%, according to amount of sale.

In 1876 it was decreed that all sales be made for cash or with 7% interest added for deferred payments, and no commissions were allowed in any form on sales. A "contractor's" schedule was issued each month under which actual consumers who had made application before April 1 for a fixed amount, to be taken in regular monthly installments, were entitled to prices 20c. a ton lower than those of the regular circular. A penalty of $1.50 a ton was imposed on all roads that shipped in excess of the quota allowed, and this penalty money was to be distributed at the rate of $1.50 per ton to those who shipped less than their quota in the same month. Since the combination was illegal there was no means of enforcing the penalty, and, moreover, the Pennsylvania Railroad Company always refused to join the combination and the Pennsylvania Coal Company also remained out.

The Lehigh Valley road declined to live up to the programme, so that the whole combination came to an end in August, 1876, as already noted.

No combination existed in 1877, but in January, 1878, one was organized and extended its control to the entire output of the mines, instead of limiting it to coal sent to competitive points. It did not, however, attempt officially to regulate prices, but it sought to limit output by imposing a penalty of $1.25 per ton on overshipments of the month's quota allotted to each interest, and took this fine out of a deposit of 15c. per ton on the monthly quota, which each was required to make in advance. Those who undershipped during the same month were allowed $1.25 per ton on their deficiency. Each company in the combination voted at the meetings in proportion to its quota.

Even these precautions were insufficient to secure "good faith" on the part of some of the members of the combination, and there was general dissatisfaction with the result. In addition, laws had been enacted in several States against all forms of trade combinations, and the anthracite companies deemed it prudent to disavow any effort to control the trade. Nevertheless the sales agents met periodically to talk over the condition of trade, and uniform prices were fairly well maintained. When the market became overstocked all the mines stopped work together for two or three days a week until the congestion was relieved.

As the years 1880 to 1883 were marked by good trade generally it was easier to maintain this kind of control, but in 1884 trade became depressed and the inducement to cut prices and overproduce quotas increased, while efforts to establish a stricter control of the business were renewed.

It was not until 1885 that the board of control undertook to regulate the output monthly. This effort was not very successful, though a penalty of 50c. a ton for overshipment of quota was prescribed in 1886, and since then the terms "combination" or "board of control" have been tabooed and the arrangements which still continued with the view of restricting production and maintaining uniform prices were euphoniously called "understandings between gentlemen." They have not been any better observed than the edicts of the combinations which threatened their violators with severe penalties.

In 1892 Mr. McLeod, president of the Reading Railroad Company, undertook to carry into effect the suggestion of his predecessor, Mr. Gowen, for controlling the trade by uniting the several transportation companies. This he sought to do by leasing several of the roads and securing a common policy in the others by having the majority in their boards of directors. He thus succeeded in controlling some 75% of the anthracite trade. The plan included also the purchase by the railroad of all the coal produced on the line of the road at 60% of the price realized in New York, and if any independent operator wished to sell his own coal he was brought to terms by an advance in freights.

Unquestionably this plan was and still is the most feasible, if not the only practicable, manner of controlling efficiently the anthracite trade. Mr. McLeod's ambition led him into ill-advised efforts to extend his control over roads in New England which were not essential to the regulation of the output of coal, and these schemes excited so much opposition among those influential in the money markets that they brought down swift and sure destruction on Mr. McLeod and the original plan.

The tendency of the evolution in the trade is certainly in the direction of the consolidation of the transporting lines, or the control of their policy by a common ownership of the stocks of the several corporations. While the companies remain independent it is extremely difficult to secure good faith in the carrying out of any agreement which in intent is contrary to law and public policy, and in practice obliges the strong to carry and support the weak whom they would prefer to absorb. The inside working of these various kinds of combinations is well shown in the several annual reports of some of the coal companies, and especially in those of outspoken Mr. Gowen, then president of the Reading Railroad Company.

POLICY AND EXPERIENCE OF THE READING ROAD.

The anthracite trade has brought into public notice many very able men, but none more gifted than the late Mr. Franklin B. Gowen, president of the Reading Railroad Company. He was a lawyer of great experience and ability, a man of brilliant attainments and of unimpeachable honor, and yet, with absolute integrity of purpose and devotion to the interests of the stockholders for whose benefit he was ever ready to sacrifice himself, he wrecked financially the most magnificent coal estate ever owned by one company. The reasons given by such a man, some years after its inception, for the inauguration of a policy which characterized the most important epoch of the anthracite trade and must be its controlling influence to the end are certainly worthy of a place in this outline of the evolution of the industry.

In his report of 1877 Mr. Gowen desired to explain to his stockholders the policy he had adopted and what he considered to be the causes of the disastrous results which had to that time befallen the company's investments in coal lands and in the mining of coal. The losses of the mining department in the years 1872 to 1876 inclusive had already amounted to about $1,000,000.

"As nearly $50,000,000 of the money raised by the company during the last five years has been used by the Philadelphia & Reading Coal and Iron Company, and as, upon a cessation of dividends, many stockholders may be disposed to criticise the policy which has resulted in the absorption of the profits of the railroad company by the annual interest charges upon the money borrowed to purchase and develop coal lands, it is but proper first to review the causes which, in the opinion of the managers, made the purchase of coal lands and the organization of the Philadelphia & Reading Coal and Iron Company a necessity. . . .

"As the second or Mahanoy coal field was opened, the lines owned or controlled by the Reading Company were gradually extended into it, so that by the close of the late war the Mahanoy and Schuylkill coal fields depended principally upon the Philadelphia & Reading Railroad Company for transportation, the detached Lehigh basins upon the Lehigh Valley Railroad and the Lehigh Navigation Company, while the northern or Wyoming coal region was principally owned or controlled by the three large coal-mining and transportation companies of New York, each of which united under one charter the power to own lands, mine coal, and transport and sell the product of their own estates. . . . Had the policy of permitting railroad companies to become the owners of land

and the miners and merchants of coal not been inaugurated by the Commonwealth of Pennsylvania, the Reading Railroad Company might never have been obliged to resort to the acquisition of coal lands. The regions it drained were nearest to tidewater; its railroad possessed the great advantage of good alignment and favorable grades; and in any competition on terms of equality with the other regions, the Schuylkill coal field and the Reading Railroad could have maintained their full share of coal tonnage. During the war, when the demand was so great that every miner could sell his entire product, there appeared to be no cause for unfavorable comparison, and this company, in common with others, made large profits out of the business of transporting coal; but when the demand of the war ceased it was soon discovered that the control of most of the coal markets of the country could be taken by those companies which, owning, mining, transporting, and selling their own coal, united all the profits of the business, as against the product of a region where tenants paid rent to a landlord for the privilege of mining and only reached the consumer through the hands of a factor. But in addition to the disadvantage resulting from the different systems of mining, the territory which had been considered as properly tributary to this company, and to develop which its railroads were constructed, was being encroached upon and absorbed by rival companies, who extended their lines and purchased coal land for the purpose of diverting tonnage to their own roads. . . .

"The capital and debt of the Philadelphia & Reading Railroad Company at this time were over $36,000,000—the safety of all of which depended upon coal tonnage—and in addition to this amount of invested capital the company was paying an annual rental, equal to the interest upon $10,000,000, upon leased lines of branch railroads located within the coal fields.

"Imminent as was the danger to the business and capital of the company from the aggressions of other lines and the consequent absorption of the lands which produced the tonnage from which its profits were to be derived, there was, however, another and equally serious cause, which in the course of a few years would have made it an absolute necessity for the company to acquire the control and management of coal lands for the purpose of securing tonnage for its lines.

"No one at all conversant with the history of mining in Pennsylvania could have failed to notice that the result of the two different systems of corporation and individual mining was so greatly in favor of the former that any transportation company dependent for its tonnage upon the product of the latter must be left far behind in the struggle for traffic.

"In the upper or Wyoming coal fields, where large companies with abundant capital owned the land and worked their own mines, the system of mining was carried to the highest perfection, and economical results obtained which were unknown in the Schuylkill region, where the lands were divided into small holdings and worked almost entirely by tenants, whose only object was to secure during the terms of their leases as large a profit as possible, without regard to the condition in which they left the property of the landowner at the expiration of their tenancy. It therefore followed that some of the best lands of the lower coal fields were almost absolutely destroyed and rendered unproductive by a system of mining that could not have prevailed had the owner of the land himself been interested in the working of the mine.

"In addition to this, as it was practically impossible for the great number of individual miners to form any organization for self-protection, the Schuylkill region became not only the hot-bed of trades unionism, but the resort of a secret association which for many years controlled and terrorized the entire laboring population. The facility with which the price of labor was raised and controlled by means of strikes—too often, it is feared, connived at by some of the coal operators themselves, with a view of securing higher prices for their product—led to a series of turnouts which in many cases for months deprived the company of any coal tonnage, and resulted in the establishment of a social system in the coal regions fraught with the greatest possible danger to every interest connected with the production or transportation of coal, and which, if it had not been eradicated, would have ultimately given the control of all property and of every interest of value to a secret association, such as desolated some of the best portions of Ireland during the reign of Ribbonmen and other kindred societies.

"Perhaps no better comparison of the result of individual mining by tenants and that of large corporations can be drawn than is furnished by the statistics of the increase of production and population in the Schuylkill and Wyoming regions during the 20 years in which the principal coal-mining companies grew into existence. The production of Schuylkill coal in 1850 was 1,782,936 tons, against 827,823 tons in the Wyoming region. In 1870 the Schuylkill region produced 3,853,016 tons, or an increase of 116%, while in the same year the production of the Wyoming region had grown to 7,825,128 tons, or an increase of 845%; and while the population of Schuylkill County in the same 20 years had increased but 91%, that of Luzerne County, in which the Wyoming region is situated, had increased nearly 187%. Indeed, the productive capacity of the regions developed by corporations had grown so large that at the close of the war the entire demand for anthracite coal in the United States could have been supplied without the output of a single ton from the region which supplied the Reading Railroad with tonnage; and there could have been but one end to a competition for the control of the markets between the product offered by the corporations, who united all the profits of landlord, miner, transporter, and merchant, and that upon which the landlord first required a royalty, the tenant a profit as the miner, the railroad company some compensation for transportation, and which eventually only reached the consumer through the hands of a factor or middleman, who levied upon the business, as his share of the profits, a sum which in times of active competition would alone have sufficed for the corporation.

"To those intrusted with the management of the property of the company and who were responsible to the stockholders for the faithful performance of their trusts, there seemed no other way to extricate the company from the dangers which threatened it than to become purchasers of coal lands. And this policy once adopted, it became necessary not only to buy sufficient to supply present tonnage, but to acquire such a control of lands in the first and second coal fields as practically to render abortive the attempts of any other transportation company to secure sufficient property in either to warrant the construction of a rival line of railroad, as it was undoubtedly better to pay interest upon the large amount of property not required for present uses than to suffer the greater loss resulting from a division of the merchandise and passenger business of the company, which would inevitably have followed the construction of a rival line of railway connecting the seaboard cities with the coal fields now controlled by the company. The Philadelphia & Reading Coal and Iron Company was, therefore, organized and supplied with means to acquire such an ownership of the lands of the two lower coal fields as effectually to secure their tonnage for the Reading Railroad.

"It was at first supposed that by improving and exercising a rigid system of inspection over the collieries the product might be mined by tenants paying a royalty to the company, but the experience of one year proved this hope to be delusive; and it became necessary to obtain control of the collieries as well as of the lands, and to place the property in such a condition for efficient working as would enable the company to produce coal at such a price as to compete with the product of other regions in the principal markets of the country. . . .

"The increased value of the estate, due to the result of the operations of the company, may best be judged by the fact that the cost of mining coal per ton has been gradually reduced from $2.51 in 1873 to $2.44 $\frac{8}{10}$ in 1874, $1.86 $\frac{7}{10}$ in 1875, and $1.35 $\frac{4}{10}$ in 1876; and it is expected that during the coming year the cost will not greatly exceed $1 per ton—a rate which was reached during each of the last three months of the past year. . . .

"About four years ago an association was formed by representatives of the various anthracite regions, the object of which was to secure a remunerative price for coal and prevent the ruinous effects of overproduction. The percentage of the total production which each region was to furnish was determined and a board of control selected to establish prices, to which all were bound to adhere. When the productive capacity was so much greater than the demand, there seemed to be no better plan than to establish the proportion which each region was to furnish of the amount actually required by the market; and if absolutely good faith had been maintained by all of the parties, the ruinously low prices at which coal is now selling might have been avoided.

"This company had frequent cause to complain, in previous years, of violations of the spirit of the agreement, but during the summer of the past year the great overproduction by one of the companies—persisted in after repeated promises and pledges to comply with its engagements—left no doubt upon the minds of the representatives of some of the other regions that the object of the offending company was to increase its tonnage by professing to agree to terms with which it never intended to comply; and after three or four months of unavailing negotiation and attempts at compromise, the association itself was dissolved and each company thrown into active competition for the market."

Notwithstanding the clear demonstration made by Mr. Gowen in 1877 that the combination had been disastrous to his company, which he claimed could under free competition make money, yet in his report of the next year, 1878, he referred to heavy losses in the mining of coal, but pointed out that the coal-mining department was an advantage to the railroad company in giving it large tonnage. He added:

"Notwithstanding the bad result of the business of the Coal and Iron Company, when it is considered that the company paid to the railroad company for coal freights alone over $5,000,000 in cash, and that the general merchandise and passenger receipts of the latter company were greatly increased by the business resulting from the large product of coal, it is evident that the profits of the railroad company from the business of the Coal and Iron Company so greatly exceed the losses of the latter that, taking into consideration the low prices and depressed condition of business, the joint result of the operations of the two companies must be considered as favorable as could have been expected. . . .

"It must be evident, therefore, that with anything like a fair price for coal assured for the future, the estates and properties of the company will become very remunerative to the shareholders. In the ordinary course of business, with the large production and great competition, fair prices could not be expected until the demand overtakes the supply. Although there can be but little doubt that relief would eventually be obtained by a demand for coal largely increased at home by low prices and gradually extending to foreign markets hitherto inaccessible to American shipments, and though there is still less doubt that the favorable location of the company's mines, together with its great transportation facilities, will enable it to make up in the long run in tonnage what may be lost in price, it has been considered prudent by the managers, in view especially of the indebtedness of the company, to accelerate the advent of fair prices by uniting with all other interests in placing the anthracite coal trade under the management of a board of control, composed of representatives of all the producing districts of the State, authorized to carry into effect the details of an agreement for the pro rata distribution of the entire tonnage, and the payment and collection of penalties for overshipments of quotas by any interest. . . ."

The results of another year's experience of coal combination were given in his next report of January, 1879, by Mr. Gowen, as follows:

"The actual cost of mining and delivering coal into the railroad cars for the year was $\$1.23\frac{7}{10}$, as against $\$1.03\frac{9}{10}$ for the previous year, an increase of $19\frac{8}{10}$c., of which about 8c. was caused by the payment of such increased wages as were due under the sliding scale to the increased price of coal and higher rates of toll and transportation, and the remainder, $11\frac{8}{10}$c. per ton, is due entirely to the decreased production, necessitating the division of certain total fixed expenses by a grealy diminished production.

"The result of the year's business, due to the restriction of tonnage imposed by the associated companies and as affecting the present and future financial condition of the company, is such as to merit the serious consideration by the shareholders of the question of the policy of remaining in an independent position, or of joining in any association with the other companies for the improvement and protection of the trade, if such association should again be proposed. . . .

"The injuries suffered by the company owing to the combination of last year, as compared with its independent position of the previous season, were an increase in the cost of mining coal; a large decrease in the railroad receipts from merchandise and passengers, owing to diminished output of coal; an increase of accidents in mining, due to the condition of the mines being affected by the frequent suspensions of mining; an unsettled feeling of discontent among the miners and laborers in the coal fields, due to want of employment, which was not at all compensated by the increase of wages; a feeling of opposition among iron and other manufacturers at the frequent interruption of mining, resulting in a disposition to resort to other fuels rather than submit to arbitrary interference with the regularity of their accustomed supply of anthracite; an absolute failure to realize in increased prices for coal or increased rates of transportation sufficient to overbalance the increased cost due to restricted production: all involving a loss of net profits to the two companies, as compared with the previous year, of $382,173.96.

"On the other hand, the benefits resulting from the combination have been the actual consumption of all surplus coal and the ability to secure fair prices in the future, which it was impossible to obtain so long as the large production kept the market overstocked."

In the following year—1880—Mr. Gowen in his annual report, after bitterly complaining of the "bad faith" of some members of the combination, by which he thought prices had been unduly depressed, said:

"The bad result of the year's business just closed is due entirely to the low price of coal and the low rates of transportation. As compared with the last few years of depression, the average rates and price realized are shown in the following table:"

Year.	Average Rate of Transportation per Ton Received by the Railroad Company.	Average Price of Coal Received by the Coal and Iron Company at Schuylkill Haven.
1876	$\$1.19\frac{9}{10}$	$\$2.06$
1877	$1.03\frac{4}{10}$	$1.30\frac{8}{10}$
1878	1.22	$1.53\frac{4}{10}$
1879	$.88\frac{2}{10}$	$1.33\frac{5}{10}$

It is certain that Mr. Gowen's sanguine temperament caused him to overestimate the advantages and minimize the dangers to his company of the magnificent policy he inaugurated, and it is also probable that he magnified the injury which the rival roads could bring to his company's investment if this policy had not been adopted. The rival roads have since been extended into every part of the field, and some of them, being less embarrassed financially, have been able to prevent the Reading from profiting fully by the vast sums it has invested in coal lands and from securing the proportion of the trade to which its property entitled it.

DISTRIBUTION OF THE ANTHRACITE TONNAGE AND CONDITION OF THE COAL COMPANIES.

The accompanying tables show the amount of coal and the proportion of the whole shipments carried by each of the coal roads since 1868, and the total production of the several fields since the opening of the mines.

This record, though very suggestive, does not tell the whole story, for the proportion of the entire business done by each interest has depended chiefly on the financial condition of the several roads. There is no competitor in market so dangerous as a bankrupt or a concern whose financial necessities oblige it to force its output and market its product regardless of consequences, because while running it can get extensions of credit and can borrow money to carry it over to

PROPORTIONAL SHIPMENTS OF PENNSYLVANIA ANTHRACITE BY THE SEVERAL COAL ROADS.

(In tons of 2240 lbs.)

Coal Roads. (a)	1868 to 1872.	1873 to 1876.	1877.		1878.		1879.		1880.	
	Per Cent.	Per Cent.	Shipments.	Per Cent.	Shipments.	Per Cent.	Shipments.	Per Cent.	Shipments.	Per Cent.
Reading Railroad	30.55	27.84	6,822,603	32.76	5,112,219	29.03	7,442,617	28.47	5,933,923	25.30
Central New Jersey	10.67	13.41	2,837,500	13.62	2,264,979	12.87	3,825,553	14.63	3,470,111	14.80
Lehigh Valley	19.26	20.04	4,511,331	21.66	3,403,319	19.33	4,405,957	16.86	4,394,533	18.75
Del., Lack. & Western	11.72	12.26	2,089,523	10.03	2,180,672	12.39	3,867,407	14.79	3,550,348	15.15
Delaware & Hudson	13.72	12.06	1,918,617	9.21	2,046,235	11.63	3,014,117	11.53	2,674,704	11.40
Pennsylvania Railroad	7.42	8.04	1,530,594	7.35	1,362,673	7.74	1,682,106	6.43	1,864,032	7.95
Pennsylvania Coal Co	6.66	6.35	1,118,011	5.37	957,032	5.43	1,427,150	5.46	1,138,466	4.90
Erie	....	....	....	......	278,133	1.58	477,782	1.83	411,094	1.75
Total shipments	....	....	20,828,179	......	17,605,262	......	26,142,689	......	23,437,242	......

Coal Roads.	1881.		1882.		1883.		1884.		1885.	
	Shipments.	Per Cent.	Shipments.	Per Cent.	Shipments.	Per Cent.	Shipments.	Per Cent.	Shipments.	Per Cent.
Reading Railroad	6,940,383	24.35	7,000,113	24.04	} 12,232,401	38.49	11,125,218	36.22	11,680,780	36.94
Central New Jersey	4,085,423	14.30	4,211,052	14.46						
Lehigh Valley	5,721,869	20.07	5,933,740	20.38	6,271,773	19.72	5,935,254	19.32	6,107,445	19.32
Del., Lack. & Western	4,388,963	15.40	4,638,717	15.93	5,079,123	15.97	5,204,362	16.94	4,987,834	15.78
Delaware & Hudson	3,211,406	11.27	3,203,168	11.00	3,512,972	11.05	3,362,680	10.95	3,301,874	10.44
Pennsylvania Railroad	2,211,363	7.80	2,332,974	8.01	2,773,419	8.72	3,169,287	10.32	3,393,685	10.74
Pennsylvania Coal Co	1,475,389	5.18	1,469,821	5.05	1,541,145	4.85	1,397,946	4.55	1,500,686	4.71
Erie	465,230	1.63	330,511	1.13	383,194	1.20	523,546	1.70	651,226	2.07
Total shipments	28,500,017	......	29,120,096	......	31,793,027	......	30,718,293	......	31,623,530	......

Coal Roads.	1886.		1887.		1888.		1889.		1890.	
	Shipments.	Per Cent.	Shipments.	Per Cent.	Shipments.	Per Cent.	Shipments.	Per Cent.	Shipments.	Per Cent.
Reading Railroad	6,695,732	20.84	7,555,252	21.82	7,205,095	18.89	7,284,692	20.52	7,527,600	20.99
Central New Jersey	4,994,752	15.54	4,852,859	14.01	5,772,279	15.13	6,073,409	17.10	5,615,040	15.66
Lehigh Valley	6,184,456	19.24	5,784,451	16.69	6,622,716	17.36	7,497.830	21.12	6,768,495	18.88
Del., Lack. & Western	5,172,023	16.09	6,220,793	17.95	7,026,192	18.42	5,295,240	14.92	5,792,769	16.16
Delaware & Hudson	3,480,687	10.83	4,048,230	11.69	4,516,188	11.84	3,777,380	10.63	3,675,399	10.25
Pennsylvania Railroad	3,478,885	10.83	3,816,143	11.02	4,584,441	12.02	3,293,027	9.28	4,017,600	11.21
Pennsylvania Coal Co	1,398,179	4.35	1,603,456	4.62	1,624,433	4.26	1,333,925	3.75	1,428,485	3.98
Erie	731,650	2.28	759,835	2.20	794,374	2.08	951,824	2.68	1,029,785	2.87
Total shipments	32,136,362	......	34,641,018	......	38,145,718	......	35,507,327	......	35,855,173	......

Coal Roads.	1891.		1892.		1893.		1894.		1895.	
	Shipments.	Per Cent.	Shipments.	Per Cent.	Shipments.	Per Cent.	Shipments.	Per Cent.	Shipments.	Per Cent.
Reading Railroad	8,601,121	21.28	8,994,496	21.47	9,022,949	20.94	8,289,088	20.03	9,905,059	21.23
Central New Jersey	5,857,968	14.49	5,271,131	12.58	5,503,475	12.77	4,847,886	11.71	5,388,194	11.58
Lehigh Valley	7,220,428	17.87	6,141,086	14.66	5,952,852	13.82	6,424,676	15.52	7,360,454	15.82
Del., Lack. & Western	6,106,075	15.11	6,529,650	15.59	6,887,123	15.98	5,997,989	14.49	6,129,261	13.17
Delaware & Hudson	3,973,286	9.83	4,058,527	9.69	4,361,624	10.12	3,997,059	9.66	4,347,843	9.35
Pennsylvania Railroad	5,021,704	12.43	5,571,321	13.30	5,848,242	13.57	4,727,576	11.42	5,025,645	10.80
Pennsylvania Coal Co	1,692,420	4.19	1,921,029	4.58	1,894,701	4.40	1,705,198	4.12	1,746,832	3.76
Erie	1,242,007	3.07	1,388,823	3.31	1,369,578	3.18	1,669,827	4.03	1,820,038	3.91
N. Y., Ont. & W	699,896	1.73	807,071	1.93	1,160,766	2.69	1,372,365	3.32	1,424,407	3.07
Del., Sus. & Schl	....	......	1,210,186	2.89	1,088,227	2.53	1,633,369	3.95	1,905,784	4.10
N. Y., Sus. & W	....	......	....	......	....	......	726,167	1.75	1,492,244	3.21
Total shipments	40,414,905	......	41,893,320	......	43,089,537	......	41,391,200	......	46,545,761	......

(a) Reading Railroad includes the Schuylkill Canal; Central Railroad of New Jersey includes the Lehigh Coal & Navigation Co. (canal and railways); Erie is the New York, Lake Erie & Western Railroad; Del., Sus. & Schl. is the Delaware, Susquehanna & Schuylkill Railroad; and N. Y., Ont. & W. is the New York, Ontario & Western Railroad.

those better times which are always looming up on the horizon to every sanguine "financier."

The condition of unstable equilibrium in which the finances of a number of the coal roads and coal 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, and have thus kept alive some of the needy concerns that otherwise would long ago have succumbed in the fight for life.

Since the weakest financially and consequently the most dangerous of the coal roads is the Reading, which owns probably more than one-third of all the anthracite coal in Pennsylvania and has the shortest and best road from the mines to tidewater, which has in fact 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 preëminent ability to borrow money. No one doubts 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. It would not, however, follow that it would then make its investments profitable.

NET RESULTS OF THE ANTHRACITE INDUSTRY

The evolution of this great industry has thus been traced from the period of the early operators, whose capital amounted to but a few hundred or a few thousand dollars and the annual output of whose mines scarcely exceeded as many tons, through the successive steps in the evolution marked by the advent of joint-stock companies, transportation-mining companies, combinations of miners in miners' unions and of operators and of transportation-mining companies, all with the object of increasing or maintaining prices above the natural level which unrestricted competition would make.

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 always 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 made 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 is comparatively easy for such 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, in order to provide temporary relief. Very few of the coal companies have, even in prosperous times, provided any reserve fund to enable them to withstand a period of depression or any sinking fund to liquidate heavy investments in mines which are rapidly being exhausted. The Pennsylvania Coal Company, which purchased its lands in early

SHIPMENTS AND TOTAL PRODUCTION OF PENNSYLVANIA ANTHRACITE, IN TONS OF 2240 LBS.

Year.	Wyoming Region.		Lehigh Region.		Schuylkill Region.		Total Shipments.	Total Production. (a)	Total Production. Metric Tons	Per Ct. Increase or Decrease.
	Shipments.	Production.	Shipments.	Production.	Shipments.	Production.				
Up to 1820..	....	10,000	....	3,000	....	5,000	....	18,000	18,288	....
1820..	....	800	365	665	....	500	365	1,965	1,996	....
1821..	....	1,000	1,073	1,473	....	800	1,073	3,273	3,325	66.7
1822..	....	1,200	2,240	2,740	1,480	1,000	3,720	4,940	5,019	50.9
1823..	....	1,300	5,823	6.523	1,128	1,200	6,951	9,023	9,167	82.6
1824..	....	1,700	9,541	10,441	1,567	1,500	11,108	13,641	13,859	51.2
1825..	....	2,000	28,393	29.493	6,500	7,006	34,893	38,499	39,115	182.2
1826..	....	2,700	31,280	32,780	16,767	19,335	48.047	54.815	55,692	42.4
1827..	....	4,000	32,074	34,274	31,360	32,893	63,434	71,167	72,306	29.8
1828..	....	6,200	30,232	33,233	47,284	52,481	77,516	91,914	93,385	29.2
1829..	7,000	16,800	25,110	29,110	79,973	87,293	112,083	133,203	135,334	44.9
1830..	43,000	58,200	41,750	46,850	89,984	104,584	174,734	209,634	212,988	57.4
1831..	54,000	78,300	40,966	47,166	81,854	104.854	176,820	230.320	234,005	9.9
1832..	84,000	121,700	70,000	82,700	209,271	243,771	363,271	448,171	455,342	94.6
1833..	111,777	161,777	123,001	132,100	252,971	298.333	487,749	592,210	601,685	32.1
1834..	43,700	53,008	106,244	128,874	226,692	274,977	376,636	b 456,859	464,169	b 22.9
1835..	90,000	108,900	131.250	158,812	339,508	410,805	560,758	678,517	689.373	48.5
1836..	103,861	125,360	148,211	178.891	432,045	521,478	684,117	825,729	838,941	21.7
1837..	115,387	139,041	223,902	269,802	530,152	630.398	869,441	1,039.241	1,055,869	25.9
1838..	78,207	94,083	213,615	256,979	446.875	521,951	738,697	b 873,013	886,981	b 16.0
1839..	122,300	146,760	221,025	265,230	475,077	545,446	818,402	957,436	972,749	9.7
1840..	148,470	177,867	225,313	269,932	490,596	560,421	864,379	1,108,220	1,125,952	5.3
1841..	192,270	229,955	143,037	171,072	624,466	725,978	959,773	1,127,005	1,145,037	11.8
1842..	252.599	301,856	272,540	325,692	583.273	659,047	1,108,412	1,286,595	1,307,180	14.2
1843..	285,605	340,441	267,793	319,209	710,200	819,276	1,263,598	1,478,926	1,502,589	14.9
1844..	365,911	435,434	377,002	448,633	887,937	1,015,623	1,630,850	1,899,690	1,930,085	28.5
1845..	451,836	536,329	429,453	509,761	1,131,724	1,298,336	2,013,013	2,344,426	2,381,937	23.4
1846..	518,389	614,291	517,116	512,783	1,308,500	1,480,247	2,344,005	2,707,321	2,750,638	15.5
1847..	583,067	689,185	633,507	748,805	1,665,735	1,889,165	2,882,309	3,327,155	3,380,389	22.9
1848..	685.196	808,531	670,321	790.979	1,733,721	1,973,185	3,089,238	3.572,695	3,629,858	7.9
1849..	732,910	862,635	781,556	920,009	1,728,500	1,942,168	3,242,966	3,724,812	3,784,409	4.3
1850..	827,823	972,692	690,456	811,286	1,840.620	2,079,387	3,358,899	3,863,365	3,925,179	3.7
1851..	1,156,167	1.355,028	964.224	1,130,071	2,328,525	2,705,591	4,448.916	5,190,690	5,273,741	34.4
1852..	1,284,500	1,502,865	1,072,136	1,254,399	2,636,835	2,967,884	4,993,471	5,725,148	5,816,751	12.1
1853..	1,475,732	1,723,655	1,054,309	1,231,433	2,665,110	2,984,765	5,195,151	5,939,853	6,034,891	3.7
1854..	1,603,478	1,868,052	1,207,186	1,406,372	3,191,670	3,572,132	6,002,334	6,846,556	6,956,095	15.3
1855..	1,771,511	2,060,267	1,284,113	1,493,423	3,552,943	4,130,852	6.608,567	7,684,542	7,807,495	12.2
1856..	1,972,581	2,288,194	1,351,970	1,568,285	3,602,999	4,143,288	6,927,550	7,999,767	8,127,763	4.1
1857..	1,952,603	2,261,114	1,318,541	1,526,871	3,373,797	3,906,857	6,644,941	b 7,694.842	7,817,959	b 3.8
1858..	2,186,094	2,527,125	1,380,030	1,595,315	3,273,245	3,741,790	6,839,369	7,864,230	7,990,058	2.2
1859..	2,731,236	3,151,846	1,628,311	1,879,071	3,448,708	3,979,809	7,808,255	9,010,726	9,154,898	14.6
1860..	2,941,817	3,388,973	1,821,674	2,098,569	3,749,632	4,319,576	8,513,123	9,807,118	9,964,032	8.8
1861..	3,055,140	3,513,411	1,738,377	1,999,134	3,160,747	3,634,916	7,954,264	b 9,147,461	9,293,820	b 6.7
1862..	3,145,770	3,608,198	1,351,054	1,549,658	3,372,583	3,937,175	7,869,407	b 9,095,031	9,240,558	b 0.6
1863..	3,759,610	4,304,754	1,894,713	2,169,446	3,911,683	4,478,877	9,566,006	10,953,077	11,128,326	20.4
1864..	3,960,836	4,526,635	2,054,669	2,348,233	4,161.970	4,756,532	10,177,475	11,631,400	11,817,502	6.2
1865..	3,254,519	3,720,717	2,040,913	2,082,858	4,356,959	4,979,457	9,652,391	b 10,783,032	10,955,561	b 7.3
1866..	4,736,616	5,413,958	2,179,364	2,433,280	5,787,902	6,245,599	12,703,882	14,092,837	14,318,317	30.7
1867..	5,325,000	6,089,272	2,502,054	2,356,867	5,161,671	5,899,505	12,988,725	14,345,644	14,575,174	1.8
1868..	5,968,146	6,846,699	2,502,582	2,865,820	5,330,737	6.097,947	13,801,465	15,810,466	16,063,427	10.2
1869..	6,141,369	7,279,543	1,949,673	2.313,989	5,775,138	6,782,146	13,806,180	16,375,678	16,637,689	3.6
1870..	7,974,660	8.814,024	3,239,374	3,480,364	4,968,157	5,516,312	16,182,191	17,819,700	18,104,815	8.8
1871..	6,911,242	7,667,129	2,235,707	2,568,764	6,552,772	7,120,340	15,699,721	b 17,356,233	17,633,933	b 2.6
1872..	9.101,549	10,698,523	3,873,339	4,202,824	6.694,890	7,131,209	19,669,778	22.032.556	22,385,071	26.9
1873..	10,309,755	11,711,003	3,705.596	3,801,447	7,212,601	7,335,333	21,227,952	22,847,783	23,213,348	3.7
1874..	9,504,408	10,204,764	3,773,836	4,139,561	6,866,877	7,286,793	20,145,121	b 21,631,128	21,977,226	b 5.3
1875..	10,596,155	11,231,924	2,834,605	3,004.681	6,281,712	6,558,615	19,712,472	b 20,795,220	21,127,944	b 3.9
1876..	8,424,158	8,929,607	6,221,934	6,595,250	3,854,919	4,086,214	18,501,011	b 19,611.071	19,924,848	b 5.7
1877..	8,300,377	8,798.399	8,195,042	8,686,744	4,332,760	4,592,725	20,828,179	22,077,868	22,431,114	12.6
1878..	8,085,587	8,570,722	6,282,226	6,659,159	3,237,449	3,431.695	17,605,262	b 18,661,576	18,960,161	b 15.5
1879..	12,586,293	13,341,475	8,960,829	9,478,478	4,595,567	4,871,303	26,142.689	27,691,256	28,134,310	48.4
1880..	11,419,279	12,104,435	7,554,742	8,008,026	4,463,221	4,773,014	23,437,242	b 24,885,475	25,283,643	b 10.3
1881..	13,951,383	14.784,465	9,253,958	9,809,195	5,294,676	5,612,235	28,500,017	30,205,895	30,689,189	21 4
1882..	13,971,371	14,809,653	9,459,288	10,026,845	5.689,437	6,040,803	29,120,096	30,877,301	31,371,338	2.2
1883..	15,604,492	16,540,761	10,074,726	10,679,209	6,113,809	6,480,637	31,793,027	33,700,607	34,239,817	9.3
1884..	15,677,753	16,618,418	9,478,314	10,047,012	5,562,226	5,895,959	30,718,293	b 32,561,389	33,082,371	b 3.4
1885..	16.236,470	17,210,558	5,898,634	6,252.552	9,488,426	10,057,731	31,623,530	33,520,841	34,057,174	2.9
1886..	17,031,826	18,053,736	5,723,129	6,066,587	9,381,407	9,944,291	32,136.362	34,064,614	34,609,648	1.6
1887..	19,684,929	20,866,025	4,347,062	4,607,886	10,639,027	11,245,569	34,641,018	36,719,474	37,306,998	7.8
1888..	21,852,366	23,163,508	5,639,236	5,977,593	10,654,116	11,293,462	38,145,718	40,434,563	41,081,516	10.1
1889..	18,654,454	19,773,721	6,481,159	6,870,029	10,371,714	10,994,017	35,507,327	b 37,637,767	38,239,971	b 6.9
1890..	18,657,694	19,777,156	6,329,658	6,709,437	10,867,821	11,519,910	35,855,173	38,006,503	38,614,607	1.0
1891..	21,353,046	22,634,229	6,311,198	6,689,870	12,750,661	13,515,701	40,414,905	42,839,800	43,525,237	12.1
1892..	22,815,460	25,513,528	6,451,076	7,213,654	12,626,784	14,123,268	41,893,320	46,850,450	47,600,057	9.4
1893..	23,839,741	26,357,957	6,892,352	7,706,717	12,357,444	14,120,632	43,089,537	48.185,306	48,956,271	2.8
1894..	22,650,761	25,368,852	6,705,434	7,510,086	12,035,005	13,479,206	41.391,200	b 46,358,144	47,099,874	b 3.8
1895..	24,949,317	27,818,488	7,203,590	8,032,002	14,392,854	16,048,032	46,545,761	51,898,522	52,728,898	12.0
Totals.	....	....	....	....	....	....	....	1,038,460,926	1,055,076,286	

(a) Including consumption at the mines. (b) Decrease.

days at very low prices and has always been managed in a careful and economical manner, is almost the only company that has accumulated a real sinking fund, by a charge of about 10c. a ton on the coal mined, to cover depreciation from the working out of the property.

It is needless to speculate now as to what would have been the condition of this industry had the mines always been worked by companies or individuals strictly limited to mining and selling coal, and had the transportation companies been "common carriers" without interest in the mines. It is sufficient to note that the natural evolution of the industry has always been in the direction of the union of the business of mining and transporting and its concentration into fewer and fewer hands, and that 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 existing roads will hereafter 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. Hereafter they will be proposed for the joint control of both bituminous and anthracite, but their ultimate outcome may safely be forecast from a retrospect of the evolution of the anthracite trade. The available supplies of coal are too great and too extended; the advantages offered by the use of fuel gas, which may be conveyed from comparatively great distances, are too real; the alluring promises of the electric transmission of heat are too near realization; and the limitless possibilities of chemistry are too easily grasped to permit of any permanent success in efforts to advance or even to maintain for any long period the market prices of coal. That prosperity in the coal trade which requires for its realization such higher values for fuel will never come, but that which is based upon a lessening in the cost of production and marketing will always be attainable.

While the amount of anthracite in the Pennsylvania fields is still large, it is by no means unlimited. Some of the fields and some of the companies have already come within sight of the end, and this fact will undoubtedly hasten the consolidation of interests which otherwise could for years to come maintain an independent existence.

The final outcome of the development 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 transportation of anthracite has been extremely profitable to the railroads—so profitable, indeed, that it has induced an overproduction of roads, and this has tended largely to an overproduction of coal. The investments in roads built chiefly to secure coal tonnage have not usually been profitable, most of the dividends paid having been more or less easily traceable to increases in indebtedness.

But the creation of numberless industries through the supply of cheap coal and the general growth of the commerce of the country have provided a permanent and increasing source of revenue for these roads that should render them profitable if the actual, legitimate investments in them could be separated from the "water" in their stocks and debts.

The country at large has been the chief beneficiary of the anthracite fields of Pennsylvania. The abundant supply of an excellent and cheap fuel they have afforded has given birth and prosperity to countless industries throughout the country and has created wealth beside which the total value of the coal produced has been as nothing. No other industry in all this broad land or in all time has ever created such magnificent results in the material prosperity of a nation as has the anthracite trade of Pennsylvania.

WHAT THE FUTURE MAY BRING FORTH.

Having thus traced the history of the anthracite trade from its commencement up to the present time, it may be asked, How much anthracite remains in the Pennsylvania fields still to mine, and how long will the supply last under the increasing production shown in the statistics here cited? The quantity of workable coal originally in the Pennsylvania anthracite fields has been estimated at widely differing figures, from about 12,000,000,000 tons to 19,500,000,000 tons, the latter being the estimate of the Pennsylvania Coal Waste Commission, but this last figure has since been reduced by one of the three commissioners to about 18,500,000,000 tons, which is probably still high. We may assume 15,000,000,000 tons as a fair estimate of the amount of workable coal originally contained in these fields. There were marketed up to the end of 1895 1,055,076,286 tons, which the Coal Waste Commission states "does not exceed 35% and possibly not more than 30% of the coal originally contained in the areas mined over," but that "by working over the culm banks and reworking of part of the territory mined this figure may ultimately reach 40%." In other words, the commission counts the amount of workable coal as two and a half times what will eventually

CONSUMPTION OF ANTHRACITE.

Year.	Population.	Increase per Cent.	Tons per Capita.	Year.	Population.	Increase per Cent.	Tons per Capita.
1821	10,000,000	....	0.0003	1870	38,587,960	10	0.45
1825	11,200,000	11	0.0035	1875	44,000,000	14	0.48
1830	12,859,852	15	0.017	1880	50,189,209	14	0.53
1835	15,000,000	16	0.046	1881–85	53,730,400	12	0.61
1840	17,063,353	14	0.066	1886–90	59,998,800	12	0.63
1845	20,000,000	17	0.119	1891–95	66,895,000	12	0.71
1850	23,191,298	16	0.17	1896–1900	74,280,000	....	0.73
1855	27,000,000	16	0.29	1900–05	82,460.000	....	0.75
1860	31,443,221	16	0.32	1906–10	90,700,000	....	0.78
1865	35,000,000	11	0.31	1911–15	100,000,000	....	0.80

be marketed, so that of the 15,000,000,000 tons of workable coal in the fields only 6,000,000,000 tons will eventually be utilized, and since of this 1,055,076,286 tons have already been marketed, the amount now remaining is less than 5,000,000,000 tons. How long will this last?

To answer this very important question we must estimate what the yearly output will probably be in the future, and in this our safest guide is the record of the past consumption per head of population. The preceding table shows the population every fifth year from 1821 to 1880 and thereafter the average by periods of five years up to 1895, and an estimate of what it will average in five-year periods during the next 20 years up to 1915. The second column gives the increase in the production of anthracite each fifth year up to 1880 and by periods of five years from 1880 to 1915, the periods after 1895 being of course estimated.

It is very important to note that the consumption (including in this the exports) of anthracite per head of population has been steadily increasing, as shown in the third column of the table. This increasing rate multiplied by the population gives the most probable figure for future output up to the time when this will be limited by the working out of some of the fields and the restricted area to which extraction will thereafter be confined. The production will continue to increase for a certain number of years, probably not more than 20 or 25 years to come, and it will then remain practically stationary for a certain number of years and will thereafter decline, as the basins are being worked out.

From this table it would appear that the output for the five years 1910 to 1915 may average about 80,000,000 tons a year, and the maximum output will probably then be reached, at perhaps 90,000,000 tons a year. It is improbable that the output of anthracite will ever reach 100,000,000 tons in any one year.

These estimates will appear as follows:

1896 to 1900 @ 54,250,000 tons a year	=	271,250,000 tons.
1901 to 1905 @ 61,750,000 tons a year	=	308,750,000 tons.
1906 to 1910 @ 71,000,000 tons a year	=	355,000,000 tons.
1911 to 1915 @ 80,000,000 tons a year	=	400,000,000 tons.
1916 to 1920 @ 90,000,000 tons a year	=	450,000,000 tons.
Total...........................		1,785,000,000 tons.
Leaving still available..........		3,215,000,000 tons.

In other words, in 25 years from this date, if the system of mining is not radically changed, one-half of all the anthracite coal in Pennsylvania will have been worked out and the output will have passed its maximum and will thereafter decline.

It is, of course, impossible to determine when it will all be worked out, but from the time at which the output becomes stationary or commences to decline anthracite will cease to be the controlling factor in the industrial life of the eastern part of the United States, and the glory of the anthracite trade will have departed, though the total original supply of this inestimably valuable fuel will be far from exhausted.

It is not important to the general reader to estimate the probable duration of the supply of coal controlled by each of the transportation lines, though that question affects their stockholders very closely indeed. No doubt the output which one loses will be made up by those having larger supplies until the limit of their capacity to produce has been reached.

It must be confessed that the perpetuation of a system of mining and marketing coal under which more than 60% of the whole is wasted is an indelible disgrace to the engineering profession; but since it has been so characterized for more than a quarter of a century without producing material amelioration, it would be rash to count on any rapid or radical improvement in the next quarter of a century. This is, however, the most important subject to which the attention of coal-land owners and the great mining-transportation companies can be directed. Not only their own future prosperity, but that of the whole country largely depends on their success in securing greater economy in this direction.

AVERAGE PRICES OF ANTHRACITE AT PHILADELPHIA PER TON OF 2240 LBS. AND IMPORT DUTY ON FOREIGN COAL. (*a*)

Year.	Retail Price Delivered (*b*)	Year.	Wholesale f.o.b. per Ton.	Import Duty.	Year.	Wholesale f.o.b. per Ton.	Import Duty.
1820	$8.40	1834	$4.84	$1.68	1853	$3.70	24%
1821	8.40	1835	4.84	(gradually reduced to 20% in 1840.)	1854	5.19	24%
1822	8.40	1836	6.64		1855	4.49	
1823	8.40	1837	6.72		1856	4.11	Free from Canada.
1824	8.40	1838	5.27		1857	3.87	
1825	7.33	1839	5.00		1858	3.43	
1826	7.33	1840	4.91	20%	1859	3.25	
1827	7.00	1841	5.79	20%	1860	3.40	
1828	6.50	1842	4.18	20%	1861	3.39	
1829	6.50	1843	3.75	$1.75	1862	4.44	
1830	6.50	1844	3.20	1.75	1863	6.06	
1831	6.00	1845	3.46	1.75	1864	8.39	
1832	6.25	1846	3.90	1.75	1865	7.86	
1833	5.75	1847	3.80	24%	1866	5.80	$1.25
1834	5.00	1848	3.50	24%	1867	4.37	1.25
		1849	3.62	24%	1868	3.86	1.25
		1850	3.64	24%	1869	5.31	1.25
		1851	3.34	24%	1870	4.39	1.25
		1852	3.46	24%	1871	4.43	1.25

(*a*) Per ton of 30 bushels.
(*b*) Retail prices 1820 to 1834 from Packer's Senate Report, 1834. Wholesale f.o.b. prices 1834 to 1871 are from the "official coal statistics" of the *Pottsville Miners' Journal.*

AVERAGE WHOLESALE PRICES OF ANTHRACITE AT NEW YORK PER TON OF 2240 LBS.

Prices actually received by the Delaware & Hudson Canal Company for Lackawanna (Wyoming) coal (all sizes, lump to pea inclusive) f.o.b. New York harbor.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1869	....	....	....	....	....	....	....	....	....	....	....	....	$5.78
1870	$6.15	$4.93	$4.76	$4.64	$3.72	$4.19	$5.48	$5.63	$5.79	$5.20	$5.07	$5.04	5.39
1871	6.28	6.94	5.55	3.47	....	3.98	5.30	4.92	5.22	5.51	4.56	4.74	5.33
1872	4.19	3.94	3.82	3.54	3 81	3.51	3.76	3.56	3.79	4.21	4.10	3 92	3.84
1873	4.34	4.52	4.67	4.36	3.42	4.27	4.98	5.01	4.62	4.94	5.01	4.78	4.76
1874	4.79	5.06	4.64	4.76	5.07	5.13	5.24	5.45	5.53	5.63	5.43	4.95	5.19
1875	5.04	5.86	5.23	3.46	4.56	5.01	5.13	5.41	5.38	5.62	5.48	5.15	5.28
1876	5.37	4.93	4.85	4.19	4.70	4.72	4.92	4.05	3.61	3.39	3.47	3.22	4.11
1877	3.03	2.98	2.60	2.94	2.89	2.55	2.58	2.80	3.01	2.67	2.30	1.92	2.44
1878	2.05	2.70	3 21	3.25	3.49	3.33	3.63	3.68	3.65	3.75	3.65	2.96	3.15
1879	2.69	2.46	2.42	2.27	2.21	2.34	2.38	2.21	2.16	2.13	2.65	2.81	2.34
1880	2.98	2.91	3.25	3.60	3.79	3.76	3.83	3.87	3.97	3.90	3.94	3.95	3.73
1881	3.99	4.04	3.95	3.86	3.78	3.75	3.80	3.79	3.83	3.78	3.75	3.99	3.84
1882	3.72	3.60	3.57	3.62	3.62	3.70	3.64	3.71	3.81	3.98	4.04	3.87	3.73
1883	3.68	3.68	3.61	3.62	3.61	3.68	3.65	3.67	3.63	3.71	3.70	3.48	3.65
1884	3.47	3.56	3.44	3.35	3.27	3.44	3.42	3.29	3.36	3.29	3.42	3.43	3.41
1885	3.14	3.30	3.31	3.28	3.22	3.09	3.11	3.05	2.99	3.23	2.99	2.90	3.12
1886	2.88	2.69	2.66	2.58	2.51	3.44	2.53	2.74	2.83	2.88	2.97	3.10	2.75
1887	3 29	3.45	3.51	3.24	3.16	3.98	3.27	3.35	3.57	3.62	3.63	3.92	3.51
1888	3.90	3.90	3.59	3.69	3.39	3.36	3.60	3.64	3.74	3.72	3.46	3.37	3.65
1889	3.34	3.12	3.09	2.96	3.09	3.25	3.31	3.52	3.32	3.44	3.25	3.22	3.25
1890	3.18	3.11	3.15	3.07	3.05	3.07	2.92	2.97	3.17	3.24	3.15	3.22	3.13
1891	3.23	3.05	3.11	2.87	2.86	2.95	2.79	2.89	3.18	3.07	3.09	2.99	3.03
1892	2.98	2.99	3.15	3.23	3.19	3.15	2.94	2.93	3.18	3.00	2.99	3.23	3.09
1893	3.54	3.25	3.11	2.96	2.98	2.99	2.98	2.78	2.96	3.10	3.09	3.11	3.11
1894	3.01	2.97	2.78	2.84	2.72	2.76	2.66	2.66	2.60	2.68	2.74	2.83	2.77
1895	2.83	2.93	2.67	2.74	2.66	2.56	2.50	2.47	2.57	2.76	2.92	2.79	2.73

Coal Mining in Illinois.

By J. J. Rutledge.

The State of Illinois has a coal-bearing area of about 36,000 sq. miles, in which there are found 16 well-defined seams of coal. At the close of 1895 there were in existence 319 shipping mines, in which there are employed about 20,000 miners. Apart from the immediate local demand in the smaller towns and cities, the chief markets for Illinois coal are in St. Louis and Chicago. In the Chicago market competition is exceedingly sharp, and coal could be bought in 1895 for $1.65 per ton upon the car. The average freight rate to that city being about $1 per ton, there is left a price of only 65c. at the mine. During the greater part of 1895 the demand for coal was not heavy and prices were reduced by competition. Moreover, during the great mining strike of 1894 much West Virginia and Ohio coal was taken to that market, and the excellent quality of those coals secured for them to some extent a continued use, so that they have partly crowded out the Illinois article. Unfortunately, also, the smoke ordinances adopted in Chicago and St. Louis have to a certain extent discriminated against Illinois coal. The production of coal in 1895 was 17,735,864 tons of all grades, of which 14,045,962 tons were lump coal, the balance being slack.

Division of the Coal Fields.—The State has been divided by law into five mining inspection districts, each of which has its own inspector. In some counties where there are many mines there are deputy inspectors for the county in addition to the State inspector. Commencing at the southern extremity of the State, the first mines are in the counties of Jackson, Williamson, Marion, and St. Clair. These are chiefly small mines worked on the solid-shooting or hand-mining system in what is known as seam No. 6 of the Illinois coal measures, and as a rule can be worked very cheaply. Further to the north are the mines of Macoupin and Montgomery counties, which also work seam No. 6. The most important mines in this field are those at Staunton and Mount Olive, which are among the largest coal workings in the State and use coal-cutting machines. One of these mines has a record of hoisting 1440 tons of lump coal in 10 hours, passing over a shaking screen, the coal averaging 70% lump and 30% small and slack.

The next important district is known as the Pana coal field, where 4 very large collieries are working on seam No. 5 at an average depth of 730 ft. The coal here is all mined by hand and is soft, about 50% of it as mined being slack and small coal. All 4 of the collieries are worked on the panel system and 3 of them are provided with mechanical haulage of the endless-rope type. The Pana district upon the whole produces coal very cheaply and is an important factor in the Chicago market.

The Springfield coal field, which lies around and near the State capital, is a rich one. In this district the coal is all blasted out of the solid, is very hard, shoots easily, and is cut by vertical seams, called horsebacks, of fireclay mixed with iron pyrites. This increases the difficulty in mining, but nevertheless very cheap coal is produced. The system of paying for mining by gross weight is the rule.

Near Peoria is a small field mostly occupied by solid-shooting mines. The shafts are generally small and the trade local. To the north and west of Peoria, in McDonough, Bureau, and Mercer counties, are coal fields of considerable extent, but the coal as a rule is of no great thickness and is apt to "crop out," so small mines are the rule. What are known as No. 5 and No. 6 seams are mined.

The most northern field of Illinois is the La Salle district, where coal is mined from seams Nos. 3 and 5 by the longwall and the pillar-and-room systems about equally divided. The price for mining is higher than in any of the other districts, but the coal is of superior quality and commands a somewhat higher price.

An extensive coal field is found in Vermillion County near the Indiana line, where seams Nos. 6 and 7 are worked or quarried very easy. It is in fact the only place in the State where coal is mined in open pits by stripping the surface overlaying the bed. At several points, notably in the Mission field, the coal is very near the surface, often overlaid by only 8 or 10 ft. of earth, and the stripping is usually performed by steam shovels. As this district is near Chicago and has the advantage of low freight rates, coal can be put on the market at a very low cost.

The Consolidated Coal Company of St. Louis, the largest coal company in Illinois, owns 69 mines and disposes of most of its coal in the St. Louis market. These mines use both hand and machine mining, but during the business depression of 1894 and 1895 a number of them were leased to individuals. Its chief competitor in the St. Louis market is the Madison Coal Company, which owns 6 large mines, nearly all of them worked by machines, and owns also a railroad connecting its mines with St. Louis.

Systems of Mining.—There are three methods used for mining coal in Illinois: By slopes or drifts, which is little used and generally in small mines. By shafts, which is the most general system. By excavation in open pits; this is a very cheap method where no water is encountered, but can be used only in a few places, where the natural conditions favor it.

The second method, that by shafts, the one in general use, may be again subdivided into three general systems, the pillar-and-room, or double-entry, the panel, and the longwall retreating and advancing. The great majority of the mines are worked up on the double-entry system, in which two entries are driven from the main entry from 12 to 20 ft. wide, leaving between them a pillar of coal varying from 20 to 50 ft. in thickness; the air for ventilation is carried up through one of these entries to the last cross cut and back the other entry. Cross cuts are driven through the entry pillars at varying distances, usually from 60 to 100 ft. apart, and rooms are turned right and left from these entries at distances of from 40 to 60 ft., pillars from 10 to 15 ft. thick being left between the rooms. The usual length of rooms is from 100 to 250 ft. In hand mines and solid-shooting mines the rooms are widened out right and left from 30 to 60 ft. Where machines are used the widening is done on one side only, generally on the left side.

The Panel System.—This method of mining is a modification of the double-entry. The 4 large collieries in the Pana district are all worked upon this plan, which is especially applicable in this field, where the mines are fiery and give off fire damp. Main entries are driven from the shaft with lateral entries about 1000 ft. apart. Out of these lateral entries stub-entries are driven from which the rooms are turned. These stub-entries are generally about 1500 ft. long, and from each about 16 rooms are worked in much the same way as in the double-entry mining, but they are driven from 230 to 245 ft. It is necessary to keep the rooms going evenly so that they will all be worked up at once. When the panel, as each set of 16 rooms is called, is worked out, it is only necessary to close up two openings, the mouth of each stub-entry, which in a fiery mine is a great saving. In this system the work is all concentrated at one point, and consequently mechanical haulage, particularly by the endless-rope system, can be used to a good advantage.

The panel system is the best that can be used where pillars are to be left. It is difficult to make any comparison with the double-entry system, as the panel method is used in only one coal field, where natural and other circumstances are very different from those of the other fields. The mining in this field is very easy, and the gas in the coal breaks it in much the same way as the overlying weight does in longwall work. The coal is mined by hand at Pana for about 20c. a ton, which is possibly more cheaply than by machine, although fully 50% of the coal mined is slack and small coal. It is decidedly the cheapest hand mining in Illinois.

Longwall, Retreating and Advancing.—The northern coal field is the only place in the State where this system of mining is used to any considerable extent. Under it all the coal is taken out with the exception of two or three acres left at the bottom of the shaft as a supporting pillar. The northern mines are all worked by hand, miners receiving from 75 to 85c. per ton in winter and from 60 to 75c. in summer. Besides mining they have brushing and keeping of the roads. About 90% of the coal mined is lump. In some cases the small coal is washed. In this district the hand mining costs more than in any other in the State, but, on the other hand, much of the coal mined is of superior quality and commands a higher market price. It is also within easy distance of the Chicago market.

The disadvantages charged against longwall work are: Difficulty in securing at all times the skilled labor necessary, as this kind of work requires experienced miners; the large amount of water encountered and the liability of premature breaks of the surface, the damage to which sometimes doubles the previous cost; where a steady output must be had and where the seam is from 3 to 4 ft. in thickness the system is very successful.

Open-Pit Mines.—This method is at present in use only at one point, the Mission field near Danville, Vermillion County, where the coal is found about 8 ft. below the surface and the seam is from 5 to 6 ft. and of fair quality. The greater part of this seam is in a valley or natural depression about 1000 acres in extent and from 80 to 100 ft. below the general level of the surrounding country. The overburden of earth is removed by steam shovels, trenches are then cut in the coal by hand picks, and it is blasted out. The coal is drawn by a steam locomotive to the foot of the slope, from which it is hoisted by hoisting engines. In addition to open-pit work, slopes are sunk into the sides of the valley and the coal is here mined on the longwall plan. This is one of the few places in Illinois where day labor is used entirely.

Attacking the Coal.—The two general methods of attacking the coal are: Undermining by hand or machine and blasting down with powder. In blasting off the solid very little cutting is done, very often none at all. The holes are drilled into the seam and the coal blasted off the end. This method requires very little skill or previous experience, while undercutting needs both experience and judgment. Where coal is hard and free from slates, blasting off the solid is the cheapest method where hand labor alone is employed. In many cases the coal is produced more cheaply than in machine mining.

Machine Mining.—As a rule, the cheapest mining in Illinois is done by coal-cutting machines. The machines so far in use are nearly all of the percussion or straight-blow type, such as the Ingersoll-Sergeant, the Harrison, the Yoch, the Chouteau, and the Legg machines, worked in most cases by compressed air. At the close of 1895 there were 320 mining machines in use in this State, and 3,531,436 tons of coal, or about 20% of the total output, were mined by machines. The disadvantages of machine mining are: First, waste of coal; second, large first cost of the plant; third, necessity of a thick seam; fourth, necessity of careful and skillful supervision. On the other hand, there can be no doubt that machine mining decreases the number of strikes, as each man is working for his own interest. There are no standing shots to delay the miner; skilled labor is necessary in only a few places; and with the machine the mine is necessarily developed more systematically and a steadier output can be relied upon.

It is true that for machine mining to be successful the seam of coal must be suitable. That is, it must be clear mining, or free from sulphur balls or pyrites in the lower part of the seam. Where there are 3 or 4 in. of fireclay under the coal the cutting is usually done in this if it is soft. If the fireclay is hard or if the bottom is rock the cutting must be done in the lower part of the coal seam itself, and this involves a waste of coal and is a source of expense. The slack and small coal made in the undercutting must be taken to the waste heap at the mouth of the shaft; if left below it is apt to be a frequent cause of fires.

The practice of forking the coal which is in use in some machine mines increases the waste largely. At many mines shaking screens are in use which clean the coal thoroughly and permit hand picking where that is desirable.

A machine mines from 30 to 60 tons per day, the amount depending very largely upon the thickness of the seam. As a general thing they are run in double shifts of 10 hours each. In one case 15 mining machines of one of the best types, running double shifts, and in hard mining coal, deliver on the railroad cars 1200 tons of lump coal in 10 hours, the coal being screened over a shaking screen which takes out about 30% of fine. In most machine mines the double-entry system, or room-and-pillar work, is used, one machine being used in each entry.

The great majority of the laborers in machine mines are Germans, Russians, Italians, or Hungarians; but little skilled labor is required. Usually there is one shooter and one timber-man in each entry, and for these positions experienced men are necessary.

Speaking generally, a machine mine can turn out the same quantity of coal as a hand mine with only about 60% as many men and at about 10c. a ton less cost. In one mine where an ontput of 1200 tons is made daily with machines the whole number of men employed is 300. The average cost of production by machine in Illinois is 50c. per ton of lump coal, although at some of the mines it is done for

40c. In this State coal costs at the face 25c. per ton, and 15c. more will pay the expense of taking it to the surface and loading it on cars on the siding.

A plant running 12 machines of any of the standard makes will cost about $12,000, or about $1000 a machine. It will readily be seen that the cost is somewhat larger per machine in smaller plants and will be slightly decreased as the number of machines is greater. In operation one machinist will attend to and keep in repair 30 machines. About one blacksmith to sharpen the tools, etc., is required to 400 tons daily output. The maintenance of a machine, including wear and tear, would not be far from $20 per machine per year.

In machine mining the general rule is to allow 30% for slack, dirt, sulphur, etc. The cost for powder is less in machine than in hand mining, as the coal is all undercut usually to a depth of 6 ft. and can be blown down with comparative ease. In some mines where the coal is soft, but has a hard band at the bottom, it cannot be shot from the solid, but must be entirely undermined; in other cases where the coal is even softer it can be shot from the solid. Naturally machines are most successful where mining is hard. One runner and one laborer are necessary for each machine, and in most mines one shooter and one timber-man, who lays the roads, besides doing the timber work, work after each machine. These and the machine runner are the only skilled men required in a machine mine. From four to eight loaders, who are laborers and not skilled men, work after a machine and are paid by the ton. The pay of machine runners varies. In some cases they are paid by the amount of coal produced and in other cases by the number of square feet undercut at the usual rate of 20 to 35c. per ton, or 1 to 1½c. per sq. ft. An average day's work would be 250 to 275 sq. ft. of undercutting. Shooters and timber-men are sometimes paid by the day, but the more general practice is to pay them on the same basis as the runner, thus making all the men mutually interested in the progress of the work. In many mines where machines are used air drills are employed to drill the holes used in blasting the coal down, and in such cases the labor and expense are much lessened.

In some of the mines in the northern and central fields chain-belt machines and electric coal drills have been used, but so far without much success. It is claimed that with these machines the undercutting is shallow and the coal when blasted does not come out in as good condition for loading as does the coal from the undercut made by the percussion machines.

Mine Haulage.—In the Illinois coal mines only two systems of haulage are in use, animal power and mechanical haulage by wire ropes. Sometimes the engine is placed at the surface and sometimes at the bottom of the shaft. The two rope systems in use are the tail rope and the endless rope, each having advantages of its own and both too well known to need special description here, for there are no mines in Illinois which present any unusual or remarkable features. The cost of mechanical haulage is usually estimated at from 2 to 3c. per ton per mile. In one mine in the State electric haulage is used and is said to be very successful. The introduction of electricity for the transmission of power for this purpose is comparatively new in the State, but the many advantages which it presents make it very probable that its use will extend rapidly.

Cost of Opening a Mine.—The cost of sinking shafts and equipping for work a machine mine capable of making an output of 1000 tons per day may be given approximately as follows:

Mine shaft, 7x15 ft., 400 ft. deep, at $25 per ft	$10,000
Escape shaft, 6x8 ft., same depth	4,000
Hoisting engine, cages, ropes, etc	4,000
Buildings, scales, shoots, elevators, etc	15,000
Ten boilers, return-flue type	8,000
Side tracks	8,000
Mine cars	6,000
Tracks in mine	2,500
Pumps	3,000
Rope-haulage plant	10,000
Machine plant	20,000
Mules	1,500
Total	$92,000

Including royalty, the whole cost of starting the mine may be put at $100,000. This sum will duplicate the largest machine mine in the State and its plant. The cost of sinking and equipping a hand mine of the same capacity and daily output would be about 60% of the amount required for the machine mine.

Cost of Producing Coal.—The cost of producing coal in the solid-shooting mines of Southern Illinois varies from 40 to 63c. per ton. In the solid-shooting mines of Central Illinois it is from 60 to 63c.; in the longwall mines of Northern Illinois it ranges from $1 to $1.15 per ton. All these costs are of good merchantable lump coal delivered on cars. If we take run-of-mine coal, unscreened, as the standard, the average would be 10 to 15c. per ton less.

In machine mines the cutting is paid for, as already stated, at so much per square foot of undercutting or at so much per ton of coal removed. Loading is paid for by the box, which usually holds a ton of coal. This rule of piece work prevails at nearly all the coal mines in Illinois, and in time will probably be extended to all branches of mine work. For instance, drivers can haul coal at a given rate per box, cagers are paid per ton of coal caged, and engineers may be paid a certain sum per ton of coal hoisted, etc. In fact, the system of complete piece work has been started in several of the machine mines, and where it has been tried has been successful. The trial was due chiefly to the practice of leasing mines to individuals.

Hand mining as carried on in the northern coal fields costs somewhat more than hand mining in the central and southern district of the State. On the other hand, the northern mines are nearer to the market, so that freight rates and other charges are less.

There is generally a differential of from 8 to 10c. per ton between the rates paid for summer and winter mining. This is the result chiefly of the smaller amount of work and the smaller demand for coal in summer. There is also a differential of from 15 to 20c. per ton in rates paid for gross (run of mine) and net (screened coal) weight in mining.

In the hours of labor there is more uniformity than in any other branch of mining economy. At practically all the coal shafts in Illinois the shifts are from 9 to 10 hours, the day's work generally beginning at 6:30 or 6:45 A.M. and closing at 5:30 or 6 P.M., with a half-hour's stoppage at noon. A few mines, both hand

and machine, employ and pay their miners by the day, but there is a decided antipathy to this system on the part of a majority of the miners.

A summary of the rate of wages and other items of cost may be given as follows: Machine runners are paid by the day $2.15 to $2.50 per shift of 10 hours; shovelers or helpers, $1.75 per day; loaders, $1.75 per day—usually a certain number of boxes or tons is required for a day's work; shooters and timbermen, $2.15 to $2.25; air-compressor men, $55 to $65 per month; machine runners are paid by the piece from 1 to 1½c. per sq. ft. of undercutting; shovelers receive from ¾ to 1¼c. per sq. ft. of undercutting. The amount of undercutting where cutting is done in coal varies from 250 sq. ft. per day with old machines to 400 sq. ft. with the latest and best improved machines. Where the cutting is made in fireclay under the coal the amount of labor is about 10% more. The amount of undercutting to a ton of coal produced varies from 4 sq. ft. in a 10-ft. seam to 6½ sq. ft. in a 6-ft. seam.

The quantity of coal mined to a keg (25 lbs.) of powder used naturally varies considerably. In the solid-shooting mines 25 tons is a good average, but in some machine mines working on a 6-ft. seam as high as 160 tons can be made. The price paid per box (usually one ton) varies from 13½ to 20c.

Taking an example for practice, we find that 30 machine runners for 23 days of 10 hours each made an average of $49.63 each. In the same period 30 machine helpers or shovelers made $32.20 each, while the drillers and blasters showed an average of $39.24 each.

Hand miners where paid by the day receive from $2 to $2.50, the higher wages, of course, being paid to the more skillful. Drivers are almost without exception employed by the day, receiving from $1.60 to $2; cagers average $2 per shift of 10 hours; some road-men receive $2.15 to $2.50, but these rates are exceptional, as the general average is about $2 for a 10-hour shift.

Some general charges common to both hand and machine mines are as follows: Company weigh-men are paid from $1.60 to $2 per day; top-men receive from $1.50 to $2 per day; a fireman's wages vary considerably owing to the situation and the amount of work required, but the average equals $1.60 to $2 per day; mine teamsters earn from $1.50 to $1.75 per day; for engineers the usual rates are from $65 to $70 per month for day shifts and $60 to $70 for night shifts; mine clerks receive from $40 to $70 per month; mine managers, who must hold the certificate required by law, are paid from $65 per month in some of the smaller hand mines up to $100 per month in the larger mines; the office force for a city agency is generally estimated at from 3 to 5c. per ton sold. The cost of haulage in the mines by mules varies from 2½ to 5c. per ton. The cost of mechanical haulage is from 2 to 4c. per ton.

It should be noted that in hand mining where men are driving entries of a certain width they receive from $1 to $1.50 per yd. advance in addition to the payment per ton of coal mined. The extra pay is to compensate them for the reduced yield of coal when they are driving on narrow work. The miner also receives a certain sum—from 50 to 75c.—for each set of timbers which he places. In the Springfield district the coal seam is cut in many places by vertical seams of fireclay and sulphur, which are called by the miners horsebacks. For mining out these seams an extra allowance is made to compensate the men for the reduced quantity of coal, and also for the extra amount of powder required to blast the clay. In hand mines the miner is paid from $3 to $5 for turning rooms. The price, of course, varies with the locality, the width of neck or entrance to room, and other circumstances.

Blasting off the solid is the cheapest means yet found of mining coal by hand, but the coal must be of suitable character and the system is subject to the drawbacks of turning-room, yardage, horsebacks, and strikes. For a limited output, however, no cheaper manner of mining coal has been devised. It is true that the longwall system would be the cheapest in some of the coal fields, but in most cases the operators are obliged to have quick returns for the money invested and therefore cannot adopt the longwall system.

The quantity of timber required for props and cross bars or collars of course varies with local circumstances. In the southern and central section, where a good limestone roof can usually be found, one running foot of timber to the ton of coal mined is considered a fair estimate. In the northern fields, where the roof is commonly of slate and shale, the estimate would be nearer two running feet to a ton of coal mined.

The repair of mining tools and their sharpening is done by the mine blacksmith, and the usual charge is from ¾ to 1c. per ton of coal mined. At least this is the custom in hand mines, where the intention is to pay for the services of the blacksmith only. In machine mines machine picks, hand picks, drills, etc., are repaired and sharpened by the mine blacksmith, no charge being made to the miners. It is usually estimated that one blacksmith is needed for about 400 tons mined daily. The usual pay of a blacksmith at machine mines is $2 per day, and at hand mines wages are about the same, so in most cases the blacksmith may make as much as, perhaps more than, $2.25 per day.

Finally, we may say that royalties vary from ¼ to 1c. per ton of lump coal produced. Coal lands at the present time can be bought in fee in Illinois for about $25 per acre if we take the average of the whole State. Of course the price varies very much according to locality, convenience of shipping, and other conditions.

Coal Miners.—During the past 10 years the character of the men employed in the Illinois coal mines has changed very greatly. Formerly English, Scotch, Welsh, and Irish miners were found everywhere. At the present time there are some Germans, but the great majority are Slavonians, Russians, Italians, and others from the east and south of Europe. This change has resulted partly from prejudices among the old hand miners. When on account of competition and frequent labor troubles a cheap and reliable system became necessary and machines were introduced, there was a great deal of bitterness and antagonism, and the result was that nearly all the old miners left the business, either finding other occupations or leaving the State, and a new race was introduced. Many operators think it doubtful whether machine mining would have been practicable without this introduction of foreign labor. The fact is that under the present system coal mining in Illinois has either ceased or is fast ceasing to be a skilled occupation.

Most of the mining companies pay wages monthly, but some pay twice a month and a few weekly. Many companies, including nearly all those whose mines are not near a large town, run company stores on the usual plan. In most of the hand mines oil and powder are supplied to the miners by the companies, and payment therefor is deducted from the man's wages on the pay roll. In such mines each miner is required to furnish his own powder, but in the machine mines explosives are supplied by the company.

The State mining law provides that miners in hand mines may select one of their number to act as check weigh-man. His duty is to see that the correct weight of all coal mined is taken by the company and properly credited to each miner. He is paid in proportion to the number of tons of coal, the amount being furnished proportionately by the miners.

There are several coöperative coal companies in the State, and where it has been tried the system seems to have worked successfully. The usual plan is to divide the total amount of stock which may be fixed into shares, usually of $10 nominal or par value. Nearly all the stock is held by the miners who work in the mines, and the companies are managed in the ordinary way by a board of directors elected by the stockholders at stated periods.

Accidents.—Fully 60% of all the accidents, fatal and non-fatal, which occur in the Illinois coal mines are caused by the falls of the roof and sides of entries, etc. Many of these could be avoided if proper care were exercised by the miners, but it seems very difficult to inculcate greater caution upon the men, who in the majority of cases seem to prefer to run the greater risk rather than take any additional trouble.

Coal Slack and Waste.—One of the greatest losses in mining in Illinois, as elsewhere, is from the large proportion of the coal taken out which is practically lost in the form of slack and waste. This is particularly the case in districts where miners are paid by the gross-weight system. At present most of this waste is piled up in the neighborhood of the mines and no attempt made to utilize it. The introduction of machinery for the purpose of making briquettes, as is done in Belgium and Germany, would seem to offer one solution, but it has only lately been seriously considered. As there is a demand for small sizes of coal, it would appear that the manufacture of briquettes would be profitable. The proportion of slack and small coal varies in different mines from about 15% in the best machine mines up to as high as 50% in some cases where the coal is particularly soft and friable. To fix a general average for the whole State would be difficult, but probably one-third of the coal removed is lost in this way.

The Springfield Iron Company formerly utilized waste slack in the manufacture of ammonium sulphate. Forty tons of coal were used per day, generating about 5,000,000 ft. of gas. There was produced at these works some 400 or 500 tons of the sulphate, which was used by the manufacturers of chemicals and fertilizers. About 20 gals. of coal tar per ton of coal were also produced, and during the experiments more than 5000 bbls. of coal tar were made. The works are not now in operation, because the process could not be carried on profitably on account of the gas carrying over large quantities of ammonia after it had been cooled. It is believed, however, that the extraction of ammonium sulphate from coal slack will eventually prove successful from a commercial standpoint.

Generally speaking, Illinois coal will not produce a hard coke such as is necessary in blast furnaces, but at several points in the State a soft coke is manufactured for local use and for shipment. Some coke is made at Collinsville for use in the zinc retorts, and in Randolph County, in the Southern field, there are 102 beehive coke ovens. They are at present making a smokeless fuel as well as coke, and there is a ready sale for the output. The quality of the coke is such as to justify its use in foundries, wire mills, etc., as well as a substitute for anthracite coal for domestic use. It is very high in carbon and low in sulphur.

In some parts of the State, notably in the Northern section, slack is being washed. This operation can be made profitable where there is a sufficient supply of water, and of late there has been a demand for washed slack.

At one of the mines in the Springfield district a machine for making briquettes of slack has lately been erected. The machine consists of an upright metal frame weighing about 10 tons and an endless metal belt having disk-shaped depressions. This belt has a rotary motion. Above the belt is a revolving shaft 2 ft. in diameter carrying metal spines having disk-shaped depressions on their points. As the belt rotates and the shaft revolves the points above strike directly over the depressions beneath, and thus the briquette is formed. The slack and the binding material are thoroughly mixed in a tank above the machine and carried from the tank to the machine by conveyer buckets, a four-bladed screw thoroughly mixing the material. The briquettes are firm and burn well, but the process has not been in use long enough to show whether it will be profitable.

Labor Difficulties and the Coal Trade in Indiana.

According to Mr. Robert Fisher, during the months of January and February, 1895, the coal mines in Indiana were in active operation. As it had been customary for several years to arrange the yearly wage scale to take effect on May 1, the miners and operators of the block-coal district arrived at an agreement, by the terms of which the standard price for mining was to be the same as for 1894–95, but that in certain contingencies the miners were to accept a reduction of not to exceed 5c. per ton, and work was continued at this rate until June 15, when by agreement the price per ton of screened coal was reduced to 65c. and other work in the same proportion. This rate continued until October 1, when the standard price of 70c. per ton was restored. No troubles of consequence occurred at any of the block-coal mines during the year.

From a complication of causes, the final settlement of a price for mining was not so easily nor speedily arrived at in the bituminous district. The condition of the coal trade made the miners averse to entering into a contract fixing the price for a year at any figure, and they were unalterably opposed to a reduction, even temporarily, below the 60c. rate of 1894–95. The price was finally fixed at that rate, to continue until July 15, and work was continued under this agreement everywhere in the district except at the mines in Vermillion County. The operators there claimed that the nature of the competition they encountered would not permit them to pay this price and demanded a reduction to 55c. per ton. The miners refused to accept and a strike ensued, which lasted, with slight interruptions, until about November 1, and was finally ended by the defeat of the miners and the refusal of the operators to treat with or in any way recognize the miners' organization.

Machine Coal Mining in Iowa.

By H. Foster Bain.

The use of mining machines in Iowa has been in the past largely experimental. A considerable number of the various coal-producing companies have at one time or another made more or less persistent attempts to utilize them, but of the large number of different types of mining machines which have been brought into the State a few only have demonstrated their fitness and are now on the ground. This is not due to any peculiar difficulties arising from the geologic conditions of the field, but is probably due rather to the fact that most Iowa mines are worked on small capital, and even when a machine has been proven a technical and a financial success, its adoption by neighboring mines is impossible because of financial limitations.

The system of selling territorial rights has also worked as a bar to the rapid introduction of machines. A company which has found a certain type of machine sufficiently economical to allow it to pay for a county right will naturally charge any competitor a sufficient royalty to prevent him from making any profit. As a result the competitor must find an equally efficient machine which is not controlled by his rival. This is not always easy, as the conditions of the coal seam itself control the manner in which it may be successfully attacked, and if one type of machine is efficient on a given coal, that very fact renders it improbable that any other type will be equally efficient.

One of the most hopeful signs is the fact that Iowa operators are more and more inventing or adapting their own machinery. There is less of the tendency to adopt as a whole methods found applicable elsewhere regardless of the local conditions. This is seen in the combined use of the Legg and Harrison machines by the Walnut Block Coal Company, neither of which would alone be equally efficient in working the Mystic coal, and the invention by the Peerless Coal Company of a machine specially designed to meet the problems encountered in its own mine.

At present machines are in operation in seven different mines. In one other plant certain types of machines proved efficient, but a change to longwall workings caused them to be laid aside. The best-known and most generally used machine in Iowa is the Harrison. It is at present in operation in three of the mines of the Walnut Block Coal Company and in two of the What Cheer Coal Company. In the former mines it is used in combination with the Legg machines. In the latter it is used alone.

The What Cheer coal represents the normal Iowa coal; the Mystic coal, worked by the Walnut Block Coal Company, is in many important particulars exceptional. The usual Iowa coal seam is characterized by great irregularities in thickness, varying rapidly from 7, 10, or even 13 ft. in thickness down to 2 or less. The workable coal usually averages from 4 to 6 ft. in thickness. It is not infrequently split by clay ironstone bands of varying thickness and extent. The floor is almost invariably of fireclay which is frequently quite hard, and the roof is in most instances a black fissile shale or slate. In certain instances a clay ironstone band comes in over the coal. Where this forms a continuous band it is a most excellent roof. In one mine such an ironstone forms the roof over the main working entry, which is 16 to 18 ft. wide and for a distance of 42 ft. has no support whatever. This is, however, the great exception. The ironstone is far more apt to be in detached masses, often of considerable extent, which require most careful timbering. The slate itself usually falls easily, and black bat, clod, and similar varieties of shale material come in to complicate the problem of holding a roof. All these factors make it usually impracticable to hold an unsupported roof along a working face for any considerable distance or time. This alone renders it impossible to use those types of machines which require much room at a working face. In this the Harrison and similar machines have a decided advantage.

The coal at What Cheer, and indeed in the major portion of the Iowa mines, is quite hard. Cutting corners and undercutting by hand is decidedly laborious work. Not only is the coal itself hard and difficult to cut, but it usually contains a most unfortunate number of sulphur balls, the latter being frequently present in the fireclay as well as the coal. A machine for working such a coal must be constructed that these nodules of pyrite may be dodged if the highest efficiency be attained. In this the pick machines again have the advantage. In one of the mines of the Crescent Coal Company a machine was experimented with a few years since in which the undercutting was done by a horizontal revolving circular saw armed with picks for teeth. Its inability to dodge the nodules of pyrite proved its destruction, as the whole set of teeth was broken off as soon as any such impurities were encountered.

Coal in this State is largely mined by blasting from the solid. But comparatively little cutting is done and much powder is used. When coal is undercut by machine and has had the sides sheared down it requires but very little powder to bring it down, and hence a roof which would not stand the heavy shock of a full powder charge may be worked by machines. In blasting from the solid the shots cut up into the slate and the rooms are frequently lost before they are driven their full length. In the What Cheer region it takes less than one-half of the powder that is used in hand work to bring down the machine-cut coal.

In the mines of the What Cheer Coal Company there are about 30 Harrison machines of the heavy standard class. They had been in use for several years up to November 1, 1895, when the short water supply forced the company to lay them aside. This machine is essentially a pick fastened on the end of a piston which is driven by compressed air. It delivers from 200 to 210 blows per minute, and the direction of the blow is controlled by the operator. In the What Cheer mines air at 60 lbs. pressure, compressed by Norwalk compressor, is used. Mr. E. M. Trescott, general superintendent for the company, supplies the following estimates as to cost. The machines have been used both in entry-driving work and in room work. The entries are driven 7 to 8 ft. wide and 5½ ft. from bottom of rail to roof. In most of the entries it is necessary, in order to get that height, to either take up bottom or shoot down the roof. The former plan is preferred as yielding better and more easily maintained roadways. The hand price of entry driving is $1.80 per yd. The cost of lifting the bottom (15 in. in 4½-ft. coal) is $1 per yd. additional. With machine work the cost is about $1.80 per yd., including the cost of lifting the bottom (15 in. at 2c. per yard-inch).

This makes a difference of $1 per yd. in favor of machine work, to which should be added the coal saved, 2 tons, which makes a total saving of $2 per yd. in a 4½-ft. vein in favor of the machines. In this work the machines are made to cut 4½ ft. and three cuts is considered a good day's work. The men often, however, make 5½ ft. at a cut and make four or even more cuts in a day.

Where the men are paid by the day in machine work the prices are: Machine men, $2.50; helper, $2; loader, usually $2 and sometimes $2.25. Where the entries are driven all in slate, fireclay, dirt, or anything but coal or rock the contract price is $2.74 per yd., whereas the cost of hand labor is usually nearer $5 per yd. In some room work the undercutting has been paid foı by the lineal foot, in which case the price is 9c. per ft. for a 4½-ft. undercut, with 5c. additional for the helper; the cost of shooting, loading, and setting timbers is 40c. per ton.

On an average the cost of coal from machine rooms is almost 10c. per ton less than hand-mined coal, the present district price for the latter being 50c. per ton gross weight. In narrow work on a basis of $1.80 per yd. for hand work there is a saving of about $2 per yd. Against this saving must be offset the cost of maintenance of plant, depreciation, interest, etc. The cost of repairs for Harrison machines is slight, but in the end the main saving here seems to be in the recovery of a large amount of coal which would be inevitably lost by ordinary methods of mining.

Near Oskaloosa and throughout the Muchakinock Valley a coal has been mined which is in most regards similar to that opened up at What Cheer. Until recently the work has been all hand labor. In the summer of 1895 the Long Brothers Coal and Mining Company installed at its mine a machine plant.

The machines are not now in operation, as a fault cut off the coal and the mine is to be abandoned. The company, however, expresses itself as well satisfied with the work done and supplies the following information. The plant consisted of a 50 horse-power Independent mine-type dynamo with Independent chain and Sperry pick machines. The plant was installed by the Independent Electric Company of Chicago. The dynamo was place in the engine room and required no extra engineer. The machines used from 25 to 50 ampères at 220 volts, depending on the nature of the cutting. The coal is a 5 to 6 ft. bed and entries are driven 10 ft. and rooms 25 ft. wide. The machines make an undercut of 5½ ft., making 8 cuts, the total number across the face of a room, in about 2½ hours. They deliver 50 to 100 tons of mine run per day with an average of 80 tons. In room work the average cost of machine coal is 60c. as against 75c. paid for hand-mined coal. In narrow work a progress of 25 ft. per day is made as compared with a corresponding progress of 10 ft. by hand with the same number of men. Two men are employed at each machine at $2.25 per day. The cost of loading the coal is 20c. per ton. In a special test the Independent machine made 125 ft. of undercutting in one day and the Sperry machine made 45 ft. of shearing in 6-ft. coal. The machines gave very little trouble and required few repairs.

Next to the What Cheer mines, those in the southern part of the State working the Mystic coal have used machines most. The Mystic coal is an important seam which underlies about 1500 sq. miles of territory almost equally divided between Missouri and Iowa. It is in many important regards exceptional as compared with the major portion of the beds worked in the two States. Physically it is a soft though brittle block coal, breaking with a clean conchoidal fracture and presenting a bright reflecting surface much resembling anthracite. Its cleanness and the readiness with which it is handled and fires make it a favorite for domestic purposes. It will not, however, stand rough handling nor stacking, and for steaming purposes is rarely so good as the lower coals worked in other parts of the State. The peculiar physical characteristics mark it wherever mined, and its uniformity in this regard is the striking feature when it is compared with other Iowa or Missouri coals. Structurally the region is as simple and as uniform as could be desired. A few broad low anticlinals, an occasional fault of a few inches and one of 50 ft., certain preglacial erosion channels, and an occasional stretch of bad roof are all that interfere with the most extended mining. The eastern border of the coal is appro .imately marked by the Chariton River. To the west it extends unbroken half way across Wayne County, where it finally becomes too thin for profitable working. The bed is not thick, but its excellent quality, wide continuity, and the ease with which it may be worked have led to the opening of a large number of mines. In Appanoose County alone there are now more than 50 shipping mines, besides a large number which supply the local trade. The total Iowa output from this seam for the year ending June 30, 1895, was 395,700 tons. In 1893 it was 697,896 tons.

A general section of the beds occurring in this region would be as follows:

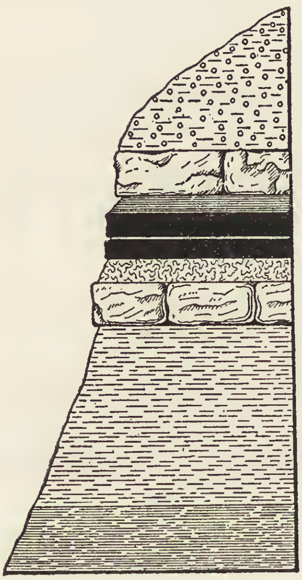
	Feet.	Inches.
16. Soil, fine black	2	0
15. Clay, yellow	33	0
14. Bowlder clay, blue, containing fragments of wood, coal, limerock, and bowlders	30	0
13. Limestone	6	0
12. Clay shale, blue ("soapstone")	3	0
11. Clay shale, red ("soapstone")	11	0
10. Sandstone, soft, containing thin, harder layers	8	0
9. Clay shale	10	0
8. Limestone, compact, gray	3	0
7. Shale, bituminous, frequently containing nodules of pyrite	7	0
6. Limestone ("cap rock")	3	6
5. Shale, hard, black ("slate")	1	2
4. Coal	1	8
3. Clay parting	0	2
2. Coal	1	2
1. Fireclay	3	0

A detailed section of the beds found at Mystic is shown in the accompanying sketch (Fig. 1). There are three general plans of work in this region. The first is regular longwall, which is now used in some of the largest and best mines and is being rapidly introduced throughout the region; the second is room and pillar; and the third is a modified form developed in this region and for a time used largely in the smaller mines and known as semi-longwall.

In room-and-pillar work in this field, as carried on in most of the mines by hand labor, the cross entries are driven 300 ft. apart. The pillars along the main roadways are usually 24 ft. thick. The entries are 8 ft. wide and taken from cap rock to bottom rock. The rooms are 150 ft. long and 40 to 50 ft. wide. In the summer of 1895 the scale of prices was as follows: Room work: Coal to

October 1 (screened), 70c.; after October 1, 80c. Narrow work—summer: Yardage, $1.10; lifting bottom and shooting down top, 90c.; coal, 70c. Narrow work—winter: Yardage, $1.20; top and bottom, $1; coal, 80c. There have been some changes in these prices since that date. At the old prices a yard of entry work in summer cost about $3.40 and in winter $3.80.

In working with machines as carried on in three of the mines of the Centerville Block Coal Company the entries are driven 10 ft. wide and the cross entries are run at distances of 400 ft. The machines in use are the Legg and the Harrison. They are used mainly in driving entries and turning rooms. But little room work proper is done by machine. Compressed air at 80 lbs. delivered from a Norwalk compressor is used. In entry driving and turning rooms the Legg machine does the undercutting and is followed by a Harrison, which cuts the corners. The coal is then wedged down. The Legg machines have a 3½-ft.



	FEET.	INCHES.
10. Drift	12	
9. Limestone, heavily bedded, gray, fossiliferous	2	10
8. Shale, bituminous, fissile	1	
7. Coal	1	6
6. Clay parting		2
5. Coal, with some pyrite near base	1	
4. Fire clay	1	6
3. Limestone, heavily bedded, fossiliferous	2	10
2. Shale, gray, clayey	11	
1. Shale, blue, clayey (exposed to water level)	4	

Fig. 1.—Section of Coal Beds at Mystic, Iowa.

bar and are supposed to average a 5-ft. cut. They average in actual work 4 ft. 8 in. Three cuts are made to an entry, each taking about 10 minutes. The undercut is 5½ in. high. Two men are employed at each machine. As quick as the undercutting is done at one point the machine moves on to the next and is followed by a Harrison machine. The Harrison machine requires two men, a runner at $2.20 per day and a helper at $1.60. The machine is expected to cut 16 corners, equal to 8 entry cuts, per day, which would cost 48c. each. Very frequently, however, as many as 21 cuts are made, which would reduce the average cost to about the figures given below. Measurement of the length of three such cuts were 52½, 61, and 52 in. each. In shearing a cut of about 4 in. wide is made. One cut or rib furnishes about 3 tons of coal and 3 carloads of dirt. The cars used in these mines have an average capacity of 1600 lbs. of coal. The dirt is hoisted and dumped in narrow work, but in room work it is usually gobbed. In narrow work the two machines will make 8 to 10 entry cuts per day of 10 hours and will keep from 4 to 6 followers busy. In wide work where there are 12 undercuts to a room they make about 30 cuts per day and keep 8 to 10 men busy.

A 4-ft.-8-in. cut on a 10-ft. entry ready for track costs about as follows: Undercut, 24c.; shearing, 37c.; coal, 3 tons at 34c., $1.02; brushing top, 84c.; total, $2.47. In comparing these figures with hand labor it must be remembered that a machine cut is 48 in. and a hand cut 36 in. On the other hand, the machines must bear the cost of repairs, depreciation, interest, etc.

In turning rooms the two 10-ft. doors are driven in 14 ft. and then opened out as shown in diagram (Fig. 2). The room is then turned over to the miners, who drive it forward by undercutting, shearing, and wedging till the room from the opposite cross entry is met. The rooms are then left till that portion of the mine is about to be abandoned, when the pillars are pulled. By that time, usually two years or more, much of the coal is not worth saving.

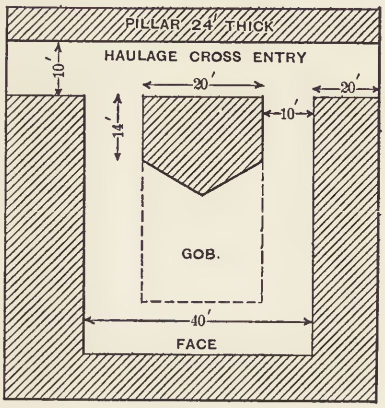


Fig. 2.

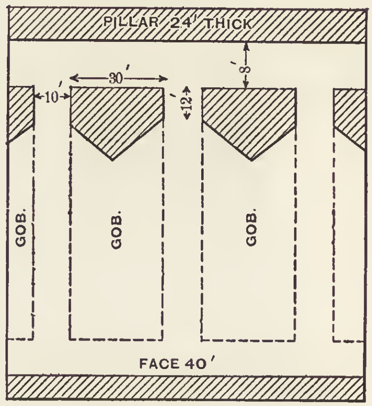


Fig. 3.

In the semi-longwall work no machines are used, and the method itself is being gradually superseded by regular longwall. As seen in the Lodwick Brothers' mine the work is about as follows: The customary cross entries are driven at suitable distances along the main entry. The rooms are turned as usual, with the exception that no pillar is left between adjoining rooms. As a result the work opens up as shown in Fig. 3. As the work moves forward each man mines 30 to 40 ft. of face with his roadway in the center. He builds his own pack walls and sets the timbers. The coal is undercut 1½ to 2 ft. and held up temporarily by sprags. No powder is used, as the weight brings the coal down as fast as it can be used. This particular mine is opened by a well-built and substantially timbered double-track slope, which cost about $7 per yd. on the incline and $3.75 on the underground level.

The large number of mines in the district which have changed or are changing to longwall workings make the success of a longwall machine a matter of some importance. The Peerless Coal Company has been for some time experimenting with such a machine, but no description of it can be given at present.

Spontaneous Combustion of Coal and Its Prevention.

By Richard Cremer.

The spontaneous combustion of coal is an important factor in mining as well as in general industry and navigation. It is a question continually growing in importance with the increased consumption of coal and its transportation on a large scale, and it is probable that a very large number of the fires in mines may be traced to spontaneous combustion, the dangers arising from this cause of course varying very much with the composition and nature of the coal. In Germany spontaneous combustion is more common in the brown coal or lignite mines than in those of true coal. But, on the other hand, a fire in a brown-coal seam can usually be extinguished much more easily than in a bed of true coal, where it is in many cases accomplished only with great difficulty and at heavy cost. A fire may cause the abandonment of the mines and occasion great danger to the working force.

Although spontaneous combustion in mines has been long known and many examples have occurred, attention was first called to this matter by the occurrence of fires on ships loaded with coal. The first statistics having any authority were obtained by the English commission appointed in 1876 to investigate the causes of fires on shipboard and to find some means for their prevention. According to the report of this commission, the number of ships destroyed during a series of years by fires originating in spontaneous combustion was about 4% of the whole number carrying coal. It was found that the danger increased with the size of the cargo.

In recent years the accumulation of large stocks of coal in manufacturing establishments has increased to a considerable extent, and many fires have been caused by spontaneous combustion in these heaps. Frequently this accumulation of stock is a necessary precaution to prevent stoppage in case of strikes or accidents in the mines, and fires in these stocks are frequently very difficult to deal with, as it is almost impossible to reach the center of a large pile of coal, and sometimes the only plan is to allow it to burn out. The increasing use of briquettes, or blocks made of coal dust with tar or other combustible matter as a binding material, seems to have increased the danger in this direction, as these briquettes when stored in large quantities have been found specially liable to spontaneous combustion. A number of instances in Europe could be given of such fires, but the fact of their occurrence is so well known that it is hardly necessary to quote them. Fires have also frequently occurred in the slack heaps or waste dumps of coal mines, and these are usually difficult to deal with.

The literature on this subject practically begins with the report of the English commission of 1876 above referred to. Up to the present time it is entirely in the form of reports, memorials, papers read before societies, and the like, so that it is somewhat difficult to consult, owing to its scattered nature. In the older standard literature Liebig's and Poggendorf's works contain some papers about spontaneous combustion and its origin, while Doring's work on *Fires at Sea* refers to the subject at some extent, but without suggesting any special preventive measures. The German Imperial Ministry of Commerce has published a brief monograph on coal cargoes in merchant vessels, giving general rules for the prevention of fires and some notes on the probable causes of spontaneous combustion. Other articles on this subject were published by Dr. Volger,* by Tatlock,† by Vivian Lewis,‡ by Richter,§ and by Dr. F. Muck.‖ Probably the best collection of information on this subject is that by Dr. L. Hapke,¶ of Bremen. The same author also published several papers on the prevention of spontaneous combustion in coal cargoes.

As to the causes of spontaneous combustion of coal there have been many opinions. It has been attributed to decomposition of the coal itself, to the escape of inflammable gases, to pressure, to a species of fermentation, and to other causes. One opinion is that the occurrence of pyrites in the coal is a frequent cause, since that mineral oxidizes when in contact with air, especially in air containing much moisture, and in this process sufficient heat may be developed to cause fire in the coal. This opinion has been supported by good authorities, such as Liebig, Hapke, and others. Dr. Hapke, indeed, believed that the danger of spontaneous combustion increased with the percentage of pyrites in the coal and quoted a number of instances. It seems probable, however, that the influence of this oxidation of pyrites has been very much exaggerated. More careful study shows that the coals most subject to spontaneous combustion are not those carrying the largest proportion of pyrites. Moreover, the quantity of that mineral in the coal is entirely too small to generate sufficient heat. This opinion has the support of some high authorities. Dr. Richter in a careful study of the subject calculates that where the coal contains 1% of pyrites, should the whole quantity become oxidized, all loss of heat being excluded, the temperature would only be increased by 72°, and in practice even this increase would not be possible under ordinary conditions. Richter and Muck believe that the coal itself when exposed to the action of the air undergoes a partial oxidation and decomposition. The greater the absorption of air the greater will be the development of heat and consequent danger of fire.

Under this view of the question spontaneous combustion may be taken as simply a result of the process usually known as weathering, occurring when that process goes on too rapidly. It has usually been found with the German soft coals that lump coal is less suited for weathering than fine coal, as the latter absorbs oxygen much more quickly. Richter's experiments seem to prove that moisture in the air does not hasten the process of weathering, as no difference was found after the lapse of nine months in coal of the same kind stored in the open air and in a dry place. If these views are accepted it may still be admitted that the pyritic contents of the coal may have an indirect effect, since the oxidation of the pyrites may cause a splitting up of the coal and thus expose fresh surfaces to the air, besides liberating gases contained. In summing up evidence on the subject, Dr. Muck concludes that with coals carrying much pyrites or inclined to absorb oxygen slowly moisture favors oxidation, while, on the other hand, coals which are non-absorbing take up oxygen and heat it more rapidly in dry air.

The conditions favoring this absorption of oxygen and consequent heating and

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* *Hansa, Journal of Marine Affairs*, 1889. † *Journal für Praktische Chemistrie*, 1891.
‡ *Journal of Gas Lighting*, 1892. § *Ibid.*, 1893. ‖ *Chemistry of Stone Coal*, Leipzig, 1890.
¶ *Spontaneous Combustion of Coal in Ship Cargoes and its Prevention*, Bremen, 1893.

spontaneous combustion are the surface attraction, the structure of the coal, and the thickness of the heap of stored coal. With regard to the structure of the coal the dry coals, or, as they are sometimes called, the hard coals, are those in which combustion occurs very seldom, though, it may be noted, many coals of this kind are rich in pyrites. Coals having much ash form a second class, having greater attraction for oxygen than the first, and are somewhat more dangerous. The soft, friable, quick-burning coals have a high surface attraction, and in this kind spontaneous combustion most frequently occurs. That the oxidation of pyrites may have some effect, although only a subordinate one, is shown by the fact that the author has observed several cases of spontaneous combustion in the waste dumps at the Westphalian mines, where the coal was washed and a considerable amount of pyrites was carried off and concentrated in the dumps.

The Prevention of Spontaneous Combustion.—The first and most important rule is that overheating must be prevented. In the coal mines care must be taken to leave no accumulations of broken coal and slack in the workings, since these are a very frequent cause of fire, and care must also be taken to remove the blocks or masses of pyrites which are frequently found in the coal. It is well to take regular measurements of the temperature in the workings and where any considerable increase of heat is shown, to cool them down by means of a strong air current, which may often have the effect of arresting the heating. Such a current, however, must not be used where decomposition has gone too far, as it might increase the force of the fire. Should the fire once start, the first step is to use water if it can be reached; otherwise the best immediate precaution is to close the air passages. The usual method of doing this is to build a barrier or dam in the passage as near the fire as possible. A very useful invention for this purpose was shown at the session of the German General Miners' Union in Hanover in 1895. It is a portable dam invented by Richard Wagner, a mine inspector in Upper Silesia, for closing passages, not only in case of fire, but also when outbreaks of gas occur. In practice it has proved very useful for shutting off the flow of air or gas effectually until a permanent barrier is built up. It sometimes happens that the pressure of gas is so strong as to blow out the dams or to cause leaks; for this reason it is a frequent practice in building a dam to use a pipe which is walled in and is furnished with a pneumatic lock, acting as a safety valve. If all other methods prove ineffectual, the last method is the drowning of the mine. Even this is not always successful, as it has happened sometimes that the fire has broken out again when the shaft was pumped out. A remarkable case of this was found at the Agrape shaft, near Mons, in Belgium, and in this case the fire was finally extinguished by forcing carbonic acid into the mine. The carbonic acid was generated by a coke fire and was then cooled by water and forced into the closed shaft, the up-cast being kept open until all the air had been forced out. The same method was used at a mine in Scotland, in which case the carbonic acid was obtained by passing gases from coke ovens through a lime kiln. In this case high-pressure steam was mixed with the carbonic acid. In any case a mine fire is a very serious matter, and it is a difficult and dangerous labor to extinguish it. It is best to prevent its occurrence.

The prevention of spontaneous combustion of coal on shipboard, where the escape and collection of inflammable gases from the coal forms an additional difficulty, is a matter requiring very careful consideration. On a coal-loaded ship it is well to take frequent observations of the temperature in the hold. Keeping up ventilation either by leaving air channels in the coal or by putting in air pipes to carry away the gases evolved and collected in the heap has been proposed, but in some cases it was found that leaving such air passages only gave a greater opportunity for fire. In loading care should be taken that there is no accumulation of sawdust, chips, or similar inflammable matter, either mixed with the coal or on the surface, the reason for which will be readily understood. Dr. Balke, of Dusseldorf, suggested a system of pipe ventilation, the pipes being set into a coal cargo and so arranged as to secure a constant circulation of air. This method has not been found beneficial. The English commission recommended a careful ventilation of the surface of the coal. In 1891 the *Shipping and Equipment Journal* of Hamburg, Germany, offered a prize for a method of prevention of spontaneous combustion in coal cargoes. A number of propositions were submitted in answer to this offer, and these were considered by a commission of experts, but none of them were approved. For dealing with fire after it has once broken out on shipboard the principal suggestions made were for the use of carbonic acid. Upon the whole this prize competition called out really nothing new, and none of the suggestions made at the time have been tried on a large scale.

On shipboard, therefore, the chief precautions to be taken are frequent measurements of temperature. In loading the ship care should be observed to break up the lump coal as little as possible, since the breaking will decrease its value besides presenting additional surface to absorption. Accumulation of coal dust under the hatches should also be prevented, since experience has shown that it is just here that many fires on vessels begin. Pyritic coal should not be loaded when wet, and steam and water pipes should be kept away from the cargo as much as possible. In storing coal on land the same general rules may be followed, and ventilation of the surfaces should be provided for; it is well also not to make the pile too high. In most cases on land it is well to arrange for wetting down the coal, which will cool off the heap and prevent the temperature from rising too high. At some of the brown-coal mines in Saxony the coal is spread upon the dump in regular layers, pressed down with rollers, and then watered.

In mine dumps the waste water from coal washers, which carries with it the pyrites, should be carried away and not allowed to flow to the dump. Ventilation should be kept up as far as possible, and no wooden ways or bridges over the dump should be allowed. When fire has once broken out in a waste dump, about the only thing that can be done is to prevent it from spreading by cutting a ditch through the pile and filling it up with clay. Water usually does no good; it may reduce the violence of the fire, but does not extinguish it, and as soon as the water is stopped the fire breaks out again. Covering the dump with clay has been tried without effect.

The most that we can say at the present time is that while probably correct ideas as to the causes of spontaneous combustion of coal have been reached, no certain preventives have been discovered. The only measures that can be suggested are to study the structure of the coal itself, to use care accordingly in working, storing, or loading it, and to insist upon close attention and a full sense of responsibility in all who have charge of such loading and storage and upon their workmen.

Coal-Mine Accounts—Itemization.

By W. N. Page.

The first requisite in mining, as in all other regular business, is a complete set of double-entry books, consisting of a ledger, journal, and the necessary cash accounts. Every item on the cash book should be detailed as fully as the journal entries, since they are posted directly to the ledger and are nowhere else explained. On the cash book it is generally necessary to keep two accounts, viz., "Bank Account" and "Petty Cash." The former should embrace every receipt from every source and the latter should be supplied with funds only through the former.

Where the bank is some distance from the office, this can be done by keeping

FORM A.—BANK ACCOUNT.

1896.	Debits.	Cash.	Bank.
January 1..	To balance	$10,000.00	$10,000.00
January 1..	To Smith & Co. (account coal), Check No. 246 on First National Bank of Cairo..	226.15	226.15
January 2..	To Brown & Jones (account coke), Check No. 310 on Mad River National	500.00	500.00
January 2..	To fuel account, cash from William Smith for 6 loads coal	9.00	....
January 4..	To rent account, cash from Kincaid for December rent	5.00	....
January 5..	To store account, cash sales	100.00	....
January 9..	To store account, cash sales	50.00	164.00
	Totals	$10,890.15	$10,890.15

1896.	Credits.	Amount.
January 3..	By E., E. & Co. (bills Dec. 2, 4, 8), Check No. 2670	$500.00
January 3..	By L., H. & Co. (bills Dec. 6, 7, 10), Check No. 2671	425.00
January 3..	By A., B. & Co. (bills Dec. 22-27), Check No. 2672	1,075.00
January 3..	By B. & B. Co. (bills Dec. 30), Check No. 2673	674.00
January 5..	By petty-cash account H. B. D. exchanged for cash, Check No. 2674	500.00
January 9..	By pay-roll account, ourselves per express, balance due on January rolls, Check No. 2675.	48.60
January 9..	By petty-cash account, balance January petty cash, Check No. 2676	164.00
	By balance	7,503.55
	Total	$10,890.15

PETTY-CASH ACCOUNT.

1896.	Debits.	Amount
January 1..	To balance	$250.00
January 5..	To bank account H. B. D. exchanged for cash, Check No. 2674	500.00
January 9..	To bank account, balance January petty cash, Check No. 2676	164.00
	Total	$914.00

1896.	Credits.	Amounts.	
January 1..	By T. W. R., on account	$125.00	......
January 1..	By pay-roll account William Bowles	....	$2.00
January 3..	By V. E. J., on account	75.00	......
January 3..	By stable account, paid G. for hauling feed	15.00	......
January 3..	By traveling-expense account A. B. to Cincinnati	25.00	......
January 5..	By pay-roll account A. C. Williams	....	5.00
January 8..	By freight, telegrams, and express account P. L. J., agent express on casting	1.50	......
January 9..	By pay-roll account Brad. Archer	....	3.00
January 9..	By stable account, paid Wood for shoeing	2.00	......
January 9..	By pay-roll account, total for January	10.00	......
	By balance	660.50	......
	Totals	$914.00	$10.00

two columns on the debit side of "Bank," as shown in Form A. In the column marked "Cash" all receipts are entered, the bank deposits being placed in the column marked "Bank." The difference between these columns at the end of the day, week, or month will show the difference between the receipts and bank

FORM B.—MINING PAY ROLL.............. .....COAL

Name of Employee.	Occupation.		Number.	Number of Pounds of Coal per Diem. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total Lbs.
Wm. Bowles.	Miner..	Dr.	1	$10.00				5.00		.50		2.00																							
		Cr.		11,800	20,100		24,000	24,100	19,900	28,000	15,900	28,000																							171,800
Jas. Morris..	Miner..	Dr.	2	$15.00				1.00	1.00		.50	1.50																							
		Cr.		13,200	13,300		9,000	22,500	17,900	26,800	21,900	13,100																							137,700

deposits, which difference should be in hand and for which a check should be drawn and sent to the bank for debit and credit, thus placing the amount to the debit of "Petty Cash," from whence it can be used without the expense of actual transmission of the currency to and from the bank.

DAY PAY ROLL.... ....COAL

Names.	Number.	Dates. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Thomas Anderson........	1	$2.00			1.50			1.50		1.00																						
		4	4		4	4	4	4	4	4																						
Richard Thomas..........	2	$3.00			1.00	.50		.50																								
			4		4	4	4	2	4	2																						
Thomas Howry...........	3	$2.00				2.00																										
		4	4		4	4	4	4	2	2																						

When the currency receipts are less than the petty-cash requirements it will be necessary to draw the deficiency from the bank, and when in excess the surplus must be transmitted to the bank, by express or some safe method.

In the beginning of mining operations and the opening of regular books the first consideration will be the division of the accounts into "capital" and "working," subdividing each as far as the conditions may require; but as a rule it may be safely assumed that the greater the divisions the more comprehensive will be the details of the business.

COMPANY FOR THE MONTH OF................189

Credits.										Debits.							Balance Due.	Number.
2240 Lbs. Tons Total.	Price Paid per Ton.	Total Am't Due for Coal.	Yardage. Number.	Yardage. Price per Yard.	Yardage. Total Am't	Days' Labor. No. Days.	Days' Labor. Rate per Day.	Days' Labor. Total Am't	Total Credits.	Store Acc't	Rent.	Fuel.	Smithing.	Doctor.	Cash Adv.	Total Debits.		
$76\frac{1560}{2240}$	$0.30	$23.02	5	$0.75	$3.75	..	......	......	$26.77	$17.50	$2.00	......	$0.27	$0.60	$2.00	$22.37	$4.40	1
$61\frac{1060}{2240}$	.30	18.44	9	1.25	11.25	..	......	......	29.60	19.00	3.00	$1.50	.30	.60	......	24.40	5.20	2
......	......	......	..	......	......	..	......	......	......	......	......	......	......	......	......	......	......	..
......	......	......	..	......	......	..	......	......	......	......	......	......	......	......	......	......	......	..
......	......	......	..	......	......	..	......	......	......	......	......	......	......	......	......	......	......	..

As capital accounts relate exclusively to investments, it is necessary to have under this branch such accounts as "Capital Stock," "Land Account" (representing the cost of realty), various construction accounts, such as "Railway," "House Construction," "Coke Ovens," "Machinery," "Mine Development," "Permanent Improvement," "Depreciation," and whatever other expenditure of

COMPANY FOR THE MONTH OF............189

Credits.			Debits.						Balance Due.	Number	Occupation.
Total Days.	Rate per Day	Total Amount	Store.	Rent.	Fuel.	Doctor.	Cash.	Total Debits.			
8	$1.50	$12.00	$6.00	$1.00	$1.50	$0.60	....	$9.10	$2.90	1	Mule driver.
6	1.75	10.50	5.00	1.00	... .	.60	....	6.60	3.90	2	Track layer.
7	1.25	8.75	4.00	1.00	....	.60	....	5.60	3.15	3	Tippleman.
6½	2.00	13.00	3.00	1.50	1.50	.60	$3.00	9.60	3.40	4	Engineer.
7½	1.25	9.37	4.50	1.00	....	.60	....	6.10	3.27	5	Knuckleman.
8	1.50	12.00	5.00	1.00	....	.60	....	6.60	5.40	6	Carpenter.
		$65.62	$27.50	$6.50	$3.00	$3.60	$3.00	$43.60	$22.02		

capital it may be found desirable to keep separately on the records for future reference.

The "working accounts" are of greater utility and importance, since upon them depend all knowledge of loss and gain in the business, and too much care cannot be bestowed upon their arrangement and division. The following names will indicate some of the more important headings, which should be treated separately and individually on the ledger: "Mines Working," "Coke Account," "Freight, Telegrams, and Express Account," "Office Account," "Store Account," "Pay-Roll Account," "Stable Account," "Tool and Supplies Account," "Travel," "Commission," "Insurance," "Discount and Interest Account," "Legal Expense and Tax Account," "Live Stock," "Rent Account," "Fuel," and any other working that may be inventoried and closed out against "Profit and Loss." In addition to these there will, of course, be numerous individual accounts, which are summed up on the balance sheet as "Sundry Creditors and Debtors."

FORM C.—RECAPITULATION OF PAY ROLL.

Coal.	Yardage.	Day Labor.	Total Credits.	Store Account.	Rent Account.	Fuel Account.	Smithing Account.	Cash on Account.	Doctor's Account.	Balance Due.
$117.95	$17.00	$1.50	$136.45	$86.50	$9.00	$3.00	$1.37	$7.00	$3.00	$26.58
....	....	65.62	65.62	27.50	6.50	3.00	....	3.00	3.60	22.02
$117.95	$17.00	$67.12	$202.07	$114.00	$15.50	$6.00	$1.37	$10.00	$6.60	$48.60

In order to minimize these individual accounts as far as possible, to save time, labor, and consequent liability to error, numerous auxiliary forms and sheets are kept for the purpose of consolidating the regular entries, the most important of which are the "Mine and Day Pay Rolls" (Form B). These rolls are filled out

FORM D.—DISTRIBUTION OF LABOR.

Mines working account:		
Mining $393\frac{380}{2240}$ tons coal at 30c.	$117.95	
Yardage	17.00	
Day labor	55.12	
		$190.07
House construction account:		
Carpenter at work on new houses		12.00
Total pay roll		$202.07

and balanced for one week, to illustrate the manner in which they are kept. By these sheets the debits and credits of all miners and laborers—frequently aggregating a thousand or more names—are consolidated, and the aggregates only for

FORM E.

1	1	1	1	1	2	2	2	2	2	5	5	5	5

.............................., W. VA., ..., 189

The .... *COAL COMPANY*

WILL PLEASE PAY

TWO DOLLARS to the bearer in Merchandise, less amounts punched, and charge the same to my account.

$2.00 ....

5	10	10	10	10	10	10	25	25	25	25

the week or month are carried to the journal and ledger. A recapitulation of "Pay Roll" and "Distribution of Labor" is illustrated in Forms C and D, in which shape it is carried to the journal and debited against the proper working, capital, or individual accounts, as the case may be.

In order to avoid accounts in the store, numerous forms of credit, or evidences of indebtedness to bearer, have been devised, that shown in Form E being one of the simplest forms, and is signed by the employee as an order on the company store, to whom the full amount is charged on the pay roll when accepted, which acceptance is evidenced in red ink across the face with proper signature. When-

FORM F.—WEEKLY STATEMENT.

No. 5. ...., January 9, 1896.

MR. WILLIAM BOWLES,

In account with the .... COAL COMPANY.

By .... days at ...... per day....................................	......	
By $76\frac{1560}{2240}$ tons coal at 30c. per ton..................................	$23.02	
By 5 yards at 75c. per yard....................................	3.75	
By .... ovens at ...... per oven....................................	......	
Total credits..		$26.77
To store account..	$17.50	
To house-rent account..	2.00	
To fuel account..	......	
To smithing account...................	.27	
To doctor's account..	.60	
To cash on account..	2.00	
Total debits..		22.37
Balance due..		$4.40

This time check is not transferable and will only be paid to the party to whom issued.

Received payment in full,

WILLIAM BOWLES.

ever the pay roll is closed and balances struck a statement (Form F) is issued to every name a few days or a week before pay day, in advance of which any error is corrected; but on that day the employee hands in this statement receipted in exchange for an envelope containing his balance in currency. By this method 500 men can be paid off within an hour, as each statement and envelope is numbered consecutively and no arguments or corrections are permitted at that time.

When a miner obtains employment he usually comes to the office with an order

FORM G.

Check No. 1.			Check No. 2.			Check No. 3.			Check No. 4.		
Car No.	Weight.	Dock.	Car No.	Weight.	Dock.	Car No.	Weight.	Dock.	Car No.	Weight.	Dock.
115	4,000	....	14	4,700	....	....	....	....	....	....	....
96	4,200	....	52	4,500	....	....	....	....	....	....	....
38	3,600	....	47	4,000	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....
	11,800			13,200							

for his "checks" and receives 10 or more brass disks, about the size of a silver dollar, stamped with the name of the company and the same number on all, with a hole by which they can be hung upon a hook in the car. At the same time his name is entered upon the mining pay roll and the number on the checks assigned him is entered on same line in a column for the purpose. If the miner so desires no one outside of the office need know his number, as it is not associated with his name elsewhere; consequently neither the weighmaster nor the dock boss is presumed to know anything more than the number of the car which they weigh and dock. Before loading the miner hangs one of his brass checks on a hook inside and near the bottom of his car, making a note of the car number stamped on the outside of every car. When loaded this check cannot be seen or exchanged (as is sometimes done when differently placed) until the car is dumped, when the weighmaster enters the weight under the corresponding number on his weight sheet (Form G) and hangs the check on a board similarly marked. He also enters the car number and docks, if any, for each separate car. At the close of each day the weight sheet is turned into the office after being

FORM H.—THE..................COAL COMPANY.

1896.	Billed.	Loaded	W.B.No.	Car Initials.	Car No.	Gross Weight	Car Weight	Company's Net Weight	Consignee's Net Weight	Consignee.	Destination.
Jan....	1	1	1	A. T. & S. F.	18,672	82,700	26,500	56,200	56,200	John Smith, fuel agent..	Savannah, Ga.
Jan....	1	1	2	A. T. & S. F.	19,124	87,600	27,600	60,000	60,000	John Smith, fuel agent..	Savannah, Ga.
Jan....	1	1	3	A. T. & S. F.	17,368	80,700	26,000	54,700	54,700	John Smith, fuel agent..	Savannah, Ga.
Jan....	1	1	4	A. T. & S. F.	18,326	83,600	26,600	57,000	57,000	William Jones...........	Seville, Ga.
Jan....	1	2	5	A. T. & S. F.	18,194	82,700	25,900	56,800	56,800	William Jones...........	Seville, Ga.
Jan....	1	2	6	A. T. & S. F.	17,358	80,100	26,200	53,900	53,900	William Jones...........	Seville, Ga.

checked with the board referred to (the number of brass checks and entries must agree), and the totals are credited to each name corresponding with the numbers on the pay roll. On the following day the sheet and board containing the checks are hung up where every miner can have free access to them, and at the most convenient time each man takes his brass numbers from the board and checks his previous day's work, noting the weights if he desires. It frequently happens that the miner forgets to hang his check in the car before loading, consequently when dumped no number is found. In such case the car number and weight is

FORM I.—DISPOSITION OF COAL.

	Pounds.	Tons.	Per Ton.	Totals.
Sold railroad company..........	634,600	$283\frac{880}{2240}$	$0.80	$226.65
Manufactured into coke..........	176,140	$78\frac{1420}{2240}$	.80	62.91
Used at mines for steam.........	5,000	$2\frac{520}{2240}$	.80	1.78
Fuel account sold employees....	8,960	4	.80	3.20
Sold Smith & Brown.............	56,000	25	1.00	25.00
Totals...........................	880,700	$393\frac{380}{2240}$	....	$319.54

entered in a separate column on the sheet, marked for the purpose, and when the miner finds that he is short on the sheet he reports the car numbers he loaded that day, and it is invariably traced and properly credited unless there has been carelessness or fraud. The total weights on the sheet are the sum of the mine cars, and when there are track scales, on which the railway cars are weighed, the two scales should be checked to within a reasonable difference.

In railway shipments it is necessary to keep a shipping book after Form H, and at the end of the month this book is summarized, as shown in Form I, for the journal entries.

As the books and auxiliary accounts must be closed to get results, and since this cannot be done every day, it is often desirable to have a daily report approximating the actual cost as clearly as possible, and such report should not only show any material variation, but should also indicate where the difference may be found. Such daily reports are given (Form J) for six days. For the purpose of

FORM J.—DAILY REPORT OF MINE COST.

THE......................COAL COMPANY, January 6, 1896.

No.	Names.	Cost per Day Each.	Total Cost per Day.	Date.	No. Tons Coal Run.	Total Cost.	Cost per Ton.
18	Mules	$0.50	$9.00	1	796	$119.08	14.9c.
18	Drivers	1.50	27.00	2	815	122.83	15.0
2	Locomotives	2.40	4.80	3	840	122.80	14.6
2	Foremen		7.12	4	819	123.13	15.0
2	Trackmen	1.50	3.00	5	822	119.98	14.6
	Timbermen			6	800	121.58	15.2
1	Laborers	1.25	1.25	7			
1	Fanrunners	1.50	1.50	8			
3	Trappers	.60	1.80	9			
2	Smiths	2.00, 1.50	3.50	10			
2	Overhaulers	1.50	3.00	11			
1	Oilers	.60	.60	12			
3	Knucklemen	1.25	3.75	13			
2	Incline repairs	1.25	2.50	14			
1	Weighmasters		2.88	15			
3	Tipplemen	1.25	3.75	16			
1	Loaders	1.25	1.25	17			
	Pumpmen			18			
				19			
				20			
				21			
				22			
	Props, caps, and ties		3.00	23			
	Yardage		35.61	24			
	Oil and waste		2.00	25			
	Bank rails		3.15	26			
	Lumber		.62	27			
	Nails and spikes		.50	28			
	Coal used			29			
	Miscellaneous			30			
				31			
	Monthly total		$121.58		4,892	$729.40	

Coal mined, 800 tons 300 lbs. Average cost labor (per week or month), supplies, and yardage per ton of 2240 lbs., 14.9c.; cost of mining (contract) per ton of 2240 lbs., 30c.; total cost, 44.9c.

comparison the totals are carried forward each day, but the details on each report refer to one day only.

While some of the items are necessarily assumptions, the totals at the end of the month should check very closely with the books and the difference should be less than 1c. per ton in cost. The mining price per ton being a fixture is not on these reports, which cover what is ordinarily known as "dead work" only.

Each mine must, of course, arrange its forms and accounts to meet every peculiar condition. The above is intended merely as a general guide to a system by which one bookkeeper and assistant can and do perform all the office work in connection with a plant employing 800 men, with an average output of about 2000 tons of coal daily, and a large block of coke ovens.

The Fire-Damp and Coal-Dust Question in Germany.

By R. Zörner.

The principal questions which at present occupy the technical staffs of most of the German and other European coal mines are (1) the best means to diminish the danger of fire-damp explosions and (2) to avoid the dangers arising from coal dust.

Attempts to diminish the danger of fire-damp explosions are not of recent date, and important results have been obtained, although we still hear occasionally of serious disasters which cause losses of life and of money. While coal-mine managers are continually studying to prevent such disasters, they are at the same time aware that small explosions will occur in coal mines in spite of the greatest care. It is encouraging to say that where the best direction is followed serious accidents occur less frequently than before, losses of life are less appalling, and the destruction of property is limited. The results which have been reached will be especially appreciated when we consider the haste with which coal mining has to be carried on at present under the spur of competition.

1. The chief means adopted to diminish the danger of fire-damp explosions are:

A. Improvements in the methods of ventilating the mines, either by improving the old ventilators or by introducing separate ventilation.

B. Limitation of blasting and more caution in the use of explosives.

A. Natural ventilation is in vogue in Germany only in mines that are perfectly safe. Ventilation by means of furnaces is seldom used. The method generally adopted is the forced circulation of air by various devices. The number of these plants has greatly increased and their construction has been much improved in most of the mining districts. But as the corners and edges in the entries and chambers can be only imperfectly ventilated, though from 2 to 6 cu. meters of air per man be rushed through the mine, the so-called separate system of ventilation has been successfully introduced in most of the dangerous mines. The motive power used for the main ventilators is generally steam, but lately electricity has been introduced. With small ventilators any available motive power is employed. Freely circulating air, as used formerly in the Saxon mines, is out of date, and air is now blown through a shaft or is so directed as to act upon the heads of the ventilators.

Where water power or electricity is available advantage is usually taken of these. Excellent results have been obtained with the water jet when conduits or pipes with sufficient pressure and corresponding outlets are provided. Mines where such arrangements have been properly utilized in the Saarbrück district and in Westphalia have often reduced the expenses of ventilation to 50% of the former cost.

The cost of ventilation in the Koenig Mine, near Saarbrück, which has a length of 1400 meters and 1000 meters of lateral development, in which 10 seams of coal are worked on three levels, amounted, without head ventilation and with parallel passages, to 44,000 marks; including parallel in passages and separate ventilation the cost was 26,000 marks; with separate ventilation alone, 13,000 marks. Separate ventilation thus presents not only the advantage of being safer, but is also cheaper. The first cost of the improvements mentioned above amounted to about 25,000 marks.

B. Limitation of blasting and care in the use of explosives.

Under the existing pressure of competition it is impossible to do away with blasting, but it should either be used only in safe coal seams or else a less dangerous method employed. Lately pick and gad (wedge) work has been adopted with success in place of blasting. This can be done in coal, but the success of this method is questionable in rock. Here the use of François & Pichardy's wedges, or gads, had to be abandoned and other devices adopted. Greater safety in blasting can be secured—

(*a*) By appointing blast foremen, selecting for this purpose reliable and experienced men, who would supervise the blasting and clearing of the coal and whose pay should not depend on the quantity of coal taken out. With a daily output of from 80 to 100 tons of coal, calculating 1 ton per man per shift, one such blast foreman would be sufficient; this would not increase very much the expenses of production.

(*b*) By prohibiting the employment of slow-burning explosives. When efforts were first made to find a proper substitute for the black powder which had been generally used for blasting, the erroneous idea that the greater the breaking power of an explosive the less danger existed led to the introduction of dynamite in its most powerful forms. It was only gradually, after trying various explosives, which were mostly ammoniacal combinations containing flaming mixtures and often nitroglycerine, that the use of so-called safety explosives was adopted. These are exclusively employed at present in most of the dangerous mines, and though they are much inferior to black powder in obtaining lump coal, they do not increase the cost of production.

(*c*) By improved methods of firing. Taking into consideration the fact that even the safest explosives are not devoid of danger, it may be said that the fuses of Von Roth, Norres, Tirman, and Lauer are equal to electric firing; but, as in the case of safety explosives, no final results have yet been reached, though many improvements have been made in this line.

2. The progress made on the Continent in diminishing the danger lurking in the accumulation of coal dust in mines is quite as important as the question of avoiding fire-damp explosions.

It has been ascertained that with the increase in depth and consequent rise in temperature accumulations of coal dust have been found in coal mines which were formerly free from them. This required the introduction of spraying devices with a view to obtaining the following results:

(*a*) To overcome, or rather prevent, the danger arising from the formation of coal dust by using jets of water under high pressure, thus forcing water through the crevices and cracks formed in the coal seams by the pressure of the superincumbent rocks.

(*b*) To eliminate the coal dust which is produced during the mining of coal or its transportation by occasionally moistening it and washing it off with a hose or by means of a permanent current of water. The first method is generally used in the rooms, the second in the galleries or tunnels.

(*c*) To localize any explosions which may take place by means of water gates or wet zones from 50 to 100 meters long, which would prevent the spreading of the explosions. These so-called wet zones are a success and have rendered very good service in time of accidents, as was, for instance, the case at the Albion Colliery, near Pont-y-Prydd, in Wales.

As in many other enterprises, the introduction of improved safety appliances is delayed by economic considerations. The question of first cost often obscures the fact that a single mine explosion, caused either by fire damp or by an accumulation of coal dust, is apt to throw back for years the development of a mine, and that the cost of repairs often amounts to a very large sum, besides the loss caused by stoppage of operations.

We are not surprised, therefore, to see that many well-managed coal mines threatened by fire damp or by the danger arising from coal dust are voluntarily adopting some of the methods described, without waiting for action by the mine-inspection officials. The fact is that safety arrangements, though expensive, pay well when they prevent a mine explosion.

BY-PRODUCT COKE OVENS.

By W. H. Blauvelt.

The American people have attained a preëminent place among the nations of the world in the mechanical arts, but have not shown the same ability to lead in the chemical industries. The undeveloped condition and wonderful natural resources of our country are perhaps partly responsible for this, as the needs for mechanical invention and development have been great and the rewards large. But the results obtained in continental Europe and the changing conditions here have at last forced upon our attention possible economies and profits from the solution of chemical problems that can no longer be neglected.

Prominent among these problems is the utilization of the enormously valuable products of the distillation of bituminous coal that are entirely wasted in the manufacture of coke by the ordinary methods. In localities where the markets are favorable it is no exaggeration to say that the value of the salable products now destroyed is equal, at prices recently ruling, to that of the coke produced.

That this condition of affairs should have continued so long in this country, while on the continent of Europe coke makers have been saving their by-products for many years until there are now but few plants of beehive ovens in all Europe outside of England, is doubtless explained partly by the opening sentence of this paper, partly by the excellent quality of the coals that have been the main supply of our ovens, and partly by the strong prejudice that has existed both in this country and in England against coke made in retort ovens. This prejudice is the more remarkable in view of the fact that outside of these two countries the beehive oven has been abandoned to an extent illustrated by the fact that when a well-known American engineer visited the Continent recently for the purpose of comparing the work of beehive and retort ovens he found his errand futile, there being practically no beehives available with which to make the comparison.

England has clung to the old practice as tenaciously as we have and has refused to take the hint from her northern sister, Scotland, where many of the iron furnaces using raw coal as fuel might almost be said to be making pig iron for the sake of the by-products obtained from the furnace gases. Large sums have been spent in equipping these Scotch furnaces with apparatus for condensing the tar and ammonia in the tunnel-head gases, and the reports of the success of the plants have been very encouraging. But in the south the coke ovens continue to furnish illumination to the country side as well as coke to the furnaces, although the extra cost of retort ovens is less and the returns therefrom greater than in the Scottish condensation plants that are in successful operation.

In this country the furnace-man, accustomed to the perfection of the coke made in the beehive oven from our beautiful Connellsville coal, has scouted as impossible the suggestion that a coke differing in any respect, whether essential or not, from his standard could be worthy of consideration. That beautiful silvery glaze of deposited carbon that does not appear on cokes quenched without the oven is a *sine quâ non,* although the most careful tests in the laboratory and furnace top fail to show any greater loss by the action of hot carbonic acid on the coke unprotected by this glaze. Notwithstanding the results of years of experience in continental Europe and the acknowledged profits from the retort ovens, any proposed departure from established methods has met with scant encouragement. But changing trade conditions, low prices, and severe competition have effected a turn in the tide.

Careful investigation of the several types of retort ovens in use in continental Europe has been made by several prominent American engineers, coal has been sent from here to be coked, and other tests have been made until conviction has come that the retort oven is really capable of making merchantable coke at a greater profit than the beehive, and now there are in operation or in course of construction in this country one or more plants of several of the leading types of retort ovens. We are therefore just at the beginning of another great step forward in our metallurgical practice; and in the manufacture of iron, where such a large proportion of all coke made is used, the retort oven will enable us to turn our backs on the last link that held us down to the rule-of-thumb practice of the past.

We mine some of the best ore in the world with steam shovels at a cost of but a few cents a ton, and before this volume reaches the hands of many of its readers we shall have furnaces that will convert the ore into iron at the rate of 500 tons of metal a day; but our beehive coke ovens belong to an earlier age, to the time when an output of 20 or 30 tons of iron was a remarkable day's work for an iron furnace, and prices were so high that it was only necessary to make iron in order to make money. But to smelt our cheap ore in our splendid furnaces let us erect by-product ovens at the furnace and make our coke where every part of the coal is recovered and utilized, down to the small amount of heat lost in the waste gases that are too cool even to make steam.

The advent of the by-product oven into this country and the interest it is awakening suggest an inquiry into the origin of these ovens and into their development from their beginnings up to the present time.

Development of the By-Product Oven.—The earliest chronicled attempts to turn into useful products the riches so long wasted by the coke makers are credited to one Stauf, the *philosophus per ignem* whom Goethe found in 1771 living in his little hut at the foot of the Burning Mountain near Saarbrücken. He had experienced some of the difficulties that later metallurgists have struggled with in attempting to "cleanse the coal from sulphur for use in iron works," for in the attempt to "also turn the oil and resin to account, not even losing the soot," his chronicler relates that "all failed together on account of the many ends in view," and at the time of Goethe's visit the "connected row of furnaces" was already falling into ruins. From other sources we learn that these ovens were in operation as early as 1760, if not before. Stauf's failure seems to have discouraged further attempts of any moment, and although some experimenting was done, but little advance was made until 1854, when Pauwels and Dubochet erected retort ovens in which the gases were used only to heat the ovens, no tar or ammonia being saved.

Carl Knab at St. Denis, near Paris, following more closely the old *Kohlenphilosoph*, Stauf, in 1856 erected and operated ovens with flues beneath the bottom and saved the tar products. His oven, like the cruder construction of Stauf, was essentially a low-temperature apparatus, and the oils would resemble the petroleum oils, while the tar was similar in composition to the shale tars. The ammonia liquor, oil, and tar ran from the retorts in a liquid condition and were separated by gravity.

A few years later Carvès added side flues to Knab's design, and the by-product oven in its essentials became a fact, although it was not until 1881 that the condensation of ammonia and tar from the gases was a success along with the production of a good quality of coke.

Profiting by Carvès' improvement, the Pauwels-Dubochet oven was modified by the introduction of side flues, and in 1870 two plants were supplying much of the illuminating gas used in the city of Paris, as well as making what was considered a good quality of metallurgical coke. These ovens were about 23 ft. long, 6½ ft. high, and 3¼ ft. wide; the temperatures were low and the gas supplied was of low illuminating power, so that it had to be enriched with ordinary bench gas. Carvès had already discovered the advantages of a narrower chamber and was building his ovens 24 in. wide, thereby obtaining better coke and gas. The earlier ovens had fireplaces in which a coal fire was constantly kept burning to augment and regulate the heat from the gas flame, but more perfect combustion and preheated air have made these unnecessary, although less gas is now burned in the flues than when the fireplaces were in use.

While Knab, Carvès, and Pauwels-Dubochet were at work in France, Huessener was following the same line in Germany and developed the horizontal-flue oven in important particulars. At the same time Coppée in Belgium had brought out an oven with vertical flues in the side walls, connected with the oven by openings at the spring of the arch. The volatile products of distillation passed directly from the ovens into these flues, and burning there produced the heat for combustion, but of course no ammonia or tar was saved. This type of oven was afterward modified by Lürman and by Hoffman and Otto so that the by-products were saved and the washed gases brought back to furnish heat for firing the ovens externally.

While all these types were being worked out in France, Germany, and Belgium, England did but little. Her large supply of excellent coking coal did not demand the development of the narrow retort oven, and attempts to save the by-products were chiefly confined to improvements on the beehive oven, either by a partial or intermittent combustion within the oven and the condensation of what ammonia and tar remained unburned, or by the use of bottom and side flues for the external heating of the oven by the combustion of the washed gases. But these ovens were hard to keep in repair, the yield of by-products was not large, and the quality of the coke was in many cases inferior; so that but few plants passed the experimental stage.

Thus we have followed the development of the by-product oven from the early attempts of Stauf down to the types from which the successful ovens of to-day have directly sprung, and it is apparent, as Mr. Watson Smith has pointed out, that these different designs, many of the less important of which have not been mentioned in this brief *résumé,* have all sprung from three "root forms," namely: first, the modified beehive oven (itself a development of the "meiler" of the charcoal burners); second, the Coppée oven; third, the Knab-Carvès oven.

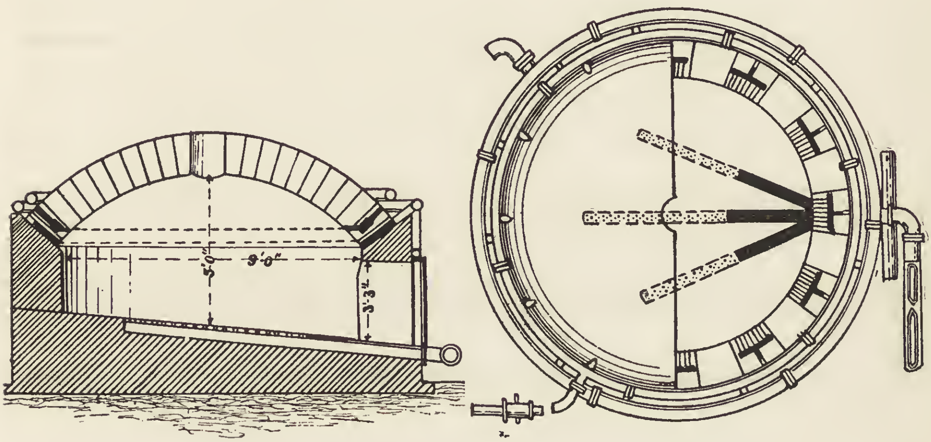
The beehive oven is a dome-shaped structure into which air is admitted, burning the gases and some of the coke to furnish the heat necessary for the process of coking. Both the Coppée and Knab-Carvès types are horizontal closed ovens, the gases evolved being used for heating the ovens from without, no air being admitted to the coke. They differ mainly in the arrangement of the flues by which the ovens are heated; the Coppée, as detailed above, having vertical flues in the side walls, while the flues of the Knab-Carvès ovens were horizontal. Each product of these root forms has its advantages and its claims for outliving its competitors, but the fitness by which any one may survive its rivals may perhaps depend as much on the development of details as each type is evolved and perfected as on the value of any essential feature of construction.

The By-Product Ovens of To-Day.—A clearer idea of the lines on which these root types have developed may be obtained by a review of some of the by-product ovens that are attracting attention to-day. As intimated above, these may be considered under three divisions—the modified beehive, the Coppée type or vertical-flue retort oven, and the Knab-Carvès type or the horizontal-flue retort oven.

The Modified Beehive Oven.—The modification of the beehive oven for the saving of the by-products has been attractive to many inventors, for a successful design of this type would permit the utilization of the present plants and at the same time it would not be so great a departure from proved forms as to frighten the ultra-conservative. We find, therefore, especially in England, where the rich, easily coking coals did not demand a narrow oven, many patents for beehive ovens in which the by-products were saved.

Among the many inventions we need consider only a few of the more prominent. Henry Aitken, of Falkirk, England, first in 1874 and J. Jameson in 1882 described their ovens, and the aim of both has been to alter the beehive oven as little as possible, while adapting it for saving part of the tar and ammonia. Their designs are quite similar, each having flues beneath the oven and connected with it by small openings in the floor, through which the tar and ammonia liquor are drawn by suction after the combustion of the coal has been well started on top. In Jameson's oven a portion of the gas and tar withdrawn from one oven was returned to an adjacent oven that had reached a more advanced stage of combustion. The purpose of this was that the carbon from these hydrocarbons might be deposited on the coke in order to harden its cellular structure, while the subsequent combustion of the separated hydrogen supplied heat for coking. Although these ovens promised well for a time, much trouble was experienced with the flues and openings in the bottom, which became clogged with dust and tar. Moreover, the air could not be kept out of the flues and much ammonia and gas was thereby burned and destroyed.

A. D. Shrewsberry, of Charleston, W. Va., has patented within a year or two a beehive oven with a double dome; the lower dome is perforated, the air being admitted through the holes in one half, and the gases withdrawn by an exhauster through the other half after a partial combustion has taken place. The purpose of the inner dome is to heat the air previous to its entering the oven, and to assist in regulating or distributing the draught so that the process of coking may take place evenly. The inventor introduces into the oven and into the flue leading to the condensing apparatus "electro-positive and electro-negative elements connected with suitable circuit wires." He states the object of this arrangement as follows: "The purpose of these elements is to secure a galvanic action within the oven to so act on the gases that they may be purified in such a manner that the chemical combination arising from the decomposition of the various elements during the process of coking may be brought about more readily and increase the



Section. Plan.

AITKEN'S MODIFIED BEEHIVE OVEN.

amount of ammonia." He does not state to what extent the yield of ammonia is increased by this device.

The Newton-Chambers oven is the most recent adaptation of the beehive for saving by-products that is in actual use, the one plant in operation at this writing being about four years old. The modifications from the standard beehive type consist of, first, a clay pipe or flue running horizontally around the dome of the oven, close to and behind the inwall, through which all the air for the combustion of the coal passes and is heated, and, second, a hole cut through the bottom of the oven through which all of the products of combustion are taken. These gases then pass through a surface condenser consisting of a series of vertical thin cast-iron U-pipes arranged each side of the oven door. In these pipes the crude oil and most of the ammonia saved are condensed, after which they are collected in tanks and separated by gravity in the usual way. The gas passes on to an ordinary scrubber, in which the last of the ammonia is removed, and is then burned under boilers. No tar is made by this process, which would seem to indicate that the temperature of the ovens is rather low. The inventors claim a yield of 8 to 10 gals. of crude oil and from 15 to 20 lbs. sulphate of ammonia, and a gain of about 10% in the yield of coke as compared with the ordinary beehive, the hot air used "preventing the combustion of any fixed carbon." The yield of ammonia seems high in view of the fact that the heat for coking is obtained by at least a partial combustion of the hydrocarbons within the oven. One hundred of these ovens are in operation near Sheffield, England, and 100 others are building. A plant of 30 is nearly completed in Western Pennsylvania. These ovens are drawn and the coke is handled by machinery, with a saving, it is claimed, of 50% of the labor usually employed.

Pernolet, Klönne, Westermann, Otto (in his modified beehive), and others have departed further from the usual beehive practice, and have heated the oven externally by burning the gases in flues under the bottom. Westermann and Otto have each adopted regenerators for preheating the air for combustion, these being placed on top and extending between the two rows of ovens. An unprejudiced comparison shows, however, that the beehive shape is not the best for uniform and rapid coking when heated from without, and these designs are but a half step toward the more perfect retort oven.

Regarding the yield of tar and ammonia from ovens internally heated, Lunge has said "it is an admitted fact that no coke oven where air is admitted into the coking chamber yields tarry products similar to ordinary coal tar—that is, such tars as contain a considerable quantity of benzene, naphthalene, anthracene, and other aromatic hydrocarbons employed as first materials in the manufacture of artificial dyes and colors. Obviously the yield of ammonia from these ovens is decidedly less than from closed ovens, the admission of air being very prejudicial to its production; some of the ammonia is evidently directly burned. The tars formed are largely low-temperature products, rather oils than tars, and are rich in the paraffines, so that their market value is low."

It is hardly probable, therefore, that the modified beehive oven will be able to withstand the competition of the retort oven with its large output of coke, greater value of by-products, and reduced labor cost, after the capital now invested in beehive plants has ceased to be a factor, and the alternative is between the erection of the modified beehive and the retort oven.

The Retort Oven of the Coppée or Vertical-Flue Type.—The Belgian oven, which is the earliest form of the Coppée type, is an outgrowth of the conditions that were met with during the early development of the coke industry of Belgium, and many of the general principles governing its construction are common to all retort ovens. In coking the dry coals of the Continent it is apparent that economy of heat and its rapid application are of high importance, and the externally fired oven with narrow coking chamber and thin flue walls is the logical result of the requirements. The width and height of the coking chamber were proportioned to the quality of the coal, the dryer coal requiring the narrower oven. The gases from the distillation passed through holes under the arch of the oven into vertical flues in the walls separating the ovens. Mingling with air drawn in by the chimney draught, the gases burned in these flues and beneath the oven and then passed off to the stack. These ovens gave an increase of yield of about 10% as compared with the beehive. Of course no by-products were saved.

The Coppée Oven.—This oven is a development of the principles of the Belgian oven and is numerically the most important of all the retort ovens. No by-products are saved in this type, and its economy compared with the beehive in coking rich coals consists merely in the increased yield of coke and the use of waste gases for steam raising. It has the advantage of less first cost than retort ovens having by-product apparatus and is equally efficient in coking lean or dry coals.

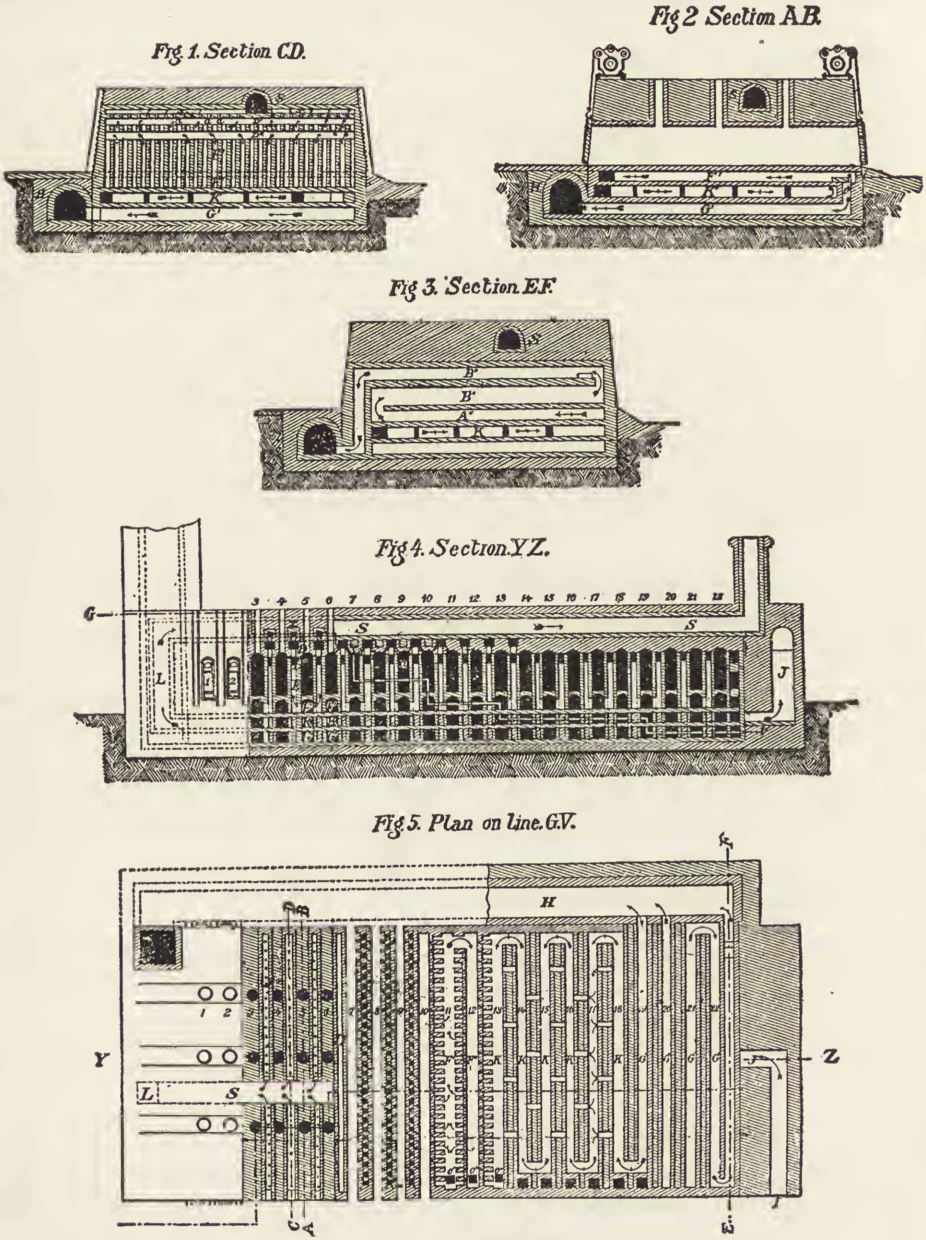
This oven is also an outgrowth of the needs of the Belgian coke makers and has been in use on the Continent over 30 years. It was introduced into England in 1873, and several plants have been erected in the United States. It preserves the main principles embraced in the design of the Belgian oven, but is much more carefully worked out in its design and operation than the Belgian. It is generally built in blocks of 20 to 30 ovens. The following description of the Coppée oven is taken largely from a paper by C. M. Percy.* The plans and sections given herewith and referred to in the following description embrace a block of 22 ovens, with chimney and other apparatus.

Fig. 4 represents a longitudinal section passing through the middle of the side wall of an oven, on the line *C, D,* Fig 5. Fig. 2 shows a longitudinal section through the middle of the oven, on line *A, B,* Fig. 5. Fig. 3 shows a longitudinal section passing through the middle of an end side wall, on line *E, F,* Fig. 5. Fig. 4 shows the cross section and elevation, on line *Y, Z,* Fig. 5. Fig. 5 is a plan from the line *G, V,* Fig. 4. The way in which the gases are traveling is shown by plain arrows, while the course of the air is shown by crossed arrows. The gas escapes from the ovens through 28 openings, *A,* situated on both sides of the oven, into the horizontal flue D_1, where it meets and mingles with the hot air brought by the flue *S* and small flues *X*, X_1. The perfect combustion of the gases takes place in the horizontal flues D_1, D_{11}. The inflamed gases descend through 28 vertical flues, E_1, into the flue F_1, situated under the floor of the odd-numbered oven; in this flue F_1 the gases of the two side walls, communicating with the same flue under the floor, mix together. The gases run from one end of the flue to the other in the flue F_1 and then pass into the flue F_{11}, situated under the floor of an even-numbered oven; next the gases go through the opening O_1, reach the flue G_{11}, situated under the regenerating air flues, and ultimately flow into the main flue *H,* which takes the gases to the boilers or to the chimney as the case may be. In the flues F_1, situated under the floor of the odd-numbered ovens, an opening, O_1, is provided with a damper which regulates the admission of gases into the lower flues G_1 and G_{11}. The requisite air for the combustion of gases is taken from the outside by an opening, *I,* situated in the end buttress wall; then it descends to reach the regenerating flues *K* from one end of the block of ovens to the other. These air flues are situated between gas flues F_1, F_{11} and G_1, G_{11}. The air which enters from the outside of the opening *I* leaves the flues *K* through the opening *L,* having been brought to a temperature of 320 to 430° C.

This hot air ascends the shaft *L* and reaches the flue *S,* situated on top of

* *Colliery Guardian*, London.

ovens. Out of this flue S the hot air is divided by the small flues X_1, X_{11}, situated above each side wall, into the flues D_1, D_{11}, also situated above the side



Coppee Coke Oven.

walls and immediately under the flues X_1, X_{11}. The ovens are discharged by a ram engine which pushes out the coke, first out of the odd-numbered ovens and then out of the even-numbered ovens, so that each newly charged oven finds itself between two others in full operation and highly heated. These new charges begin generating gases at once, which, escaping on both sides through the 28 openings, enter the flues D_1, D_{11}, mingling with the hot gases of the adjoining ovens and the hot air supplied through the flues X_1, X_{11}. When using very dry coals the alternate charging and discharging of the ovens is claimed as an important help in obtaining the diffusion and maintenance of an even heat. With coals richer in volatile matter this is not so important. These ovens are constructed of varying height and width, as may be required for coking coals of different compositions.

The Coppée oven has been perfected under the control of Dr. C. Otto & Co., of Germany, and as the Otto-Coppée oven is recommended by them as specially suited to those who do not desire to make the extra investment for the by-product plant. All the gas distilled from the coal is burned around the ovens, but it is stated that by passing the waste heat under boilers from 1 to 1½ lbs. of water can be evaporated per pound of coal coked. In this country the cost of erection is about $1000 per oven.

The Otto-Hoffman Oven.—This oven is a development of the Coppée type combined with the Siemens regenerator. It has been successfully and largely introduced by Dr. C. Otto & Co. in Germany, and one plant of 60 ovens has recently been started in this country. The following description of this oven and its accompanying by-product plant is taken from a paper by B. Leistikow, read before the German Mining Engineers in 1892.* The method for the separation of the by-products is given quite fully, as it is in general the system in use in all coke-oven works, whatever may be the style of oven.

The Otto-Hoffman ovens are narrow chambers 16 to 24 in. wide, 33 ft. long, 5 ft. 3 in. high to the spring of the arch, and are closed at both ends by luted doors. The construction of these ovens is based on a combination of the Siemens regenerator, adapted by Hoffman, with the ordinary Otto oven, to which a large number of improvements have been added. Figs. 6, 7, and 8 show sections of an Otto-Hoffman coke-oven plant. On the right side, marked a, is the pushing engine; the coke is discharged on the left, where it is cooled. There is no direct connection between the coking chamber and the side flues. In the arch over the oven there are three openings, c, through which the coal is charged into the ovens, and two openings, d, through which the gases evolved in coking pass off. Under the base of the arch, in the side walls, there are horizontal flues, e, which connect the entire system of vertical flues. The bottom flues f, running lengthways of the oven, are divided by the side walls g into two equal halves, h and i. Each of these halves is connected with regenerators, R, R_1, used for preheating the air necessary for the combustion of the gases. To each half of these base flues gas admission pipes, p and p_1, are connected, which are fed through the gas-supply pipes q and q_1. The regenerators are long brick chambers filled with checkerwork running across all the coking chambers. A reversing valve connects them at one end either with the air-distributing pipe k or with the chimney.

As soon as the oven is charged and the coking process in operation the gases evolved escape through the openings d d into the supply pipe, as in a bench gas plant, and from thence through the opened valve into the gas receiver, from

* *Stahl und Eisen*, September, 1892.

which they pass through the conductor v into the condensation plant. From the latter the gases, freed from their by-products, tar and ammonia and benzol, are returned to be burned around the ovens. On the way to the ovens is a reversing

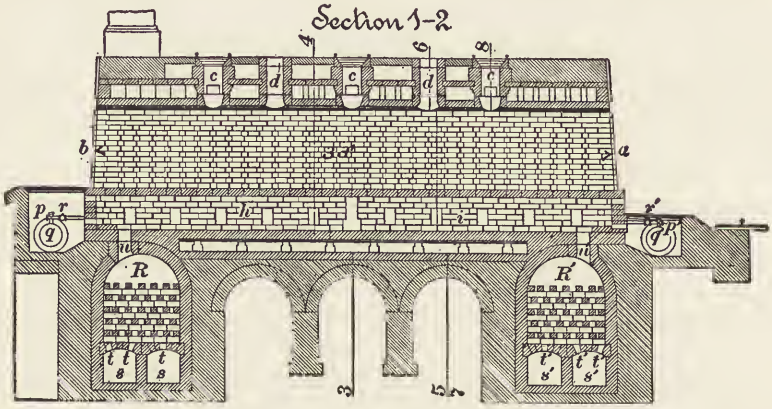


FIG. 6.—OTTO-HOFFMAN COKE OVEN.

valve which leads the gas at will into the supply pipe q or q_1. When the gas enters through the pipe q and passes through the pipe p by means of the cock r into the half h of the bottom flue, then the reversing valve is so set that the blast

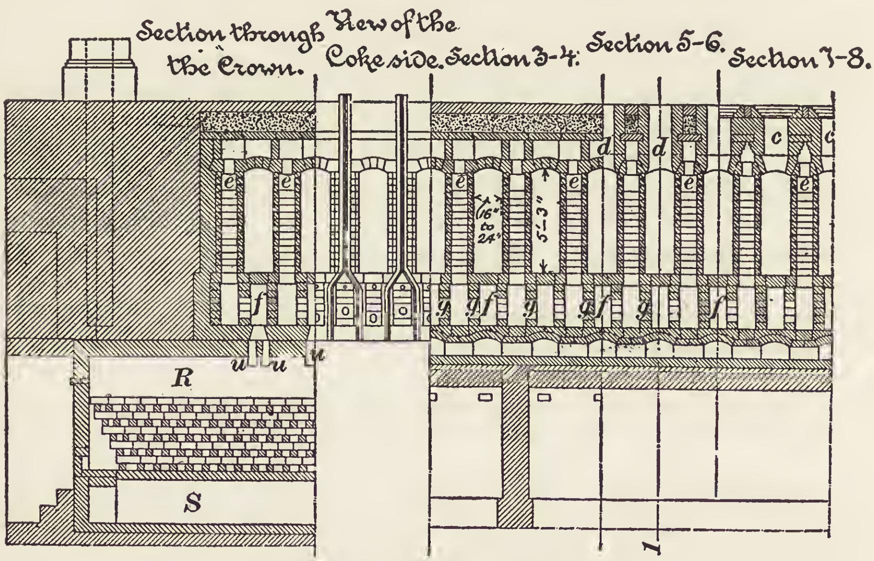


FIG. 7.—OTTO-HOFFMAN COKE OVEN.

enters the flue s and thence through the small opening t into the regenerator R and is heated there, passing upward through the small openings u, u_1 into the bottom flue h, where combustion takes place. The heated products of combustion pass through the side vertical flues, then to the horizontal flues e, and downward through the other vertical half to the bottom flue *i*, from thence through the opening u_1 into the regenerator R_1, heating it and passing it through the small openings *t* into the flues s_1 s_1, and from thence through the air valve to the chimney. The valves are reversed after a certain time and the gas takes the opposite direction.

In the earlier development of this oven it was thought necessary to preheat the gas as well as the air. For this purpose a second pair of regenerators was arranged alongside of the others. This, however, was discontinued, as it was found to be better to heat the necessary air, amounting probably to ten times the volume of the gas, to a high temperature than to heat the comparatively small volume of gas, thus running the risk of explosions. So in all later plants only one regenerator has been used. These regenerators preheat the air to about 1000° C., thereby re-

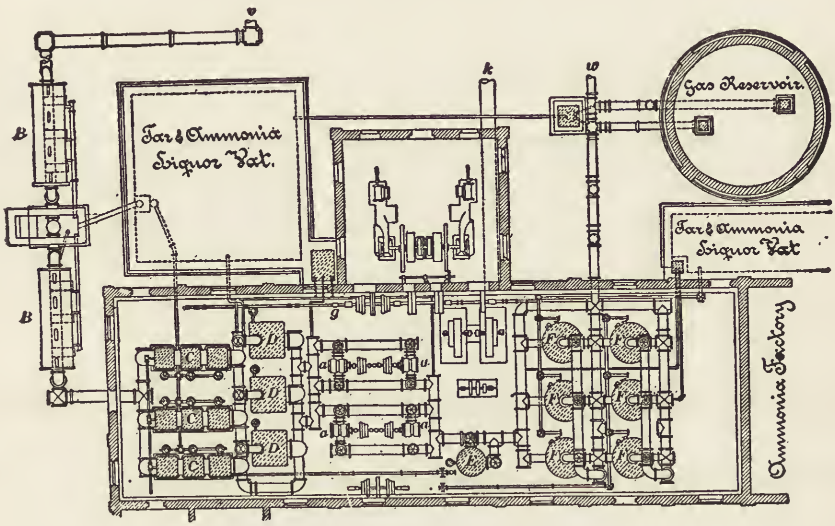


Fig. 8.—Condensation Plant.

ducing the amount of gas necessary to heat the ovens and leaving the excess for other purposes. The gases evolved from the ovens pass through the valve into the receiver and are aspirated into the condenser by the exhauster *A*. On its way to the condenser the gas passes into a separator, *B*, wherein it is cooled by air and separated from particles of dust and much of the tar. The gases now pass into the condenser *C*, consisting of a square wrought-iron box in which are arranged a large number of wrought-iron tubes through which cold water flows. The gases travel around the tubes, while the products of condensation—tar and ammonia liquor—continually run off below.

After the gases have passed the cooler they arrive at the scrubber *D;* this is square and the gas is distributed through a number of tubes which are immersed in water. In the scrubber the gas is first washed with weak ammonia water and then with pure water, and the remainder of the tar is precipitated. The apparatus is so constructed that the water continuously enters at the top and flows off at the bottom. This water, together with the products of the air and water coolers, passes into a large cistern, where the tar and ammonia liquor separate by their specific gravities. The gas passes through the exhauster *A* at this point and begins to be compressed. This compression causes the temperature of the gas to rise several degrees, and it is therefore passed through another cooler, *E*, to reduce it to a minimum temperature of 13 to 18° C. After leaving the cooler *E* the gas flows into the bell washer *F*, where it is distributed to a number of bells, the edges of which are toothed and extend under the water, whereby the gas receives a thorough scrubbing. The washer contains from 4 to 6 shelves, one under another, and the water flows from above downward; the gas takes the opposite direction and is always driven against the fresh water, whereby it is completely separated from the tar and ammonia. The purified gas may now be conducted to the ovens for combustion, unless it is desired to separate the benzol, which is done in some works by a secret process. The gas before being forced into the pipes q and q_1 is led through a small holder, which acts as a pressure regulator and indicator; a constant pressure is necessary to insure constant temperature in the ovens. The usual temperatures are found to be as follows:

In the hearth flue	1200–1400° C.
In the side walls	1100–1200° C.
In the regenerators at the beginning of the air supply	1000° C.
In the regenerators at their ends	720° C.
In the chimney	420° C.

The tar, which separates at the bottom of the cistern by reason of its weight, is conveyed by a wall pump to the high receiver *H*, from which it may be run directly into cars and taken to the refineries.

The ammonia water from the cistern is pumped to the receiver *T*, from whence it is piped to the distilling room of the ammonia factory. In this latter are two column apparatus, *O*, of the Grueneberg-Blum system (in other works Dr. Feldmann's apparatus is used, with equally good results), each capable of working 30 tons, in which the water passes downward from column to column, coming in contact with a current of dry steam, which takes out the ammonia and carries it with it. In an apparatus situated above the columns the ammonia is set free from its compounds by milk of lime, which is pumped into the apparatus from the lime reservoir *Q*. The steam, saturated with ammonia, is led into sulphuric acid in the lead-lined chambers *P*, where it is converted to ammonium sulphate, or into the condenser *K*, where it is taken out as ammonia water. When the chamber acid is neutralized the liquor is drawn off and the salt removed to the draining platform *T*, from which, when the liquor has entirely drained, it is transferred to lead-lined tanks. If the ammonia water is simply condensed in the cooler *K* it runs into the receiver *U* (holding about 10 tons), from which it may be piped into tank cars for transportation. The sulphuric acid may be stored in the receiver *V*, to be run off by means of air pumps or siphons as needed into the boxes *P*. The waste water, which runs off from the apparatus *O*, is led into tanks, where the lime settles out.

The cost in the United States of the Otto-Hoffman oven is stated by its representatives to be about $250,000 for the usual block of 60 ovens, with by-product apparatus, building, coal larries, etc.

The Horizontal-Flue Retort Ovens.—The various modifications of this type are all outgrowths from Carvès' modification of the old Knab oven. About 1860 Carvès added horizontal side flues to Knab's design, which had flues only in the bottom, and his ovens have been worked for a long time in France. As these

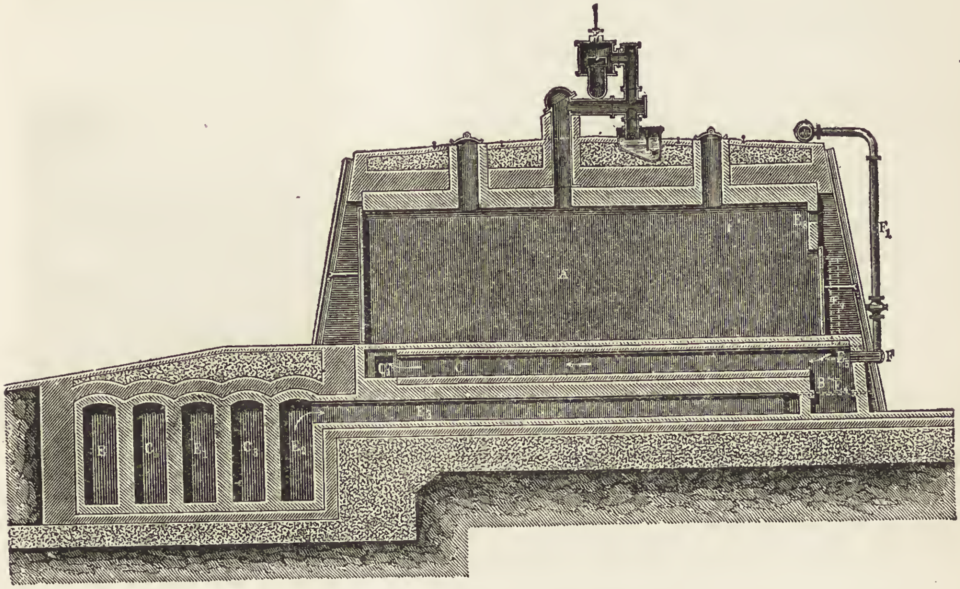


FIG. 9.—SIMON-CARVES COKE OVEN.

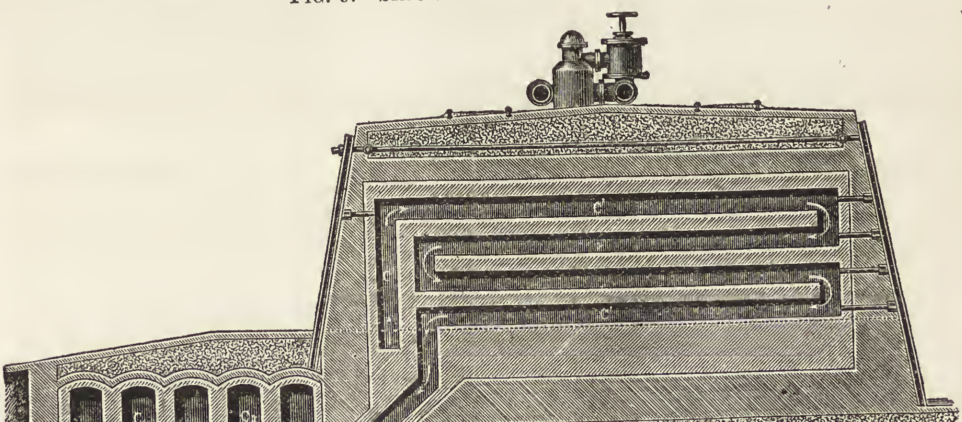


FIG. 10.—SIMON-CARVES COKE OVEN.

ovens are now out of date a full description of their construction is unnecessary. Their design was similar to that of the improved Simon-Carvès oven described below, but without the recuperators.

The Carvès oven was improved by Henry Simon, who in 1883 added recuperators for preheating the air for combustion by means of the heat in the waste gases, thereby overcoming some difficulties that Carvès had found in the distribution and economy of the heat from the burning gases.

Figs. 9–13* illustrate the main points of the design of this oven. Fig. 9 is

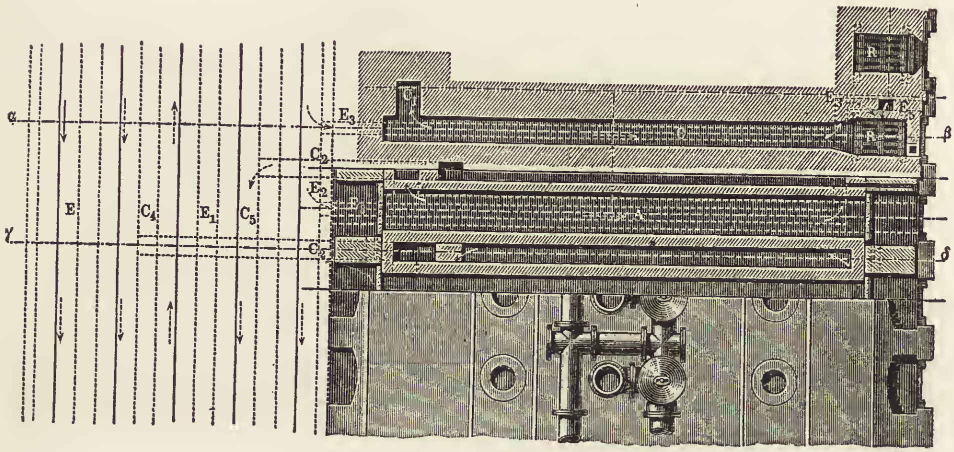


FIG. 11.—SIMON-CARVES COKE OVES.

a longitudinal section through a coking chamber and a cross section through the air and chimney gas flues of the recuperator; Fig. 10 is a longitudinal section through the partition walls, showing the flues in which the gases are burned; Fig. 11 is a part plan and part horizontal section of the coking chambers and

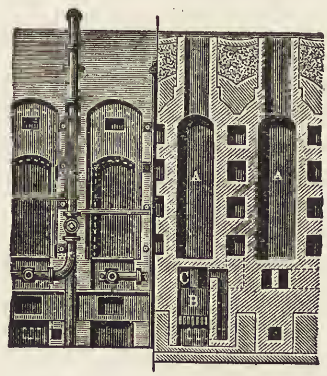


FIG. 12.—SIMON-CARVES COKE OVEN.

flues; Fig. 12 is partly front elevation and partly cross section; while Fig. 13 is a horizontal plan on a smaller scale of the flues for air and waste gases. These ovens are 23 ft. long, 18 to 20 in. wide, and 6 ft. 6 in. high. They are heated by the gas, which enters by the pipe *F* and is ignited over the grate *B*. The

* From Lunge's *Coal Tar and Ammonia*.

products of combustion pass along under the bottom of the oven, rising to the top in C_1, pass back and forth twice between the ovens, and escape by C_2 to the recuperator. This is composed of a series of parallel passages through which travel the hot escaping gases and the incoming air in opposite directions and in alternate passages, E, E_1, and E_2 being for the air and C_4 and C_3 for the hot gases. The heat is transmitted through the thin brick walls. After leaving the recuperator the gases may be used for steam raising, evaporating, etc.

The air for burning the gas after being heated by contact with the hot walls of the recuperator passes through the branch flues E_3 to the combustion chamber, where it meets the gas entering through the pipe F. The hot-air flue may also be led up the front wall of the oven, supplying air to burn any unconsumed gases in the horizontal flues C_1. The charge of coal is about 5½ tons to each oven and the coking time is about 48 hours. The coal is charged through the openings in the roof on each side of the gas exit G, and is leveled off in the usual manner through the doors, which are afterward tightly luted with clay. The gas valve is then opened and the coking operation commences; the gas passes into the hydraulic main shown over the middle of the oven and then on to the by-product apparatus, where it is freed from ammonia and tar. Whatever amount is needed

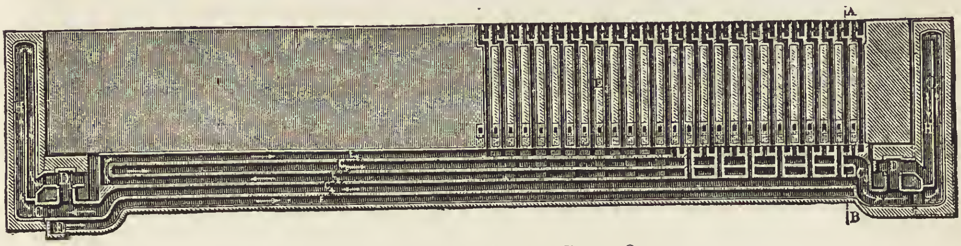


FIG. 13.—SIMON-CARVES COKE OVEN.

for heating the ovens is then brought back through the pipe F and burned as described above, the remainder being available for other uses. When the coking operation is completed the doors are opened, the coke is pushed out by the usual mechanical ram, and is quenched on the platform shown at the left of the drawing. The ovens are then ready for another charge.

Another line of development of the recuperator for use in coke ovens is illustrated with varying details in the ovens bearing the names of their designers, Huessner, Semet-Solvay, Festner-Hoffman, Siebel, and others. These different designs have each their several claims to superiority over the others and have met with varying degrees of success in practical use. A brief review of the salient points of some of these designs will suffice to show their differences and relative merits.

The Huessner oven, shown in the accompanying illustrations* (Figs. 14–16), differs from the Simon-Carvès principally in the arrangement of its regenerators. The dimensions of the oven are: length, 29 ft. 6½ in.; width in the middle, 1 ft. 10½ in.; height, 5 ft. 11 in. The available space in these ovens is about 88% of the total, and they take a charge of 5½ tons of coal. The charging takes place in the usual manner through four holes in the roof, the ends are closed by hinged

* From Lunge's *Coal Tar and Ammonia*.

doors, and the coke is pushed by the usual steam ram. The walls between each two ovens carry the three flues in which the gases are burned, and in one design these flues are shown* 19 in. high and 12 in. wide, the walls between the flues

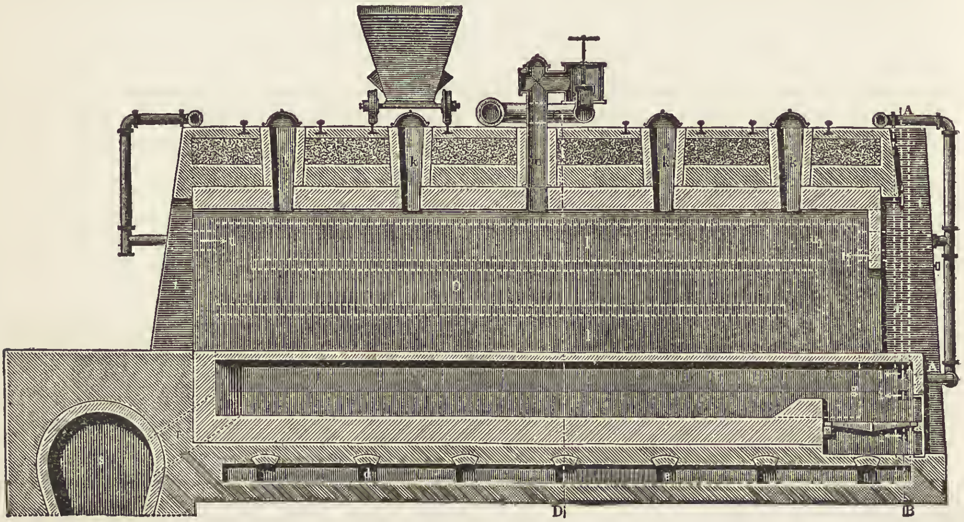


FIG. 14.—HUESSNER COKE OVEN.

and the oven being 6 in. thick. The ends of these walls are strengthened by buttresses, which at the same time prevent the air from entering the flues.

The gases are aspirated by means of an exhauster through the outlet and are forced through the condensers and scrubbers; they then return to the ovens and

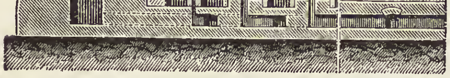


FIG. 15.

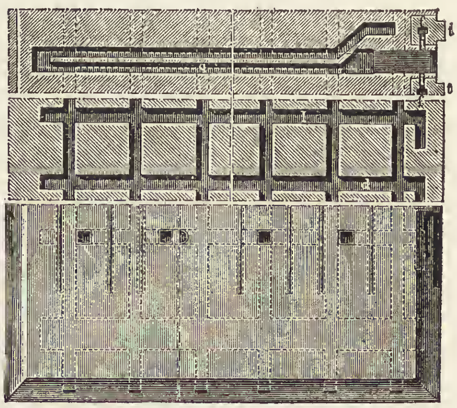


FIG. 16.

HUESSNER COKE OVEN.

issue by the tube *A* over the fire grate, where they ignite. The flame travels around the partition *Z*, rises at one end and up into the top flue *l*, and descends through the three horizontal flues *l* into the main chimney flue *S*. The mouth

* Dürre, 1892.

of the gas inlet pipe A is an annular double tube like a Bunsen burner, the outer tube conveying the gas, the inner the hot air for combustion. Additional gas is added in u and u_1, thereby giving a uniform heat throughout the flues. The air for combustion is heated to about 300° C. in the flues d, e; it then passes through f and meets the gas at g and u. According to recent statements the charge of coal is 7 tons and the time of coking 48 hours. It is stated that the cost of these ovens in America is about $2700 to $2800 each, including the by-product apparatus.

The Semet-Solvay oven is shown in the accompanying cuts (Figs. 17–22). This oven departs from the Carvès type more than the other horizontal-flue ovens, especially in the arrangement of its flues. Instead of only one set of flues in each side wall, the flues being built in the wall, the designers have made the wall solid, with flues composed of large hollow tiles on each side. Thus they claim for their design that each oven has its own independent flues, and all the weight

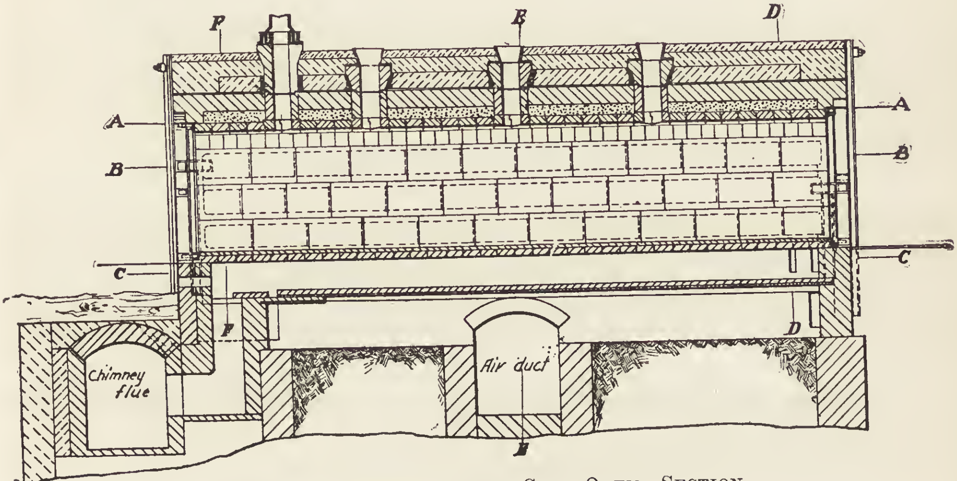


FIG. 17.—THE SEMET-SOLVAY COKE OVEN—SECTION.

of the heavy mass of brickwork in the roof, as well as that of the coal cars, tracks, etc., is supported on the solid division walls and not on the hot thin walls of the flues. Thus the walls of the flues through which the heat has to pass to the ovens can be made much thinner, as they have no weight to support, and the flue temperature necessary to get a given heat in the oven is of course lower than in flues with thicker walls. The heavy wall between each oven, besides taking the weight off the thin flue walls, serves an important purpose as a reservoir of heat which keeps the temperature of the ovens uniform and prevents sudden changes in temperature of the flue tiles when the ovens are opened at charging time. The arrangement of the tiles with the expansion space above the oven, which permits the tiles to expand and contract without affecting the main body of the brickwork, is claimed as a valuable feature in prolonging the life of the oven and permitting repairs to be made without disturbing the main structure. This oven was originally designed to coke the "dry" coals (those low in bituminous matter) of Belgium, but it has proved equally successful with pitchy coals and those running as high in volatile matter as 40% or more.

The coking chamber is usually 30 ft. long, 16 to 17 in. wide, and 5 ft. 6 in. high. The width is somewhat increased when coking pitchy coals, as in other

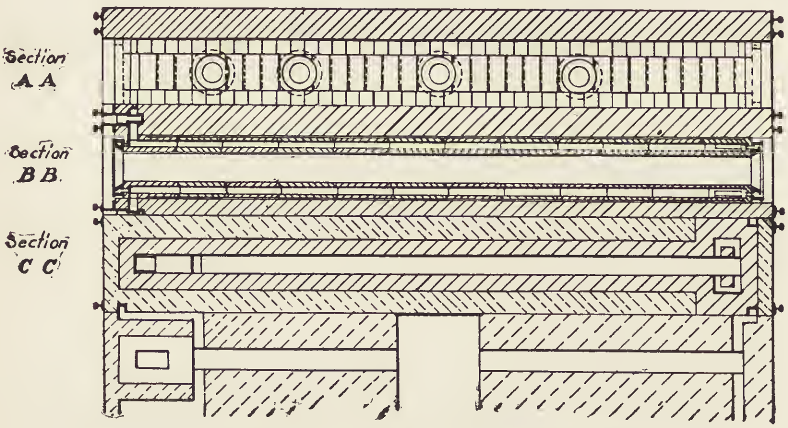


Fig. 18.—The Semet-Solvay Coke Oven—Sectional Plan.

ovens. The coal is charged in the usual manner through the three charging holes in the roof, while the gas escapes through the fourth opening to the hydraulic main and by-product plant. The portion of the gas necessary for heating the ovens is returned in a pipe running in front of the ovens just beneath the

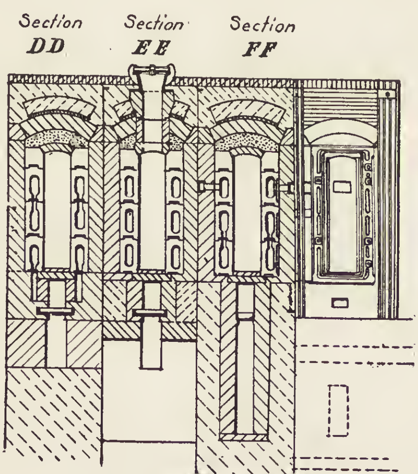


Fig. 20.

Fig. 21.

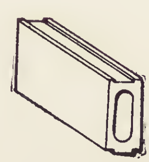


Fig. 22.

Fig. 19.—The Semet-Solvay Coke Oven—Cross Section.

surface of the ground, and is delivered into the end of each flue, or more usually into the middle and upper ones. There it meets the air that has been heated by the recuperative system below the ovens, and complete control of the temperature of each flue is maintained by regulating the proportions of gas and air. The waste gases pass from the flues to the recuperator, where the air is heated to the necessary temperature without any special attention. The waste heat from the recuperators is used under boilers to raise steam for pumping water, exhausting gas, etc., in the by-product works. The thin flue walls and even distribution of the heat in the flues permit high temperatures to be maintained in the ovens without danger of overheating the brickwork. This allows rapid coking and a larger output of coke than in ovens having thicker flue walls. A leading authority gives the time of coking as about 30% less than that of its chief competitors. The following temperatures have been observed in the flues of this oven: Top flue, 950–1100° C.; center flue, 1100–1400° C.; lower flue, 1000–1350° C.; chimney flue in front of ovens, 600–800° C. The great difference between the temperature of the lower flue and that of the chimney flue is due to the well-developed recuperator system, which robs the gases of their heat after they have done their work and transfers it to the incoming air, which is either blown into the recuperators or drawn in by the chimney draught.

These ovens are usually built in batteries of 25 or 50, the larger number permitting the most economical use of labor and machinery. The cost of these ovens in this country is given as somewhat less than $150,000 for a block of 50, with by-product apparatus and machinery complete.

On low volatile coals these ovens have a record of over 1500 tons of coke per year per oven. On account of the easy transference of heat through the thin walls of their flues, the time of coking is shortened considerably in comparison with other retort ovens. The usual time of coking is from 18 to 22 hours, against 30 to 48 hours in ovens having thicker flue walls.

The Festner-Hoffman oven was designed to be an improvement on the Otto-Hoffman oven in those particulars wherein the latter seemed faulty to the designer. It does not differ greatly, except in the recuperator, from the Huessner oven that has been fully described. It was developed by Festner with the aid of Hoffman, one of the inventors of the Otto-Hoffman oven. The special purpose of the design was, according to the inventor, to dispense with the reversing of the regenerators, to highly heat the air for combustion, and to get the benefit of the horizontal flues, which the inventor had found in his experience to be much easier to heat uniformly and more convenient for inspection than the vertical flues. The recuperative arrangement is quite efficient; the air passes over a considerable surface of hot brickwork, is constantly split up by impingement upon small brick piers, and reaches the combustion chambers at a temperature of 900° C. A fan is used for supplying the air, to prevent a difference of pressure between the oven and the flues and consequent leaks of oven gas into the flues.

Siebel's oven was specially designed to provide the same application of heat to the coal as is obtained in the beehive, viz., from the top downward. The construction of his oven does not differ essentially from others of the Simon-Carvès system, but the designer seeks to attain his object by burning the gases only in the top flue, thereby making it the hottest. The fresh coal when charged chills the lower part of the oven, and the arch and top flue remaining hot, the distillation begins at the top and the gases are distilled from the coal in the same way as in the beehive, thereby improving (it is claimed) both the structure and the yield of the coke.

The Barnard oven is the only design combining vertical flues with recuperators, and the inventor states that when it is desired to save the by-products horizontal flues are substituted for the vertical ones. A battery of 54 of these ovens is in

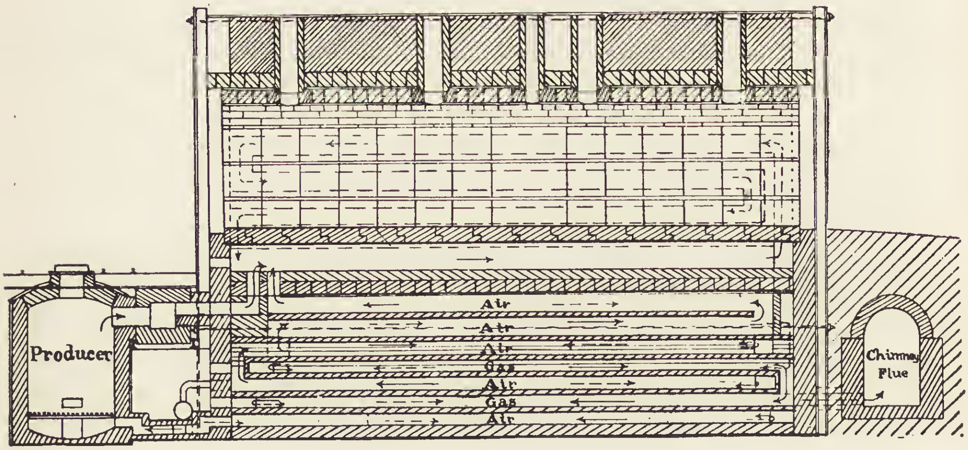


Fig. 23.—Slocum or Full-depth Oven.

operation in Nova Scotia on local coals, and when carefully washed these coals are reported to make a fairly good furnace coke in these ovens. The vertical-flue ovens do not differ essentially from the Coppée in design or method of operation.

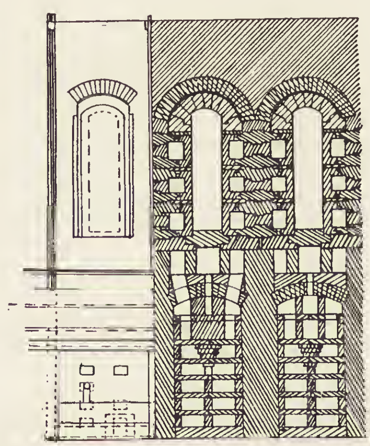


Fig. 24.—Slocum or Full depth Oven.

The capacity of the oven is about 6 tons of coal and the time of coking is from 40 to 48 hours.

The Slocum or full-depth oven, of which Dr. F. L. Slocum, of Pittsburg, is the patentee, has been designed with the intention of combining the best points of the Huessner and Semet-Solvay ovens. The designer states that the special feature of this oven is the tile shapes used in the construction of the flues. These shapes are designed to admit of being replaced at little cost and of changing the thickness of tile or the width of the oven at will. This construction is shown in the accompanying sketch. The oven may be used either with or without the recuperative arrangement. There have as yet been no ovens built on this system.

Any comparisons of the relative merits of the different retort ovens cannot be conclusive without fuller reports of results gotten by the several ovens under similar conditions than are as yet obtainable. Regarding the details of construction, the tendency seems to be toward thinner flue walls and more rapid coking. The vertical and horizontal flues have each their advocates, with perhaps an increasing number in favor of the latter plan. From the published statements of the temperatures of flues and time required for coking a charge in representative ovens of each of the types, the advantage in economy of construction and heat seems to be rather with the ovens having horizontal flues.

As quoted in previous descriptions of the ovens, temperatures in the flues of representative vertical and horizontal flue ovens are as follows:

VERTICAL-FLUE OVENS.	
In the side walls	1100–1200° C.
In the hearth flue	1200–1400° C.
In the regenerators at hot end	1000° C.
In the regenerators at cool end	720° C.

HORIZONTAL-FLUE OVENS.	
In the top flue	950–1100° C.
In the center flue	1100–1400° C.
In the lower flue	1000–1350° C.
In the chimney flue in front of ovens	600– 800° C.

This shows that the temperatures maintained at various points roughly corresponding are about the same, and that the gases give up about the same amount of heat in the 12 ft. of vertical flues and the regenerators of the one oven as in the 120 ft. of travel in the three horizontal flues and recuperator of the other.

In the type of horizontal-flue oven from which the above figures are obtained the shorter time of coking reported, due to the thin flue walls, would indicate that as the temperatures of the flues and waste gases are maintained at about the same point, the total amount of gas burned per ton of coal coked would be less than in the slower ovens—about in proportion to the time of coking.

THE PRODUCTS OF THE BY-PRODUCT OVEN.

Coke.—The essential distinction between the retort oven and the ordinary beehive is that in the former the coal is coked without the admission of air by heat applied from the outside, while in the latter the air is admitted to the oven and the combustion takes place immediately over the body of coal. The result is that in one case the hydrocarbons are simply distilled off, with a certain breaking down and deposition of graphitic carbon on the coke, so that a yield of coke greater than the so-called "theoretical" can be counted on, while in the other case the most of the hydrocarbons are burned in the ovens, some graphitic carbon is deposited, and some of the fixed carbon of the coal is burned, resulting in a yield of coke less than the theoretical. As an illustration of the difference in yield resulting from this difference in method of coking, a good yield of coke from Connellsville coal in a beehive oven is 65%, while in a good retort oven it is easy to get 75%, an increase of about 16%. Of course this increase reduces proportionately the percentage of ash, phosphorus, etc., remaining in the coke, so that the retort oven yields more coke and a purer coke than the beehive from the same coal. This increase in yield varies with the proportion of fixed carbon, ash, etc., in the coal.

The quality of the coke made in the by-product ovens has long been a subject of discussion, especially among the blast-furnace-men of Europe. The English authority, Sir Lowthian Bell, made a series of careful tests a number of years ago and pronounced against the coke in comparison with that made in beehive ovens, and his conclusions were accepted by English ironmasters. But improved construction and practice have combined to produce a better coke, and it is reported that Sir Lowthian Bell has modified his views and no longer condemns the product of the retort ovens. On the Continent retort-oven coke is now the standard, and in this country we are just beginning to realize that a coke not made in the old beehive oven and not having the famous silvery gloss of coke quenched in the oven is proving itself quite equal to it in fuel value.

The essential difference between beehive and retort oven coke lies in its hardness and shape, caused by the different application of the heat in the oven. In the beehive the coal is spread out in a thin layer 23 or 24 in. thick over a surface some 12 ft. in diameter. The bottom of the oven having been cooled by the quenching of the previous charge and by contact with the new one, the coking begins at the top and extends downward, reaching the bottom in from 32 to 34 hours. The coke has ample opportunity to swell and develop a cellular structure in accordance with the composition of the coal, and entirely independent of any attempts at control. The typical form of beehive coke is therefore long finger-like pieces, narrowing toward the bottom of the oven and with an inch or two of spongy coke at each end. The inability to control the formation of the cells makes it essential that just the right coals are used, or the requisite hard body, resistant alike to pressure and the action of hot carbonic acid in the blast furnace, cannot be obtained. The fact that the coal from the Connellsville district gives just the requisite structure when coked in the beehive oven is the reason for its present preëminent position as a blast-furnace fuel in America.

In the retort oven the coal lies in a high narrow mass, about 5 ft. high and from 16 to 20 in. wide. The previous charge having been pushed out rapidly by machinery and quenched outside, the oven is hot when the fresh charge is introduced and the evolution of gases begins immediately from the coal lying in contact with the hot sides. The flow of gases being from the sides, they meet in the center and rise to the top, where they escape, forming a sort of cleavage plane midway between the two walls. Thus the pieces of retort coke are stouter than the long, slowly developed "fingers" of the beehive oven, and are a little shorter than half the width of the oven. The end of the piece next the wall is denser and the end next the cleavage plane is more spongy than the main body.

The cellular structure is more compressed than beehive coke, principally on account of the narrow retort that permits no expansion in the direction of the flow of the gases, and also because the depth of the charge is usually about two and one-half times as great as in the beehive. The cellular structure of retort coke is dependent somewhat on the proportions of the ovens, the temperature, and time of coking.

The ability of the retort oven to coke coals that cannot be used in the beehive is due to the more rapid application of the heat, fixing the pitchy or coke-making portion of the coal before it has time to escape and the formation of a firm cellular structure by the pressure.

Taking Connellsville beehive coke as the standard, it has yet to be definitely determined, by prolonged test in the blast furnace, just what effect the increased hardness of Connellsville coal coked in retort ovens will have on its value as a blast-furnace fuel.

It is quite within the bounds of possibility that some of our American coals, equal in chemical purity to the Connellsville, yet inferior to it in adaptability to the conditions of the beehive oven, may prove to make a coke in the retort oven that will be of equal value in every respect with the Connellsville beehive coke. Indeed, experiments already made would seem to point in that direction.

Objection has been made to the retort coke on the ground that it is watered outside of the oven, thereby destroying the carbon glaze found on coke quenched within the oven and increasing the percentage of moisture in the coke. Careful tests have proved that retort coke is somewhat more resistant to the action of hot carbonic acid in the top of the furnace than is beehive coke from the same coal, which seems to show that the carbon glaze has in practice no value. The absence of a glaze on retort coke is no indication that carbon is not deposited from the gases, for in the first place the yield of coke is always higher than the so-called "theoretical" yield, and in the second place, as the coke is leaving the oven the glaze can plainly be seen, but its brightness is destroyed by the water.

A long series of tests have shown that coke properly quenched outside of the oven need not contain over $\frac{1}{4}$ to $\frac{3}{4}\%$ of moisture, but the amount of moisture in the coke after its arrival at the furnace is altogether another question, and depends more on the time it is on the road and on the humidity of the atmosphere than on the method of quenching.

The effect of moisture in the upper part of a blast furnace is an open question. Experiments have been made by leading furnace-men which indicate that its cooling action on the ascending gases saves the coke in a measure from solution in the hot carbonic acid and permits more coke to reach the zone of fusion, with the result that the fuel consumption is noticeably lowered.

The great and final test, from which there is no appeal, is the blast furnace; and only by long-continued trials under varying conditions can the relation of the retort-oven coke to our almost perfect standard, the Connellsville beehive coke, be thoroughly determined. But to the great bituminous coal fields of this country, to which the Connellsville district does not bear the relation of one to the hundred, the retort oven comes with a promise of help. Many coals that, although pure enough chemically for metallurgical use, make a soft coke in the beehive oven, when coked in the retort oven give a structure so hardened and strengthened that the product is an entirely acceptable metallurgical fuel. In other cases, when the impurities are too great for furnace or foundry use or the structure is hopelessly weak, or when the coal is dry and lies dead in the beehive without a suggestion of coking, a coke can often be made in the retort oven that is easily salable for domestic purposes, brewers' and maltsters' use, and for many other uses where a clean-burning fuel, free from smoke, is desired. The demand for coke for these purposes is growing rapidly, and the supply of this market should be very profitable in a properly located and designed plant, from which the gas and other by-products would have a ready sale.

The ability of the retort oven to coke coals that have hitherto been considered non-coking brings into prominence the subject of laboratory tests of coals for coking purposes and of the coke made. A chemical analysis of the coal or coke, while important, does not fully indicate its value, and physical tests are quite as important. The well-known coke expert, Mr. John Fulton, has made an extended investigation of the physical properties of coke, and has developed a system of tests that will show very completely the relative value of any coke for blast-furnace or other metallurgical uses.

The coking qualities of a coal are hardly shown at all by an ordinary chemical analysis, and an actual test in the oven is the usual method for determining this point. A laboratory method for making this test has been recently developed by Louis Campredon in the laboratory of the Vignac Works, France. His method is similar to that used in ascertaining the binding power of cement. The principle is the mixing of the coal with an inert body and carbonizing the mixture in a closed vessel; the greater the binding or coking power of the coal the more inert matter will it bind into a solid mass. The practical operation of the method is as follows: Pulverize the coal finely, passing it through a sieve of fine mesh. A suitable inert body is a fine siliceous sand of uniform grain, but somewhat coarser than the coal. Several equal portions of coal (say of 1 gm. each) are mixed with variable weights of sand, and the mixtures are heated to a red heat in closed porcelain crucibles, so as to carbonize the coal. After cooling, either a dry powder or a more or less hard coked mass is obtained. After a few trials it is easy to determine what maximum weight of sand a coal can bind together.

Taking the weight of coal as unity, the binding power will be given by the weight of the agglomerated sand. The binding power is *nil* for a coal giving a powdered coke, and it has been found to be 17 for the most binding coal yet tried by the experimenter, while pitch is 20. Experiments by this method show that there is no relation between the proximate analysis and the binding power of coals, confirming actual oven experience.

THE BY-PRODUCTS.

These consist primarily of ammonia, tar, and gas, and in addition to the increased yield of coke are the sources of profit from the by-product oven which are wholly lost in the ordinary beehive. Some retort ovens, such as the Otto-Coppée, for example, recover no ammonia or tar, but use the excess gas for raising steam, evaporating about 1.5 lbs. water per pound of coal coked. But the by-products are so easily saved and the profits therefrom make such an acceptable addition to the right side of the ledger that they can hardly be neglected. A brief consideration of each one may be of interest.

Ammonia.—This substance is given off from the coal in the oven very slowly at first, but as the temperature of the charge rises the quantity increases, and after some 10 hours the evolution is quite rapid. As the coking approaches completion the yield becomes much less and stops altogether, although usually a quarter or more of the nitrogen originally in the coal still remains in the coke. The yield of ammonia varies very much in different coals, and depends partly on the amount of nitrogen and of hydrogen uncombined with oxygen in the coal. It varies also with the temperature at which the coal is coked. Perhaps the most reliable method to determine the yield from any coal, except by an actual oven test, is by the distillation of a sample of the coal in a small retort, under the same temperature and conditions as are present in the oven. But the results are liable to be misleading unless the operation is conducted by an experienced person, as it is hard to maintain the proper conditions.

The ammonia from the ovens is collected in the hydraulic main and condensers, along with the tar, by the cooling and scrubbing of the gas, much as in an ordinary gas works, and the two are separated by gravity. Fuller details are given in the description of the by-product apparatus of the Otto-Hoffman oven on a previous page. The ammonia occurs in two forms in the liquor, "fixed" and "volatile;" the former containing the sulphates, chlorides, cyanides, etc., while the latter contains the carbonates, sulphides, and, according to some, free ammonia. The bulk of the fixed salts is condensed first and the volatile salts later. The ammonia liquor is quite weak when it is first drawn off from the tar, usually containing from ¾ to 1% of ammonia. This is generally considerably concentrated before further treatment, whether it be sold as liquor or converted into sulphate.

Ammonia liquor was formerly valued by the hydrometer, but this method is deceptive, as the density of the liquor is affected by the condition in which the ammonia occurs. The more accurate method is the distillation of the liquor with some caustic lime or soda, which drives off all the ammonia, volatile and fixed. The distilled ammonia is absorbed in standard acid, and the excess of acid is afterward titrated with a standard alkali solution. The yield of ammonia is usually reckoned as ammonium sulphate, although it may be sold as liquor or sulphate, according to the market.

The cost of making sulphate from ammonia liquor varies, of course, with locality and cost of materials, and any general figures given might easily be misleading. Although the price of sulphate is lower than formerly, yet it is stated on good authority that it cannot be expected to go below 2½c. per lb., for at that price or above it it comes into competition with the artificial fertilizers, of which it is among the very best; and it is estimated by those familiar with the trade that were the price of these artificial fertilizers to be lowered slightly, the sulphate from all the coke made in the United States, were it all saved, would fall short nearly 1,000,000 tons a year of supplying the demand that would then arise. The yield of ammonia from the coals in the vicinity of Pittsburg is from 18 to 22 lbs. per ton of coal, reckoning it as sulphate.

Tar.—Since the manufacture of illuminating gas by the water-gas process has attained prominence the market for tar is very much improved. Very large quantities are used for roofing, paving, etc., and in Europe much is distilled and separated into pitch and the various lighter oils, which are further treated for the almost endless number of valuable substances which they contain. In this country but little of this is done, and the tar is used for the cruder purposes. Properly developed, its manufacture into the more valuable products should yield very satisfactory profits.

The yield and quality of tar from retort ovens depend on the coal and also on the temperature at which the distillation takes place. As above pointed out, some of the modified beehive ovens hardly produce a tar at all, but rather an oil, which has comparatively little market value. The tar from the leading retort ovens is usually of excellent quality and commands the best price. The yield of the coals in the vicinity of Pittsburg is from 70 to 80 lbs. per ton of 2000 lbs. of coal.

CHART SHOWING COMPOSITION OF GAS FROM A RETORT OVEN DURING PROGRESS OF COKING.

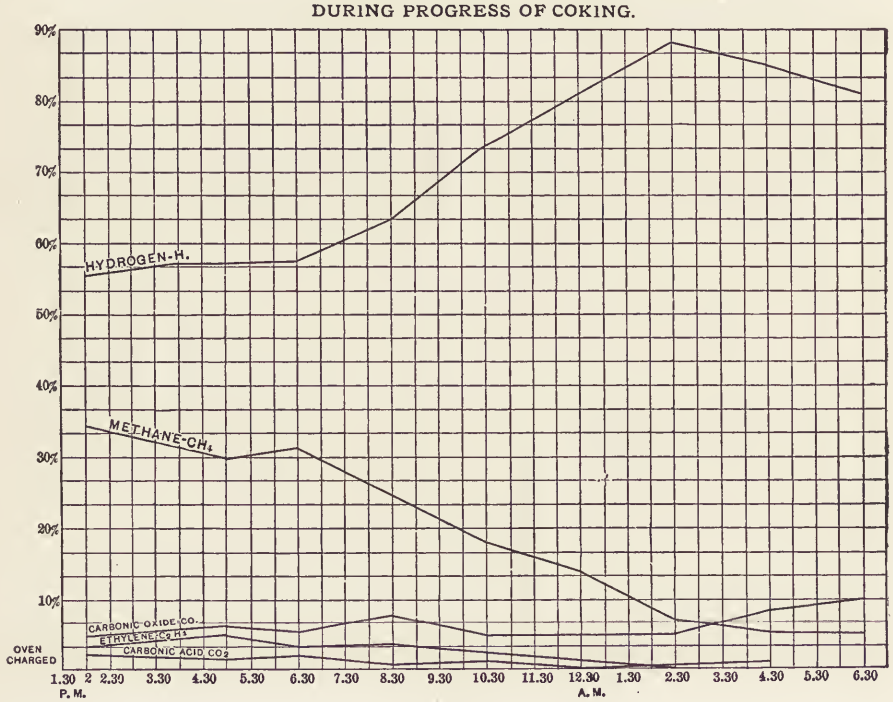


FIG. 25.

Gas.—The gas that is obtained from retort ovens is a by-product the value of which varies very greatly with the locality in which the ovens are situated. When the ovens are at the coal mine the gas is frequently valuable only for steam-raising purposes, and at the usual prices of coal at the mines would be worth but a very few cents per thousand feet. An intermediate condition would be when the ovens were adjacent to an iron or steel works, where the gas could be used for heating furnaces, soaking pits, etc., where it would supplant producer gas, being much more conveniently applied and easily freed from all impurities. The most favorable locations for obtaining a good value for oven gas are those adjacent to large towns, where there is a demand for illuminating or fuel gas. The discovery and use of natural gas in this country has caused a great demand for fuel gas, especially for domestic purposes, and many hundreds of thousands of dollars have been spent in attempts to supply this demand. But while these experiments have been going on the beehive coke ovens of Pennsylvania alone have been quietly burning to waste nearly 1,000,000,000 feet a week of a very superior quality of fuel gas without exciting any special attention.

Coke-oven gas from properly managed retort ovens is approximately the same article as that from the retorts of a gas house, the processes of manufacture being similar. It usually contains rather less illuminants, however. Its quantity and composition vary with the coal used and the temperature of distillation, but made from any good gas coal it is suitable for illuminating purposes after being passed through the ordinary lime boxes to remove the sulphur, etc. If from the nature of the coal the illuminating power of the gas is low, it can either be enriched by any of the well-known methods or burned with incandescent burners or used as a fuel gas; for the lack of 1 or 2% of illuminants will not appreciably affect its fuel value.

In arranging an oven plant for the supply of fuel or illuminating gas, it is necessary either to provide a holder of rather large dimensions or with a smaller holder, to have not less than say 25 or 30 ovens, that shall be drawn in rotation at approximately even intervals; for in common with other substances containing hydrocarbons, when coal is distilled in an oven or elsewhere the gases given off are not at all uniform in composition, but change constantly as the distillation progresses.

The chart shown herewith illustrates the variation. It is made up from a series of analyses taken of the gas from a retort oven of one of the leading types while coking a charge of standard coal. The first sample at 2 P.M. was taken half an hour after charging, and at 2.30 A.M., 13 hours after charging, very little gas was coming off. Of course none of these analyses represent the gas that would be delivered from a holder. That would be a mixture of these in very uneven proportions.

The following are analyses of retort-oven gas from European coals:

	Percentage by Volume.			
	I.	II.	III.	IV.
Carbonic acid	3.0	0.90	1.4	3.27
Carbonic oxide	8.8	4.90	6.5	7.95
Hydrogen	58.0	58.57	53.3	52.77
Nitrogen	2.4	5.74	0.5	1.99
Methane	24.7	27.56	36.1	31.45
Olefines	3.1	2.33	2.2	2.57
Totals	100.0	100.00	100.0	100.00

One of the more valuable constituents of coke-oven gas is the benzol, which is the principal source of luminosity in the gas. When the gas is to be used for fuel purposes this benzol may be separated with considerable profit. The gas from a good coal will give a yield of benzol of about 1% of the weight of the coal.

Herewith is given a table showing from the best attainable data (much of it is taken from the published statements of the representatives of the ovens) the cost of a number of the leading kinds of coke ovens, their product per day, the cost of operation, value of by-products, net cost per ton of coke, etc.

COMPARATIVE TABLE OF COKE-OVEN COSTS—THEIR OUTPUT AND COST PER TON OF COKE.

Items.	Kind of Oven.									
	Not Recovering By-Products.				Recovering By-Products.					
	Beehive	Belgian	Bernard.	Coppée.	Otto-Hoffman	Simon-Carvès.	Huessner.	Semet-Solvay.	Festner-Hoffman	Siebel.
Cost per oven	$300	$900	$1,000	$1,000	$4,160	$2,400	$2,750	$3,000	$3,000	$2,500
Output of coke per day per oven, net tons	1.75	2.40	2.25	2.20	3.34	2.2	2.9	4.0	2.94	3.10
Yield of coke	65%	68%	75%	72%	75%	75%	75%	75%	75%	75%
Number of ovens required to produce 100 tons coke per day	58	42	44	46	30	46	35	25	34	33
Cost of plant to produce 100 tons coke per day	$17,400	$37,800	$44,000	$46,000	$124,800	$110,400	$96,250	$75,000	$102,000	$82,500
Repairs and depreciation per ton of coke	0.047	0.102	0.119	0.124	0.337	0.298	0.264	0.203	0.275	0.223
Labor on coke and by-products per ton of coke	0.32	0.27	0.25	0.27	0.39	0.39	0.39	0.39	0.39	0.39
Total cost per ton of coke.	0.367	0.372	0.369	0.394	0.727	0.688	0.654	0.593	0.665	0.613
Value of by-products per ton of coke	....	....	....	....	0.53	0.53	0.53	0.53	0.53	0.53
Net cost per ton of coke	0.367	0.372	0.369	0.394	0.197	0.124	0.124	0.063	0.135	0.083

It is assumed that all the ovens are working on Connellsville or other coal of similar chemical composition. No credit is given to any of the ovens for the increased yield of coke over that of the beehive, for it is manifest that in computing the cost of making a ton of coke this item is not a factor. It belongs rather to the determination of the cost of the coal to make a ton of coke, but this item has not been introduced, as it varies between such wide limits with the market and the locality. From the yields of coke from the different ovens shown in the table it will be seen that the beehive, for example, requires 1.54 tons of coal to make a ton of coke, while the ovens saving the by-products require 1.33 tons.

In computing the value of the by-products the ammonia liquor has been estimated at its value for making sulphate worth 2½c. per lb. On both ammonia and tar a liberal percentage has been allowed for freight, as coke ovens are not infrequently rather distant from the markets.

The value of the disposable gas is not included in the figures given, for, as pointed out on a previous page, it varies very widely with the location of the ovens and the use to which the gas can be put. A low estimate of its value under average conditions would be 20c. per ton of coke. Adding this value to that of the other by-products as given in the table, it is safe to say in a general way that the cost of coke made in by-product ovens does not exceed the cost of the coal from which the coke is made.

COPPER.

THE status of the American copper industry at the close of 1895 was on the whole more satisfactory than a year before. During 1895 production was greatly stimulated, but by no means in excess of requirements, and the average price for the year is more than 1c. per lb. higher than in 1894 and practically the same as in 1893. Average New York quotations of Lake copper for the last four years have been: In 1892, 11.55c.; in 1893, 10.75c.; in 1894, 9.56c.; in 1895, 10.76c. The improvement upon the prices for 1894 rests on a substantial basis, for the gradual recovery from recent depression of the various industrial pursuits using copper and its alloys in one form and another has had a beneficial effect; while the extended use of the metal in new applications, and especially in connection with the wonderful development in the electrical industry, places it in a peculiarly favorable position.

The domestic production in 1895 was 386,453,950 lbs., a gain of 32,949,536 lbs. (9⅓%) over the make in 1894, and by far the largest yet recorded. Thus the output, which showed an actual increase in quantity even in the years of general business depression, again displayed a steady growth, while the increased demand at one time forced prices up to the highest level known for several years. Although this gain in price was not fully maintained, the net improvement was marked. Nearly all of the leading mines in the United States maintained their output or increased it, and many of the smaller ones also increased theirs considerably.

There was a decrease of about 12% in the exports of copper during the year, so that the gain in price was largely due to the heavy domestic demand. While the American production is advancing, the foreign output is practically steady, so that whatever advantage arises from a general increased demand accrues mainly to producers in this country.

The market price of copper makes the question of its cost of production a most important one. At its present figure, when trade and enterprise are normally healthy, the consumption is greater than it has ever been before, and so far as new work is concerned there is every prospect of a slight and steady increase in the consumption. At the same time, it must always be borne in mind that copper is not a metal that can be entirely worn out, corroded, and cast away, so that with a greater use of copper in industrial enterprises the greater will be the supply from what might be termed the reserves of old copper. This was forcibly shown in the collapse of the copper deal in 1889. The ruling price at the close of 1895 seems a very healthy one, since the mines that are best equipped and best managed can make satisfactory and in some cases ample profits at the then rate of cost and marketing.

The official reports and special information from the principal copper mines in this country and abroad prove that about 11c. per lb. is sufficient to pay expenses and fair dividends, but at the same time the margin of profit at that figure is dangerously narrow for other considerable producers under different conditions. In the present as in preceding volumes of THE MINERAL INDUSTRY, such data as to the cost of production that are available are given and will be found further on. To pursue the history of the subject, the volumes (I., II., and III.) for 1892, 1893, and 1894 should also be consulted.

COPPER PRODUCTION IN THE UNITED STATES.

(Pounds of fine copper.)

States.	1892.		1893.		1894.		1895.	
	Pounds.	Long Tons.	Pounds.	Long Tons.	Pounds.	Long Tons.	Pounds.	Long Tons.
Arizona	38,383,116	17,135	43,773,675	19,542	44,531,108	19,880	48,329,403	21,575
California	3,200,000	1,430	2,825,773	1,261	120,156	54	225,650	101
Colorado	7,250,000	3,236	7,121,257	3,179	6,528,214	2,914	6,125,000	2,734
Michigan	108,179,576	48,294	113,537,793	50,686	114,526,555	51,128	129,740,765	57,920
Montana	161,051,477	71,898	154,300,100	69,330	183,094,755	81,739	194,768,925	86,950
New Mexico	500,000	223	273,515	123	154,730	69	....	....
Utah	2,000,000	893	1,312,171	585	1,183,098	528	2,664,757	1,190
Eastern and Southern States	1,300,000	580	415,025	185	2,437,986	1,088	3,255,000	1,453
All others	1,211,416	540	3,441,168	1,535	927,712	414	1,344,350	601
Total domestic production	323,075,585	144,229	327,000,477	146,426	353,504,314	157,814	386,453,850	172,524
From foreign ores	10,200,000	4,553	7,723,387	3,448	8,279,761	3,696	4,493,760	2,006
Total smelted	333,275,585	148,782	334,723,864	149,874	361,784,075	161,510	390,947,610	174,530
Stock January 1	75,414,848	33,667	55,434,000	24,743	57,418,689	26,073	78,738,689	34,698
Imports of bars, ingots, and old	1,552,515	693	5,536,690	2,472	3,446,724	1,539	9,381,800	4,188
Total supply	410,242,948	183,142	395.694,554	177,089	422,649,488	189,122	479.068,099	213,416
Deduct exports	190,036,800	40,198	180,066,880	80,387	167,651,153	75,737	121,703,978	54,332
Deduct consumption	264,772,148	118,201	158,208,985	70,629	176,259,646	78,687	270,392,841	120,262
Stock December 31	55,434,000	24,748	57,418,689	26,073	78,738,689	34,698	86,961,280	38,822

Arizona.—The production has increased in nearly the same ratio as that of the whole United States, being 48,329,403 lbs., as compared with 44,531,108 lbs. in 1894, considerable gains having been made by the Arizona Copper Company and Copper Queen, while United Verde, which now takes the lead among Arizona copper producers, turned out nearly half as much again in 1895 as in 1894. Detroit, however, fell off 1,387,516 lbs.

The Copper Queen Consolidated Company has been operating successfully, with not only larger output, but more satisfactory metallurgical results than heretofore, and has increased its roasting, smelting, and converter capacity. The prosperity of the company was shown by a voluntary advance of 50c. in daily wages in September.

Old Dominion, closed down during the year, has since passed into new ownership and will again be an important producer.

The Arizona Copper Company has been steadily augmenting its output during the past four years, at a yearly increment of about 2,000,000 lbs., and reports satisfactory progress.

United Verde, under its enterprising management, has recorded another long stride in advance, with the handsome gain of 5,586,949 lbs. over the output for 1894.

Besides the six very important companies, four of which were producing in 1895, some of the lesser mines were more active, and their aggregate output quadrupled. In Arizona, as elsewhere, the future production must be looked for from the larger plants where economies are possible, and not from scattered small deposits of high-grade ore worked at a disadvantage. Arizona no longer enjoys the distinctive position of having large bodies of oxidized ores, but has for some time had to face the problem of profitably handling its sulphides, so that good metallurgical work is as important as the volume of ore supply, and in this direction progress has fully kept pace with advances elsewhere.

COPPER PRODUCTION IN ARIZONA.

(Pounds of fine copper.)

Mines.	1891.	1892.	1893.	1894.	1895.
Arizona	5,673,611	5,893,533	7,871,819	9,935,812	11,308,910
Copper Queen	13,022,957	12,916,416	13,795,618	12,688,372	15,741,731
Commercial	....	282,451	273,330	90,805	....
Detroit	4,194,672	1,918,594	4,942,728	5,777,744	3,790,128
Old Dominion	6,982,101	7,698,297	7,665,293	4,839,386	....
United Verde	7,350,087	9,524,492	9,121,146	10,904,453	16,491,402
United Globe	2,302,765	....	....	....	....
Other mines	2,368,506	149,333	103,741	214,536	997,232
Totals	41,894,699	38,383,116	43,773,675	44,531,108	48,329,403

California.—The small quota from this State has remained practically unchanged. There are many occurrences of copper ore in the State and some fair mines; but under existing conditions of the market and the overwhelming competition of the great and more favorably situated mines of Arizona, Montana, Michigan, and elsewhere, the small scale upon which the California mines have been worked, coupled with high labor and fuel costs and distance from open markets, has precluded profitable work. The local demand hitherto has been mainly for bluestone making.

Colorado.—The output from local sources, derived almost wholly from mixed ores treated also for their gold, silver, and lead contents, remains at something above 6,000,000 lbs., showing a very slight decline from that of 1894. No very important deposits of true copper ores (that is, ores valuable mainly for copper and not for other metals) have as yet been opened in the State. Considerable quantities of copper-bearing ores from without are treated at the Argo Reduction Works, Denver.

Michigan.—Again the Lake mines have exceeded their former records, and in 1895 yielded over 15,000,000 lbs. more than in 1894, though the difference is practically accounted for by the increase from a single establishment—the Calumet & Hecla—the aggregate output of the other active companies having remained almost stationary.

The Michigan mines are now so thoroughly developed and well understood that great surprises are hardly to be expected from them. Progress lies along the lines of new deep shafts, greater capacity for milling plant, keeping up the high-pressure activity, and in numerous small economies in all departments of mining, reduction, and accessory operations. Year by year closer savings at lower costs are being made, and naturally as the possible limit of cheapness in the production of copper is approached, the successive steps toward that limit, wherever it may be, are smaller and smaller.

In the preparation of this volume special efforts have been made to ascertain the actual cost of producing copper, not only of the Lake product, but of all other. Some of the Lake companies issue detailed reports, of which those of the Atlantic Company are admirable examples, either giving the cost per pound directly or stating the items from which such cost may be computed. Others—and in this respect two of the largest producers have been and are the chief offenders—have pursued a policy of secretiveness, in the mistaken idea of thereby gaining some advantage over competitors, and their reports have been as vague and confusing to their shareholders, who certainly have the right to the fullest information as to how their interests are being provided for, as to the public at large. In this connection it may be remarked that at a meeting of the Tamarack Company, in the spring of 1896, a motion was made and carried that the directors should submit a report to the shareholders once in every 12 months, it being of course understood that such report should contain real information. The Calumet & Hecla Company has relaxed its policy of mystery to the extent of allowing its output to be made known, but if the shareholders desire (as they certainly must) to get at the actual business results of that corporation, they must still rely on other sources of information than the company's official reports.

It is not possible to state exactly the cost of producing copper by all the Lake Superior mines, considered together, nor to arrive at a general standard of economy, for the cost varies widely according to the percentage of copper contained and the economy with which each mine is worked. It is well also to point out that the copper mines of this district are dependent on their copper product alone and do not have the advantage of any by-product, as is the case at Sudbury, Ontario, where the nickel value of the ore is greater than that of the copper, and at Rio Tinto, Spain, where there would be sometimes no profit at all were it not for the sulphur contained and paid for in the pyrites exported; and in the Butte, Mont., and other mines yielding silver and gold in addition to the copper. But for several of the Lake mines it is possible to state precisely or to estimate the cost per pound, and some details are here given.

At the Allouez nothing has transpired to promise success in working the mine under present conditions, and nothing has been done beyond maintaining the organization to protect the property. Nor do the Centennial, Copper Falls, Huron, or Peninsular appear among recent producers.

The Atlantic still holds the record for successful handling of low-grade copper rock, though the average content (or rather the yield, since the figures are based on mill returns, not on assays) has slightly improved and was 14.6 lbs. per long ton of ore, equal to 0.73% refined copper in the rock treated. The ground broken was 20,037 fathoms; rock stamped, 331,058 tons; mineral produced, 6,239,000 lbs. (containing 77.46% copper); product of refined copper, 4,832,497 lbs., selling for $508,252 (average price 10.52c.). The gross value of the product per ton treated was $1.5352. The cost per ton of rock for mining, selecting, and breaking, and all surface expenses, including taxes, was $0.7525; stamping and separating, $0.2220; all working expenses at mine, $1.0153; cost per ton for freight, smelting, and marketing, including New York office expenses, $0.1881. Taking the actual running expenses only, the total cost per ton of rock treated was $1.2034, which would make the average cost per pound of refined copper 8.242c. The company, however, and very properly, does not carry a separate construction account, charging construction to working expenses. In 1895 the company, having used up its tailings ground on Portage Lake, removed its mill to a new location on Lake Superior, and at the new site will not be hampered by want of room for tailings. This plant, arranged with a view to extension of stamp mill and boiler house, and the new railroad from mine to mill, brought up the expenditures to a total of $1.5605 per ton of rock treated—that is, about 10.69c. per pound of refined copper. That with such low-grade rock the heavy outlay for construction could be balanced speaks well for the administration of the company's affairs. Its product was larger than in any previous year, due to the small increase in average yield and the stamping of 5% more rock than heretofore. From its beginning to the close of 1895 the mine has produced $9,532,851 worth of copper and has paid $700,000 in dividends. No dividend was paid in 1895.

Calumet & Hecla produced 15,597,185 lbs. more copper in 1895 than in 1894, and has reached the highest figure in its history for one year's output, with a record of 77,439,907 lbs. during the year under review. This is considerably more than half the aggregate production of all the Lake mines during the same period. As has hitherto been the case, such information as is given in the official reports has to be pieced out from private sources, and even then the accounts are fragmentary. As the company's fiscal year closes April 30 and the publication of reports is delayed, a further obstacle occurs in attempting to get at the results for the calendar year. During the year covered by the last report (April 30, 1895) mineral equivalent to 39,738 tons of copper was produced, and the actual make of refined copper was 31,233 tons. During that period three dividends of $5 each per share were paid. The company has disbursed $44,350,000 dividends in all. Its stock quotations are at the rate of about $30,000,000 valuation for the property.

The principal shaft, the Red Jacket, a vertical shaft, has reached a depth of 4880 ft. It has six compartments and is 14x22½ ft. inside timbers. It is timbered with Georgia pine, 2,832,855 ft. board measure being used in it. The hoisting plant over it is designed to hoist a load of 10 tons 50 ft. per second. The capacity is four times as great as that of either of the other shafts. The first cross cut to Calumet No. 4 shaft is at a depth of 2106 ft. and is 1153 ft. long, intersecting the lode on the thirty-sixth level. The second cross cut is at a depth of 2290 ft. and intersects the lode on the thirty-ninth level. The third cross cut, 2463 ft. down, intersects the lode on the forty-second level. Endless hoisting cables are used, so that large drums are not required. When lowering men the steel cages make the run in 6 minutes. The cost of sinking the Red Jacket shaft averaged $25.70 per ft. The maximum distance sunk in this shaft per month was 78 ft.; average, 74 ft.; maximum in one week, 18¼ ft.; least, 9½ ft. Average number of holes drilled per day of 11 hours by power drills, 120; average depth of hole, 5 ft.; two blasts are made in each day of 11 hours.

There are at the Calumet & Hecla Mine 9 working shafts. The 4 central shafts have reached the forty-second level, 3790 ft. on the dip of the lode (38°). In the slopes or inclined shafts the skips run at 400 ft. per minute; load, 3800 lbs. No. 4 shaft is down to the fifty-first level, 260 ft. less than a mile. The temperature at the bottom of the Red Jacket shaft, 4880 ft. down, is 78° F. when the power drills are working and 81° F. when they are stopped. Although the practice of transporting men by cages has been adopted, there are two man engines at the Calumet & Hecla. The average number of men underground is about 1000.

The Calumet conglomerate bed is harder and tougher than the amygdaloid, and work in it rather more difficult. The breasts in the stopes are carried 35 ft. high, and the practice is to use waste rock from the cross cuts to fill in the stopes. All the exhausted levels down to the thirty-third are walled off. The development work is such that 4000 tons or more can be raised daily, and the reserves are opened to allow, it is said, for about 10 years' work at the present rate of extraction. The average cost of stoping is $16.45 per fathom; winzes, $11.20 per ft.; drifting, $9.30 per ft.

The Calumet & Hecla milling plant is practically two separate mills, each having 11 Leavitt-Ball steam stamps, or 22 heads in all. The present working capacity is about 4000 tons in 24 hours, but it is said that as much as 6000 tons might be put through. The equipment includes Cullom jigs, Evans slime tables, large sand wheels, etc. The stamp rock is transported from the mine to the mill in trains of 30 to 40 20-ton cars, which make 8 trips daily. Average wages at mill are about $40 per month. The smelting works are at Groverton and Buffalo. The experimental electrolytic plant at Buffalo is reported to have been running successfully. The tenor of the ore in 1895 is shown by the following figures: Yield of refined copper per ton stamped, 70 lbs.; yield of mineral per cu. fathom broken, 1141 lbs.; yield of refined copper per fathom, 860 lbs.

The company has recently bought 120 acres of land. At the opening of 1896 it had on hand at the sheds at Lake Linden 120,000 tons of coal. This coal is taken to the mine in ore cars, the rise from the lake to the main track being 355 ft. The entire force of the company is over 5000 men, and the monthly pay roll is about $400,000. There are nearly 5000 members of the local aid society, each of whom pays $1 a month dues, to which the company adds an equal amount.

The cost of producing and marketing refined copper by the Calumet & Hecla for the 10 years ending December 31, 1891, ranged between 16.3 and 7.9c. per lb., the cost in 1891 being 10c. per lb. The production for the fiscal year ending April 30, 1895, was 31,233 tons of refined copper, and the amount of dividends during the same period was $1,500,000, from which it may be assumed that if reserves were not impaired the cost of producing copper was in the neighborhood of 7.1c. In the absence of definite and reliable data on which to compute the costs exactly, various estimates have been put forth. According to one statement, which may not be very far out of the way, the cost is now at the rate of 6⅓c. per lb.

The accompanying table gives the official financial statement of the Calumet & Hecla Company for the years 1890 to 1894:

Years ending December 31........	1890.	1891.	1892.	1893.	1894.
Amount invested in real estate..........	$5,626,387.22	$5,432,927.79	$5,718,369.01	$6,096,484.05	$6,354,690.40
Amount of personal estate..............	4,954,975.71	5,128,658.58	5,255,080.34	5,731,960.40	6,054,216.16
Unsecured or floating debt..............	1,441,453.95	1,557,866.81	1,262,955.66	689,572.36	812,123.99
Amount due corporation................	4,083,224.43	4,193,809.71	4,045,277.01	4,185,729.14	5,464,670.59
Production refined copper...............	59,868,106 lbs.	63,586,600 lbs.	72,273,300 lbs.	73,537,053 lbs.	79,769,293 lbs.

The directors of the Central Mining Company report disappointment in the results obtained during 1895. Operations were conducted merely with the object of determining beyond question the faulting of the vein at the intersection with the Kearsarge conglomerate and making a thorough exploration of the ground in the vicinity of the fault, in order to find a continuation of the ore body which has been so productive from the surface to the thirty-first level. At times some encouragement was given, but on the whole the copper found has not been enough to pay expenses.

In the Kearsarge the lode is somewhat pockety, but at the close of 1895 much more available stoping ground was opened than a year before. During the year 840 ft. of winzes and 4119 ft. of levels were opened. The working shaft No. 2 is now practically 13 levels below developments in the north part of the mine, so that sinking was stopped and drifts pushed north. Mineral produced, 2,292,805 lbs., yielding 1,946,163 lbs. refined copper; yield of copper per fathom broken, 409 lbs.; percentage copper in stamp rock, 1.51. The total cost per ton of rock hoisted is reported at $1.72, and per pound of refined copper produced, 9.42c. A dividend of $40,000 was paid December 30, 1895.

Work in the Osceola consisted in sinking 971 ft. of shaft and 150 ft. of winzes and running 7799 ft. of levels. The product of mineral was 7,399,846 lbs., yielding 6,270,373 lbs. refined copper, being at the rate of 437 lbs. per cu. fathom broken and 1.37% of the rock stamped and 1.77% of all the rock hoisted. The cost per pound of refined copper is reported as 8.75c. The total dividends since 1878 have been $2,022,500. On September 7, 1895, a fire occurred in No. 3 shaft by which 30 lives were lost. All the timber in the shaft from the twenty-eighth level to within a few feet of the surface was burned out. Repairing the shaft began immediately, and the mine was soon in working shape again.

Quincy again increased its output, thus maintaining the progress made in a long series of years, while its operations have been very successful financially, the annual report showing a mining profit of $692,074 for 1895. The product was 19,732,970 lbs. of mineral, yielding 16,304,721 lbs. refined copper, realizing $1,657,701 gross; dividends in 1895 (two of $4 each per share), $400,000; average total force employed, 968 men; average number of miners, 336; wages of contract miners, $50 per month; yield of refined copper per cu. fathom broken, 517 lbs.; rock mined, 563,360 tons; rock hoisted, 506,058 tons; stamp rock treated, 495,402 tons.

The breakage of the hoisting engine at No. 1 shaft and the encountering of poor ground in the territory tributary to No. 2 shaft cut down production at the Tamarack somewhat, and the dividends distributed in 1895 were not fully earned, the surplus being drawn upon. Total dividends to the close of 1895 have been $4,-470,000. The depth of the several shafts (February 19, 1896) is: No. 1, 3232 ft.; No. 2, 3535 ft.; No. 3, 4450 ft.; No. 4, 4450 ft.; No. 5, 226 ft. No. 5 will be connected on the twenty-seventh level with No. 2 (3920 ft. vertical), when it will be about 1480 ft. from the lode in the hanging wall country; will tap the lode at about 4700 ft. vertical, and is so located that it will not require a companion shaft. Experience has shown that several hoisting shafts are required to maintain production, and as it takes at least five years to sink to 4000 ft., the company has to take a long look into the future. The new (No. 5) shaft is 27 ft. 2 in. by 7 ft. 2 in. inside timbers, with four hoisting compartments and one smaller chamber for piping and ladderway, and will be the most important shaft on the mine. The cost of sinking shafts Nos. 1, 2, and 4 was $25.40 per ft. In 1895 the yield of refined copper was 49.72 lbs. per ton of rock; yield of mineral per cu. fathom broken, 1120 lbs.; yield of refined copper per fathom, 840 lbs.; percentage of mineral in stamp rock, 3.32; percentage of refined copper in stamp rock, 2.49; percentage of refined copper in mineral, 74.97. One estimate places the cost of producing copper by the Tamarack Company at 5.17c. per lb., which is doubtless much too low.

Wolverine, which is under the same financial management as the Atlantic, has been increasing its output and reports a small mining profit, though an assessment of $60,000 was levied in March. The mine has been working without interruption, and the 120 acres of recently purchased ground are being opened up. For the company's fiscal year ending June 30, 1895, the results were: Rock hoisted, 118,085 tons; rock stamped, 90,195 tons; mineral produced, 1,992,940 lbs. (87.51% copper); refined copper produced, 1,744,070 lbs.; copper in rock treated, 0.965%; cost per ton hoisted, $1.045; per ton stamped, $1.369; cost per lb. refined copper at mine, 7.08c.; construction expense per lb. copper, 0.15c.; smelting, freight, and marketing, including New York office expenses, 1.22c.; total cost, 8.45c. per lb. No. 2 shaft has been sunk below the thirteenth level, and ample reserve stoping ground, at present capacity of plant, is reported.

COPPER PRODUCTION IN MICHIGAN.

(Pounds of fine copper.)

Mines.	1891.	1892.	1893.	1894.	1895.
Allouez	1,241,423	546,530	....	....	....
Atlantic	3,653,671	3,703,875	4,221,933	4,437,609	4,832,497
Calumet & Hecla	63,294,634	58,292,576	62,825,674	61,842,722	77,439,907
Centennial	435,784	....	....	....	....
Central	1,321,417	1,625,982	1,177,500	584,950	370,381
Copper Falls	1,440,000	1,400,000	1,000,000	....	....
Franklin	4,319,840	3,767,000	3,504,244	3,602,608	3,086,933
Huron	1,215,734	461,499	562.776	....	....
Kearsarge	1,727,390	1,580,192	1,546,318	1,998,710	1,946,163
Mass	30,114	17,450	22,737	41,805	18,372
National	103,888	36,358	63,433	36,390	50,128
Osceola	6,543.358	6,894,256	6.216,975	6,879,000	6,270,373
Peninsular	1,599,670	973,217	....	....	....
Quincy	10,542,519	11,015,686	14,398,477	15,484,014	16,304,721
Ridge	43,049	41,462	25,988	52,481	64,363
Tamarack	16.161,312	16,426,643	15,085,113	15,375,000	14,840,000
Tamarack Junior	....	796,769	1,610,259	2,350,000	2,605,000
Wolverine	312,112	500,074	1,025,062	1,665,255	1,817,806
All other mines	121,509	11,750	251,304	176,011	94,121
Total pounds	114,107,424	108,091,336	113,537,793	114,526,555	129,740,765

Montana.—Anaconda has not increased its product so much, actually or proportionately, as did Calumet & Hecla, but by running up more than 4,000,000 lbs. over the figure for 1894 it has a record of nearly an even 100,000,000 lbs., or more than the output of the whole United States only 13 years ago, thus maintaining its preëminence over all other producers of copper. The ore "in sight," according to the most recent reports, contains about $40,000,000 at the present market value of the three metals produced (copper, silver, and gold) in about 3,000,000 tons of ore. The percentage of copper during the four years 1891–94, inclusive, was 7.66, and for the first half of 1895 it was 6.75. The selling value of the property, on the basis of the price obtained for one-quarter interest recently sold in London, was $30,000,000. The original Anaconda Mining Company had a capital of $12,500,000 in stock and $7,500,000 in bonds, representing a total investment of $20,000,000. From its organization, February 1, 1891, to June 30, 1895, the company earned $10,147,555 profits, which was mostly reinvested in buying additional copper territory and coal lands, a railroad from Butte to Anaconda, sawmills, timber lands, and various improvements in the mining, smelting, and electrolytic plant. The entire investment having then exceeded $30,000,000, it was decided to form a new company with a capital of $30,000,000 in 1,200,000 shares of $25 each; and this has been done.

The mines of the Anaconda Copper Mining Company have been developed to a depth of 1300 ft., and since 1880, when work was begun, have produced ore yielding nearly 400,000 tons of copper, besides a large amount of silver and some gold, though until the late development of electrolytic refining there was but little profit from the precious metals. The ore continues good with increasing depth, and a new body was struck at 1150 ft. in 1895. In the report of Mr. Hamilton Smith (November, 1895) the united capacity of the two sets of reduction works is stated as 5000 tons of pig copper monthly, while the electrolytic refinery turned out 1500 tons of refined copper per month during the latter part of 1895, and the new electrolytic plant will increase the total monthly refining capacity to about 3000 tons.

In the same report Mr. Smith states that the cost of producing copper is less than at any other of the large copper mines. This is due to the recovery, at reasonable cost, of the silver and gold contained in the pig copper, by electrolytic refining. This, of course, places the Anaconda on a similar footing with the Spanish mines, whose sulphur is so important a source of revenue. From the technical point of view and comparing costs on a strictly copper basis, both the costs and the returns should be charged and credited to each metal in due proportion; so far as the total net commercial results are concerned, it may be fair enough to lump in the by-products with the copper.

The policy of the management has always thus far been to absorb earnings in development, improvements, and purchase of new ground, so that notwithstanding the immense output and magnificent showing, the palpable returns to shareholders have been postponed from time to time. The company now, however, has certainly got beyond the stage of "getting ready."

The question of erecting additional smelting and electrolytic refining plant by the Anaconda Company at some other point than Anaconda has been mooted, but since the company has its own coal lands and railroad and therefore cheap fuel, it is doubtful whether any advantage would be had in carrying the crude metal to a distant point for treatment even at somewhat lower cost per ton. Of late about half the product has been refined at Anaconda and the other half at Baltimore.

The output of the Boston & Montana and that of the Butte & Boston companies are for mysterious reasons reported together by the officers of the companies. The report of the former company for the calendar year 1895 states the total sales of copper, silver, gold, and bluestone from organization to the close of 1895 at $26,765,703; total dividends (Nos. 1 to 18), $3,425,000; dividends in 1895 (Nos. 17 and 18), $1,050,000. During the year the work included: shafts sunk, 185 ft.; winzes, 1362 ft.; levels and drifts run, 6790 ft.; stopes, 11,623 fathoms. At the company's reduction plant at Great Falls the blower plant has been increased and a new power house has been planned, to contain 2 horizontal turbines to drive 2 Westinghouse generators for additional current for the electrolytic plant. The concentrating mill has been improved and is now claimed to make a closer saving of the mineral content than any similar plant in Montana, and to this better saving of copper in the concentrating mill is largely due the increased yield of the ore, which in 1895 was about 10%: 225,859 tons of ore gave 47,750,000 lbs. of copper, or 212 lbs. per ton. The plant at Great Falls has also increased its smelting capacity for raw ore and concentrates, and a further increase in this direction is contemplated in 1896, as the company's metallurgist believes that a better saving of the copper contents of the ore can be made by limiting the number of operations. It is also proposed to replace the Brückner furnaces with improved roasters. A considerable reduction is reported in the cost of concentrating, reverberatory smelting and electric refining, and a slight reduction in converting and blast-furnace smelting, while there was a slight increase in the cost of calcining and furnace refining.

Butte & Boston, which when working produced several hundred tons of 5% ore daily, with 1 oz. silver to the per cent. of copper, has been involved in litigation and its affairs are badly mixed.

The Butte Reduction Works increased its copper output by over 1,000,000 lbs. as compared with 1894.

Parrot shows a slight decrease, while the Montana Ore Purchasing Company and some of the smaller producers increased their output. Altogether the Montana mines produced 11,674,170 lbs. more copper in 1895 than in 1894, and they lead the Michigan mines by no less than 65,028,160 lbs. in 1895.

COPPER PRODUCTION OF MONTANA.

(Pounds of fine copper.)

Mines.	1891.	1892.	1893.	1894.	1895.
Anaconda	46,500,000	100,000,000	75,256,657	95,578,000	99,775,294
Boston & Montana	26,507,929	30,386,595	31,800,000	57,937,633	60,746,000
Butte & Boston	18,392,054	10,641,269	20,457,928		
Butte Reduction Works	2,915,000	2,864,000	2,985,485	2,282,000	3,390,000
Colorado Smelting and Mining Company	3,641,384	4,560,972	6,703,488	5,158,730	7,750,000
Hecla Consolidated Mining Company	91,090	159,859	77,565	362,897	239,631
Parrot	14,108,382	12,438,782	7,791,167	7,469,908	7,257,000
Montana Ore Purchasing Company and others	204,000	....	9,227,810	14,305,587	15,611,000
Totals	112,359,839	161,051,477	154,300,100	183,094,755	194,768,925

THE WORLD'S COPPER PRODUCTION.

As a whole, the annual supply of copper is increasing. The grand total advanced from 310,704 metric tons in 1893 to 330,132 tons in 1894, and during 1895 the highest figure yet was reached—339,699 metric tons. But while the world's output was thus 9567 metric tons more in 1895 than in the preceding year, the total net gain was not equivalent to the increase (11,100 metric tons) from the United States alone; in other words, the sum of the products of all other countries shows a slight decrease, though the individual changes were not marked. The American annual quota at present is a little more than one-half ($51\frac{3}{5}$%) of the whole supply; the Spanish mines rank second with 16%.

THE WORLD'S COPPER PRODUCTION, 1893–95.

Countries.	1893.		1894.		1895.	
	Tons of 2240 Lbs.	Metric Tons.	Tons of 2240 Lbs.	Metric Tons.	Tons of 2240 Lbs.	Metric Tons.
Australasia	7,500	7,621	9,000	9,144	10,000	10,160
Austria-Hungary	1,400	1,423	2,120	2,154	1,310	1,331
Bolivia	2,500	2,540	2,300	2,337	2,250	2,296
Canada	3,630	3,679	3,786	3,847	3,924	3,987
Cape of Good Hope:						
Cape Company	5,225	5,309	5,150	5,233	5,350	5,436
Namaqua	890	904	1,500	1,524	1,730	1,758
Chile	21,350	21,694	21,340	21,681	22,075	22,428
Germany:						
Mansfeld	13,454	13,669	14,963	15,202	18,860	15,098
Other mines	2,951	3,000	2,210	2,260	1,695	1,722
Italy	2,460	2,500	2,500	2,540	2,500	2,540
Japan	18,000	18,288	20,050	20,371	18,430	18,725
Mexico:						
Boleo	7,979	8,107	10,371	10,537	10,600	10,769
Other mines	1,480	1,500	1,400	1,422	1,170	1,189
Newfoundland	2,000	2,032	1,900	1,930	1,800	1,829
Norway	1,740	1,768	1,785	1,813	2,685	2,728
Russia	4,920	5,000	5,000	5,080	5,000	5,080
Spain and Portugal:						
Rio Tinto	31,000	31,499	32,689	33,215	32,985	33,513
Tharsis	11,000	11,177	11,000	11,177	12,380	12,638
Mason & Barry	4,400	4,470	4,200	4,267	4,100	4,166
Sevilla	1,010	1,026	1,170	1,188	1,050	1,069
Other mines	6,500	6,605	4,805	4,882	4,300	4,369
Sweden	544	552	500	508	515	523
United Kingdom	426	433	400	406	400	406
United States	149,874	152,271	161,510	164,194	172,524	175,294
Venezuela	2,861	2,907	2,500	2,540	....	....
All other countries	620	630	670	680	635	645
Totals	306,714	310,704	324,859	330,132	334,268	339,699

All the copper companies in which the English and French investors are interested have shown remarkable improvements in their dividend distribution for 1895 over the preceding three years, as will be seen from the following table, which is taken from the *Economist:*

	Dividends.				Price.	Yield.
	1895.	1894.	1893.	1892.		
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	£	Per Cent.
Cape Copper	$9\frac{3}{8}$	$6\frac{1}{4}$	$6\frac{1}{4}$	$6\frac{1}{4}$	$2\frac{3}{8}$	$7\frac{7}{8}$
Copiapo	10	$6\frac{1}{4}$	2	10	10	10
Mason & Barry	$3\frac{1}{8}$	$3\frac{1}{8}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$3\frac{1}{4}$	$4\frac{1}{8}$
Rio Tinto	11	4	7	7	$18\frac{3}{4}$	$5\frac{7}{8}$
Tharsis	$17\frac{1}{2}$	10	$12\frac{1}{2}$	15	$5\frac{3}{8}$	$6\frac{1}{2}$

Australasia, which at one time was so important a factor in the copper market, now figures only for 10,160 metric tons out of the enormous total for the world of nearly 340,000 tons. The Wallaroo & Moonta Company produces more than half the quantity credited to Australasia, in 1895 raising 28,579 tons of ore, of which nearly one-half contained 20% copper and the balance was of 14% grade. When we come to the cost, and judging from our knowledge and experience of what is being done elsewhere on low-grade ores, it seems almost incredible that such high-grade ores, worked upon this large scale, should not be more profitable than they are, and it would require an expert's report to explain why the mining cost per ton of copper should be, as shown in the company's own reports, more than $153, the smelting cost per ton of copper $52.50, and the shipping and other charges (exclusive of the charges deducted in the account sales) more than $5 in addition per ton of copper, or in all $212.88. This being equivalent to £42 12s. per ton of copper delivered would seem to indicate that in place of any dividend-paying capacity there would be an absolute loss, as the average price in England for 1891 was £51 9s.; for 1892, £45 12s.; for 1893, £43 15s.; for 1894, £40 7s.; for 1895, £43.

Austria-Hungary.—The output is not large and is variable. Thus while it rose from 1423 metric tons in 1893 to 2154 tons in 1894, it fell off again to only 1331 tons in 1895. There is no special news from the Austrian mines, and as their capacity is pretty well understood from long working, there is no expectation of any large increase in the supply from this source.

Bolivia.—Under existing conditions this country is not in a position to compete advantageously with other copper-exporting regions having better development and greater transportation facilities. The capacity of the mines is an indeterminate quantity, but may be much larger than the actual production would signify. For the last three years, however, the amount of copper made has been steadily, though slightly, decreasing, falling from 2540 metric tons in 1893 and 2337 tons in 1894 to 2296 tons in 1895.

Canada.—Production has slightly increased, reaching 3924 long tons in 1895. The most important mines, those at Sudbury, are in ore containing nickeliferous pyrrhotite, chalcopyrite, and some millerite, and are worked for both nickel and copper. The ores are simply roasted in heaps to reduce the sulphur down to a sufficient point to admit of concentration in matte, and then they are very cheaply smelted to a copper-nickel matte in Herreshoff blast furnaces. There are other smaller blast furnaces in the district, but not so efficient, and it may be safely stated that 90% of the ore hitherto treated at Sudbury has been handled in this manner by the Canadian Copper Company. In making a comparison between Spanish and Sudbury ores, so far as copper alone is concerned, it is in favor of the Sudbury ores, as their treatment, heap roasting and smelting together, does not cost more than $2 per ton, the resulting matte (about 23% copper) besides having the advantage of the accompanying nickel. From the report of Commander Folger and Lieutenant Buckingham to Secretary Tracy, of the United States Navy, on the subject of Sudbury, we learn that "the average amount of copper and nickel combined is about 8%, 5 of copper and 3 of nickel," in the Copper Cliff Mine. At the Evans Mine "the grade of the ore is not quite so high as at Copper Cliff, and averages about 7%" (copper and nickel combined). At the

Stobie Mine "the percentage of nickel and copper is smaller than at either of the others, hardly averaging above 5%, but several pockets very rich in nickel have been worked. This ore is remarkable for its fluxing qualities, and forms a valuable mixture to smelt the less fusible ore of the other mines and entirely obviates the necessity of the addition of any foreign fluxing substances." The Sudbury ore as a class appears to be considerably richer in copper than the Spanish ores, which latter contain 2½ to 3%. The mining cost at Sudbury cannot be put at less than $1.50 a ton, or say 1.95c. per lb. of refined copper. The above comprise the mines being actively worked in the Sudbury district, and all belong to the Canadian Copper Company.

On the authority of Dr. E. D. Peters, Jr., Commander Folger, and others, we learn that roasting ores costs 50c. per ton of ore, including handling from mine bin or loaded ore cars and delivery to blast furnace, and it is stated now to be considerably less. From the price of fuel and the rate of wages paid, including all repairs, renewals, etc., with the furnaces in use at the Canadian Copper Company's works the cost of smelting cannot exceed $1.50 per ton, no dead flux being used, and about 6 tons of ore produce 1 ton of matte. This matte contains about 23% copper; therefore 460 lbs. of copper in matte are produced, so far as roasting and smelting is concerned, at a cost of $12, or 2.61c. per lb. To this has to be added the freight on the matte to the refiners and cost of refining, amounting altogether to about 4c. per lb., making the treatment and handling cost of 1 lb. refined copper about 6.67c., which added to the mining cost would make a total of 8.56c. per lb. At the same time, in making a comparison of cost of producing copper at Sudbury, the direct cost should not be reckoned with alone, as the nickel produced should bear part of the refining cost or its value must be looked upon as a very handsome profit on the operation of the two metals jointly. The actual cost of extracting and refining the copper from the copper-nickel mattes produced at Sudbury is about 1½c. per lb. of copper.

It is not reported how much ore and of what value the Sudbury mines of the Canadian Copper Company have "in sight," but from all accounts the deposits are very large. At late quotations for shares the selling value of the property would be $3,500,000.

In British Columbia the amount of prospecting going on promises to lead to something in the way of copper as well as other ores.

Cape of Good Hope.—The yield of copper from Cape ores, though not yet very large, is remarkably steady and has stood at something over 5000 tons annually in the past four years (5350 long tons in 1895); while the Namaqua mines, also controlled by the Cape Copper Company, produced 1730 tons in 1895, a considerable increase over former years. The company has paid £43,125 in dividends and carried over a balance of £66,101, out of which a further dividend was paid (January 1, 1896). The financial showing is better than in any year since 1889, which is attributed to better prices, lessened costs, and closer work.

Chile.—The proportion which Chile's present production (22,428 metric tons in 1895) bears to the world's supply is small in comparison with what it used to be. The cost of production is extremely difficult to arrive at, but private advices and the slight increase in the product over that for 1894 indicate that there still is money in the business. The largest producers are private firms or close corporations publishing no accounts, and the only guide to the cost of production in Chile is the annual account published by the Copiapo Company. Taking this mining company's property as representative, we find that the amount of ore produced during the year is very small in comparison with the large copper mines of other countries, being in the 12 months ending June 30, 1895, 10,813 metric tons of 18.27% ore, showing an increased production and value over 1894. The reserves as recently estimated, however, are quite considerable, amounting to 28,614 tons of 17% ore and 44,000 tons of 3% ore. But in spite of all these advantages of working high-grade copper ores and a very fair tonnage, the best profit that could be shown, without making any allowance for decrease in value of property, was but little over $10 per long ton on the total copper production, or less than ½c. per lb. of copper produced. The improvement in the market has caused some old mines in the neighborhood of Autofagasta, where costs are excessive and water scarce, to be taken up, and there is a possibility that Chile, once the greatest producer in the world, may increase its copper output.

Germany.—The production is very steady, and of the 16,820 metric tons made in 1895 the Mansfeld Company produced nearly all (15,098 tons).

Italy.—The copper yield of Italy is stationary, and for several years has stood at about 2500 tons.

Japan ranks next after the United States, Spain, Portugal, and Chile as a copper producer, with a fairly steady output, though declining slightly in 1895, when the make was 18,725 metric tons.

Mexico.—In 1895 nearly all of the total product (11,958 metric tons) came from the Boleo Mine. Among the improved facilities for producing copper, the extensive concentrating and bessemerizing plant of the Guggenheims at Aguas Calientes has recently become productive, turning out high-grade blister copper. Other works have been or are to be built in Sonora, and in the future an augmented production may be looked for.

Newfoundland.—Owing to improved means of treating the ores at Tilt Cove considerable savings have been effected, and the mines operated by the Cape Copper Company showed a profit of £8824 for 1895, as against a small loss the previous year. The ore mined by this company came from the East Mine; the West Mine has been unwatered and put in shape for active operations. The total copper output of the province is still small, and indeed of late has been slightly decreasing, notwithstanding the supposed possibilities of its mines.

Norway.—A deposit of copper ore, said to be of some importance, is reported to have been discovered at Kaafjoord, from which sampling gave 7 to 9%. The older sources produced 2728 metric tons, an increase over 1894.

Spain and Portugal.—The great Rio Tinto deposits continue their remarkably uniform yield, and by a small increase have now reached the highest mark in their history (33,513 metric tons copper for 1895). The report of the company by no means gives all the information desirable, especially in the way of data from which costs might be computed, and much that would be of great professional value, the publication of which could in nowise hurt the company commercially, is omitted.

There is no question whatever that the financial part of the company's affairs is ably managed. Taking advantage of the money market, the conversion of the

5% bonds of three different issues into one consolidated 4% debt, through the assistance of the Messrs. Rothschild, has already resulted in a saving to the company of £64,000 a year, and during the current year this saving will amount to £74,000, which is equal to more than 2¼% on the share capital of the company.

The Rio Tinto Company is more of a manufacturing than a mining concern. Within the 23 years of the company's existence 23,000,000 tons of ore have been extracted, and yet, by the aid of the diamond drill, the management is satisfied that it still has in sight 135,000,000 tons. Of this quantity it is estimated that 35,000,000 tons consist of low-grade copper, leaving 100,000,000 tons of a grade not lower than the average which has paid the dividends of the past years, so that at the present output of nearly 1,400,000 tons per annum it may be safely said that there are still 70 years of life in sight. There are estimated to be 106,164 tons of copper in the reserve heaps of washed mineral, which will yield part of their contents gradually.

The quantity of overburden removed during 1895 was 596,675 cu. meters. The quantity of pyrites extracted for the year was: For shipment, 525,195 tons; for local treatment, 847.181 tons; total, 1,372,376 tons, of an average copper content of 2.821%. The quantity of pyrites invoiced to consumers in England, Germany, etc., was 518,560 tons, against 485,441 tons in 1894, 469,339 tons in 1893, and 435,758 tons in 1892. The copper produced in 1895 by treatment at the mines was 20,762 tons, and the copper in the pyrites shipped amounted to 12,223 tons; total, 32,985 tons. Sales of copper were: Refined copper, 20,230 tons; copper in pyrites, 11,065 tons; total, 31,295 tons.

RIO TINTO PYRITES AND COPPER STATISTICS.

Year.	Pyrites Extracted.				Pyrites Consumed.		
	For Shipment.	For Local Treatment.	Totals.	Average Copper Contents.	Tons.	Average Copper Contents.	Copper Produced at Mines. Tons.
1892..........	406,912	995,151	1,402,063	2.819	435,758	2.569 / 1.465	20,017
1893..........	477,656	854,346	1,332,002	2.996	469,339	2.659 / 1.544	20,887
1894..........	498,540	888,555	1,387,095	3.027	485,441	2.594 / 0.988	20,606
1895..........	525,195	847,181	1,372,376	2.824	518,560	2.595 / 0.986	20,762

The capital of the Rio Tinto Company in shares is £3,250,000, all issued and fully paid. In addition the company has outstanding 4% bonds to the amount of £3,600,000—in all about $34,250,000. Par value of shares, £10; late London market price, £15 10s. The stock paid 11% in 1895.

The character of the Spanish and Portuguese ores (for although the Mason & Barry property is on the same mineral belt as the other two, it is situated in Portugal) is chalcopyrite and pyrites of iron (bisulphide), giving a percentage of sulphur usually running between 47 and 48, and therefore of considerable value for sulphuric-acid manufacture in that portion of the product exported. The percentage of copper in 1895 was 2.821, and the value of sulphur contained in pyrites in this country is about 10c. per unit. The large tonnage treated locally at Rio Tinto is mostly calcined in piles and leached out with water, the copper extracted being precipitated on scrap and pig iron and shipped in form of copper precipitate (cement copper), equal to about 75 to 80% metallic copper, afterward to be reduced to refined metal.

It is difficult to say how long these Spanish mines have been worked, but it is well known that they were worked by the Romans and formed one of their principal sources of copper supply 2000 years ago. Probably the Rio Tinto Mine was worked by the Phœnicians prior to the Roman period. In the case of the Rio Tinto the records of its past working are wonderfully complete as to data, and the discoveries made from time to time in the old workings are silent but irrefutable testimony as to the age of the mine. In 1887 a wooden water wheel was discovered on the reopening of old workings which had caved in about 1500 years ago. This was one of many uncovered at various depths, and was found 407 ft. below the surface, therefore proving many years' work prior to the caving in. Mr. E. Cumenge, in a report on these pyrites deposits in 1883, mentions that in the Rio Tinto alone the Phœnicians and Romans have left, as evidence of the activity with which they worked these mines, more than 180 miles of workings, and accumulated no less than 20,000,000 tons of slags and cinders on the surrounding dumps.

In the case of the Rio Tinto the latest well-authenticated statement of cost is that of Mr. Cumenge, which for roasting, leaching, precipitating, and freight on precipitate to England would amount to 3.12c. per lb., to which add cost of converting into refined metal, say ¾c. per lb., making the total cost 3.87c. per lb. The proportion of dead work in stripping at Rio Tinto is set down at 20c. per ton of ore, and the cost of actual mining, crushing, transportation to heaps, sorting, etc., at 50c., making a total of 70c., and taking the average grade of the ore treated, this would give a total cost of refined copper marketed of about 7.44c. per lb. It is true that the company claims to be still cheapening production, but it is impossible to arrive at any accurate estimate of cost, and no authentic statement on the subject has recently been made on independent authority. What makes it more difficult to arrive at an exact figure is the fact that the ore is handled by no less than three different processes, about one-third being exported crude and deriving its value from sulphur contents in addition to copper, a comparatively small percentage of selected ore being smelted to a high-grade matte, to which selected ore there is occasionally added poor-grade precipitate, and the wet process of extraction producing precipitate (cement copper), which is shipped to England in bags for reduction to pig copper and refining. The figures of cost as given above apply to the bulk of the copper product, viz., that in form of precipitate.

The Rio Tinto Company in 1894 produced 32,689 long tons of copper. We also know that the average price of copper per pound in England during 1894 was 8.97c., and that the published accounts of the operations of the same year show a net profit of £230,086, of which £71,173 was brought into the balance sheet as undivided profit from the previous year. Deducting this amount, the net profit per pound of copper was apparently 1.08c. per lb., and therefore the cost of production 7.89c., or 0.35c. higher than the calculation made above, starting from a different standpoint, viz., that of cost of stripping, mining, transportation, leaching, refining, etc.

In reality, from the accounts of the Rio Tinto, the actual and legitimate profits in placing copper on the market would seem to "disappear" entirely, for of the net available balance which we have taken as the profits, on their own showing, £97,678 was credited to revenue account as "rent on company's houses in Spain (less repairs) and other profits" and "adjustment of exchange account," which, if deducted from the real business of copper production, would make the cost of copper per pound about 8.60c., or within 0.37c. of the average market value.

Furthermore, it must be borne in mind that of the total copper produced, viz., 32,689 long tons, 12,083 tons was sold as copper in pyrites exported, for which it is not probable that the average price of refined copper mentioned above was obtained, at least in this country. The discount from the regular market price is very heavy, so that the direct cost of producing copper from Rio Tinto ore in 1894 clearly exceeded its market value.

But there is still another deduction from this apparent profit to be made, viz., the price realized from the sulphur contents of the pyrites exported. Taking the sale value of this at 7c. per unit after deducting all cost of mining, shipping, etc., more than the whole of the available net profit is more than accounted for by the sale of sulphur, and the copper production really shows a loss, as in the 485,441 tons delivered the value of the sulphur paid for amounted to over $1,-590,000, or £318,000.

For 1895 the ore averaged 2.801% copper, a little lower than of late years. The cost of production is reported to have been materially reduced, but no definite statement is made.

The number of men employed by the Rio Tinto Company in 1893 was 10,474, of whom 2245 were in the mine, 7068 on top and in open cuts, removing overburden, etc., and 1161 at Huelva, the shipping port. This would be about 1 man to every 3 tons of copper produced. At the Tharsis and Mason & Barry the proportion is possibly a little larger, and in the absence of late official figures the total force now engaged in the copper industry of Spain and Portugal may be estimated at between 16,000 and 17,000 men.

The figures of mining cost given by Mr. J. D. Delprat are very interesting, the cost of removing overburden per cubic yard in 1891 being 15c., which is very conclusive in favor of the system of working by open cast adopted by the Rio Tinto Company, underground mining having been practically abandoned. A railroad system arranged in a corkscrew fashion brings out the ore from the lowest portion of the cut and the old pillars of the abandoned workings. The limit at which the removal of overburden becomes unprofitable is generally put at 4 cu. yds. of overburden for every ton of ore laid bare. The cost of quarrying the ore after having it laid bare may be taken as follows, exclusive of general charges: Breaking the ore, miners, $0.038; materials (explosives), $0.012; shops, $0.004; tools, $0.005; total, $0.059. Loading into wagons, $0.038; weighing, $0.003; total cost per ton, put into wagons and weighed, $0.10. While the breaking of ore in the open cast may cost $0.07 per ton, the breaking in galleries will cost on the average from $0.52 upward. When the ore is very hard it may reach $0.85. A miner will break per shift in the latter case less than a ton, but in open cast 10 to 12 tons.

The present Tharsis Copper and Sulphur Company was organized in 1866, with its office at Glasgow. The stock issued and fully paid represents £1,250,000, with outstanding bonds of £26,500. Par value of shares, £2; market quotation, about £5. There are six lodes or deposits of the same general character as the Rio Tinto, and the workings are of great antiquity. The upper portion of the pyrites bodies averaged between 3 and 4%, but at a depth of about 350 ft. the run is said to be of much lower grade. The old method of treatment was by calcination; the present by natural oxidation in large heaps, the oxidation being expedited by intermittent washings with water. The copper is precipitated from the leach water on iron in creosoted lumber sluices.

The total quantity of mineral raised at all the mines of the Tharsis Company in 1895 was 612,483 tons, against 588,427 tons in 1894, an increase of 24,056 tons. Production of copper at the mines was the largest in the history of the company, owing to a great extent to the abundant supply of water all through the year. Pyrites shipments were 197,832 tons large mineral, 22,996 tons small, and 6001 tons washed mineral. Of copper precipitate 9443 tons were shipped, against 7386 tons the previous year. The reduction works and the refining works produced over 1200 tons more of copper than they did last year, owing to the larger shipment of precipitate from the mines. The refined copper was produced at a considerably lower cost than in previous years, great benefit being derived from the concentration of their scattered works; £23,690 were written off of the mines in Spain and £20,000 have been written off railway rolling stock and shipping piers. A dividend of 17½% was paid from the earnings of 1895. There is no information as to the average price at which the copper and sulphur was marketed nor the actual amount that was marketed, but only the figures as to the amount shipped, with the rather vague statement that the cost of copper was lower than it had ever been, and that the amount produced was greater than it had ever been. Figures relating to cost of removing overburden and cost of mining and marketing are entirely omitted.

The Mason & Barry Company at one time had a capital of £2,100,000, which now is reduced to £840,000 by writing off and return of capital in place of dividends. Par value of stock, £4; quotation, £4 15s. The output of copper continues steady at over 4000 tons annually. The character of the ore and percentage of copper are about the same as at Rio Tinto. The Sevilla Mine, not a large producer, decreased its output slightly in 1895.

Russia.—The copper industry has not yet made much progress, notwithstanding the number of occurrences of ore and of localities which have been more or less productive. In fact, the annual yield, standing at about 5000 tons for some time past, is even less than it was 12 years ago. It is anticipated that the pushing of the Trans-Siberian Railway will tend to encourage the opening of the deposits of Eastern Siberia.

Sweden shows no gain in the amount of copper produced, which in 1895 was only a little over 500 tons. Most of the copper ore mined in Sweden is exported, either as ore or after matting, for treatment.

United Kingdom.—The small quantity of copper now coming from the Cornish mines shows that with the prevailing prices for the metal and in face of the keen competition of the larger foreign producers the local industry is by no means flourishing.

The New York Copper Market in 1895.

The great financial disturbance which visited our country during 1893 cast its shadow far into 1894. As during previous severe depressions, history repeated itself, and it took a considerably longer time than could have been foreseen, even by the shrewdest business men, before the vitality of the country was restored to its full extent.

In the mean time the manufacturing communities were among those on whom the burden fell most heavily, and it was only by degrees that business could again be greatly extended. The unhealthy financial depression in which a great many of the large railroad systems found themselves after the panic, and which necessitated the greatest economy, had a marked influence on all metals, as for a long time only the most necessary repairs were made, while there was practically a suspension of new orders for a period of about 18 months. Building operations also were greatly affected, perhaps not so much in the larger towns on costly buildings, but in the country at large, both for manufacturing and private purposes.

Under all these adverse factors, copper had to suffer most severely, as was fully reported in our review of 1894, and although some signs of a larger consumption were noticeable toward the end of 1894, it was not until the spring of 1895 that consumption became considerably larger and quickly absorbed the stocks, which had never been very large during the past two years. The main demand was for electric purposes, and wire drawers found themselves busier and with more orders on their books than at any period before in the history of copper.

Enormous quantities of copper were used for trolley wires, the extension of trolley roads in the suburbs of larger towns and connecting neighboring centers and the conversion of horse railroads into electric lines having all at once made extraordinary progress.

Whether the construction of similar roads will continue at the same rate is a question difficult to answer, but it may be fairly assumed that it will not be quite as rapid as during 1895. A great many roads were projected and would have been built during 1893 and 1894 had it been possible to raise the necessary amounts of money at advantageous rates, and after this difficulty was overcome, the amount of work done during a period of 12 months was equal to that of 30 to 36 months in ordinary times. The most thickly populated neighborhoods of our country are now provided with trolley or cable roads.

A most interesting statement is found in the annual report of the president of the Western Union Telegraph Company for the year ending June 30, 1895, in which it is stated that during the previous 12 months 15,748 miles of new wire were constructed, of which over 10,000 miles are of copper, "in accordance with our policy of replacing the defective iron wires on our trunk routes with copper wires. This has been made practicable by the fully assured processes for the manufacture of hard-drawn copper, and important advantages are gained by using it." Nothing could more plainly show nor put in a brighter light the advantages of copper over iron wire than this statement from one of the largest consumers of wire—both of iron and copper.

Similar reports have been received from Europe, and the continued extension of the telephone system all over the world insures for years to come a very large consumption of copper in this direction.

Extensive trials have been begun with the view of utilizing the trolley system for general railroad purposes, and satisfactory results have been obtained by several companies on local lines and branches. There may be some details which still require perfection, but in the main it is only a question of time when the introduction of electricity, replacing steam power, will revolutionize the railroad system of the world. This will again greatly extend the use of the metal.

Not alone for electric purposes, but in a great many other ways has the consumption of copper expanded. The brass and yellow metal trade was very good. The modern technique of war requires copper to a very large extent for weapons, cartridges, and other military purposes, and the revival in the shipbuilding trade had a marked and beneficial influence. Not alone did Europe consume large quantities of the metal at all the large shipyards, but our own industry made wonderful progress in this respect, and besides the many men-of-war which have been built in the United States during the past two years, two of the finest steamers now riding the Atlantic were built at the shipyards of Cramp & Sons, in Philadelphia.

The demand for sulphate of copper during the year was larger than ever, and unless all signs fail, consumption in future will be larger than it has ever been in the past. While thus the outlook for a steady demand for copper remains very good, production, especially in the United States, has of late shown signs of a not inconsiderable increase. The famous camp of Butte, Mont., has been exceedingly busy, and with the great progress which has been made of late in the smelting and refining process, handsome returns were made on the capital invested.

The Lake region in Michigan, in conformity with its known conservatism, slowly but surely increased, and the cost-sheets of the main producers reflect great credit on the careful management of the different concerns.

Arizona also reported a heavier output, which is likely to increase during 1896, for the Old Dominion Mine, which has been closed down for almost 12 months and has since changed hands, will again become a producer. The Copper Queen Mines, which have during the year been equipped with converters, which are known to give satisfactory results, are producing more than before, and the excellently managed United Verde Company is more and more pulling to the front. Besides, the smaller producers in that State are also gaining, even if not in the same proportion as their larger colleagues.

Among the other States, Colorado and Utah show increases, and from California larger supplies are expected during 1896. Besides, the Republic of Mexico will more and more come into the foreground, as extensive works have been and are in course of erection in the States of Sonora and Aguas Calientas. British Columbia too is being eagerly prospected and appears to give fair promises.

Lake copper early in the year was quoted at $9\frac{3}{4}$c. per lb., and this price was fairly maintained until the period for the opening of navigation drew near, when a slight falling off in prices took place, and during the months of March and April $9\frac{3}{8}$@$9\frac{1}{2}$c. was freely accepted for large quantities. The production of electrolytic copper, which by that time had again increased, added largely to the supply of fine copper, but with the great consumption then experienced, especially for wire purposes, not much difficulty was experienced in selling. Besides, Europe was taking fairly large quantities, but the buying from this quarter was, as at all times during the year, conducted with great caution, and very often buyers exacted sacrifices from producers so far as prices were concerned.

In any case, during the months of March and April very large contracts were made, and the accumulation of Lake copper prior to the opening of navigation was quickly absorbed. The steamers could not bring the metal down quickly enough, and it all very readily found its way into manufacturers' shops or was exported. Under the circumstances it did not take long for the market to stiffen, and a period of uninterrupted rise set in, which carried Lake copper up from about 9¾c. at the end of April to 10½c. at the end of May, 11¼c. at the end of July, and 12c. at the end of August. Whatever was offered found ready buyers, either for spot or forward deliveries, and such a veritable boom as the summer months experienced had not been seen for many a year past. Consumers seemed never to be satisfied, and, as usual in similar periods, prices were driven up against themselves, so that they could not be prevented reaching a level which to real and true friends of the industry became alarming. Thus while Europe was all along a ready buyer of our product, prices here were driven up far beyond the parity of those abroad. Speculation was at its height, and no means were too good or too bad to raise prices still higher. In Europe reports were eagerly spread that consumption here was so large that our own production would not suffice, and in order to make the story the more plausible, several hundred tons of copper were taken from warehouses on the other side and shipped to this side, where most of it was stored away to be reshipped later on when a suitable opportunity presented itself.

For some time past the activity of the mining stock markets in London and Paris, especially in South African mining enterprises, had been a source of envy to the brokers on this side, when all at once a large field for their operations was opened. Copper shares, mainly dealt in on the Boston Stock Exchange, experienced even larger fluctuations than during the time of the French Syndicate bubble, and the value of some of the shares was doubled, while some even exceeded their quotations earlier in the year by more than three times. The fact that this could not last forever was not lost sight of by those who had for years past been patiently awaiting an opportunity to get rid of some of their high-priced stocks, while on the other hand the appetite of new buyers appeared to have no bounds. The highest price for the shares was reached in August, and after copper became quieter and the market for the metal eased off somewhat the decline was almost as rapid as the advance, and with the exception of the dividend-payers which have justly retained part of the advance, values have pretty nearly reached their former level. Meanwhile the active business in the metal continued, and with it the desire on the part of producers to constantly exact higher prices.

Toward the middle of September business in the raw metal began to fall off perceptibly. Prior to that the Calumet & Hecla Company had made a very large sale, said to be between 15,000,000 and 20,000,000 lbs. of copper, for delivery up to the end of the year, at 12c., and this filled the requirements of buyers for a long time to come. Values abroad were too low to admit of exports. Manufacturers were well covered with orders, but in the absence of new business did not wish to enlarge their holdings—on the contrary, tried to reduce their interests—and kept out of the market. Thus a long period of inactivity set in, seldom witnessed in such an important trade as copper. Many of the larger producers considered the crumbling off of prices as only temporary, and this was taken advantage of by one of the largest operators in the market to get rid of enormous holdings of copper which he had accumulated and which were now marketed, irrespective of price, mainly in Europe.

A large increase in the production of some of the main producers, principally Anaconda and Calumet, frightened buyers more and more, and thus, without any business of consequence being done, prices for Lake copper quickly receded from 12 to 10¾c. by the beginning of December.

As usual during the latter month there was hardly any demand on the part of consumers. The Presidential message on the Venezuela dispute caused quite a flurry on the Boston Stock Exchange, and copper shares experienced a heavy drop, which was partly recovered after the excitement had subsided a little. However, the disturbance of the money market and the threatening financial outlook naturally adversely influenced prices of the raw material and values declined still further.

Within the last few days of December it was reported that the Calumet & Hecla Company had made a sale to home manufacturers at 10c. per pound. The quantity involved is said to be 10,000,000 to 12,000,000 lbs.

In other grades the decline was even more marked. Electrolytic copper, which in the fall readily sold at 11¾c. per pound, could be bought at 9⅞@10c. at the end of December, and casting copper, which earlier in the year was quoted at 9⅛c. and later sold as high as 11½c., declined to 9¾c.

The market closed in a very unsettled state. While consumers gave no evidence of business being brisk with them, few had covered their wants for the first few months of 1896. Closing quotations were: for Lake copper, 10c.; electrolytic, 9¾@9⅞c.; cathodes, 9½c.; casting copper, 9½c.

The statistical position of the article at the close of the year was considered a rather favorable one, and with a revival in business and subsequent better demand on the part of consumers higher values were expected.

The following table shows the average prices in New York for each month of the last six years, the figures being taken from the weekly reports of the *Engineering and Mining Journal* :

AVERAGE PRICE OF LAKE COPPER PER POUND AT NEW YORK.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1890..	14.800	14.333	14.500	14.400	15.125	16.000	16.800	15.400	17.000	16.900	16.800	15.900	15.750
1891..	14.750	14.500	14.000	13.750	13.200	13.000	13.000	12.200	12.500	12.250	11.000	10.625	12.625
1892..	11.000	10.625	10.375	11.500	11.625	11.875	11.500	11.500	11.125	11.500	11.875	12.375	11.550
1893..	12.125	12.000	11.875	11.375	11.000	11.000	10.875	10.000	9.875	9.750	10.000	10.250	10.750
1894..	10.125	9.625	9.813	9.500	9.800	8.938	9.000	9.125	9.400	9.875	9.600	9.800	9.560
1895..	10.000	10.000	9.750	9.750	10.250	10.625	11.250	12.000	12.250	12.000	11.000	10.500	10.760

Electrolytic copper averages usually about ½c. per pound below the price of

Lake, with ¼c. additional off on cathodes. Casting copper is usually about ⅜c. below Lake quotations. The price of Arizona is generally kept above its true relative value, because a large part of the output is taken by parties who control the production.

For the years previous to 1890 the figures will be found in THE MINERAL INDUSTRY, Vols. I. and II.

THE LONDON COPPER MARKET IN 1895.

THE new year opened in downward tendency, the increase of 2000 tons in the visible supplies of copper having brought out selling orders resulting in a fall of 12s. 6d. in G. M. B.s, to £40 12s. 6d. sharp cash. Later in the month there was a rally of a few shillings, followed by a fresh decline, though the total range of the fluctuations was limited, the prevailing note being apathy, as shown in the small volume of speculative business and the inertia of values. Refined copper remained steady, with tough qualities ruling at about £43 to £43 15s. and best selected at about 15s. per ton higher. In America, on the other hand, things wore a decidedly firm aspect, Lake being held for 10c., the consumption, specially for electrical purposes, being very active and production proceeding on a reduced scale. This should, in the natural course of things, have given a lift to our market, but there were unfortunately some counteracting elements, as the very large American shipments (mostly in execution of old orders, it is true) and the unsatisfactory aspect of finances in the States, with the heavy gold shipments thence which excited apprehensions of large copper exports ensuing. The second fortnight of January, as a matter of fact, brought an increase of about 1000 tons in the statistics, and under this influence February opened dull at £40 1s. 3d. G. M. B.s spot, and before the month closed the value had fallen to £38 17s. 6d. Factors in this movement were the continuation of large shipments from the States, and more immediately still, Stock Exchange manipulations in connection with Rio Tinto shares. As to the market for consumers' copper, the general demand was poor, business being hampered by the prolonged frost and the manufactured trade (sheet, plates, tubes, etc.) being in a sorry plight. There was, however, some very important business done in fine copper (English best selected and Australian copper) with the English Admiralty, which took nearly 2000 tons in all, while one large English smelting concern sold over 1000 tons of tough and best selected chiefly to the Continent, which also took large quantities of electrolytic copper. Fine sorts consequently grew scarce and their value tended upward.

Lake had meanwhile declined to 9.62½c., which price was still dear in comparison with European values.

Throughout the month of March the G. M. B. market remained, on the whole, decidedly in a lethargic state, the advices from America being of a nature to check rather than encourage active interest in the article. The weaker silver market likewise had an adverse effect on copper values, and toward the middle of the month the market was affected by the falling due of prompts of the large balance of French Syndicate stock realized three months previously. Cash G. M. B.s were consequently depressed to £38 12s. 6d., but from this point rallied to

£39 5s., assisted by an advance of over 3d. per oz. in the price of silver and by the anticipation of good statistics. Previous to that advance demand on the part of consumers was of the poorest, and the pressure of American offers, especially of cathodes, at low prices, coupled with the lack of orders and the unremunerative prices complained of by brass and copper manufacturers, sufficiently accounted for the hesitancy shown by consumers to cover anything beyond their present needs. The rise in silver, due mainly to Chinese purchases, gave a momentary fillip to demand, resulting in business in manufactured copper for India and in refined sorts for home and Continent.

At the beginning of April the improvement in G. M. B.s was still in progress, £39 12s. 6d. being ultimately paid for spot; but the upward movement in silver having culminated, and being followed by a relapse, copper followed suit, but only for a brief space, a potent factor for good making its appearance in the shape of a general revival of trade in the States and at home. In both countries there was quite an active demand for fine sorts, including electrolytic. The hardening tendency which this exerted upon prices of consumers' copper was enhanced by the fact that producers had in many cases sold the bulk of their make for forward delivery. Good business took place in India sheets, and Birmingham consumers, though still complaining of unprofitable prices, were all decidedly better off for work than they were during the previous quarter, and were now, in fact, working full time, as against three-quarters time previously. Encouraged by the brighter outlook, speculators again began to take an interest in copper, and their purchases resulted in an advance to £40 13s. 9d. spot.

May opened with further large sales of English copper, followed by the withdrawal of first hands from the market, while the price of Lake in America was steadily advancing. The second week of the month was marked by greater excitement than at any moment since the time of the French Syndicate. The cause of this was the negotiations between the European and the American producers for the limitation of American exports to 60,000 tons per annum and the reduction of the European output by 7½%. While the American imports for the present year so far had not exceeded the rate proposed to be fixed as a limit, the announcement of the agreement being carried through inspired great confidence, the previous year's exports having greatly surpassed the figure named. A rapid rise ensued in G. M. B.s from £40 13s. 9d. to £44 15s. 1d. and £45 10s. three months, when, to the general astonishment, came the news that one of the largest of the American producers declined to enter into the agreement. The disappointment of those who were so greatly misled by bull operators was intense, and selling became general, with the result that a drop of £3 took place in G. M. B.s, while English and continental consumers, who had been buying freely, at once ceased purchasing. Lake, which had risen to 10.62½c., and of which very large quantities had been sold, now declined to 10.25c.

The various attempts subsequently made to take up the thread of the negotiations created a momentary flutter, but did more harm than good by unsettling the minds of some of the smaller speculators, though the general trade practically disregarded these manipulations, the more so as American shipments were proceeding on a moderate scale, while the intrinsic position of the article appeared good. A reaction to £44 for spot and £44 10s. three months ensued upon the fall above named, but the month closed with a fresh collapse due to the operations of certain speculators and to the lack of confidence thereby induced, and the value of spot on May 31 stood at £42 16s. 3d.

June opened with a brisk advance to £43 15s. spot, but the value was again depressed to its former level by realizations and "bear" sales. Thenceforward the speculative market was subject until the end of the month to minor fluctuations, the close being at £42 8s. 9d. spot.

Consumption continued active, but fresh orders were sparse and inquiry for refined copper was consequently not very active. Toward the middle of the month came the first sign of reaction from America, whence a quiet market and a reduction of 12½ points in the Lake price was reported. Statistics, too, were bad, the month of June showing a total increase of 4000 tons.

Early in July things again began to wear a more cheerful aspect, and a revival of speculative demand led to a brisk advance in G. M. B.s, which carried the value from £42 7s. 5d. to £43 7s. 6d. for spot. American reports also came firmly; but here, although consumption was admittedly good, while very little copper was offered, consumers themselves held aloof and seemed disposed to wait for lower prices. The Continent, however, bought freely at full prices, and these had risen considerably, following the gradual advance in America from 10.75 to 11 and then to 11.75c. for Lake. Meanwhile G. M. B.s—from the above-named price (£43 7s. 6d.)—had risen to £45 11s. 3d., the cash value on July 31. Despite somewhat extensive realizations at the higher figures, the market continued to rise during the first week in August, and £46 5s. was reached for cash G. M. B.s, demand, both speculative and consumptive, being brisk, while Lake copper had advanced to 12c.

A check was, however, given to this improvement by gold shipments from America, and the realizations of G. M. B.s which ensued here led to a relapse of 23s. 9d. per ton. But the market quickly took heart again, and an active speculative demand setting in, in which America joined, G. M. B. values rapidly recovered and touched £47 8s. 9d. before the month closed. In America the consumption appeared to be enormous, and quantities of American copper, bars, ingots, and electrolytic, were bought back and reshipped from Liverpool and other ports to America, while several parcels of English copper, chiefly best selected and tough, were also bought and shipped to America. Meanwhile Lake had risen in New York to 12.25c., after a very large sale had been made at 12c. The demand for high-conductivity wire had been very extensive indeed, and the purchases of electrolytic copper for this purpose had brought about quite a scarcity of this description.

September opened less strong, with the quotation for Lake nominally lower and with America no longer a buyer in London, while in Birmingham the demand was practically nil, and low prices, £51 for best selected and £50 10s. for tough, were accepted for delivery in Birmingham, or equal G. M. B.s receded to £46 3s. 9d.; but a rally was caused by hopes that the English Syndicate, who had purchased one-fourth of the Anaconda shares (with the intention of issuing the same in London), would take an active interest in supporting the copper market. The advance in pig iron also aided copper, which rose to £47 2s. 6d. for cash G. M. B.s, but pig iron collapsing again and no effectual support coming from the said syndicate, G. M. B.s receded to £46 3s. 9d. for spot. America was now a rather freer seller of copper, but the month closed with good prospects, the Japanese Government having given out good orders for armaments and ships, which, with other important work, appear to have filled the order books of North country and Scotch engineers and shipbuilders for a long period in advance. Refined copper had become rather scarce, and the demand continued good, electrolytic copper for the Continent being particularly in request. The statistical position improved during September to the extent of about 2600 tons, and October opened in upward tendency with firmer cable news from America, whose offers of copper to Europe continued to be at full prices. From £46 10s. G. M. B.s advanced during the first week of the month to £47 6s. 3d. spot, but although copper in itself was sound enough, the improvement was converted into a decline owing to extraneous influences, chiefly to the fall of values on the Stock Exchange and to the unsettled state of the iron market; £45 17s. 6d. was eventually touched for spot, which afterward rallied to £46 3s. 9d. and then fell rapidly to £45 on the closing day. The offer of the Anaconda shares to the public toward the close of October fell flat and, taken together with the evidence of increasing readiness to sell on the part of the Americans, tended also to discourage and depress our market, and early in November the collapse of African gold shares, the resulting weakness and panic on the Stock Exchange, and further, the serious Scotch labor disputes, all combined to induce heavy realizations of G. M. B.s, and the value fell quickly from £45 5s. to £43 10s. spot. Consumers, however, bought more freely at the lower prices, and the good mid-monthly statistics, showing a decrease of 2400 tons in the visible supplies, gave a satisfactory indication of the intrinsic healthiness of the article. A greater confidence in the political situation, which had created a certain degree of perturbation, sprang up, and a recovery was thus induced to £44 7s. 6d. spot. But the better feeling was unable to assert itself permanently against the widespread distrust in the financial and political situations and against the apprehensions of heavier American shipments and lower American values. The offers from this latter source had grown very pressing and unduly low prices were accepted for electrolytic and other sorts. The effect on G. M. B.s was a decline from £44 7s. 6d. to £42 7s. 6d.; a rally of £1 per ton was followed by a relapse to £43 3s. 9d.

During December the market was at first steady. The cash value of G. M. B.s during the first fortnight fluctuated very gently in the near neighborhood of £43, mostly a few shillings under that figure. No salient feature marked the course of the market, which was devoid of all speculative elements. As to consumers' copper a moderate business was noted, American and English sellers meeting the market more readily. Consumptive demand was quiet, the approaching holidays and the prolonged deadlock in the relations between masters and men at Belfast and on the Clyde combining to check purchases.

In the closing week G. M. B.s again declined, touching £41 10s. at the opening, and fell to £41 2s. 6d., or about 10s. above the opening in January. Refined sorts showed about an even range, tough closing at £44@£44 10s., with best selected about £1 higher. Exports from America were reported heavier during December, which helped to weaken the market at the close.

Historical Sketch of Copper Smelting in the United States.

By James Douglas.

Our ancestors, before the Revolution, showed as much courage in undertaking, if not as much skill in carrying out, metallurgical enterprises, with a view to developing the scanty mineral resources of the narrow Atlantic seaboard, as their children to-day exhibit in unfolding the marvelous metalliferous wealth of our great interior.

As early as 1619 iron works were erected on Falling Creek, a branch of the James River, in Virginia, and though the Pilgrim Fathers landed on Plymouth Rock only in 1620, an iron furnace was built about 1644 by the "Company of Undertakers for the Iron Works" at Lynn, Mass., under the promotion of John Winthrop. Within less than a century afterward, despite the battles the early settlers had to fight against nature, a sterile soil, Indians, and the selfish trade policy of the mother county, there were, besides blast furnaces, two slitting and rolling mills in Massachusetts Bay and one each in Pennsylvania and New Jersey. Massachusetts had also one plating forge to work with a tilt hammer, Connecticut had six, New York, New Jersey, and Pennsylvania each had one, while Maryland had one with two hammers. Massachusetts, Connecticut, and New Jersey had each one steel furnace and Pennsylvania had two.

The colonies had meanwhile become more than self-sustaining in iron, for between 1728 and 1748 there were exported over 38,000 tons of pig iron and 417 tons of bars. After that date the trade grew, for in 1771 the returns show 2222 tons of bars and 5303 tons of pigs exported. The iron was in great measure made from bog ore.

That the smelting of copper was less actively pursued was due only to the scarcity of the ore, for even in 1648 Governor Endicott, of Salem, Mass., having in 1640 discovered copper between Danvers and Topsfield, Mass., petitioned the Legislature for 300 acres of woodland from which to cut fuel for smelting. He sent to Sweden and Germany for smelters, but the mine, after all his trouble and cost, proved too poor to be profitably worked.

About 1700 the Simsbury copper mine was discovered near Granby, Conn., and in 1707 a company of landowners was formed who paid the town 10s. per ton of copper, the proceeds to go to the support of a schoolmaster at Simsbury and to Yale College. A contract was made with three brothers, all clergymen, John, Dudley, and Timothy Woodbridge, to smelt the ore. But their theological and classical learning was evidently at fault when applied to metallurgy, and they failed. Yet the enterprise was still stubbornly followed, for Governor Belden stated in 1735 that he had spent £15,000 to no profitable purpose, though he had erected a smelter at Boston.

Hope fortunately never dies in a miner's breast, and therefore the Simsbury vein was still worked, and that notwithstanding the enactment requiring copper ores to be smelted in England so as to render her independent of the continent of Europe. Ill-luck never forsook the enterprise. Two shiploads of ore were lost —one wrecked, one captured by a French frigate. Despite the law, smelting and refining works were erected about this period at a village named Hanover by a German workman. They or Governor Belden's Boston works doubtless made the planchets of the purest copper, which were in demand by gold beaters, for alloys, and out of which the Granby copper cents probably were struck.

But a really lucrative copper mine had meanwhile been struck by Arent Schuyler in the town of Harrison, near Belleville, Hudson County, N. J., between the Passaic and the Hackensack rivers. No attempt was made to smelt the ore. The richness of the mine and the abundance of the ore shipped from it are said to have been the reason why copper was put on the *enumerated list* of the British Board of Trade and its manufacture in the colonies forbidden. Britain's selfish commercial policy of the last century was doubtless very reprehensible, but it sprang not only from the same self-seeking desire by those holding political power to help themselves out of other people's pockets, in which our own protective tariff and other trade-curtailing enactments have their origin, but from the necessity which her frequent continental wars forced on her of being as far as possible independent of European products. However that may be, the Schuyler Company acted wisely in merely concentrating and shipping its very siliceous ores, derived from impregnated sandstone, and not attempting to smelt them.

Other mines were opened on these sandstone beds besides the Schuyler, for Mr. Hewitt, in his interesting address as president of the American Institute of Mining Engineers in 1876, tells how his father, who had been sent to this country by Bolton & Watts, built the first American steam engine in the machine shops adjacent to the Belleville Smelting Works. These works were on the site of the present Hendricks copper-rolling mill. Mr. Hendricks tells me that the property, owned by his family since 1812, was in 1794 purchased by the directors of the New Jersey Copper Mine Association, and that this company afterward erected a smelting works, though nothing is recorded as to their extent or character.

The seductive native copper in the traps of New Jersey tempted two German refiners, before the Revolution, to erect a smelting furnace at Bound Brook. They derived what ore they smelted from the Bridgewater Mine, near Somerville.

The only other copper-smelting furnace in the colonies seems to have been erected by an English company in the middle of the eighteenth century on the Deer Park tract of land in Maryland, to work the ores of the Liberty and Mineral Hill mines. Whatever profit or loss may or may not have resulted, the company's metallurgist made rich slags, which were resmelted a century later in Baltimore.

We have no information as to the shape or size of the copper furnaces erected in the colonies. As German smelters seem to have been employed, the furnaces were probably low brick stacks provided with fore hearths; open at the top, whence they were fed, and discharging their fumes into hoods, the blast being supplied by bellows—in all respects like the furnaces so graphically depicted by Agricola in his *De Re Metallica.* The refining was probably done on open hearths. As the ores were everywhere acid, the difficulties attending the smelting must have been most aggravating.

The activity of the mercantile marine in the first half of this century made a brisk demand for copper sheets for ships' bottoms. In 1808 Paul & J. W. Revere, of Boston, petitioned Congress, as smelters and refiners of copper and manufacturers of copper sheets, bolts, and nails, for a duty of 17½% on sheets to assist native manufacturing. Old copper was to be admitted duty free. Nevertheless the copper-rolling business does not seem to have been successful, for in 1810 the Boston rolling mill, said to have cost $25,000, was idle. The same report states that copper was extracted from pyrites in Vermont, New Jersey, and Tennessee—the first mention of Tennessee as a copper producer.

In 1815 another petition was addressed to Congress by Joseph Revere, of Boston, and Levi Hollingsworth, of Maryland, asking for a duty on copper sheets. It states that there were then three copper mills in the country—the Boston mill, Hollingsworth's Gunpowder Mill, and one owned by a Mr. Livingston in New York. The two last had a capacity of 100 tons per annum. Crude copper was said in the petition to be imported from South America (Chile), Buenos Ayres, Carracas (Venezuela), Mexico, and the Levant to the amount of 400 tons annually. The Boston rolling mill survives till to-day, still under the title of the Revere Copper Company. The Levi Hollingsworth Works, on the Gunpowder River, 11 miles from Baltimore, with 2 sets of rolls, 2 refineries, and a slag cupola, were in operation under different ownerships till 1861. Baltimore's trade with South America was probably the inducement to Isaac McKim to erect a copper-rolling mill on Smith's Wharf in 1827. It ran till absorbed by the Baltimore & Cuba Smelting Company, which was incorporated by Haslett McKim and David Keener in 1845.

But copper-ore smelting was necessarily moribund for lack of profitable material. We find that in 1829 a furnace was erected at Strafford, Vt., to treat the pyrrhotite of that region, and in 1838 Isaac Tyson, of Baltimore, reopened the Liberty Mine, in Maryland, and attempted to smelt its ores. Later another Maryland concern was launched, and stranded after an even less successful voyage—the Patapsco Copper and Cobalt Company—for its furnaces were never blown in.

The year 1845 was notable in the history of the copper trade. The Copper Cliff Mine, on Lake Superior, was opened in 1844, but it was 1845 before Lake copper appeared on the market. In the same year the Baltimore & Cuba Smelting and Refining Company Works at Baltimore and the Revere Copper Company Works at Boston were started. This date, therefore, marks the real beginning of the active copper industry in this country.

The Revere Copper Smelting Works, erected at Port Shirley, in Boston harbor, began operations in 1845 and continued in operation until the tariff laws were so changed as to make their further employment absolutely fruitless. They were finally closed down in 1868. Their supply of ores was drawn chiefly from Chile, moderate quantities from other foreign sources, and a trifling contribution from mines then opened in this country. The system adopted was copied from the German. The smelting furnaces were small brick cupolas with two rear tuyères and the blast was supplied by Sturtevant fans.

The sulphureted ores were roasted in large piles in the open air. Twelve shift furnaces made matte, which was roasted in 24 kilns. The roasted matte was enriched by fusion in cupolas and the resulting coarse copper and rich matte brought up to blister in reverberatories, of which there were 4 used for that purpose and for refining the blister. When the works were closed the method was about to be modified by the introduction of calciners to roast crushed matte, and the reduction of this more thoroughly oxidized matte in reverberatories, to which end 4 large calciners and 4 additional reverberatories were being added to the plant.

During their life of 23 years the Revere Company's smelters were the most active competitors of the Baltimore works, but the enterprise must have been handicapped by the use of the cupola furnace, which is less easily adjusted than the reverberatory to custom ores of variable composition. The Revere Company rolling mills are still in active operation.

Reverberatories handled by Welsh smelters, following the Swansea methods, have always been the favorites in Baltimore. Mr. Brent Keyser, in the chapter on copper mining and smelting communicated to *Maryland, its Resources, Industries and Institutions*, prepared for the Board of World's Fair Managers of Maryland, Baltimore, 1893, from which has been borrowed most of the previous details on copper smelting in Maryland, thus summarizes the many vicissitudes of the Baltimore Smelting Works:

"In 1845 the Baltimore & Cuba Smelting and Refining Company was incorporated with Haslett McKim as president and David Keener as agent. The company was originally organized to mine and smelt the ores from the Elodie mines of Don Bartolomeo de Trenard, near Santiago de Cuba, he being one of the original promoters of the scheme. A tract of land was purchased on Locust Point, Little Cuba Street still remaining as a landmark to indicate the spot, and the erection of furnaces commenced at once. Trenard was made agent for the company in Cuba and sent out to open the mines and commence the shipment of ore. Early in 1846 the works were ready, but the expected ore did not arrive, and a commission sent to Cuba reported so unfavorably on the Trenard mines that all connection with him was broken off. At this time Baltimore was largely engaged in trade with the West Indies and the west coast of South America, and the company commenced operations with ores purchased from Cuba and Chile, supplemented with small parcels from Maryland and the neighboring States.

"In 1849 a rolling mill was built to enable the company to put part of its product upon the market in a more finished form, and in 1850 a yellow-metal mill was added. In 1849 Dr. Keener left the service of the company and became connected with the rival works just being started at Canton, on the opposite side of the harbor. The company had not been successful. The failure of the Trenard mines had left it without a regular supply of ore, and the buying of large cargoes of Chilean ore, with the attendant loss of interest and risk of the market during the passage round Cape Horn, had as a rule resulted in loss. The management had much to contend with in getting men competent to organize a business which required so much expert knowledge, and after a year of apparent prosperity the deficit became larger until 1851, when it was determined to wind up the concern. The furnaces were demolished, part of the land sold, and finally in 1854 the works themselves were sold. In dismantling the works a large amount of copper was discovered in the furnace bottoms and also in the slags which had been thrown out. Much of this was shipped to England, and the amount realized was so great that the company was encouraged to recommence operations. The sale of the works was canceled, additional capital was put in, and in 1855 work commenced with an enlarged plant. Then came a year or two of rising market and large profits, followed by a year of heavy losses. About this time the company became interested in a process for treating sulphuret ores by leaching them with water and then precipitating the copper with iron.* Experiments were made at a mine in Virginia [near Hillsville, Carroll County—J. D.], but without success and with considerable loss. About 1860 Clinton Levering became president, and in 1864 the rival works at Canton were absorbed, both being known thereafter by the name of the Baltimore & Cuba Smelting and Refining Company. This rival concern was the Baltimore Copper Smelting Company, with Dr. Keener as agent and George Brown president. Works were built at Canton, where the present copper works now stand, a favorable contract made with a copper mine in Chile, and the company had a prosperous existence till it was finally sold, as stated above, to the Baltimore & Cuba Smelting and Refining Company. Mr. Levering was shortly afterward succeeded as president by Henry Martin.

"In 1868 the works at Locust Point were removed to Canton, the property being sold to the Baltimore & Ohio Railroad Company, and the company reorganized as the Baltimore Copper Company. The changed condition of affairs after the war and the uncertain supply of ore and other causes brought the company into financial straits, and the prohibition tariff of 1869 was the finishing stroke. In 1870 Wm. Keyser became president in order to wind up the affairs of the company, J. W. Garrett and Johns Hopkins being at the time virtually the sole owners. About this time ore from Colorado, Arizona, and Montana began to come upon the market, and the firm of Pope, Cole & Co. was formed to operate the works at Canton, George A. Pope and George B. Cole, of the Gunpowder Copper Works, being the general partners, and Johns Hopkins, J. W. Garrett, Wm. Keyser, J. S. Gilman, and G. W. Ward the special partners. The concern now ran altogether upon Western ore and did a large and constantly increasing business. In earlier days a sulphuric-acid plant had been added, in accordance with some crude idea of utilizing the sulphur in the South American ores. This idea had been abandoned and the acid was now made from brimstone and sold on the market. The combination of sulphuric acid and copper led to the manufacture of sulphate of copper, or blue vitriol, which became a large branch of the business.

"The old Gunpowder Works at the close of the war had been incorporated into a company and had started operations again. In 1866 the property was sold to the city of Baltimore in connection with the city water supply. The company then leased the works from the city and ran them till 1883, when, owing to lack of water sufficient to furnish power and the wearing out of the antiquated machinery, the plant was abandoned and a new and modern rolling mill was built adjoining the copper works. The name of the company was changed to the Baltimore Copper Rolling Company. In 1885 the firm of Pope & Cole, consisting of the general partners of Pope, Cole & Co., became embarrassed and carried down the latter firm with it. In 1887 the Baltimore Copper Rolling Company was changed to the Baltimore Copper Smelting and Rolling Company, with Wm. Keyser as president, and with an increased capital purchased the business

* The Monnier process of sulphatizing copper by roasting with sulphate of soda.

and remaining assets of Pope, Cole & Co. Since that time the business has been actually carried on by this concern. After several years of experiment an electrolytic plant for the purification of copper by electrolysis was added. This process had long been a successful laboratory experiment, but it was not a commercial success till 1890. [This statement is perhaps open to some qualification. —J. D.] In 1891 the Baltimore Electric Refining Company was organized and a large plant erected about half a mile east of the copper works, and the next year the capacity of the works was doubled. The present plant of the Baltimore Copper Smelting and Rolling Company consists of the copper-smelting works, the blue-vitriol works, the copper-rolling mills, the electrolytic department, and the acid works, each run as a separate department. The smelting works consists [or rather consisted at the date of Mr. Keyser's article—J. D.] of calcining furnaces, 18 reverberatory furnaces, 6 refining furnaces, 2 cupola furnaces, a crushing plant, and the other necessary adjuncts. The blue-vitriol works is one of the largest in the country, supplying last year all the sulphate of copper used by the Western Union Telegraph Company in addition to large quantities to Paris-green makers and others. The rolling mill is especially adapted to the rolling of thin copper sheets for bath-tub manufacturers and produces about 100,000 lbs. a month. The electrolytic department is worked under what is known as the Pierce system, the current being furnished by 2 Edison 80-kilowatt dynamos. The acid works now only make acid for the blue-vitriol and electric works—none for sale. The Baltimore Electric Refining Company's works are operated under the Hayden system. They consist of a rolling mill for rolling the anode plates, a large depositing house, the current being furnished by 6 Edison and 3 Westinghouse direct-coupled 80-kilowatt dynamos, 4 refining furnaces, a slimes house for treating the residues and refining the bullion, and the necessary warehouses, repair shops, etc.

"These two companies being virtually under one management form one of the largest copper works in existence, and the Baltimore Copper Works casting copper is a standard brand, both at home and abroad. Both these works are running entirely on copper material from the Anaconda mines at Butte, Mont."

Since the above statement of their operations was made by Mr. Keyser, the exclusive shipment of Bessemer bars and the cessation of matte shipments by the Anaconda Company has led to the closing down of the smelting furnaces at Baltimore. At present their operations are confined to the making of cast and of rolled anodes, and the electrolysis of about 5,500,000 lbs. monthly of anodes at the two electrolytic works and the refining of the same in 8 refining furnaces. The bluestone department continues in active operation, with a production of from 400 to 500 tons monthly.

Shortly after 1845 two other general smelting works were started, one at East Haven, the other at Bergen Point. The latter seems to have had a very short and precarious existence; the former survives in the Seymour rolling mill. The works at East Haven drew a scanty supply from abroad, principally Chile, and smelted the ore from Verchere, Vt., and from the Bristol Mine, Connecticut, but their operations were never extensive. They employed at first reverberatory furnaces only, but subsequently made matte in 3 small cupolas with 2 rear tuyères and a tuyère at each side, completing the reduction of the matte in reverberatories. When Mr. John Williams had charge of the company's operations he is said to have reduced white metal to copper direct by smelting it with rich carbonate ores, thus availing himself of substantially the reaction now so skillfully and economically applied by Messrs. Nicholl & James in the direct method of the Britton Ferry Works in Wales.

These older works, depending for their supply on imported ores, were of course either hampered or killed outright by the war tariffs of 1861–62, 1863, and 1869. The importation of foreign ores never reached a very high figure, but they increased in value from $195,332 in 1850 to $1,031,493 in 1860, when the Morrill Tariff Act checked their introduction.

The Eighth Census gives the following very meager statistics of the copper industry in 1860:

	Number of Establishments	Capital Involved.	Value of Raw Material.	Value of Product.
Copper mining	47	$8,525,500	$506,614	$3,361,222
Copper, rolled	2	1,250,000	1,454,750	1,800,000
Copper, sheets	5	1,220,000	1,082,450	1,308,768
Copper smelting	10	1,535,000	4,237,567	4,945,360

The 10 smelting establishments were probably those of the Baltimore & Cuba Company; Revere Company at Boston; New Haven Copper Company at New Haven; Bergen Point Company, New Jersey; Crocker Bros. at Taunton, Mass.; Hussey & Howe Company at Pittsburg; J. G. Hussey & Co. at Cleveland; the Detroit & Lake Superior Company at Detroit and Hancock; Ely Company at Verchere, Vt.; and the Union Consolidated Company at Ducktown, Tenn. The Crocker Bro.'s small smelting works at Taunton, Mass., were started about 1836 and are still running, but never assumed important proportions.

In the 60s custom smelting works were erected by Mr. C. M. Wheatley at Phœnixville, Pa., but they were never either financially or technically successful, owing to the dearth of profitable ores. The main supply came from low-grade ores in a slaty gangue from Pottstown, which were with difficulty smelted by the aid of small parcels of ferruginous copper sulphides from the Cornwall iron-ore bank and the Jones iron-ore mines, and of the rich selected ores from the St. Genevieve copper mines, Missouri. Before the works were finally abandoned and demolished they were used by the Orford Copper Company to refine the mattes made at their Canadian mines pending the erection of their own large works at Bergen Point in 1881.

The Orford Copper Company's works are to-day the most important custom works on the coast, as they are equipped with cupola ore-smelting as well as refining furnaces, though they are not provided with an electrolytic separating plant. Their anodes are treated at the Balbach electrolytic works at Newark, N. J. The Orford Company is also the largest manufacturer of nickel oxide and metallic nickel, made from Sudbury ores by special methods which it controls. The company has from the first doubted the economy of employing water-jacketed furnaces and has used very large brick furnaces, but protected their walls by interposing water pipes between the layers of brick. Its managers must also be credited with the first construction of the ingenious well now so commonly attached to large matting furnaces, which is provided with a vertical partition that permits of the continuous flow of both matte and slag. The mattes are reduced to metal in calcining and reverberatory furnaces. The smelting and refining capacity of the works is about 3,000,000 lbs. monthly.

The Orford Company when it erected these works at Bergen Point owned pyrites mines at Capelton, P. Q., Canada, and the primary purpose of the works was to matte the cinder returned by the chemical factories after extraction of the sulphur and to refine the mattes. With a similar object originated the works of the New Jersey Extraction Company, erected at the same date, not far from the Orford Works, on the Kill von Kull, New Jersey, by some of the shareholders of the Rio Tinto Company of London. They were designed by the well-known metallurgist Thomas Gibbs, of Newcastle, to extract by the Henderson & Claudet wet methods the copper and precious metals from the cinder of the Rio Tinto ores, which it was then expected would have a large sale in this country. This expectation was, however, not realized, the only company buying Rio Tinto ore in large quantities being the Pennsylvania Salt Company of Natrona, that extracts the metal at its own reduction works. The leaching works of the New Jersey Extraction Company have therefore long been idle, but the smelting works of the same company have been competitors for ores, mattes, and Chile bars. Its plant consists of 10 large reverberatory furnaces, 2 large cupolas of the Orford type, and 6 calcining furnaces. Mr. George Thomson, the manager, uses his cupolas to bring up roasted matte to black copper and white metal. He roasts his white metal and high-grade matte in piles and completes their reduction in the reverberatory. The works have a capacity of about 1,000,000 lbs. monthly.

Two other large general smelting establishments had their origin in plants attached to chemical works, and designed to merely work up the cinder of pyrites burned in their acid manufactory, namely, the Nicholls establishment at Laurel Hill, Long Island, and the Pennsylvania Salt Company's reduction works at Natrona, Pa. The Nicholls Company, using a somewhat siliceous cupriferous pyrites from mines at Capelton, in the Province of Quebec, has always, as did the Orford Company, which worked pyrites mines in the same district, matted the cinder. Mr. Herreshoff, the manager, unlike the Orford Company, preferred the water-jacketed cupola, and designed a most excellent furnace for that purpose, with water-jacketed well to resist the cutting action of the basic material he has had to treat. From this beginning have grown works equipped with 2 Bessemer converters and 4 large reverberatory refining furnaces, which are built and braced on novel lines. These reverberatories make anodes and refine the cathodes of the company's large electrolytic plant, which now has a capacity of about 3,000,000 lbs. of copper monthly.

The Natrona Company, using in the acid works the very pure pyrites from the Rio Tinto Mine of Spain, followed the European procedure and extracted the metal from the cinder by the Henderson method, but has added to its original leaching plant furnaces and an electrolytic separating establishment of large capacity.

The only other active competitor for ore and matte is the Chicago Copper Refining Company, the other electrolytic refiners confining their operations chiefly to the treatment of bar copper. Of these establishments the most important are those of Balbachs, of Newark, which was the forerunner on a large scale of this branch of metallurgy (though small electrolytic separating works were first operated in 1879–80 at the Phœnixville Works, with two of Weston's nickel-plating dynamos), and of the Lewisohn Brothers, whose two works at Central Falls, R. I., and Ansonia, Conn., have a gross capacity of about 80,000,000 lbs. of copper annually.

But while this large Atlantic coast smelting and refining industry, dependent on purchased or custom supplies, was being developed between 1845 and the present date, smelting works at or near the mines have been still more conducive to the development of mining and metallurgy, and they even better express the progress that has been made in this branch of technical science and art.

Upon the discovery of profitable mines and the inauguration of successful mining on the Lakes, native copper from the mass mines, the only ones at first worked, was shipped to both the Baltimore Works and the Revere Works, Boston. But in 1848 Messrs. Hussey & Howe erected reverberatories and refineries in Pittsburg, and in 1850 Messrs. J. S. Hussey & Co. built smelting works at Cleveland. They were the first reverberatories designed with removable roofs to permit of the insertion of large masses. Works were also built at Hancock, on Portage Lake, Mich.

In 1850 the Detroit & Lake Superior Smelting Company was formed. It absorbed the Hancock Works and erected smelting works at Detroit and a rolling mill at Dollar Bay. Its two branches virtually smelted all the Lake mineral till the Calumet & Hecla Company built its own smelting works on Torch Lake and subsequently branch works at Buffalo. The system of smelting and refining has been the same almost from the first. The mineral has been smelted and refined at one operation and the slags resmelted with lime in cupolas. The construction of the refineries has been modified and improved, notably with the view of controlling the admission of air to the ash pit and to the charge. But there has not been the same tendency to enlarge the size of the furnaces which has been the most conspicuous departure from older practices in other copper refineries. The charge is from 8 to 10 tons. The reason is that Lake copper, owing to its exceptional purity, has been in special demand for sheets and wire, and it is found to be difficult to keep a large charge up to invariable pitch during the protracted ladling of 15 or 20 tons. The custom of the Detroit & Lake Superior Company has been to smelt the mineral and to re-fuse slags of each mining company by itself, and to return to the mining company the copper of both grades, the quality of the copper obtained from the mineral being superior to that from the slags. A somewhat higher charge used to be made per pound of copper for reduction from the slags than for that recovered directly from the mineral, but it is understood that a uniform scale is now followed. What the smelting charges have been from time to time has not been published, but they have always been much lower than the coast works demanded for refining even copper bars. For minute details of the refining of Lake Superior copper up to 1880, see Professor Egleston's paper on "Copper Refining in the United States" (*Transactions* of the American Institute of Mining Engineers, Vol. IX.).

But when we turn to the history of the smelting of pyritic ores since 1845 a very different story has to be told of growth both in method of treatment and in size and character of the implements used. The Longs at the Verchere mines of Vermont were the pioneers in local smelting. They used small brick furnaces of the German type with ore hearths, at first with one and then two tuyères in the rear. The furnaces had a capacity of about 10 to 12 tons daily and a life of a week or 10 days. They matted in these the ore which had been heap roasted under sheds. The mattes, roasted in stalls, were concentrated to black copper and white metal in similar small brick cupolas of a capacity of 6 to 7 tons a day. These primitive contrivances were retained till shortly before the Ely Mine was closed, early in the 80s, when Carzin erected a new concentrating plant and Peters built and started a large furnace of the Orford type. But the mine as opened was incapable apparently of satisfying the increased demand of the reduction works.

The operations at the Ely were, however, always contracted compared to those at Ducktown, Tenn., which between 1850 and 1860 was the scene of operation with almost every system of smelting and style of furnace then in vogue. The first ore shipped was in 1847. By 1852 the Ducktown furor was at its height, owing to the large quantities of rich black ores extracted from beneath the iron cap. In 1854 two blast furnaces were built on the Tennessee Mining Company's property, but as they were not very successfully handled, in the following year Welsh reverberatories were erected at the Eureka Mine. Then cupolas were revived. A number of small stacks of 12x15 in., horizontal section, were built into a solid mass of masonry, like Mexican adobe furnaces. The stacks were at first lined with brick, for which local soapstone was soon substituted. On the formation of the Union Consolidated Company under Mr. A. Raht, well-built and strongly bound furnaces, with thin walls, replaced the older clumsy and destructable stuctures, and the smelting of the undecomposed pyrites ores of the various mines was concentrated at one point.

Very full and interesting details of the operations of the establishment were given by Wendt in the *School of Mines Quarterly* in 1886. The ore, selected and concentrated to 5 to 7%, was roasted in piles 6½ ft. high containing 500 tons; matted in brick furnaces of a capacity of about 12 tons daily, run by 3 men to a shift and consuming 1 lb. of charcoal to 2 lbs. of ore. The charcoal cost 3c. per bushel of 22 lbs. The matte fines, about one-third, were roasted in hand furnaces and the coarse in piles by 5 fires, and coarse and fines were concentrated in 4 small brick cupolas, 2 kept in blast and 2 constantly under repairs. To reduce the repair account Wendt says he built in 1876 what he believed to be the first water-jacketed copper furnace in the United States. The furnace, he said, worked well, but its small capacity, due to its constricted diameter—2 ft.—admitted of a burden of only 10 tons per day, which finally led to its abandonment. This may have been the first water-jacketed cupola applied to copper smelting in the East, but larger furnaces of the type had been used prior to that date at the Copperopolis Mine, Utah.

The product here, as elsewhere, of the roasted matte concentration was black pig copper and white metal, which were brought up to blister in a reverberatory and refined with wood as fuel.

The Ducktown and Verchere plants and methods were repeated in 1876 at the Ore Knob Mine, in North Carolina, the only other large copper producer in the Southern States. This last mine had been opened in 1873 by gentlemen who had successfully applied leaching at the Davidson Mine, in the same State. They therefore first put up a large wet plant, and for a time made cement copper so advantageously, using ferrous chloride as a solvent, that they had already nearly completed a duplicate of their first plant, when the deeper ores became too calcareous for wet treatment and smelting was resorted to. The details of the plant and methods did not notably differ from those of Verchere and Ducktown, from which they were copied. Professor Egleston in his paper contributed to Vol. X. of the *Transactions* of the American Institute of Mining Engineers gives minute details with cost of each operation. The cost of making ingot from a 4% ore at Ore Knob, with wood and charcoal as fuel, charcoal of 18 lbs. to the bushel costing 5c. per bushel, and 981 lbs. of charcoal being consumed to the ton of ore smelted, was 12½c. per lb.

Though smelting was carried on by the Fannin Company of Georgia; at the Stone Hill Mine, Alabama; at Milan, N. H.; at the Blue Hill Mine of Maine, the operations everywhere else than at the three establishments already described were conducted on a very limited scale, and they were uninteresting except in the case of the Milan furnaces, which out of inciferous copper sulphide made argentiferous mattes. The copper mines of the Appalachian chain are remarkably barren of the precious metals.

Recently the Ely and some of the Ducktown copper mines have been reopened and smelting restarted with large furnaces in plants, better planned than formerly. The Ducktown Sulphur, Copper and Iron Company, an English organization, keeps two Herreshoff furnaces in blast, converting 200 tons of ore daily into 50% matte (see Carl Heinrich on "Ducktown Ore Deposits," in *Transactions* American Institute Mining Engineers, 1895).

For nearly 30 years of the active prosecution of local smelting on the Atlantic coast no notable improvement in furnace methods and appliances was made. It was not till the West entered the field that a strong stimulus toward progress was given, and it has been in the West that the most radical changes have been made. The mechanical calciners, if we except the original Spence and the Oxland, have been the inventions of Western men; the general use and the expansion in size of water-jacketed cupolas have been in the West; the enlargement of the reverberatory till its smelting capacity has become six times that of an old cupola has taken place in the West; the adoption and perfecting of the Manhès modifications of the bessemerizing of copper matte must be credited to the West; and in the West the most vigorous efforts are being made to economize fuel by the application of pyritic smelting.

Within the present area of the United States the first Western smelting was done in New Mexico and Arizona before the Gadsden Purchase. The copper mines in the Santa Rita Mountains of New Mexico near Silver City were actively worked and their ores smelted early in the century, and the first copper smelting done after the cession of New Mexico and Arizona and before the war of secession was at the Hanover Mine, in the same region. Here copper was made from carbonate ores in a group of small adobe furnaces, whose ruins still attest the fact. The copper bars were hauled all the way to Galveston. Shortly after that date copper was mined on the Bill Williams Fork, Arizona, which discharges into the Colorado at Aubrey. Most of it was shipped as ore; but there stands at Aubrey an old ruined water-jacketed furnace of most odd design. It has a single tap hole for slag and matte, vertical walls for some feet above the tap hole and then a steep taper, and like the older German cupolas and most of the adobe furnaces of Mexico was open at the top, but unprovided with even a hood. There is no local tradition as to when it was used, and it may therefore represent the first attempt at water-jacketed furnaces as applied to copper smelting.

The first important copper-smelting establishment in the West was that of Professor Hill at Black Hawk, Gilpin County, Colo., which has since expanded into the great Argo Works. At first he merely roasted and matted the lump sulphurets which form the selvage of the gold veins of Central and Black Hawk and the concentrates collected by the amalgamating mills. He shipped the matte to England for separation. But after the rival furnaces of the Swansea smelters on Clear Creek, below Georgetown, were closed, Mr. Richard Pierce, who had managed them, joined Professor Hill, and a parting plant was added to the Black Hawk Works. The silver is separated from the matte by the Ziervogel and Augustin processes and the gold from the copper pig by a secret process. But what is of even more interest to metallurgists are the large reverberatory furnaces which have been developed by Mr. Pierce step by step from those of 15 ft. by 9 ft. 8 in. hearth to 15x16 ft., with an increasing capacity of from 12 tons of cold ore to 50 tons, partly of hot ore from Pierce turret calciners. The large furnaces smelt 3.7 tons of ore with 1 ton of coal, as against only 2.4 tons of ore to the ton of coal in the old standard-sized reverberatories.

In the 60s the only copper mines extensively worked besides those on the Colorado in Arizona were the sulphuret mines in Calaveras, Amador, and Nevada counties, California; but no smelting was done then till the following decade, and then only at two small establishments, and that for a very short period. What copper was not shipped as ore was extracted as cement by heap roasting, leaching, and precipitation by iron. In the 70s there was some sporadic copper smelting done by Lewis Williams at Copperopolis, Utah, by Edward Reilly near Elko, Nev., and by Peters at Mount Lincoln, Colo.; in California, and at the Longfellow Mine, in Arizona, and elsewhere. But it was not till the Southern Pacific had penetrated Arizona and the Utah & Northern was approaching Butte that the Western copper mining and smelting operations commenced, which have not only controlled the copper trade of the world, but have revolutionized the methods of smelting.

Arizona took the lead, but Montana soon outstripped her in the race. In Southern Arizona, where the ores treated were exclusively oxides and carbonates, the problem was easy and the appliances simple. At the three great centers of Clifton, Bisbee, and Globe the plants have been till recently virtually the same, differing in little else than the size of the water-jacketed furnaces. "Although other sections of the United States have yielded small quantities of carbonate ore, in Arizona alone have been exposed as yet large bodies of decomposed sulphides converted into oxides of copper and iron. All the large mines have, however, struck sulphides, either completely or partially unaltered, and therefore have already introduced modifications in their mode of treatment or are considering how best to overcome the complications which the presence of sulphides invariably involves. Heretofore when the same mine, as in the case of the Copper Queen, supplied a mixture with the requisite proportion of basic and acid material, the oxidized ores have been fed with coke alone into water-jacketed cupolas, and from the furnace has been tapped metallic copper combined with more or less iron and sulphur and a slag carrying from 1½ to 2½% copper. In other districts the ore being too acid more or less limestone or iron has to be added to the charge.

"The furnaces invariably used in this district are water-jacketed cupolas, either circular or oval, tapering slightly from feed door to crucibles. The short diameter at the tuyères, whether of round or oval shells, seldom exceeds 36 in. through. For open charges furnaces of 42 in. or even 60 in. are built. The largest oval-shaped furnaces at the Arizona Copper Company, the Detroit Copper Company's works at Clifton, and the Queen are 120 in. in longer diameter. Owing to the liability of the metallic copper to chill outer wells cannot be used when making bars, and therefore the copper is tapped directly from the crucible through a tap hole generally 18 in. below the tuyères.

"The coke consumption varies with the character of the ore and the character of the coke from 1 of coke to 6 of ore to 1 of coke to 8 of ore. The percentage of copper in the charge is also determined in the different districts by the cost of treatment. It is possible by rejecting ores of lower grade to raise a furnace mixture to almost any given standard which it will pay to smelt. For instance, at the Copper Queen Mine, which is connected by a line of standard gauge with the railroad system of the Southwest, the management is satisfied if a yield of 7% of copper is obtained from wet ore fed into the furnace; whereas heretofore at the Globe furnaces, where coke hauled 150 miles from the nearest railroad station has cost over $40 per ton, ore had to be selected so as to give a furnace yield of about 12%. The copper contents of the copper bars is also variable. Tapped directly from the cupola they cannot be made of the same uniform percentage as Chile bars, which are brought up to a given standard in a reverberatory furnace. The percentage of the bars is influenced by the character of the charge, being higher where lime is the base and lower where iron predominates. Those made from the Queen furnaces of late years, since the charge has become more and more ferruginous, have been lower than those made at Clifton and Globe. But the bars now made at the Queen furnaces at Bisbee, where the pneumatic method has recently been introduced, run higher on an average than any bars made directly from carbonate ores.

"The water-jacketed furnace is an actual necessity to the Western smelter, owing to the heavy cost of refractory building materials. When the owners of the Longfellow Mine at Clifton commenced smelting in 1873, the nearest railroad station was 700 miles distant. The first furnaces used there were small Mexican adobe cupolas, the capacity of which is little over 1 ton daily. The blast was derived from large bellows worked by hand. Reverberatory furnaces were next tried, but the ores being basic and firebrick worth $1 apiece, the cupola was again resorted to. This time it was supplied with an iron water back and water tuyères. The water back once burning out, an attempt was made to cast one in copper as a substitute. But the casting turned out to be a mere plate with a hole in it. For lack of better this was built into the furnace and was found to stand so well that the cupolas within the area of fusion were constructed entirely of copper slabs, cooled at first by a spray of water, afterward by the air alone. Such copper-plate furnaces lasted in good order for about 60 days when charcoal was used, but the intense heat produced by coke twisted the plates out of shape so rapidly that they were replaced by copper water jackets. These were clumsy deep copper troughs, open at the top, which were cast in close molds from the coarse alloy of copper and iron made by the furnace. The ordinary boiler-plate jacket soon supplemented these copper troughs.

"The quantity of ore a jacket of given size will smelt depends upon the fusibility of the charge, the strength of the blast, and the supply of water. The 3-ft. round furnace is usually designated a 30-ton furnace. Under exceptionally disadvantageous circumstances a furnace of that size will smelt only 30 tons, but with fair ore and good management it smelts from 45 to 60 tons a day. The medium-sized furnace at the Copper Queen (36x72 in.) under 12-oz. blast smelts as high as 160 tons daily, the ore being exceedingly fusible, whereas the Arizona Copper Company's furnace, of larger size, on less fusible ore, puts through only 100 tons daily.

"No statistics are available of the relative capacity of brick and jacketed furnaces, nor is it possible, otherwise than by actual experiment under exactly similar conditions, to determine whether more heat is lost by radiation from the brick furnace than by convection in heating the water of a jacket. As bearing, however, upon this point, a modification of the jacketed furnace introduced and applied by Messrs. Walker & Murphy at Globe is interesting. In their furnace the blast is forced around the hot crucible, which is simply brick lined and not water jacketed, with the following results, the temperature having been taken for about a week in summer at all hours of the day: Blast entering the air jacket, 99° F.; blast leaving, 154° F.; difference, 55° F.

"A twenty days' run for comparison was made between two furnaces of the same style and size, fed with the same ore and coke, all conditions as nearly equal as it was possible to make them, which gave the following results. Furnace No. 1 was without the wind jacket and No. 2 with it:

	No. 1.	No. 2.
Pounds of ore smelted............	2,233,600	2,325,000
Percentage of coke to ore........	17.67	16.84
Percentage of coke to burden....	13.60	13.00
Number of charges smelted......	3,756	3,875

"The difference, therefore, seems to be in favor of No. 2 to the extent of 91,400 lbs. more ore smelted and 19,297 lbs. of coke saved, and an increased average burden of 4%.

"If the heat radiated from the crucible alone was effective in raising to such an extent the temperature of so large a volume of air, the loss of heat by radiation must be enormous in the ordinary brick furnace, and it makes no difference whether that be carried away by water or dissipated by air.

"Another modification of the water jacket is due to Mr. W. H. Pierce, of the

Baltimore Works. He attaches to the top of the jacket a regular boiler separated from the influence of the furnace heat. The water may be allowed to boil in the jackets and the cold water be admitted by a valve from an elevated source only as fast as a water gauge in the boiler above the jackets shows that it is being evaporated as steam.

"Till bessemerizing was introduced into Arizona—and that was very recently—the peculiarity of Arizona smelting has been the simplicity and smallness of the plant needed to make such a considerable quantity of copper. No calciners have been employed to prepare the ore for the smelting furnaces, whioh have consisted of simple jacketed cupolas distributed as follows: At the Queen's smelter, 4; at the Old Dominion smelter, 3; at the Arizona Copper Company's smelter at Clifton, 5; at the Detroit Copper Company's smelter at Morenci, near Clifton, 3; at the United Verde smelter, 3; total, 18 cupolas; and these never all in blast at the same time. Their product reached 44,531,108 lbs. in 1894.

"At all the Southern Arizona furnaces more or less matte derived from imperfectly oxidized ores has for years been tapped with the black copper, roasted in heaps or kilns, and returned to the black-copper furnace. At the mines of the United Verde Company at Jerome, in central Arizona, whose ore deposits are in compact slates, the carbonate ores are very superficial and the deeper ores have been exclusively rich sulphides. They have therefore been heap roasted and smelted in water-jacketed cupolas, with the production chiefly of matte. Reverberatories have been used there to a limited extent for the matting of ores carrying the precious metals. Now, however, the non-argentiferous mattes are being converted into copper in Bessemer converters, of which three, with their supplementary shells, have been erected. They are of the ordinary upright type.

"At the Copper Queen mines the matte had become so abundant that bessemerizing has been resorted to exclusively for the treatment of both the oxidized ores and of the large bodies of sulphides which have been met with during the extraction of the carbonates. Although in parts of the mine carbonates are being mined on the 400-ft. level, when that level is actually 1100 ft. vertically below the apex of the hill, in other parts the sulphides have been so protected from decay that they occur unaltered on the second level. As there are, therefore, available large quantities of both classes of ore, matte is made by mixing oxides and sulphides in the jacketed furnaces, thus dispensing with the cost of roasting except to a very limited extent. These mattes are concentrated in trough converters."

But the progress of the copper industry of Arizona has not kept pace with that of Montana. Argentiferous copper ores were shipped from Butte and copper mattes from the Hecla furnaces before 1880, but it was not till 1880 that the smelting of ores was commenced in Butte.

The Williams smelter was the first establishment built to smelt Butte ores on the spot. It was built as an auxiliary to the Boston & Colorado Works and was assisted from the first by Mr. W. A. Clark, the object being to make a matte rich in silver. The matting furnaces of this company have been always supplied in great measure from the western extension of the great lode, notably from the Gagnon Mine, and reverberatories have been used. The Parrott Works and the Meaderville Works of the Montana Copper Company date their existence from

1880, two years before the railroad entered Butte. In 1882 the Bell ores were treated in a small separate establishment which was the only smelter in Butte which has ever used the cupola exclusively. In 1882 the product of these four smelting plants reached the then large daily production of 30,000 lbs. of metallic copper, which was almost entirely exported as matte. The system adopted at the three large inaugural works was concentration, roasting the concentrates in hand furnaces, and matting the roasted concentrates in reverberatories. Heap roasting of the more heavy sulphureted lumps and cupola smelting were tried to a limited extent from the first, but not preferred. Reduction of the mattes to blister in reverberatories was also practiced, but not found economical, the more so as prior to the general adoption of the electrolytic method of refining argentiferous and auriferous matte was more marketable than metal, except to the bluestone manufacturers, for whose product there was but a limited demand.

The next smelting works were built by Mr. W. A. Clark, not far from Meaderville, to treat the ores from his small but wonderfully rich section of the Colusa Lode, and I think I am correct in saying that he first in Butte replaced hand by mechanical roasting by introducing an O'Hara furnace, the prototype of the Brown-Allen and other calciners, in which the ore is agitated and moved forward by rakes attached to an endless chain.

In 1883 the Anaconda was discovered to be a great copper mine, and large quantities of rich oxysulphurets were shipped while the smelting works were being erected on the Deer Lodge River, 36 miles from Butte. The system adopted there was at first that in vogue elsewhere—concentration, roasting in hand furnaces, and reverberatory matting. Though the second smelter erected in Anaconda to treat the more argentiferous ores of the Chambers Syndicate differed in its concentrating department from the first mill, the system of smelting was the same. No attempt was then made to carry the concentration beyond a 60% matte, which commanded in Europe, where most of it was reduced, a slightly higher figure than its copper value indicated, on account of its silver contents.

But before the Anaconda had become portentous by its enormous output, Mr. Franklin Farrel had introduced at his Parrott Works, in Butte, the bessemerizing of copper, under Mr. Manhès' instruction. The first converters were upright, but with elevated tuyères, though certain modifications were made subsequently by Mr. Farrel in the tuyères and air boxes, to which the present facility of handling the charge is partially due. As at first conducted, a 40% matte was blown up to white metal, poured, remelted in a cupola, and again blown up to blister—a complicated procedure which showed but slight gain in economy over the older methods. But experience soon proved that the process could be reduced to a single blow. The adoption of the Bessemer converter as a tool for speedily making copper bars was concurrent in Mr. Farrel's plans with the intention of refining these bars and separating the gold and silver by electrolysis. His electrolytic refinery was built at Bridgeport, Conn. This complete series of operations thus inaugurated is now the almost universally adopted method of recovering the three most valuable constituents of the Butte ores.

The ores of the Anaconda Company are smelted and bessemerized entirely at Anaconda and the copper refined electrolytically in part at Anaconda and in part at Baltimore. The mines of the old Montana Copper Company passed in 1886 into the hands of the Boston & Montana Copper Company, whose field of operations was extended by the purchase of the Mountain View and the Shannon, claims intervening between the Anaconda and the West Colusa, and of other claims. For a time this company reduced its ores to matte at the old Meaderville smelter and shipped its matte. But it did this as a temporary expedient while its large and complete works were being erected at the Great Falls of the Missouri, where now are propelled by water power their concentrating, smelting, bessemerizing, and electrolytic departments.

When smelting was inaugurated in Butte the Silver Bow Mill was treating by chlorination in White-Howell furnaces and pans the silver ores from a group of mines owned by Judge Davis lying to the northwest of the copper mines. As depth was attained copper became the preponderating metal, and the products of these mines, which have passed into the possession of the Butte & Boston Company, were smelted at the matting works of that company. As the company was closely allied with the Boston & Montana the mattes were bessemerized at the latter company's establishment at the Great Falls. Work has been recently suspended by the Butte & Boston Company.

Another company has more recently grown into prominence, the offspring of an ore-purchasing company established by the Messrs. Heinze. Though it now operates a well-equipped furnace plant, supplied largely from its own mines, it retains its original designation, the Montana Ore Purchasing Company. The Butte & Boston, the Heinzes, and to a greater extent than formerly the Boston & Montana use the cupola where it is possible to replace by it the reverberatory. The earlier procedure has also been changed by the general adoption of mechanical calciners. The Brückner cylinder, after years of experimental modification, was adopted by the Anaconda Company, whose example was followed by the Boston & Montana. The Butte & Boston uses the Brown-Allen modification of the O'Hara, Mr. Allen being the metallurgical superintendent of the Butte & Boston Works. At the Parrott Mr. Keller has devised and is using two rake furnaces, and at the Clarke Works Mr. Wethey has built another style of rake furnace, all three of which apply in vastly improved manner the cardinal conception of the Spence calciner.

Though the reverberatory smelting furnace maintains its preferential position in Montana, it is no longer the reverberatory of bygone years. Those of the Anaconda Company, supplied with air heated by the waste gases as they escape through the stack and fed by hot ore from the Brückner cylinder, smelt from 50 to 60 tons daily; those of the Boston & Montana Company, designed after the steel tilting furnace of the Pennsylvania Steel Company and heated by gas, discharge their slag and matte almost without the intervention of the rattle.

The Parrott Company is transplanting its old works from the plain immediately below its mine and the town of Butte to a site on the Northern Pacific Railroad some 30 miles east of Butte, where there is an abundant supply of water.

At all the Butte smelters except the Williams and Clark smelters, where the precious metals are the principal ingredients of value, and the Butte & Boston, whose mattes are concentrated at the Great Falls, the Bessemer converter concentrates at one blow the 50 to 60% mattes to metallic copper. The converters of the Boston & Montana Company differ from the huge 15-ton steel converters only in having elevated tuyères. Those of the other companies are of smaller size, but all work with almost undeviating regularity and uniformity of result. The upright converter is still the favorite in Montana, while in Arizona at the Verde and Copper Queen works the trough converter is preferred because operated on a much lower blast and more accessible for patching.

Pyritic smelting, a branch of bessemerizing, is the direction in which progress will be made, but the advance will be slow and the results less invariably successful, for in applying pyritic smelting ore of a limited range of composition will be required to attain any decided advantage, while the bessemerizing of mattes can be practiced on matte of any grade and composition. The establishments in which pyritic smelting has been essayed are in Colorado and Dakota, but in none has fuel been entirely dispensed with and none has yielded very positive results from an economical point of view. In Newfoundland are probably the only furnaces in the world which make a matte without any carbonaceous fuel. The Cape Copper Company at Tilt Cove runs its lower-grade cupriferous pyrites, which carry about 8% of silica, into matte, concentrating a 2% ore into a 6% matte. It is claimed that the furnaces run more uniformly than with coke; that the addition of coke in quantity is distinctly deleterious; that the furnaces, though of brick, are not unduly corroded; and that the addition of silica has not been found to raise the matte or improve the working of the furnace.

Butte has been the arena in which the great revolution in copper metallurgy has been worked out which has made it possible to treat in a comparatively limited space the enormous output of its great mines. The works as they stand to-day are the largest in the world, but they would have been unmanageably stupendous in size had they been on the old Vermont or the English roasting and reverberatory furnace lines. A comparison of old and new methods explains how it has become possible for copper mines to survive the decline in price of the product, and shows how they have been enabled in fact to so raise the production as to depress the price to its present standard. Formerly to matte 200 tons of ore there would have been required, even when the ore was very fusible and well roasted, not less than 20 small brick furnaces. To-day the work can be done in one large cupola. Formerly the matte was roasted five times at least in stalls and then resmelted with the production of black copper and white metal. These were in some cases brought up to blister in a reverberatory. In others the white metal was roasted and returned to the concentrating cupola. To-day the matte flows directly from the cupola well into the converter, and within little more than an hour is reduced almost to purity without handling or consumption of fuel except for blast. Of yore about 200 days' labor was expended, or one day's labor to the ton of ore, in doing what to-day is done by 50 days' labor, or one day's labor to 4 tons of ore. And the goal has not been reached. The stagnation which for centuries characterized the metallurgy of copper has been replaced by intense activity. All the old prejudices and fallacies which were fostered by the pretension that certain mysterious mixtures of ores which could be collected only in certain favored localities and handled by certain highly skilled workmen, who had inherited the instincts of their trade with secrets which they would not divulge, have vanished, and with their dissipation has dawned an era of scientific investigation and rational practice.

GOLD AND SILVER.

By Frederick Hobart.

The expansion in the output of gold, which was so prominent a feature in 1894, continued throughout 1895, and the total production reached the highest point ever recorded, amounting for all the countries of the world to the vast sum of $203,443,772, a gain of no less than $20,874,489 over 1894. The total was more than double the amount for 1883, when the always varying tide of gold production reached its lowest point and began to rise again. Even in the first years of the Californian and Australian discoveries there was no year in which the addition to the world's stock of the yellow metal approached $200,000,000, and the fact that in 1895 it exceeded that amount is a most notable one. All the great gold-producing countries showed gains over 1894, and in many of the smaller producers there was also an increase. The whole world, in fact, seems to have joined in the search for gold, and in most cases with some degree of success.

The silver production of the world also showed an increase in 1895 over the preceding year, though the gain was less in proportion than in gold. The production, like that of gold, was the largest ever recorded in a single year. There was, moreover, in spite of the abundant supply, an increase in the average commercial value of the white metal of 3.7% as compared with 1894. The decline in production which began in 1893 was not only arrested, but an upward movement began to be felt again.

GOLD AND SILVER PRODUCTION OF THE UNITED STATES.

The gold production of the United States was by no means backward in feeling the impetus given to the industry, and was larger in the aggregate than that of any year since 1878. The total amount for 1895 was $46,830,200, showing a gain of $7,065,492, or 17.8%, as compared with the previous year. The silver production again showed a slight decrease, though a much smaller one than had been expected. At the same time there was a large gain in the quantity of silver obtained in this country from foreign ores.

The following table shows the production of gold and silver in the United States for 1894 and 1895 by States, the quantities in all cases being given in fine ounces—that is, in pure metal:

PRODUCTION OF GOLD AND SILVER IN THE UNITED STATES BY STATES. (*a*)

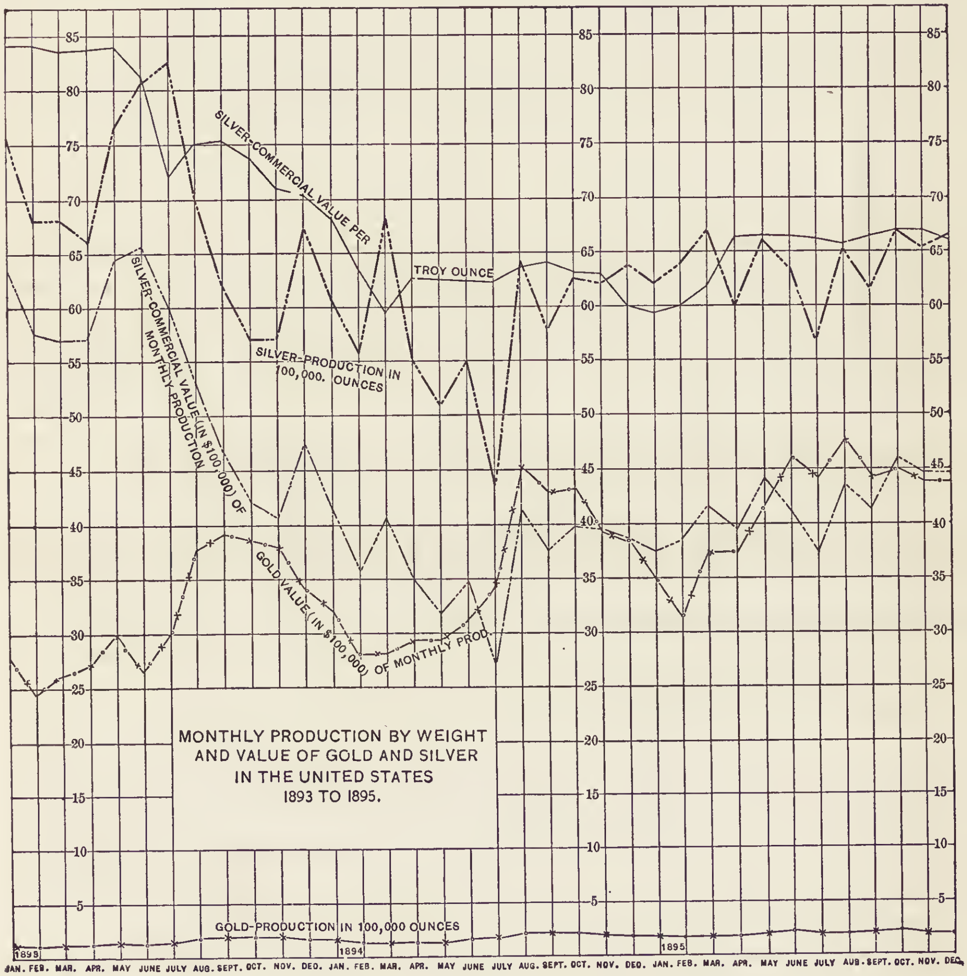
State or Territory.	1894.				1895.			
	Gold. (*b*)		Silver. (*b*)		Gold. (*b*)		Silver. (*b*)	
	Fine Ounces.	Value.	Fine Ounces.	Value.	Fine Ounces.	Value.	Fine Ounces.	Value.
Alaska	53,868	$1,113,550	22,261	$14,124	90,307	$1,866,645	74,616	$48,724
Arizona	96,313	1,990,966	1,539,453	969,955	90,548	1,871,627	859,379	561,174
California	656,468	13,570,397	717,368	451,942	741,863	15,334,308	463,910	302,933
Colorado	461,969	9,549,731	23,236,025	14,638,696	656,021	13,559,954	17,891,626	11,687,150
Georgia	4,728	97,738	325	205	5,381	111,225	7,890	5,152
Idaho	100,682	2,081,281	3,288,548	2,071,785	100,414	2,075,557	3,425,653	2,236,951
Michigan	2,150	44,444	35,122	22,127	2,200	45,574	35,329	23,070
Montana	176,637	3,651,410	12,820,081	8,077,151	177,919	3,677,586	15,046,409	9,825,305
Nevada	55,042	1,137,819	1,035,151	652,145	73,020	1,509,323	807,230	527,120
New Mexico	27,465	567,751	632,183	398,275	50,894	1,051,979	409,549	267,430
North Carolina	2,254	46,594	352	222	1,920	39,686	10,127	6,614
Oregon	68,792	1,422,056	26,171	16,687	39,918	825,105	11,686	7,631
South Carolina	4,733	97,839	305	192	5,983	123,668	3,865	2,524
South Dakota	159,594	3,299,100	58,973	37,153	165,148	3,413,609	70,226	45,858
Texas	....	....	429,314	270,468	....	....	529,974	346,073
Utah	41,991	868,031	5,891,901	3,711,898	55,605	1,149,356	6,579,043	4,296,115
Washington	9,438	195,100	113,160	71,290	6,971	144,092	98,523	64,336
Other States	1,495	30,903	182	116	1,500	31,006	200	136
Total domestic product	1,923,619	$39,761,205	49,846,875	$31,403,531	2,265,612	$46,830,200	46,331,235	$30,254,296
Foreign product	117,765	2,434,202	20,342,711	12,815,908	217,234	4,490,227	30,105,836	19,659,111
Total refined or exported	2,041,384	$42,198,910	70,189,586	$44,219,439	2,482,846	$51,320,427	76,437,071	$49,913,407
Domestic product—kilos	59,824	....	1,550,387	....	70,470	....	1,441,087	....
Foreign product—kilos	3,663	....	633,739	....	6,756	....	936,412	....
Total kilos	63,487	....	2,184,126	....	77,226	....	2,377.499	....

(*a*) These statistics of gold and silver production were collected for THE MINERAL INDUSTRY, but we are indebted to the Director of the United States Mint for the approximate distribution by States.
(*b*) Gold, $20.67 per oz., or $664.60 per kgm.; silver, commercial value in 1894, 63c. per oz., or $20.26 per kgm., and in 1895, 65.3c. per oz., or $20.99 per kgm.

The total production given in this table has been very carefully compiled from returns made to us by all the refiners of the precious metals, who have most cordially aided us in obtaining the necessary information. The figures represent, therefore, very closely the absolute quantities of gold and silver which have been put into final and marketable form during 1895. The distribution by States and Territories is necessarily approximate only, since it is not always possible to discriminate very closely as to the exact origin of metal obtained from each parcel of ore or bullion treated. In some of the States we have obtained the information from our special correspondents, and in California the figures are from the very full report issued by the State Mining Bureau; but in the majority of the States the results have been obtained by careful approximation, based in many cases on the returns made to the Director of the United States Mint.

The report given for 1895 is certainly a gratifying one. The gain was due in some degree to new discoveries or the opening of new districts, but in larger part to a general and steady growth of the industry in all directions, and to the application of improved processes and more economical methods of working ores.

The increase in the quantities, of silver especially, produced or refined in this country was due largely to the treatment here of base bullion from Mexico. The unwise imposition of a duty on silver-lead ores some years ago has not only deprived our smelters of a large amount of work which they formerly had and of a class of ores which were particularly desirable for treatment in connection with our own; it has also built up in Mexico a large and flourishing smelting industry which is now well established and able to hold its own. This is shown by the extraordinary increase in the quantity of bullion obtained by smelting given in the Mexican returns. The greater part of the base bullion made in that country is sent here to be refined, and to this is due the fact that while our own output of silver showed a decrease of 3,515,640 ozs., or 7.1%, there was an actual gain of 6,247,485 ozs., or 8.9%, in the total quantity of fine metal turned out by our refiners.



We give below, in alphabetical order, some notes on the production of the various States and Territories.

Alaska.—This Territory has within its limits the largest gold mine in the world, if we take into account the extent of its workings, the size of its mills, and the quantity of ore treated; though its total gold production is surpassed by several others, owing to the very low grade of its ores. The Alaska-Treadwell Company has continued to work satisfactorily and to show a fair amount of profit on ores averaging a little under $3 per ton, in spite of its remoteness from supplies and the comparatively unfavorable climate. The same thing may be said of its sister mine, the Alaska-Mexican, although the latter is a much smaller mine. The Apollo and a few other mines added to the total, and in the coast district there was a good deal of prospecting, with some promising discoveries. The far northern placers attracted a number of miners, but the results actually obtained from the Yukon region were not large, and much suffering has been reported among miners who were ill prepared for the severities of an arctic winter.

Arizona.—An account of the progress made in the mines of this Territory will be found on another page.

California.—According to the report of the State Mining Bureau, the production of gold in 1895 was 741,863 fine ozs., or $15,334,308, and of silver 463,910 ozs., having a commercial value of $302,933. A notable increase is shown in the production of gold, amounting to $1,763,920 over the production of 1894 and to $3,254,317 over that of 1893, a gain made notwithstanding the fact that the resumption of hydraulic mining, which was promised under the present law, has only been very partial and on a limited scale. The greater gold output has come almost altogether from the quartz mines of the State. It has been divided among all sections of the gold-bearing region, nearly every county which is a producer at all showing an improvement. Of the 52 counties in California 33 produce gold in some quantity and over 20 in large amounts. The greater part of this gain came not from new discoveries, but from the extension of existing mines, the reopening of old mines which were abandoned years ago, and the adoption of improved processes and methods of working at many mills.

Gold is by far the most important single interest in the State, and the mining of silver holds an exceedingly subordinate place. No silver mines of any size are found outside the Calico district, in San Bernardino County, which produced a little over one-third of the silver reported, the remainder being silver parted or obtained from gold bullion.

Colorado.—On another page will be found some account of the changes in mining during 1895, contributed by the State Geologist.

Idaho.—The gold production of this State showed but little change. Some new mines, of comparatively small importance, were opened, and there was a small increase in the number of placers worked. Arrangements have been made to work the auriferous gravels of the Snake River on a large scale, but no considerable returns have yet been obtained. The De Lamar and some others of the large mines of Owyhee County continued to work steadily. In silver production there was a slight increase, chiefly from the border districts of Northern Idaho. The silver-lead mines of the Cœur d'Alênes were nearly all producers, in spite of the discouragements from labor troubles and low prices of the metals. There is yet abundant room for expansion in the Idaho mountains.

Michigan.—Very slight changes are shown in the gold and silver production from this State, which is principally obtained from a few of its copper mines. Most of the Michigan copper, however, carries no silver.

Montana.—The slight increase in gold in 1895 over 1894 shows less progress in this State than might have been expected, and indicates how much is still to be done to develop its undoubtedly very great resources. There was a gain in the silver production, which came largely from the Butte copper district, where mining and development work are very energetically carried on. Few people realize, for instance, that the Anaconda, so widely known as the greatest copper producer in the world, is also, with one exception, the greatest silver mine. Outside of the Butte district some good work has been done in the Hope, the Iron Mountain, the Drumlummon Mine of the Montana Company, and others; but not many new mines have been opened.

Nevada.—An increase of 18,000 ozs. in gold and a decrease of 228,000 ozs. in silver make up the report from this State. Part of the gain in gold was from the new mines at De Lamar and elsewhere; part of it was from the Comstock mines, in many of which an increasing proportion of gold is shown in the bullion obtained from the ores. The explorations of the Brunswick lode undertaken by several of the Comstock companies showed little result in 1895, though some promising indications have been reported since the close of the year.

New Mexico.—In the Cochiti and other districts in this Territory a great deal of work was done in 1895, and without any extraordinary discoveries there was a substantial gain—$484,238, or 85.3%—in the gold output. In silver there was a slight decrease.

Oregon.—A large comparative decrease was shown in the output of both gold and silver. This was due partly to an unfavorable season, partly to the closing of two or three important mines by litigation, and partly to the increasing demand for labor in agricultural and lumbering work.

South Dakota.—The mines of this State recovered some of the ground lost in 1894, and 1895 showed an increase of $114,509 in gold over its predecessor, though there was still a decrease of $592,791 as compared with 1893. There was a good deal of prospecting done during the year and some promising discoveries reported, but none of them reached the producing stage. In this State there is an increasing interest in the wet processes of reduction, such as chlorination and cyaniding, and some new plants are to be established for the treatment of the Black Hills ores. The silver output is unimportant.

Texas.—No gold is produced in this State. The silver output, which is from the Presidio, the Cibolo, and other mines of the Trans-Pecos district, shows a gain of some comparative importance.

Utah.—An increase in the gold production of 32.4% is the result reported by this State. Much of the gain was from the Mercur district, where great progress was made in working the large deposit of low-grade ores which exists there. The Mercur Gold Mining Company, which first located there, the Sunshine, and other new companies are at work on a large scale and with results that have been very encouraging thus far. The silver production also shows a very considerable increase, and it is to be noted that the Ontario, the Daly, and several other companies have been able not only to continue work on a large scale, but to pay their stockholders dividends which must be considered very satisfactory under the circumstances. The great Ontario drainage tunnel, which reached the workings of that mine in 1894, has been extended and is now carrying off the water from the Ontario and the Daly with a notable economy in operation.

Washington.—This State is one of the few reporting a decrease in gold production. As in Oregon, the increased demand for labor carried away many men from the mines, while others left for British Columbia and Alaska, which seemed to present more promising fields for the time being. The difficulties of prospecting in a heavily wooded region like this State presents are also a discouragement to new discoveries.

The Southern States.—In Virginia the production of gold was trifling in amount and very little legitimate work was done. In North Carolina the usual small amount of placer mining was carried on. Several mines were worked steadily and others at intervals, but the production showed a decrease. In South Carolina there was an increase of about 25% in the gold output. Nearly all of this comes from the Haile Mine, where the chlorination plant under the charge of Mr. Adolph Thies continues to work the low-grade sulphuret ores successfully; the Haile is one of the few Southern mines where a large deposit is found. We may add that Mr. Thies is now engaged in putting up a chlorination plant at the Franklin Mine, in Georgia, where somewhat similar conditions are found.

According to Mr. William M. Brewer, much attention has been directed to the gold-mining interests in the States of Georgia and Alabama, and there have been many contributions to the literature on the subject of Southern gold mining. In the gold belt extending through those States several old prospects which had received no attention for years past were developed. In a great many instances, unfortunately, this work was undertaken more for the purpose of selling stock or booming some property than to determine the actual value, extent, and permanency of the ore body, but there were some exceptions. In Cherokee County, Ga., the work done at the old Latham Mine was of such a character as ought to be done everywhere. The holder of the bond on this property directed all his efforts toward determining by actual work the extent and permanency of the ore body below water level and below the line of decomposition in the hornblendic and mica-schist country rock. Work of similar character was also performed during the year by John Cross on the old Grantville Mine, in Meriwether County, Ga., which had been idle since 1878. An English syndicate which had purchased some mineral land near Villa Rica, in Carroll County, Ga., also expended a considerable amount of money during the summer and fall in systematic prospecting. In Harralson County, near Tallapoosa, the old Camille Mine was unwatered and a force of men put to work clearing out the drifts on the 200-ft. level. A mill run of the ore was made under the directions of Mr. Adolph Thies. In Gwinnett County some work was done on the Piedmont Mine. In the Dahlonega district, in Georgia, about the same degree of activity was apparent during 1895 as has been the case for several years past, and many of the mines were worked with satisfactory results on a limited scale. The same may be said of the mines in White County, in the Nacoochee Valley. The number of dredge boats on the Chestatee River near Dahlonega has been increased during 1895 from one to three, but little can be learned as to the results of the work done. The only producers in the State of Georgia from which bullion was shipped regularly during the year were the Franklin Mine, in Cherokee County, owned and operated by the Creighton Mining and Milling Company, and the Walker Mine, in McDuffie County, owned and operated by Mrs. J. S. Smith. Among the mines in Georgia which produced bullion at irregular intervals, besides those of Dahlonega and the Nacoochee Valley district, are the Charlotte Mine, near Villa Rica, the Grantville Mine, in Meriwether County, the Doctor Charles Mine, in Forsyth County, near Ball Ground, and the Georgiana Mine, near Acworth, in Cherokee County.

In the State of Alabama there have been no regular bullion producers during the year, but some activity has been manifested in prospecting at various locations, especially at Arbacoochee, in Cleburne County. At the Silver Hill Mine, in Tallapoosa County, mining operations have been carried on through a portion of the year and experiments have been conducted with a view to saving a larger quantity of the gold than in former years. The difficulty of treating this ore satisfactorily is caused by the graphitic character of the slate country rock, which is so closely associated with the lenses of auriferous quartz as to render it almost impossible to separate the ore from the slate previous to milling. In other portions of the Alabama gold fields a limited amount of prospecting work has been carried on, especially at Pinetuckey, in Randolph County. A Chicago syndicate has been developing that property by sinking a new working shaft to cross cut the ore body about 80 ft. further to the southeast than it has been heretofore worked. During the summer of 1895 there were employed at one time in the old Arbacoochee district about 60 men, engaged in prospecting on those sections of land which produced much placer gold about 40 years ago, but toward the end of the year work was suspended upon all properties except that known as Section 7, which was purchased by a Chattanooga syndicate early in the summer. There heavy machinery has been set up and preparations made for hydraulic working in the valley of Clear Creek.

To sum up, it may be said that while little advance was made, yet there were no failures such as occurred in 1893, and really the industry at the close of 1895 was in a more healthy condition than at its opening.

THE GOLD PRODUCTION OF THE WORLD.

The following table shows the gold production of the world in the years 1894 and 1895. In the majority of cases the returns are from statistics, chiefly official, received from the various countries; in some cases it has been necessary to estimate the output, and in these we have generally adopted the very close and careful estimates made by the Director of the United States Mint. We have added to the table a column giving the production in fine troy ounces as well as in kilograms, though we hope that the time is rapidly approaching when the ounces may be dropped altogether and the metric measure alone be required everywhere. The column of "Reported Ounces" shows the amounts given—as they are in many countries—of the base gold bullion produced of variable fineness; in all cases these have been reduced to fine ounces from the values or other data furnished by the reports. The reporting of gold and silver production always in fine ounces—that is, in pure metal—is a change or reform that is very desirable. Such a change would prevent some misunderstanding, and would permit comparisons without the further calculations which are now necessary in many cases to insure correctness, and for which the data needed are not always at hand or easily to be obtained. Where estimates have been necessary they have always been made in fine ounces or kilograms:

GOLD PRODUCTION OF THE WORLD. (*a*)

Countries.	1894.				1895.			
	Reported Ounces.	Fine Ounces.	Kilograms.	Value.	Reported Ounces.	Fine Ounces.	Kilograms.	Value.
North America:								
United States	....	1,923,619	59,824	$39,761,205	....	2,265,612	70,470	$46,830,200
Canada	52,983	46,146	1,435	954,451	110,881	92,449	2,876	1,910,921
Mexico	....	217,707	6,771	4,500,000	....	270,924	8,427	5,600,000
Central American States	....	22,762	698	470,500	....	23,222	722	480,000
South America:								
Argentine Republic	....	4,596	143	95,000	....	4,500	140	93,015
Bolivia	....	3,241	101	67,000	....	3,144	98	65,000
Brazil	....	107,378	3,340	2,219,500	....	108,000	3,359	2,232,360
Chile	....	22,467	699	464,400	....	22,550	701	466,209
Colombia	....	139,516	4,339	2,892,800	....	154,000	4,890	3,183,180
Ecuador	....	3,309	103	68,400	....	3,800	118	78,546
Guiana (British)	139,596	119,215	3,708	2,464,176	122,936	104,987	3,265	2,170,081
Guiana (Dutch)	31,807	27,035	841	579,500	....	28,219	878	584,795
Guiana (French)	75,812	64,340	2,001	1,329,200	90,280	76,738	2,387	1,586,080
Peru	....	3,599	112	74,400	....	3,650	113	75,445
Uruguay	....	6,854	213	141,600	....	6,884	213	141,600
Venezuela	....	41,200	1,281	851,600	....	41,200	1,281	851,600
Europe:								
Austria-Hungary	....	88,348	2,748	1,826,153	....	88,500	2,753	1,829,300
France	12,088	11,640	362	240,600	....	11,640	362	240,600
Germany	....	139,365	4,335	2,880,673	....	139,365	4,335	2,880,673
Italy	....	12,145	379	252,057	....	12,500	389	258,375
Russia	....	1,304,407	40,572	26,942,093	....	1,644,852	51,161	33,990,000
Sweden	....	30,092	936	622,001	....	30,225	940	624,750
Turkey	....	392	12	8,000	....	392	12	8,000
United Kingdom	....	3,183	99	65,800	....	3,000	93	62,010
Asia:								
China	451,514	413,974	12,876	8,556,344	....	225,000	6,998	4,650,750
India (British)	208,237	182,808	5,686	3,766,251	249,355	218,185	6,786	4,519,894
Japan	....	23,696	747	489,800	....	21,000	653	434,070
Korea	....	22,603	703	467,200	....	10,000	311	206,700
Africa:								
Transvaal	2,265,853	1,848,936	57,509	38,217,197	2,549,036	2,080,013	64,697	42,993,869
Other countries	79,347	64,747	2,014	1,338,339	....	75,000	2,232	1,550,250
Australasia	2,200,359	1,930,900	60,059	39,911,703	2,350,562	2,070,335	64,395	42,793,824
Indian Archipelago	....	2,000	62	41,340	....	2,500	78	51,675
Totals	....	8,832,220	274,708	$182,569,283	....	9,842,386	306,133	$203,443,772

(*a*) The figures for the United States have been compiled by the *Engineering and Mining Journal* from returns collected from smelters and refiners For Canada, Mexico, the Guianas, Austria-Hungary, France, Germany, Italy, Russia, Spain, Sweden, British India, the Transvaal, and Australasia the figures are from official returns. The kilogram of gold is taken at the value of $664.60, United States money.

The following table shows the production of silver in the world for the same years, 1894 and 1895. The silver is counted at its commercial value or selling price in the markets of the world. This average price, which is calculated from the daily reports of the London and New York markets, showed a slight increase in 1895, having been 65.3c. per oz., against 63c. in 1894, showing an appreciation of 2.3c., or 5.5%; that is, the value ratio between gold and silver declined from 1 : 32.81 in 1894 to 1 : 31.65 in 1895. The fluctuations in the price during 1895, it may be noted, were not great; for several months the averages were almost the same, and at no time were there any sudden or considerable changes in the quotations or in the demand for the metal. The quantities of silver are all stated in fine metal. The same statements apply to this table of silver output as to that of gold production; they have been separated chiefly for convenience in arranging:

SILVER PRODUCTION OF THE WORLD. (*a*)

Countries.	1894.			1895.		
	Fine Ounces.	Kilograms.	Commercial Value.	Fine Ounces.	Kilograms.	Commercial Value.
North America:						
United States	49,846,875	1,550,387	$31,403,581	46,381,235	1,441,087	$30,254,296
Canada	649,494	20,202	409,192	1,775,683	55,230	1,159,278
Mexico	47,047,056	1,463,361	29,640,378	50,890,267	1,582,901	33,225,091
Central American States	1,547,154	48,123	974,731	1,600,000	50,000	1,049,000
South America:						
Argentine Republic	1,200,288	37,334	756,200	1,212,625	37,500	787,125
Bolivia	22,004,039	684,418	13,862,888	20,767,852	642,857	13,500,000
Chile	2,851,062	88,680	1,796,213	2,925,650	91,000	1,910,090
Colombia	1,688,230	52,511	1,063,610	1,720,025	53,500	1,122,965
Ecuador	7,716	240	4,861	7,716	240	5,037
Peru	3,461,590	107,670	2,180,856	3,697,250	115,000	2,513,850
Europe:						
Austria-Hungary	1,877,592	58,401	1,183,184	1,816,475	56,500	1,185,935
France	3,117,103	96,955	2,133,000	3,102,475	96,500	2,025,535
Germany	14,281,488	444,213	9,653,769	14,146,000	440,000	9,235,600
Italy	1,884,826	58,626	1,289,772	1,768,250	55,000	1,154,450
Norway	151,566	4,705	95,299	146,216	4,859	101,990
Russia	325,262	10,117	204,920	330,250	10,272	215,653
Spain	6,196,752	192,745	3,905,014	7,426,650	231,000	4,848,690
Sweden	92,238	2,869	58,126	93,238	2,900	60,871
Turkey	49,059	1,516	30,707	49,059	1,516	33,821
United Kingdom	255,018	7,939	160,662	253,985	7,900	165,821
Asia:						
Japan	1,956,938	60,869	1,232,901	1,768,250	55,000	1,154,450
Australasia	18,176,755	562,263	11,388,638	19,971,580	621,200	13,038,988
Totals	178,668,101	5,554,144	$113,428,502	181,850,731	5,651,962	$118,748,536

(*a*) The average commercial value of silver was 63c. per oz., or $20.26 per kgm., in 1894, and 65.3c. per oz., or $20.99 per kgm., in 1895.

The increase shown in gold production in 1895 as compared with 1894 was $20,874,489, or 11.4%. In silver the total gain was 97,818 kgms., or 1.8%, in quantities, and of $5,320,034, or 4.7%, in value.

The production of silver in 1895 was, in weight, 18.5 times that of gold; but the value of the gold was 1.7 times that of the white metal.

The United States has regained the first rank as a gold producer, which it yielded to Australasia in 1894 by a few thousand dollars only. The Transvaal in 1895 took the second place, its production exceeding that of Australasia by $200,000, but falling $3,836,331 below that of the United States. Russia held the fourth rank, and no other country approached any one of the four great producers. Of the total output of the world 23.1% is credited to the United States, 21.2% to the Transvaal, 21.1% to Australasia, and 16.7% to Russia. These four countries thus contributed 82.1% of the whole amount.

The decrease in the silver produced in the United States and the activity in the Mexican mines have given Mexico the first place as a silver producer. Bolivia stands third, though with less than half the output of the United States, while Australasia is fourth in order. Mexico supplied 28% and the United States 25.5% of the silver produced in 1895.

In the following pages we give some notes on the production of the precious metals by countries.

NORTH AMERICA.

The production of the United States has already been referred to in detail.

Canada.—The gold production of Canada showed a remarkable gain, having just about doubled, as compared with that of 1894. The details of the yield for 1895 are reported by the Geological Survey of Canada as below:

GOLD PRODUCTION OF CANADA IN 1895.

Provinces.	Reported Ounces.	Fine Gold.		Value.
		Ounces.	Kilograms.	
Nova Scotia	20,870	19,679	612	$406,770
Ontario and Quebec	4,011	3,077	96	63,606
Northwest Territory and the Yukon	10,000	7,257	226	150,000
British Columbia	76,000	62,436	1,942	1,290,545
Totals	110,881	92,449	2,876	$1,910,921

The production of gold in Nova Scotia continues steadily and there are a number of mines which are regular producers, though as a rule they are small. No unusual output was noted in 1895.

A little gold is obtained in Quebec, but the amount is not reported separately. In Ontario little that is new can be reported. Some work has been done in the new Rainy Lake and Seine River gold fields, but not very much product has yet come forward.

In British Columbia there has been great activity in mining and prospecting, both in gold and silver properties. Many new locations are reported, and the number of mines opened and actually worked is steadily increasing. Several British Columbia properties have been placed in London with companies which propose to work them on a large scale, and there has been a continued inflow of men and capital from the United States. A large part of the product from the mines comes to this country either in the form of ores sent to the smelters or of base bullion to be refined. The greater part of the silver production of Canada is from the mines of this province.

The gold contributed by the Northwest Territory and the Yukon placers is largely from the latter, and much of it was obtained by American miners who enter the region from Alaska.

Mexico.—In theory all the gold and silver produced in Mexico should be entered at the Mint for coinage or for export. In practice it is claimed by experts that to obtain a fair estimate of the total gold and silver production of Mexico during the fiscal year the following additions should be made to the official figures: 15% of the total, for exports made without returns; 0.5% used in the arts in Mexico; 1% retained in the banks; 2% in circulation; total, 18.5%. This is to a great extent a matter of conjecture. The 3% estimated as being retained by the banks and put into circulation represents that portion of the annual production applied to the increase of the circulating medium of the country.

Both gold and silver production in Mexico showed large increases in 1895. While silver mining continues to be the chief interest of the country, gold mining is gaining rapidly, as is shown by the increase of nearly 25%.

The exports of gold and silver from Mexico in various forms for the fiscal year ending June 30, 1895, and for the preceding year were as follows. The comparison between the two years is imperfect, owing to a change in the system of classification:

EXPORTS OF PRECIOUS METALS FROM MEXICO. (IN MEXICAN DOLLARS.)

Substance.	1893–94.	1894–95.
Argentiferous copper ore	$374,224	....
Gold ore concentrates	55,799	$59,660
Silver ore concentrates	9,023,596	10,935,353
Mexican gold coin	37,592	34,887
Foreign gold coin	135,999	164,113
Gold bullion	155,954	4,139,645
Doré bars	478,890	....
Foreign silver coin	209,250	485,326
Mexican silver coin	17,386,338	17,077,119
Silver slags	60,590	50,866
Silver bullion	3,130,823	18,803,876
Silver bullion, gold-bearing	4,750,774	....
Silver concentrates	757,101	....
Lead, base bullion	9,927,324	....
Zinc, base bullion	106	....
Totals	$46,484,360	$52,535,854

The following table shows the production of gold and silver in Mexico by calendar years for the six years ending with 1895:

PRODUCTION OF GOLD AND SILVER IN MEXICO.

Year.	Gold.		Silver.		Year.	Gold.		Silver.	
	Kilos.	Dollars. (*a*)	Kilos.	Dollars. (*a*)		Kilos.	Dollars. (*a*)	Kilos.	Dollars. (*a*)
1890....	1,154	767,000	1,211,646	50,356,000	1893....	1,964	1,305,300	1,380,116	57,357,600
1891....	1,505	1,000,000	1,084,100	45,055,200	1894....	6,771	4,500,000	1,463,361	*b*29,640,378
1892....	1,699	1,129,200	1,228,994	51,077,000	1895....	8,427	5,600,000	1,582,901	*b*33,225,091

(*a*) Kilogram of gold, $664.60; kilogram of silver, $41.56, United States coinage rate. (*b*) Commercial value.

These silver-value figures for the years prior to 1894 are given in Mexican dollars, the average value of which in our currency, at New York, during the year ending June 30 last, was $0.5101. In the item of "gold bullion" is included the gold contained in the bars exported, and "silver bullion" includes the silver contained in the argentiferous lead and copper as exported.

The report of the operations of the Mexican mints for the fiscal year 1894–95 shows total receipts of 3991 kgms. fine gold, valued at $2,674,278, or $643.52 per kgm. The receipts of fine silver were 983,222 kgms., valued (at coinage rate of $39.11 per kgm.) at $38,934,191. The total coinage was (in Mexican dollars): Gold, $545,237; silver, $27,628,981; copper, $32,957. A very large proportion of the silver produced is coined for the reason that Mexican dollars usually command a premium over bar silver owing to their general currency in China, the Straits Settlements, and nearly all the far East.

In the mint accounts are specified the various metallurgical processes employed in obtaining the precious metals and the amounts produced by each. For the fiscal years 1893–94 and 1894–95 they were as follows, including base bullion:

PRODUCTION OF BULLION BY VARIOUS PROCESSES IN MEXICO.

Process.	1893–94.	1894–95.	Process.	1893–94.	1894–95.
	Kilos.	Kilos.		Kilos.	Kilos.
Patio	738,054	654,949	Pan-amalgamation	165,375	166,869
Barrel	28,930	30,301	Smelting	3,537,330	19,070,358
Lixiviation	88,510	69,357	Totals	4,559,199	19,991,834

The remarkable increase in base bullion from the smelters shows the great growth of the smelting interest in Mexico, to which reference has already been made.

Central American Countries.—A slight increase in gold production is reported, chiefly from Nicaragua. Some rich placer discoveries are reported in that State, but not many are actually worked as yet. In Costa Rica there was a decrease, owing to the failure of the Costa Rica Mining Company and the stoppage of work on its property. The silver production is practically unchanged.

SOUTH AMERICA.

Argentine Republic.—The mining interests of this country receive comparatively little attention, and the yield of gold and silver varied little last year from that of 1894. Both are obtained from districts in the western part of the Republic, in the foothills of the eastern slope of the Andes. Very little progress has been made in working the gold placers which are believed to exist in Argentine Patagonia.

Bolivia.—The gold production of Bolivia is small and does not increase. The silver output is a large one, however, putting the country third in rank among the silver producers of the world. In 1895 the production of the great Huanchaca Mine was reduced for a time by the drowning out of some of the workings by a sudden influx of water; but other mines continued steadily at work. The Huanchaca has, unfortunately, suffered in its management, and its great plant has not been used to the best advantage. The following table shows the production of silver in Bolivia for the six years ending with 1895, the values being given in Bolivian dollars:

PRODUCTION OF SILVER IN BOLIVIA.

Year.	Value.	Year.	Value.	Year.	Value.
1890	$7,698,326	1892	$7,453,935	1894	$13,862,888
1891	7,440,085	1893	9,368,823	1895	13,500,000

The increase in recent years shows the impetus given to mining by the completion of railroad connections with the coast.

Brazil.—In this country the Ouro Preto Company continued to work steadily through the year. The St. John del Rey Gold Mining Company made many improvements in new machinery and methods of mining, but the full effect of these has not yet been felt, and the ore worked during the year was of lower grade than usual. Some other mines have been opened, and it is quite probable that an increase over 1895 will be shown in the current year.

In the State of Bahia gold mines are worked by Brazilian companies at Morro de Fogo and at Jacobinas, where a 20-stamp mill is running. Placers of some extent are also worked at Momondo, not far from the Morro de Fogo Mine.

Chile.—There was a slight increase in both gold and silver, but mining presented no especial features.

Colombia.—This country is the chief gold producer of the group of States forming the northwestern shoulder of the continent and grouped along the northern chain of the Andes. This region was the great gold producer during the sixteenth and seventeenth centuries, and its resources are not by any means exhausted. Colombia especially possesses great mineral wealth, and more attention is being continually paid to its gold mines.

Ecuador.—The Playa de Oro Company has been reorganized by the New York stockholders, but the output of gold is and probably will continue to be small. In other placer workings there was a fair increase.

The Guianas.—In Dutch Guiana the production of gold in 1895 remained about the same as in 1894. In British Guiana the disputes over the boundary with Venezuela and difficulty in obtaining labor limited the output, and there was a decrease of $294,095 in the amount reported. French Guiana showed a gain of $336,510 over 1894; the statement for that colony is based on the amount exported. About one-third of the production of this colony was from the territory in dispute with Brazil, but the boundary question there has not yet reached an acute stage. The following table shows the gold production of the Guianas for the five years ending with 1895:

GOLD PRODUCTION OF THE GUIANAS.

Year.	British Guiana.		Dutch Guiana.		French Guiana.	
	Kilos.	Value.	Kilos.	Value.	Kilos.	Value.
1891	3,150	$1,801,389	821	$452,158	1,511	$837,623
1892	4,031	2,303,163	944	627,025	1,482	821,546
1893	4,441	2,542,996	1,098	729,059	2,000	1,108,700
1894	4,308	2,464,176	872	579,600	2,200	1,219,570
1895	3,855	2,170,081	880	584,795	2,807	1,556,080

All the gold reported was from placer workings, though a beginning has been made of quartz mining in British Guiana.

Peru.—There was a small increase in gold production and also some gain in the silver output, which is much larger and of considerable importance. The gain was chiefly from the Cerro di Pasco.

Uruguay.—But little is known of the mines of this country and the estimate of its production is based chiefly on its exports of gold.

Venezuela.—The gold production of this country as estimated remained substantially the same in 1895 as in 1894, and there were no changes of importance. The new mines whose working was undertaken by El Callao Company have not met expectations, and the operations of that company have been limited, but other mines were steadily at work.

EUROPE.

The production of gold in Europe, outside of Russia, is not large. A considerable amount of silver is obtained, chiefly in connection with other metals.

Austria-Hungary.—Gold is mined chiefly in Hungary, only a small amount coming from the Austrian mines. Silver is obtained in both countries; the output is regulated by the government, which controls the mines.

France.—A small amount of gold is obtained, which varies little from year to year. The silver is chiefly from the lead and zinc mines.

Germany.—The gold production of this country varies little. Silver is obtained from the ores of Freiberg and the Harz and from the Mansfeld copper mines, the last-named company being the largest producer. It is probable that some silver from foreign ores is included in the German product.

Italy.—The placers of Piedmont and the Southern Alps are the source of the gold reported. The silver is chiefly from lead and zinc ores.

Norway.—Norway reports no gold. The silver is from the Kongsberg Works and in 1895 showed some increase over the previous year. Some complaint is made that the low price of silver has made its extraction unprofitable, and there was a loss on the company's operations in 1895.

Russia.—In Russia (in which Asiatic Russia or Siberia is included), as in many other gold-producing countries of the world, the output of the yellow metal in 1895 showed a large increase. The extension of placer working in the Ural and Siberia has continued, and there has been a notable movement toward introducing improved methods and closer working than have heretofore been customary. During the year several companies were formed, in Russia itself and in France, for the purpose of working gold mines on a large scale.

The production of silver in Russia is not large; it varies slightly from year to year, but does not show any considerable increase.

We have obtained, through an esteemed correspondent in St. Petersburg, the official figures of the gold and silver registered in the Imperial Mint and its branches. These returns cover the years 1893 and 1894 in full and the year 1895 up to November 15. We give the figures in the table below, adding for 1895 the estimated amount necessary to bring the returns up to the close of the year:

GOLD AND SILVER PRODUCTION OF RUSSIA.

Year.	Gold.			Silver.		
	Fine Ounces.	Kilos.	Commercial Value.	Fine Ounces.	Kilos.	Commercial Value.
1893	1,224,626	38,091	$25,514,169	334,355	10,400	$261,466
1894	1,185,825	36.884	24,138,664	325,261	10,117	204,920
1895	1,495,320	46,512	31,163,750	330,250	10,272	215,653

Under Russian law all gold and silver produced must be registered and brought to the Imperial Mint, which has agencies for its reception established at convenient points. The silver, which is mainly produced in the smelting works of Siberia, is probably closely so registered; but it is quite possible that a considerable amount of gold is concealed or otherwise fails to reach the mint. An allowance of 10% for this gold is probably within the mark; making this addition we have the output of gold for three years as follows:

GOLD PRODUCTION OF RUSSIA.

Year.	Quantity.		Value.
	Fine Ounces.	Kilos.	
1893	1,347,088	41,900	$27,844,209
1894	1,304,407	40,572	26,942,093
1895	1,644,852	51,161	33,990,000

The increase in value shown in 1895 was $7,047,907, or 26.2%, as compared with 1894; and $6,145,791, or 22.1%, as compared with 1893.

The production may be expected to increase for some years to come. The rapid extension of the Siberian Railroad is not only opening new fields, but will, by reducing the cost of supplies and facilitating the transportation and introduction of machinery, permit the working of deposits which have heretofore been considered of too low grade for profitable exploitation. The increase will be further aided by the growing importance of vein mining, to which more attention is being paid each year. So far the greater portion of the Russian gold output has been from placer workings.

New gold fields were discovered during the year in Russian Turkestan, but little is yet known as to their value or extent.

Sweden.—A small output of both gold and silver is maintained, with but little change. The industry is not an important one.

Turkey.—Owing to the absence of all reliable statistics in this country the production given is conjectural entirely. It is claimed by some that the amount is too small, but no reasons for increasing the estimate are given.

United Kingdom.—The production of gold from the Welsh mines continues, with few changes. One or two new companies were recently organized, and it was claimed that new discoveries of importance had been made, but they do not seem thus far to have developed as expected.

ASIA.

As in previous years, the statistics from most Asiatic countries are largely conjectural, and it is only in the case of colonies under European governments that figures can be given with any approach to accuracy. The Siberian production is included in that of Russia.

China.—The amount and the sources of the gold production of China continue a matter of discussion among outsiders, and no addition was made to our knowledge during the year. The same may be said of the silver. The war in China probably affected the actual production but little, though it may have decreased to some extent the amount of gold carried into the country by natives returning from America, Australia, and elsewhere. This gold is believed to have in former years constituted a considerable amount, but as it is not reported in the countries from which it is taken, there would be no duplication even if it could be accurately stated. As it is, the estimates for China are based chiefly on a comparison of the exports and imports.

India.—The Colar gold field in Mysore continues to be the only one where regular workings are in progress, and this field showed a healthy growth during 1895. The monthly returns showed in almost every instance increases over 1894, and the larger companies were able to pay steady dividends to their shareholders. The following table shows the reports made by the leading companies in this field for 1894 and 1895, giving the tons of ore worked in the mills and the quantity of gold obtained, as reported, and not in fine ounces; these companies in the latter year produced 95% of all the gold reported:

PRODUCTION OF THE PRINCIPAL MINES IN THE COLAR GOLD FIELD.

Companies.	1894.		1895.	
	Tons.	Ounces.	Tons.	Ounces.
Ooregum	45,294	68,224	53,370	70,349
Champion Reef	44,644	53,516	51,645	70,960
Mysore	60,756	52,115	60,654	58,830
Nundydroog	29,730	29,745	32,965	38,613
Totals	180,424	203,600	198,634	238,752

During 1895 there were two new companies—the Yerrakonda and the Mysore West & Wynaad—added to the list, but neither of them is a large producer as yet. The ores of the Colar field can, for the most part, be worked by amalgamation, and average from $25 to $35 in gold per ton. With increased depth of working there is said to be but little variation in the value. Several of the companies are now working part of the tailings from their mills by the cyanide process with success. Since the close of 1895 the Mysore and the Champion Reef companies have opened up new and promising veins of ore.

Japan.—The war interfered to some extent with mining operations, but not sufficiently to make any important changes. The gold and silver production are not large.

Korea.—This country has been known as a gold producer only through the fact that it exports gold in some quantity, the amount reaching $918,659 in 1893. The amount in 1894 did not increase; in 1895 it probably decreased, in consequence of the disturbed condition of the country.

AFRICA.

Interest in the African mines centers for the present entirely in the Transvaal and the adjoining regions.

The Transvaal.—The gold-mining industry of this country, which has been the basis of one of the most extraordinary speculative movements which the world has ever witnessed, made some progress during 1895, but less than had been expected or promised. The course of production in the Witwatersrand district, where by far the greater part of the output is obtained, will be found in the following table:

GOLD PRODUCTION OF THE WITWATERSRAND DISTRICT.

Months.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.
	Ounces.	Ounces.	Ounces.	Ounces.	Ounces.	Ounces.	Ounces.	Ounces.	Ounces.
January	....	7,328	25,506	35,007	53,205	84,560	108,374	149,814	177,463
February	....	12,180	22,457	36,887	50,079	86,649	93,252	151,870	169,295
March	....	11,976	27,919	37,780	52,949	93,245	111,474	165,373	184,945
April	....	14,146	27,029	38,697	56,372	95,562	112,053	168,745	186,323
May	887	13,397	35,028	38,836	54,673	99,436	116,911	169,774	194,580
June	734	12,773	30,878	37,419	55,863	103,252	122,907	168,162	200,941
July	240	16,687	31,091	39,457	54,924	101,279	126,169	167,953	199,453
August	1,409	18,616	30,520	42,864	59,070	102,322	136,069	174,978	203,573
September	1,936	20,242	34,143	45,486	65,602	107,852	129,585	176,708	194,764
October	4,029	27,165	32,214	45,249	72,793	112,167	136,682	173,379	192,652
November	5,463	26,827	33,722	46,783	73,394	106,795	138,640	175,304	195,218
December	8,457	26,784	39,050	50,352	80,323	117,748	146,357	182,104	178,428
Total crude ounces	23,155	208,122	369,557	494,817	729,238	1,210,867	1,478,473	2,024,164	2,277,635
Total fine ounces	18,894	169,827	301,558	403,770	595,058	988,067	1,206,434	1,651,217	1,848,250

The figures given in this table are those reported by the Johannesberg Chamber of Mines. As the Transvaal gold averages 816 fine, we have converted the totals into fine ounces also.

The monthly production passed 200,000 crude ozs. in June and reached the maximum of 203,573 ozs. in August. From that point it declined slightly and did not again reach the level of 200,000 ozs. The production in December was only 965 ozs. greater than in January, and was 3676 ozs. less than in December, 1894.

In October the number of stamps at work in the Witwatersrand mills reached 2716, and the ore crushed during that month was 309,800 tons. At the close of the year there were 2900 stamps in operation or ready to start. No important improvements were made during the year, and the work was mainly on the old lines of mill amalgamation with treatment of the tailings by the cyanide process and of the pyritic concentrates by chlorination. The use of the Siemens-Halske electric process is gradually extending.

The proportion of gold obtained from the tailings by the cyanide process continued in 1895 to be about 30% of the total output. Nearly all the companies have worked off their old accumulations of tailings, and are now treating only those which come from the mills in the regular course of working.

The reduction of output in the later months of the year from the maximum reached in August seems to have come from several causes. The scarcity of water, resulting from an unusually dry season, and the difficulty of obtaining a sufficient supply of native labor were the chief causes. At the close of the year political troubles intervened, and though the immediate consequences to the mining industry were not serious, they have since greatly interfered with its development. An event of importance to the Witwatersrand was the beginning, in November, of milling work on the ores of the Geldenhuis Deep, the first of the so-called deep-level mines to reach the extension of the Main Reef. The results so far obtained by this company have been quite discouraging.

The production of the districts outside the Witwatersrand reached a total of 271,401 ozs. for the year, showing an increase of 29,742 ozs., or 12.6%, over 1894. This gain was the result of extended operations in the Lydenberg and Potchefstroom districts and of new development in the Sheba Mine.

The prospects for an increased production in the Transvaal this year are somewhat uncertain. The political troubles are in course of gradual settlement, and some concessions are promised by the government which will benefit the industry. On the other hand, the labor problem presents serious difficulties, for which no satisfactory remedy has yet been proposed. The Transvaal is a country of low-grade ores and cheap labor is essential to its continued growth and prosperity, since any considerable increase in mining and milling costs must make many of the mines unprofitable. The trouble is not so much in the number of men to be had as in their indisposition to steady work. The limited wants of the Kaffir or Zulu are supplied by a few months of work, and he usually declines to stay longer in the mines. European labor (at European wages) is not a possible solution, as the ores would not bear so heavy a charge.

Other Countries.—The mines in the British South Africa Company's territory made little progress during 1895, and their production was very small, notwithstanding the great promises made for them.

In other parts of Africa there is a small production, the amount of which can only be estimated. On the Gold Coast some attempt has been made at systematic working. Gold has been found in the Zambesi country and in the Soudan, but is obtained only irregularly by the natives. In Natal and Cape Colony there is a small production, though most of the miners have been drawn off by the greater attractions of the Transvaal.

AUSTRALASIA.

The production of gold in the Australasian colonies for the years 1894 and 1895 is given in detail in the following table, the figures being from the official returns. The reported quantities have been reduced to fine ounces on the basis of the values stated:

GOLD PRODUCTION OF AUSTRALASIA

Colonies.	1894.				1895.			
	Reported Ounces.	Fine Gold.		Value.	Reported Ounces.	Fine Gold.		Value.
		Ounces.	Kilos.			Ounces.	Kilos.	
New South Wales	324,787	284,189	8,839	$5,874,187	360,165	315,144	9,802	$6,514,026
New Zealand	221,533	199,380	6,202	4,121,185	293,491	264,142	8,216	5,459,815
Queensland	679,511	560,597	17,437	11,587,541	623,000	513,975	15,987	10,623,863
South Australia	35,844	33,156	1,031	685,335	47,343	43,792	1,363	905,181
Tasmania	57,873	51,507	1,602	1,064,650	54,964	48,918	1,521	1,011,135
Victoria	673,680	633,259	19,697	13,089,464	740,086	695,681	21,638	14,379,726
West Australia	207,131	168,812	5,251	3,489,345	231,513	188,683	5,869	3,900,078
Totals	2,200,359	1,930,900	60,059	$39,911,703	2,350,562	2,070,335	64,396	$42,793,824

The total increase in Australasia was therefore $2,882,121, or 7.2%, as compared with 1894. The production, which in 1894 exceeded that of the United States by $150,498 only, in 1895 fell below ours by $4,036,376, and was also $200,045 less than that of the Transvaal.

The future production of Australasia depends largely upon the general condition of business. A revival in trade and manufacturing would undoubtedly draw away from the mines and placers many men now employed there. The attractions of the towns will prove greater than those of the mining camps whenever it becomes possible to earn a living in the city.

The silver production of Australasia, which is almost entirely from the Broken Hill and other mines on the Barrier range in New South Wales, showed an increase of 58,937 kgms., or 10.5%, over that of the preceding year.

New South Wales.—The gold production in New South Wales shows a rate of increase of 10.9%. It could hardly be expected that the phenomenal rate of gain made in 1894 could be kept up, and the advance secured in 1895 is as great as could be expected. The increase in 1894 was very largely from alluvial workings, the labor conditions in the colony having driven a great number of men—many of them old miners—from the towns and cities to prospect for new placers and to work in old ones, abandoned when more profitable employment was offered in manufacturing, in building, and other trades. This movement back to the gold fields was aided by the government, and was carried so far in 1894 that comparatively little increase was to be looked for last year. The gain seems to have been about evenly divided between placer workings and deep mining. The gold production of New South Wales for 10 years past has been as follows:

Year.	Reported Ounces.	Fine Ounces.	Year.	Reported Ounces.	Fine Ounces.
1886	101,417	88,740	1891	153,336	134,169
1887	110,228	96,502	1892	156,870	137,261
1888	87,503	76,565	1893	179,288	156,877
1889	119,759	104,789	1894	324,787	284,189
1890	127,760	111,790	1895	360,165	315,188

The total production of gold in New South Wales since the discovery of the gold fields has been 11,394,562 ozs., equal to 9,970,242 fine ozs., having a total value of $206,084,900. It will be seen that the production in 1895 was more than double that of 1893.

In silver production the application of new processes to the treatment of the sulphide ores of the Broken Hill Proprietary mines and other mines on the same range is to be tried on a large scale. The exhaustion of the carbonate ores at Broken Hill, which was expected a year ago, has been postponed by the discovery of some new ore bodies. The future of the great mine, however, may be said to depend largely on the sulphide ores, of which there is a large reserve. Should the new treatment prove successful, an increase in output, for several years at least, may be expected.

New Zealand.—This colony shows the effect of the new work started in the Hauraki and other districts in an increase of 32.5% in its gold output, and the present indications are that the gain will continue. It is a notable one, because very little of it is due to new discoveries; it has come mainly from the development of old mines and districts and from the adoption of improved processes for working ores formerly considered too refractory to pay. There are indications of a "boom" in New Zealand mines, but it is to be hoped that it will be a moderate one and will not approach the extent of that in West Australian mines, which is now beginning to collapse. This colony has a better climate than any of the other Australian States, and the conditions of mining in the supply of fuel and other necessaries are very favorable. Above all, it has an abundant supply of water, the lack of which is so serious a drawback in many parts of the Australian continent. Very little outside capital has been invested in New Zealand mines until recently, nor has it attracted much attention; yet the records show a total gold production up to the close of 1895 amounting to $249,512,000.

Queensland.—This colony showed last year a decrease of 8.3% in its gold production, which seems to have come from a reduction in a few of the principal mines and the absence of new discoveries. Some of the loss is to be attributed also to the financial depression prevailing, which has prevented the undertaking of new work, and to the extremely dry year from which the colony suffered.

South Australia.—Very little has been heard of South Australia recently, its reputation having been overshadowed by that of its western neighbor. Nevertheless the increase in 1895, while not so large in actual amount, was proportionally greater than that of any of the other colonies except New Zealand. The gain, as compared with 1894, was nearly one-third, and the colony has attained a very respectable rank as a gold producer.

Tasmania.—This colony in 1895 showed a decrease of 5% from 1894. This should not be taken as an indication that the gold mines of the island are becoming exhausted. The decrease was due in part to difficulties attending exploration and prospecting, in part probably to the diversion of labor to the copper and tin mines, in which work was conducted last year on a greater scale than ever before.

Victoria.—This colony, the earliest and greatest of the gold producers, continues to lead all the Australasian colonies, and in 1895 showed a moderate increase—9.9%—in its output. Considering the drought from which the colony suffered, like all its neighbors, this is a favorable result. The production is very nearly one-third of the total and more than twice that of any other colony except Queensland.

West Australia.—If we consider only the difficulties attending work in the gold fields of West Australia, which were last year increased by a season unusually dry even for that country, its increase of 11.8% in 1895 would be satisfactory. But if we take into account the excitement caused by its mines, the large number of men who have gone into them, and the enormous amount of capital which has been invested there, the result appears an extremely disappointing one. Almost as much has been said of West Australia as of the Transvaal, and a very great number of companies have been floated on the strength of its supposed riches; and yet the total production of the colony in 1895 was but little more than one month's output of the Witwatersrand. Some improvement is possible this year, since the railroad has reached Coolgardie, the chief mining center, and the introduction of machinery is thus made possible and supplies will be cheapened; but it is manifest that the country has been overrated from the first, and the prospect for shareholders in the very large majority of the companies is not encouraging.

OTHER COUNTRIES.

In our table this year we have made a separate line for the Indian Archipelago, which has an appreciable and growing production of gold. The precious metal is obtained in Borneo and Celebes by the natives, who use it in trade, and is supposed to come from alluvial deposits in the interior. In the Philippine Islands gold has for years been obtained in the same way, and two years ago quartz mining was begun by two English companies, which are now carrying on regular work. Gold is believed to exist also in the islands of New Caledonia and New Hebrides, but nothing about it is really known.

GOLD AND SILVER PRODUCTION FOR FOUR CENTURIES.

We reproduce the table (published in previous volumes of THE MINERAL INDUSTRY) giving approximately the production of gold and silver during the four centuries which have passed since the discovery of America, making some necessary corrections in the figures for 1894 and adding those for 1895. The figures for the years up to and including 1850 are those collected by Dr. Adolph Soetbeer; for the years subsequent to 1850 they have been completed from the reports of the United States Mint and other reliable sources. Those for the years 1892 to 1895 are based on the reports collected especially for THE MINERAL INDUSTRY.

The production and value of gold in 1895 is there shown to have been the largest ever recorded in a single year and very nearly double that of 10 years ago. The quantity of silver is also the greatest ever reported in one year, though its commercial value was less than for any of the four years 1890–94.

The relatively greater increase in gold production is shown by the fact that the weight ratio of silver to gold decreased from 23.3 in 1890 to 20.2 in 1894 and to 18.4 in 1895. The value ratio attained its maximum of 32.81 in 1894, and in 1895 there was a slight appreciation, the ratio falling to 31.65. That is, while it would have required on the average 32.81 ozs. silver to pay for 1 oz. gold in 1894, last year 31.65 ozs. silver would have been sufficient. That this slight appreciation is the beginning of a continuous upward movement is still uncertain.

THE DISPOSITION OF THE GOLD AND SILVER OUTPUT.

The effects and causes of the changes in the relative production and value ratios of the precious metals were discussed in Vol. III. of THE MINERAL INDUSTRY. The influence of the great additions made to the world's stock of gold has been apparent in many directions, but an extended discussion of this subject would hardly be possible within the limits of this paper.

In the article just referred to it was shown that only a small portion of the gold production is usually available as an addition to the world's stock of money. The demand for use in the arts, the quantities sent to and hoarded in India and other Eastern countries, the lesser amounts lost and destroyed in various ways absorb a large proportion of the output, so that only a part, variously estimated at from 25 to 30%, is added to the circulating medium. The quantity of gold used in the arts is increasing with the growth of wealth and luxury in our times, and last year was certainly above the average. The gold absorbed by the East during the year was, owing to the war between China and Japan and to the general course of the Indian exchanges, less than the usual amount. If we accept the highest estimate given above, 30%, we find that of the total gold product

WORLD'S PRODUCTION OF GOLD AND SILVER SINCE THE DISCOVERY OF AMERICA—1492.
(1 kilo gold = $664.60.)

Period.	Gold.				Silver.			Weight. Ratio of Silver to Gold.	Value Ratio Gold to Silver
	No. of Years	Production.			Production.		Total Commercial Value.		
		Annual.	Total.	Total Value.	Annual.	Total.			
		Kilos.	Kilos.		Kilos.	Kilos.			
1493–1520...	28	5,800	162,400	$107,836,848	47,000	1,316,000	$81,434,080	8.1	10.75
1521–1544...	24	7,160	170,400	114,102,912	90,200	2,164,000	138,015,440	12.6	11.25
1545–1560...	16	8,510	136,160	87,305,536	311,600	4,985,600	293,510,720	36.6	11.30
1561–1580...	20	6,840	136,800	90,835,080	299,500	5,990,000	346,428,040	43.8	11.50
1581–1600...	20	7,380	147,600	96,870,400	418,900	8,378,000	470,573,600	56.8	11.80
1601–1620...	20	8,520	170,400	113,149,960	422,900	8,458,000	459,963,960	49.6	12.25
1621–1640...	20	8,300	166,000	110,227,320	393,600	7,872,000	372,831,760	47.4	14.00
1641–1660...	20	8,770	175,400	116,467,680	366,300	7,326,000	344,770,800	41.8	14.50
1661–1680...	20	9,260	185,200	122,974,600	337,000	6,740,000	298,366,320	36.4	15.00
1681–1700...	20	10,765	215,300	142,961,844	341,900	6,838,000	302,702,680	31.8	14.97
1701–1720...	20	12,820	256,400	167,875,680	355,600	7,112,000	309,757,000	27.7	15.21
1721–1740...	20	19,080	381,600	253,389,080	431,200	8,624,000	380,666,720	22.6	15.08
1741–1760...	20	24,610	492,200	326,831,120	533,145	10,662,900	479,636,640	21.7	14.75
1761–1780...	20	20,705	414,100	275,970,920	652,740	13,054,800	590,339,960	31.5	14.73
1781–1800...	20	17,790	355,800	236,257,840	879,060	17,581,200	774,099,760	49.4	15.09
1801–1810...	10	17,778	177,780	118,048,000	894,150	8,941,500	380,926,140	50.3	15.61
1811–1820...	10	11,445	114,450	75,998,160	540,770	5,407,700	231,666,820	47.2	15.51
1821–1830...	10	14,216	142,160	94,397,940	460,560	4,605,600	194,015,220	32.4	15.80
1831–1840...	10	20,289	202,890	135,722,280	596,450	5,964,500	251,261,360	29.4	15.75
1841–1850...	10	54,759	547,590	363,609,260	780,415	7,804,150	326,900,140	14.3	15.83

Year.	Gold.		Silver.		Weight Ratio Silver to Gold.	Value Ratio Silver to Gold.
	Kilos.	Value.	Kilos.	Commercial Value.		
1851	107,153	$67,600,000	875,600	$37,651,000	8.1	15.46
1852	198,315	132,800,000	888,735	37,638,000	4.5	15.59
1853	233,975	155,500,000	888,735	38,509,000	3.9	15.33
1854	191,845	127,500,000	888,735	38,509,000	4.5	15.33
1855	203,280	135,100,000	888,735	38,393,000	4.4	15.38
1856	222,013	147,600,000	904,270	39,073,500	4.1	15.38
1857	200,572	133.300,000	904,270	39,355,000	4.5	15.27
1858	187,632	124,700,000	904,270	39,073,500	4.9	15.38
1859	187,933	124,900,000	906,490	40,722,400	4.9	15.19
1860	164,460	119,300,000	906,490	39,459,500	5.5	15.29
1861	171,215	113,800,000	1,013,617	43,474,200	6.0	15.50
1862	162,228	107,800,000	1,025,955	43,423,800	6.4	15.35
1863	160,999	107,000,000	1,105,659	47,864,500	6.9	15.37
1864	170.027	113,000,000	1,172,349	50,645,500	6.9	15.37
1865	180,860	120,200,000	1,189,152	51,182.100	6.6	15.44
1866	182,215	121,000,000	1,357,477	58,411,200	7.4	15.43
1867	156,485	104,000,000	1,448,332	61,843,800	9.3	15.57
1868	165,062	109,700,090	1,341,444	57,145,300	8.1	15.59
1869	159,795	106,200,000	1,269,295	54,071,700	8.0	15.60
1870	160,848	106,900,000	1,378,855	58,876,100	8.6	15.57
1871	160,999	107,000,000	1,903,998	81,300,700	11.8	15.57
1872	149,849	99,600,000	2,034,852	86,521,800	13.5	15.63
1873	144,487	96,200,000	1,967,683	82,120,000	13.6	15.92
1874	136,090	90,800,000	1,719,901	90,673,000	12.4	16.17
1875	146,704	97,500,000	1,939,539	77,578,000	13.2	16.59
1876	156,034	103,700,000	2,107,210	78,322,000	13.5	17.88
1877	171,532	114,000,000	2,174,619	75,240,000	12.7	17.22
1878	179,055	119,000,000	2,326,432	84,644,000	13.0	17.94
1879	164,008	109,000,000	2,174,531	83,383.000	12.6	18.40
1880	160,397	106,600,000	2,322,999	85,636,000	14.5	18.05
1881	154,980	103,000,000	2,453,581	89,777,000	16.0	18.16
1882	153,626	102,000,000	2,690,109	98,230,000	17.5	18.19
1883	143,575	95,400,000	2,774,227	98,986,000	19.2	18.64
1884	153,039	101,700,000	2,537,564	90,817,000	16.6	18.57
1885	163,105	108,400,000	2,841,572	97,564,000	17.4	19.41
1886	159,509	106.000,000	2,896,882	92,772,000	18.1	20.78
1887	159,156	105.775,000	2,992,451	94,031,000	19.0	21.13
1888	165,659	110,197,000	3,424,771	102,283,000	20.6	21.99
1889	185,809	123,489,000	3,901,809	112,399,700	20.9	22.10
1890	178,825	118,848,700	4,180,532	132,399.700	23.3	19.76
1891	196,586	130,650,000	4,267,380	135,524,800	21.6	20.92
1892	220,133	146,297,600	4,757,955	133,822,600	21.6	23.72
1893	256,236	158,437,551	5,339,746	134,241,121	20.9	26.43
1894	274,708	182,569,283	5,554.144	113,428,502	20.2	32.81
1895	306,133	203,443,772	5,651,962	118,748,536	18.4	31.65
Totals	12,757,776	$8,468,340,366	248,026,864	$10,393,632,819	19.5	16.13
At U. S. coining value	....	....	....	10,309,649,980	....	16.00

NOTE.—The figures from 1493-1850, both years inclusive, are Soetbeer's; those for 1811-51 are from the reports of the Director of the Mint; those for 1892-95 are from direct returns of United States refiners, made to the *Engineering and Mining Journal.*

about $61,000,000 were probably added to the world's stock of money, though this was in part tied up in war funds which are not available in business.

Now the tendency of the governments of Europe to accumulate gold has increased rather than diminished, and the stocks so held grew steadily in amount through all of 1895. The following table shows the amount of gold reported by the leading State banks at the opening of the years 1895 and 1896 respectively, reduced to American currency:

GOLD RESERVES OF EUROPEAN BANKS.

Banks.	1895.	1896.	Changes.
Bank of England	$166,811,945	$222,882,625	Inc. $56,070,680
Bank of France	413,918,911	392,598,700	Dec. 21,315,211
Imperial Bank of Germany	267,340,000	220,440,000	Dec. 46,900,000
Austro-Hungarian Bank	75,525,000	143,032,900	Inc. 67,507,900
Bank of Russia, bank reserve	294,139,200	358,368,000	Inc. 64,228,800
Bank of Russia, government deposit	150,278,000	112,992,000	Dec. 37,286,000
Totals	$1,368,008,056	$1,450,314,225	Inc. $82,306,169

The total increase here shown absorbed considerably more than the allowance above made for coinage. If to the bank reserves were added the additions made to the treasury holdings of the various governments, the amount of which cannot be ascertained, the quantity of gold absorbed would be very largely increased. It must be remembered that, with the exception of the Bank of England, these State banks are under government control, and their gold reserves are at the disposal of the respective governments in case of war or other emergencies.

In a word, the enormous gold output of 1895 added nothing to the stock of circulating money; it was completely absorbed in the arts or hoarded.

The Commercial Movement of Gold and Silver.—Of interest in this relation are the statistics of the leading commercial countries with relation to the movement of gold and silver. Unfortunately only a few countries furnish complete or intelligible returns of this kind. The imports and exports of the United States for the five years ending with 1895 are given in the following table:

UNITED STATES IMPORTS AND EXPORTS OF GOLD AND SILVER.

Year.	Gold in Ores.		Silver in Ores.		Gold Coin and Bullion.		Silver Coin and Bullion.	
	Imports.	Exports.	Imports.	Exports.	Exports.	Imports.	Exports.	Imports.
1891	$323,269	$100,918	$9,717,443	$1,090,514	$79,086,581	$44,970,110	$27,692,879	$18,192,750
1892	714,110	9,262	9,726,704	1,592,931	76,532,056	17,450,946	35,975,834	21,726,252
1893	518,186	276,933	9,490,892	....	79,775,820	72,762,389	46,288,721	18,274,804
1894	743,046	149,501	7,809,186	....	101,819,924	20,607,561	47,044,205	9,824,408
1895	1,857,656	*a*740,312	12,087,340	62,584	104,605,023	32,538,736	53,833,153	11,286,007

(*a*) Gold and silver reported together.

The net excess of exports of silver in 1895 was $30,522,390; of gold, $72,748,-943, or some $26,000,000 in excess of our production.

The movement of gold and silver in Great Britain for the years 1894 and 1895 was as follows, specie and bullion alone being included; the amounts are reduced to dollars at the rate of $5 to £1:

GOLD AND SILVER MOVEMENT IN GREAT BRITAIN.

Year.	Gold.			Silver.		
	Imports.	Exports.	Excess.	Imports.	Exports.	Excess.
1894	$137,861,735	$78,237,755	*a*$59,623,980	$55,027,085	$60,825,245	*b*$5,798,160
1895	180,030,190	106,346,615	*a*73,683,575	53,348,410	51,837,180	*a*1,511,230

(*a*) Imports. (*b*) Exports.

The imports and exports of gold in France for the two years 1894 and 1895 are given below:

GOLD MOVEMENT IN FRANCE.

Year.	Imports.	Exports.	Excess.
1894	$90,308,712	$43,374,614	Imp. $46,934,098
1895	50,602,695	65,061,424	Exp. 14,458,729

The silver imports in 1895 were $28,183,468 and the exports $16,185,287, showing a balance of $11,998,181 imported.

One of the most important elements in the silver market is found in the exports of silver to the East. The exports from London for the five years ending with 1895 are reported by Messrs. Pixley & Abell as follows:

EXPORTS OF SILVER FROM LONDON TO THE EAST.

	1891.	1892.	1893.	1894.	1895.
India	£4,462,754	£7,229,199	£7,052,271	£5,012,093	£3,535,596
China	241,985	147,882	2,390,969	2,728,771	1,630,023
The Straits	2,209,966	3,826,739	1,612,513	1,233,446	753,883
Totals	£6,914,705	£11,203,820	£11,055,753	£8,974,310	£5,919,502

The exports to Japan were £175,000 in 1895 and £955,800 in 1894. The decrease in these silver shipments from London was partly made up by an increase in the exports from San Francisco to China and Japan, which were $12,824,907 in 1894 and increased to $18,032,830 in 1895; but there was still a decrease of nearly $10,000,000 in the amount taken by the far East in 1895 as compared with 1894.

Notwithstanding the smaller Eastern demand, there was a generally stronger market and a slightly higher price for silver, as shown by the following table, which is based on the record of the daily prices of silver published by the *Egineering and Mining Journal:*

RANGE OF PRICES OF SILVER PER OUNCE.

		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1894	London, pence	30.31	29.18	27.28	28.95	28.69	28.68	29.82	28.29	30.88	28.69	31.41	27.78	29.13
	New York, cents	66.63	63.43	59.49	62.92	62.96	62.59	62.45	61.83	64.14	63.06	65.13	60.43	63.00
1895	London, pence	27.36	27.47	28.33	30.39	30.61	30.47	30.48	30.40	30.54	30.89	30.79	30.40	29.53
	New York, cents	59.69	59.90	61.98	66.61	66.75	66.64	66.75	66.61	66.90	67.64	67.40	66.47	65.28

The quotations in the New York market are always per fine ounce—that is, for pure metal; the London quotation is per standard ounce, 925 fine.

The total gold and silver coinage of the mints of the United States for the six years ending with 1895 is shown by the following table:

COINAGE OF THE MINTS OF THE UNITED STATES.

Year.	Gold.	Silver.	Year.	Gold.	Silver.	Year.	Gold.	Silver.
1890	$20,467,183	$39,202,908	1892	$34,787 223	$12,641,078	1894	$99,474,913	$6,024,898
1891	29,222,005	27,518,857	1893	30,038,140	12,560,935	1895	59,596,357	5,698,010

The amount of gold coined in 1895 was the largest ever reported with the exception of 1894.

PROGRESS IN GOLD AND SILVER MINING.

While the year 1895 was marked by no great changes in mining or milling the ores of the precious metals, it has showed progress in the direction of closer working, careful watching and regulation of costs, and intelligent application of processes to the ores. Much good work has been done in this country and much also in South Africa; some of the best results reported in that country have been obtained under the management of American mining engineers.

There is a tendency at present in favor of the adoption of the wet or lixiviation processes for treating gold ores, either as a substitute for amalgamation where the ores are not entirely free milling or for the supplementary treatment of tailings or concentrates saved. Chlorination and cyaniding have been the more prominent of these processes, the former being best adapted to rich ores and making a much closer extraction, and the latter to low-grade ores and ores containing both silver and gold.

For the purposes of comparison, so far as it is possible to compare results at two different mines, we give below the costs reported for 1895 by two great gold mines. The Alaska-Treadwell is the largest in existence if we take into account the size of its mill and the quantity of ore crushed, but the Robinson, in the Transvaal, holds the first rank as a gold producer. The main difference is that at the Robinson about two-thirds of the tailings from the mill are treated by the cyanide process, while nothing of that kind is done at the Alaska-Treadwell; both mills save some pyritic concentrates which are treated by chlorination:

	Alaska-Treadwell.	Robinson.
Tons ore crushed	241,278	140,655
Tons concentrates treated	4,261	3,695
Tons tailings by cyanide	....	75,825
Mill returns, per ton	$1.75	$14.73
In concentrates, per ton ore	.90	2.11
In tailings	....	2.47
Total per ton ore	$2.65	$19.31
Cost, mining	.55	3.04
Cost, milling	.52	.92
Cost, general	.30	.62
Total cost per ton	$1.37	$4.58
Profit per ton	1.28	14.73

The grade of the Robinson ore is somewhat higher than the average for the Witwatersrand mines, and the proportion of gold obtained by treating the tailings is lower. In most of the mines not far from 30% of the total yield is obtained by cyanide. Taking the figures given above, we find that an ounce of gold in the Alaska-Treadwell cost approximately $10.69 and in the Robinson $5.90.

It would be unsafe to accept these two examples of economical working as any approach to the average cost of producing gold. Very few mines are able to put their ore in the mill as cheaply as the Alaska-Treadwell or to work it on so large a scale. At the great Mount Morgan Mine, in Queensland, for instance, with ore averaging about $21 per ton, the cost of working last year was close upon $12 per ton. The Mysore Company in India, treating in 1895 60,654 tons of ore and obtaining about $21 per ton, reported costs amounting to about $9.50 per ton, including the cyaniding about one-half the tailings.

Instances might be multiplied from all parts of the world to show the utter uselessness of attempting to fix any average cost of production. The two given in the table represent about the lowest point attainable. The costs of mining and treatment will vary considerably from time to time in the same mine even, and it has been found impossible to make any fair average of the mines in a single district, working under similar conditions as to cost of fuel, supplies, and labor. Any so-called average based on a number of mines can only prove deceptive.

As has been heretofore shown, it is very probable that the cost of producing gold, taking the entire output over a series of years, is fully equal to its value, if not actually in excess of it.

CONCLUSION.

For reasons easily understood the production of the precious metals attracts an attention out of proportion to its real importance. To most minds gold and silver represent the chief item in the production of this country, yet the total value of both metals produced in the United States in 1895 was only 11.4% of the total mineral production. It was only about three-quarters that of the pig iron and one-third as great as that of the coal mined. Not far from the same ratios would be maintained if we could sum up the entire mineral output of the world.

As to future production, we may fairly expect to see for several years to come a large increase in the production of gold and the maintenance of the silver output at nearly its present rate; a continued interest and investment of capital in gold mining which will not be discouraged by the collapse of some local booms; a continued advance toward the placing of gold and silver mining upon a business basis—though until human society is completely reorganized we can never hope to see the speculative element altogether eliminated from the pursuit of the precious metals.

ARIZONA.

BY JOHN F. BLANDY.

IN making a review of Arizona mining for 1895 it is necessary to report a falling off in the production over the previous year. This is not only a surprise, but a disappointment. It is easy to explain it, but it is nevertheless not a pleasant fact. Of course this was to be expected in the silver returns. Yavapai County shows a large increase—nearly 35%—in gold production, but has hardly been able to make up the falling off in the other counties. The decrease in the yield of the Harqua Hala, where mining work has practically ceased, the suspension of work for about all the year at the Mammoth, in Pinal County, and also the bad showing of the Goldfield district, in the same county, from which such good results had been given in the two previous years, account for most of the deficiency for the Territory. The almost total suspension of work in the Tombstone district also caused a falling off from the previous year. The low price of silver caused considerable diminution of work at the White Hills, in Mohave County, and as this ore carried a marked amount of gold there was a deficiency in that county also in the total production as compared with that of the previous year.

This decrease in production is, however, not to be interpreted as a decay in any respect of mining in the Territory, for in fact the business has never been more active or had brighter prospects than now. Several companies started late in the year and did not reach the shipping point, and still others only began to get under way. In Mohave County the Gold Basin group has lately gone into the hands of a strong company which will make extensive improvements, and in Cedar Valley the old Arnold Mine is being reopened on a large scale. In Yuma County, 20 miles from Yuma, a 20-stamp mill was nearly ready to start at the close of the year. The ore is claimed to be rich and the vein large. A shipment of 8 tons of assorted ore gave a net return of $1100. A 5-stamp mill was lately started near Tyson's Well. Many small veins of great richness have been known and worked by arrastra in that neighborhood for several years. With a judicious application of capital much is expected from this district in the future.

In Yavapai County, as stated above, the production in 1895 was about 35% above the previous year, and the probabilities from present appearances are that 1896 will show a like increase. The 20-stamp mill on the Santa Maria, which ran part of the year, is to be increased to 60 stamps. Several strong veins are known in that district which are only awaiting equipments of mills. In Fool's Gulch, 3 miles east of Congress, a large discovery was made and very active work has been going on there ever since. The operators have reached a depth of 175 ft. and report themselves highly pleased with the mine. The Crown King, Little Jessie, and McCabe mines will no doubt do as well, if not better, this year than last; there is every indication that they are really improving as work progresses.

A 10-stamp mill was being erected on Groom Creek, 7 miles from Prescott, on the Silver Flake—a gold mine. They have a strong vein and some tons of assorted ore have been sold from there by the prospectors which went $120 to the ton. There are several mines which are being well opened; some under bond and some have just been sold.

It is to be noted that all the large producers and profitable mines in Yavapai County have been developed without the help of outside capital. Several groups of claims have changed hands during the last few months of the year, and we consequently look for a very active year in 1896. The use of capital here also is expected to produce a great improvement.

In Pinal County the Mammoth Mine has unfortunately been closed for nearly the whole year awaiting the decision of the company as to the erection of a new mill at the mine. Its neighbor, the Mohawk, has erected a 20-stamp mill at the mine and will soon be ready to start. In Cochise County there was much excitement the closing months of the year over discoveries of gold in South Pass, 15 miles from Tombstone; also at Pierce, in the Sulphur Spring Valley. Both these discoveries are to be thoroughly tested.

For several years much has been said of the gold veins of Tonto Basin, Gila County, but the past year is the first one in which any regular work of milling has been done. A 5-stamp mill at Payson has shipped $13,500 in bullion. Many veins are known there and very excellent ore is found, but the difficulty of long transportation has been the great drawback. They are about equidistant from Flagstaff, Globe, and Prescott—that is, about 100 miles from each. At present their outlet is Flagstaff, but when the railroad is finished to Globe that will be the better route. They are not troubled by a scarcity of water or timber. The mill has been run mostly on custom ore, and a second mill was begun to meet the demand for more facilities.

The use of the cyanide process has been established at 6 different points in the Territory, namely, at Harqua Hala and Congress mines for handling the tailings, also at the old tailing piles of the Vulture Mine at Wickenburg and Smith Mills on the Hassayampa, at Tombstone, and at Oro Blanco. All have been worked successfully.

The usual number of placer washers have been at work at many points in the Territory, but at no point has any work in that line been done by companies. The dry-washing machine is a good deal in use, it being easily packed from place to place. Some of the workers have told me that they prefer it to sluices or rockers. Still, the total amount of gold obtained in that way in the Territory is not very great. The richest diggings are at Greaterville, in Pima County.

The copper mines of the Territory are treated on another page in the article on that subject.

It is evident that the future of the Arizona gold mines depends principally upon the amount of capital which can be secured for their exploitation. For years they have been left largely to themselves, and the progress which has been made has been almost entirely through individual effort. Under these conditions progress has been slow, and it will remain so as long as they last. What has been actually accomplished goes far toward proving the real value of the country.

My estimate for the production for the year 1895 is: Gold, $1,871,618; silver, 1,170,193 ozs. The lead output reported is 1,790,149 lbs.

COLORADO.

BY T. A. RICKARD.

THE second volume of THE MINERAL INDUSTRY contained a description* of the gold resources of Colorado, in the course of which the writer emphasized the impossibility of setting defined limits to the productive areas. The two years which have elapsed since then have told a story amply confirmatory of that statement. Colorado yielded gold valued at $7,487,071 in 1893, $10,616,463 in 1894, and approximately $15,250,000 in 1895.

The granitoid rocks of the Front range are the source of most of this product. Out of them has been built the backbone of the Rocky Mountains, and upon their massive foundations have been laid the superstructure of long succeeding geological formations. In fact, the early Archæan crystallines, with their associated later eruptives, are as characteristically the geological habitat of our gold veins as the carboniferous limestones are the home of our richest silver depositories.

The history of the mining development of the past year centers around Cripple Creek, whose yield sprang from $2,100,000 in 1893 to approximately $8,000,000 in 1895. This increase continues. It comes from a gold-bearing area whose boundaries are continually undergoing a shifting which answers to the active explorations carried on with the utmost of energy and enthusiasm. The region consists of a complex of volcanic rocks penetrating and overlying the granite of Pike's Peak, whose snowy crest has at length seen the birth of a mining camp worthy of the traditions of the pioneers of 1858.

The high tenor of the ores produced in the Cripple Creek area is a remarkable feature of its production. The output of 1895 came from ores averaging over 2½ ozs. per ton. Instead of the slow development from the embryo of a prospect hole to the full-grown organism of a well-opened mine, the discoveries of this district spring into immediate productiveness as a consequence of the richness of the ore, the facilities for transportation, and the near neighborhood of large reduction establishments. On the other hand, these very conditions are inimical to the creation of large ore reserves and give the industry a sporadic character which lends itself very readily to the vagaries of a speculative epidemic. These features are, to a varying extent, common to all new, growing gold districts, and become balanced by the systematic and intelligent development characterizing sound enterprises of much moment.

The lesser discoveries made in Park County during 1893 have not fulfilled their promise, and they have been replaced in the public mind by certain finds of alleged importance made in the neighboring county of Douglas upon the highlands whose drainage feeds the South Platte. It is to be expected that some of the new camps which spring into existence at a time when renewed vigor has been given to both exploration and speculation will prove disappointing; nevertheless the checkered career of Cripple Creek is a strong reminder of the fact that the gathering of men in times of excitement toward discoveries which eventually are found to have been exaggerated may yet prove not altogether

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* "The Gold Resources of Colorado," Vol. II., pp. 325–329.

harmful, since it leads to their dispersion over the adjoining territory and to the prospecting of regions which would otherwise remain unexplored.

Of the new discoveries of 1895, the most promising are the gold fields near the head waters of the southern tributaries of the Gunnison, a district embracing a cluster of camps of which Spencer, Dubois, and Camp Creek are the most flourishing. The La Plata Mountains, in the county of that name, have begun to justify their oft-repeated promise. In the region around Silverton there are at least two localities which give assurance of important development. In the northern area Pine Creek, Hahn's Peak, and the placers of Routt County make claim to consideration. The general revival of the eager search after gold which marks the recovery from the silver collapse of 1893 is destined, ere the wave of its enthusiasm shall sweep past, to leave the State dotted with a number of new centers of production such as will make the closing years of the century memorable in Colorado history.

Already the curving contours which mark on the map the granite core of the Front range are fast becoming a linked line of gold camps extending through the counties of Boulder, Gilpin, Clear Creek, Douglas, El Paso, Fremont, Saguache, Custer, and Costilla. It is impossible to postulate where within this region gold may not be found, while experience teaches that its occurrence is particularly associated with dikes and larger intrusive masses of later volcanic rocks, many of which have been determined as andesites of early Tertiary age. Such are the dikes accompanying the familiar vein phenomena of Gilpin and Boulder counties. Of such are the masses of tuff and breccia characterizing Cripple Creek and forming the rugged crests of the mountains of the San Juan.

Of Colorado's gold yield for 1895 about one-half came from El Paso County, and the only other districts producing more than $1,000,000 were Gilpin, Lake, and San Miguel counties. These four are responsible for about four-fifths of the total. Of El Paso we have spoken, for the county owes it all to Cripple Creek. Gilpin has always been a steady producer. In the spring of 1859 it was the scene of the discovery which marked the birth of the mining activity of the State, and in spite of the ordinary vicissitudes of a mining camp, it has added every year an annual tribute averaging over $2,000,000. In 1894 the yield was $2,122,838, but that of 1895 was less, owing to unusually heavy summer rains which flooded many mines; to this, as an obstacle to production, must be added an accident which drowned out an important series of mines at the lower end of the county. The outlook for 1896 is excellent in every way.

Lake County means Leadville, the silver camp perched two miles above sea level. At the close of 1893 much was anticipated as the result of certain unexpected developments in the eastern part of the district which indicated the occurrence of gold deposits amid the pyritiferous porphyry of Breece Hill. The gold production sprang from $262,629 in 1892 to $1,657,002 in 1894. This sudden and important contribution of gold from a famous silver district attracted the attention of the press, and prompted all sorts of wild statements as to the occurrence of a gold-bearing horizon underneath the silver zone. As a matter of fact, the gold comes from a continuation of the old ore measures into an outlying portion of the district where the geological environment is somewhat modified, and the silver values become relatively less important than the gold.

The past year has seen a great deal of money sunk in expensive shafts without any notable addition to the list of producers, and it is a fact that of the total yield of $1,327,500 there is only a small portion which is not traceable to the ore bins of the Little Johnny Mine, within whose extensive territory is included most of the ground so far proven to be of value upon the Leadville gold belt. There is reason to expect that the explorations carried out during the past year on Breece Hill, South Evans Gulch, and Iowa and Empire gulches will shortly lead to several additions to the small number of gold producers. In the mean time the developments within the old silver area, particularly on Fryer Hill and in the deep-level shafts under the town itself, have been a very encouraging feature of the operations carried out during 1895, and exhibit a marvelous re-adjustment of the silver industry to unfavorable conditions.

San Miguel County is a part of the San Juan region. The upper country drained by the San Miguel River includes a group of mountain amphitheaters, immediately above the town of Telluride, traversed by a series of gold-bearing veins of remarkable continuity. The increased yield of one or two older mines and the organization of several new enterprises have been supplemented by a general scattering of activity over the Ophir and Mount Sneffles ranges.

It is a geological parallel worthy of mention that the bulk of the gold of the San Juan region comes from veins whose incasing rock is very similar to that of Cripple Creek. The occurrence of the valuable ore deposits of the latter within masses of andesite breccia and tuff is now known even to the untechnical, but it is a fact less generally appreciated that a similar formation, of the same (Eocene) geological age, occurs in enormous thickness capping the crests of the mountain land of the Southwest and inclosing lodes of a richness which even the new camp will hardly eclipse. To this may be added the observation that the veins of the Hauraki gold field, in the north island of New Zealand, are also found in an andesite breccia of Tertiary age.

Of the other gold-producing sections of the State, Clear Creek and Boulder counties are the most important. In both districts the decline in silver did for a time seriously affect the production of the yellow metal, because the two occurred in close association. Of late there has been a strong recovery accompanied by the organization of several well-planned enterprises.

For the first time in a quarter of a century the annual gold yield of Colorado has exceeded in value that of its silver product. The gold yield of 1895 is estimated at about $15,250,000, the silver at $12,500,000, or 20,000,000 ozs. The maximum silver production was reached in 1892, when it was 26,350,000 ozs. The decline in the discredited metal will continue because exploratory work in the old mines is diminishing, while prospecting for new deposits has practically ceased. Since, with the exception of Aspen and Creede, there is a notable amount of gold produced in the operation of so-called silver mines, it becomes evident that the increased gold production is even greater than first appears, because compensation has been made for the decline of gold from the source just indicated. The mines of Rico, for example, yield a product one-quarter of whose value is in gold, and they are now crippled on account of inadequate development due to the discouragement of a low silver market. Hence the gold production of Dolores County suffers. Other instances might be quoted. The diminution in silver might go on indefinitely were it not for the fact that it is largely a by-product to gold mining; indeed, gold, silver, lead, and copper have been so associated by nature that it is often difficult to say which one is the by-product to the other.

There is an idea prevalent that certain silver mines have been turned into gold producers. It is indeed a fact that in rare instances, such as the Amethyst Mine at Creede and the Guston on Red Mountain, the lower workings of silver mines have encountered ore carrying a proportion of gold larger than that characterizing the yield of upper levels. This, however, is only a part of those changes in the composition of the ores of large mines which are as frequently observed in a lateral as in a vertical direction, along the strike quite as much as along the dip of the vein. The reverse, the diminution of gold values, also occurs, but for obvious reasons receives less frequent mention.

Omitting this factor, there is the more common one of an increase in the gold value not absolutely, but only relatively, on account of a fall in the market value of the associated silver. When the white metal was in fashion, certain properties which yielded both the precious metals were spoken of as silver mines, although their ore might carry one-third of its value in gold. When the price of silver dropped 24%* the relative importance of the two metals in such an ore became reversed; it now carried more gold value than silver, and the mine owner hastened to remove the stigma clinging to a silver property by labeling it a gold producer. No mysterious transmutation had taken place, no geological *bouleversement*—only a sudden disturbance in the commercial relation between the two metals.

In certain sections of the State where gold occurs liberally associated with silver the depreciation of the one metal and the consequent appreciation of the other, the discouragement given to the mining of the former and the enthusiasm evoked in the search for the latter, have resulted in a dwindling of the number of active silver mines and an expansion of the operations of those producing gold sufficient in some cases to transfer the balance from one side to the other and cause a silver-mining district to assert itself as a gold region. Thus San Juan County yielded in 1892 gold worth $155,624 and silver $354,125; but in 1894 the gold increased to $360,320, while the silver diminished to $235,000. This is an example which typifies the present status of mining in the State, illustrating the fact that Colorado has accepted the bitter logic of recent events and turned her concentrated energies to the industry of her earliest youth.

* At the beginning of 1893 silver was quoted at 82½c. per oz. On June 29, 1893, it had fallen to 62c.

Stamp Milling.

By T. A. Rickard.

In the accompanying tabulated statement an endeavor has been made to exhibit the distinctive features of the milling practice of representative districts in several countries. It is very difficult to arrive at "average" figures, and it is not always easy to determine which mills are typical and which are abnormal in their methods. Nevertheless, it is hoped that the data given, which are founded on a personal knowledge of each locality, will serve as a trustworthy basis of comparison.

Even the well informed will be surprised at the costs of treatment given in the second column of the table. That the large establishments of the Homestake Company (in South Dakota) should not be able to work with any considerable diminution of the expense incurred by the smaller and much less completely equipped plants of Blackhawk (in Colorado), in spite of a rapidity of crushing four times as great, is a fact demanding an explanation. That the mills of Grass Valley (in California), which are the model plants of this country, should treat their ores at a cost greater than either of the above-quoted regions seems also odd.

An analysis of the costs of milling in the four representative American districts will indicate the causes underlying these anomalous results. These figures are per ton of ore and are given in cents.

District.	Labor.	Shoes and Dies.	Water.	Fuel.	Supplies, etc.	Total.
Black Hills......	15	2	20	19	14	70
Gilpin............	42	5½	....	10	17½	75
Grass Valley.....	32	9	31	....	8	80
Amador..........	20	4½	17	....	4½	46

The item of labor is dependent upon the rate of crushing and the automatism of the mill. In the latter regard the Gilpin County district is the only one exhibiting defects, for the mills of the other three are uniformly provided with rock breakers, self-feeders, and other appliances inseparable from an economic handling of the ore. And although an inadequate equipment of labor-saving machinery still remains a characteristic of the old plants at Blackhawk (in Gilpin), it is well to add that the new mills erected in other parts of Colorado during recent years have been quite up to date in this respect. This is not true of the Australian colonies, however, for there even new mills have been designed on obsolete lines, and a plant recently built at Bendigo perpetuates the ancient barbarism of breaking and feeding the ore with hammer and shovel.

The labor cost in the Black Hills is less than it is in California, notwithstanding a higher rate of wages,* because the crushing capacity of the batteries is nearly double. This is largely due to the employment of a mortar of a most excellent design, promoting amalgamation while hastening pulverization. The labor cost at Grass Valley is higher than that of its neighbor, Amador, because the crush-

* Ordinary laborers get $3 per shift. In Colorado and California the rate is $2.50. The skilled workmen are paid proportionately.

ing rate is in the proportion of 2 to 3, itself a consequence of a decidedly harder ore. The maximum cost which distinguishes Gilpin is traceable to a low rate of crushing accompanying the absence of labor-saving devices.

The cost in shoes and dies exhibits a very striking variation because the price of the iron or steel used is dependent upon purely local conditions, such as the distance from the foundry. The wear, as measured in ounces of metal consumed per ton of ore crushed, is as follows: Black Hills, 13; Gilpin, 14½; Grass Valley, 16; Amador, 15. The Homestake Company makes its own dies and buys the shoes in large lots, hence the cost is relatively small. The Grass Valley

VARIATIONS IN STAMP MILLS FOR THE TREATMENT OF GOLD ORES.

Name of District.	Yield of Ore. Dwts.	Cost of Milling Cents	Stamps in Mill.	Weight of Stamps. Lbs	Drops per Minute.	Height of Drop. In.	Depth of Discharge. In.	Crushing Capacity. Tons.	Description of Screen in Use.
UNITED STATES:	(a)	(b)			(c)		(d)	(e)	(f)
The Black Hills, S. D.	4½	70	160	850	85	9½	10	4.0	No. 8 (35 mesh) diagonal slot Russia iron.
Gilpin County, Colo.	6–8	75	75	550	30	17	14	1.0	No. 1½ (50 mesh) burr slot planished iron.
Grass Valley, Cal.	5–7	81	40	850	85	7	4	1.6	No. 0 (40 mesh) perforated tin plate.
Amador County, Cal.	3½–5	45	40	750	95	6½	7	2.4	No. 7 (30 mesh) angle slot Russia iron.
AUSTRALIA:									
Bendigo, Victoria	9–9½	58	40	900	72	9	3½	2.3	Round punched Russia iron, 148 holes per sq. in. (30 mesh).
Ballarat, Victoria	8½–9	56	60	1000	73	8¼	2	2.4	Round punched Russia iron, 120 to 200 holes per sq. in. (20 to 40 mesh).
Clunes, Victoria	7–9	59	60	890	80	8	4½	2.8	Perforated copper plate, 81 to 100 holes per sq. in. (30 mesh).
Charters Towers, Queensland	25	300	30	950	74	8	2	2.6	Perforated charcoal iron, 225 holes per sq. in. (50 mesh).
NEW ZEALAND:									
Otago, South Island	10–12	70	20	800	77	7½	3½	1.5	Round punched Russia iron, 148 holes per sq. in. (30 mesh).
The Thames, North Island	7–9½	95	30	675	68	8	2	1.6	Round punched Russia iron, 160 to 180 holes per sq. in. (35 mesh).

(a) The figures in this column indicate the yield per ton of the ore treated. A pennyweight is approximately equal to one dollar or four shillings. The figures are those of representative mining companies, and do not apply to either unusual bonanzas or unprofitable mines.
(b) These costs are obtained from representative establishments and for periods of one year or more.
(c) The slowest drop is 26 per minute and the quickest 110.
(d) This gives the average issue between the time of placing new dies and the time when they become worn down so as to require replacement by a fresh set.
(e) Short tons of 2000 lbs.
(f) Different mills at different times use a great variety of screens. The prevalent type is given in this column. The mesh, in brackets, gives a basis for an approximate comparison of the relative fineness.

mills use steel for their shoes and local castings for their dies. The price of the former is high, since they come across the continent—from Brooklyn. Furthermore, the ore crushed in this district is very hard. The Amador mills use shoes and dies made at Sutter Creek, in the same county, and sell back the remnants. The Gilpin County plants are provided with local castings and also resell the scrap. The greater softness of the ore of this region is offset by the high drop which is conducive to excessive wear.

The cost of water falls heavily upon the establishments in the Black Hills, because they pay a subsidiary company for that which they use in the batteries, and the item of fuel is likewise a serious one, because their motive power comes from steam obtained from the burning of wood, also provided by a subsidiary company. The fuel and water cost amounts to 39c., or more than half the entire milling cost. The Californian mills pay for their water at rates varying from 18 to 20c. per miner's inch (of 1.574 cu. ft.). The Blackhawk mills get their water free from a dirty creek laden with partially oxidized pyrites whose acid corrodes the screens. In winter a diminished water power is supplemented by steam.

VARIATIONS IN STAMP MILLS FOR THE TREATMENT OF GOLD ORES.

Name of District.	Life of Screen.	Service of Screen.	Percentage of Concentrates.	Contents of Concentrates.	Retort Percentage.	Fineness of Bullion.	Loss of Mercury.	Consumption of Water.	Description of the Ore Treated.
	Days.	Tons.		Ounces.		Per 1000	Dwts.	Gallons	
UNITED STATES:	(*g*)		(*h*)	(*k*)			(*l*)		
The Black Hills, S. D.	7	140	Variable		36	815	5	3–3¼	Enormous bodies of gold-bearing schist.
Gilpin County, Colo.	60	300	12–15	1–1½	40	780	3½–8	1½–2	Veins rich in pyrites in granitoid gneiss.
Grass Valley, Cal.	18	145	2¼–3	3–5	40	845	9–14	3½–4	Quartz in veins in hard diorite.
Amador County, Cal.	32	380	1–1½	3–4½	45	830	2½–5	3–3½	Lodes of simple quartz in slate.
AUSTRALIA:									
Bendigo, Victoria	11	130	1–2	1½–2½	50	955	7–9	6½–7½	Clean quartz within beds of slate and sandstone.
Ballarat, Victoria	12	140	1–3½	1½–3½	48	970	3–5	5–7	Strong veins penetrating slate and sandstone.
Clunes, Victoria	25	350	1–3	3–4	38	975	½	8–10	Very simple quartz in veins in slate and sandstone.
Charters Towers, Queensl'nd	5	65	5–25	2–12	35	800	Very variable		Sulphide ores in veins in syenite.
NEW ZEALAND:									
Otago, South Island	9	70	Not saved		40	930	5–8	3½–5	Irregular lodes in quartzose schist.
The Thames, North Island	5½	44	Not saved		42	640	12–15	4½–6	Veins of complex ores in andesite breccia.

(*g*) The acidity of the water and the retention in service of screens that are worn out increase the differences in the life of screens.
(*h*) That is, percentage of concentrates actually saved.
(*k*) These are the contents in ounces of gold per ton. The silver contents are generally negligible.
(*l*) Pennyweights Troy. Mercury is sold by avoirdupois.

The cost of supplies, mercury, chemicals, lubricants, etc., depends largely upon the distance from a large manufacturing town. It is heaviest in the Black Hills and least in Colorado.

These explanations will now have rendered intelligible the resulting totals, which prove that the mills of Amador do much the cheapest work, and in this respect they are typical of Californian practice, in Calaveras, Tuolumne, Mariposa, Plumas, and other representative districts, more so than Grass Valley, whose millstuff has a quite exceptional hardness. Widening our survey to foreign lands, we note that the three chief gold-mining centers of Victoria exhibit closely approximating averages, while Charters Towers has a high cost because its ores are not amenable to simple treatment, but require an expensive supplement of pans and settlers. The New Zealand districts are similarly related, Otago's ores being simple and docile and those of the Thames complex and refractory. Thus because of complete equipment and cheap motive power the mills of California still retain their pride of place as affording the least expensive method of reduction yet devised by man for the obtaining of gold from its ores.

The number of stamps in a mill is ordinarily, but not always, dependent upon the output of the mine behind it. Where the plant is erected upon a flat mill site, 80 stamps, divided into two rows, back to back, makes a very convenient and economical arrangement. Where a graded mill site, upon a hill slope, is chosen, 40 to 60 stamps is a good number. Up to this size there is no proportionate increase in labor costs, but a further enlargement requires a notable augmentation of the force employed. To avoid losses by fire or flood it is, moreover, advisable not to have too many stamps under one roof.

The weight of stamps varies from 500 lbs. to twice as much. Only prospecting plants are now provided with stamps of less than 500 lbs., although some old mills are still at work with stamps of 400 to 450 lbs. The light weights in use in the old-fashioned Colorado mill are rendered as effective as the heavier type because of their long drop. The most desirable weight for given ores is dependent, much more than is usually supposed, upon the attainment of conditions favorable to amalgamation. Thus the light stamp (of Gilpin) is the consequence of the long drop, and the long drop is necessary in order to obtain the interval required to permit of the action of gravity in causing the minute particles of gold to separate from the pyrites and settle upon the amalgamated plates placed within the mortar. Where the gold particles readily detach themselves from the quartz or other incasing mineral it is not necessary to emphasize this feature, and heavy quick-dropping stamps are desirable because their greater crushing capacity diminishes the cost per ton.

On the other hand, while the added weight gives greater crushing force to the stamp a practicable limit is soon reached, because the pulverization becomes too rapid for the amalgamation, the ore being reduced so fast that there is not sufficient opportunity given for the gold to be arrested by the mercury on the plates. Steam stamps have for this reason proved unsuitable for gold milling, as was proved by the experiments made by the Homestake Company, described by the writer in the *Engineering and Mining Journal* of September 14, 1895 (p. 250). The Alaska-Treadwell Company, among others, carried out a series of experiments and found that a weight of over 1000 lbs. made the mill a rapid pulverizer but a poor amalgamator.

The heaviest stamps are usually given to mills designed with iron frames. And, in parentheses, it may be asked why iron frames are not in more general use. At Bendigo and Ballarat such batteries have been pounding away for 30 years past and are yet working sweetly. The supposed weakening of the iron because of the excessive vibration is a bugbear feared by many. A certain simple detail of construction readily prevents any injurious results. Such mills, it may be added, are particularly adapted to the conditions obtaining in some of our Western mining regions, where suitable lumber is becoming scarce at a rate proportioned to the cheapening of iron and steel following upon lessened railroad freights and multiplication of machine shops.

The height of the drop is necessarily proportioned to its rapidity. A high drop needs a long cam, and the endeavor to get speed out of such a combination invariably leads to breakages. Similarly a low drop permits the use of short-armed cams, which lessen the leverage and decrease the strain, allowing of greater speed. A very heavy stamp is not needed with a long drop, nor is it practicable. The fastest work is done by a 750-lb. stamp dropping $6\frac{1}{2}$ in. 95 times (with a maximum of 105) per minute; the slowest arrangement is the old Colorado mill with its 550-lb. stamp falling a height of 17 in. (and sometimes as much as 20) at the rate of 30 times (occasionally as low as 25) per minute. The divergence of practice in this respect is most assuredly wide enough and furnishes material for a very interesting study.*

The depth of discharge, that is, the distance from the level of the issue (the bottom of the screen) to the top of the die, is a factor whose importance in stamp milling is generally underrated. The deepest discharge is from 14 to 16 in.; the shallowest from *nil* to 5, with an average of 2 in. The maximum depth gives conditions which compel slow crushing and a pulverization more minute than the fineness of the screen indicates, because the pulsation of the water inside the mortar is weakened and the force of the issue impaired. The minimum discharge gives only a thin cushion of water between the ore upon the die and the descending stamp; it causes a violent splash and a forceful issue. In the Australian mills there is but rarely any serious effort made to obtain a uniformity in this respect, so that the discharge will usually vary from 1 in. with the new dies to 5 in. as they become worn out. Obviously a difference of 3 or 4 in. causes more variation in the case of a shallow issue than would result from the wearing down of the dies in a deep mortar where the depth of discharge is so great that the increase is only a small fraction of the total. Hence this factor causes more irregularity in the operation of the colonial and Californian mills than in those of Colorado or Dakota.

In two districts, the Black Hills and Amador, the height of the drop is less than the depth of discharge, which means that in these instances the stamp is never lifted entirely out of the water in the battery. It is doubtful whether this condition seriously impairs the crushing capacity of the mill. It promotes a regular pulsation of the water and pulp such as conduces to regularity of discharge, itself nearly synonymous with rapidity, since not more than a certain amount of pulp can go through the screen apertures at any given time, no matter how violent the splash of the water against them. It does also, I believe, favor conditions helpful to amalgamation, because as against a very violent splash it permits of the settling of the gold particles and minimizes scouring action on the inside plates.

The rate of crushing should not be surprising in the light of the consideration of the different factors which regulate it. One factor, namely, the character of the ore, its composition and its quality, is given in the last column of the table. The possession of very large bodies of extremely low-grade ore is sufficient explanation for the hurried treatment which characterizes the methods of the companies in the Black Hills. The average Californian and Australian mills treat an

* See *Engineering and Mining Journal*, Sept. 3 and 10, 1892. Also the *Transactions* of the American Institute of Mining Engineers, Vol. XXIII., p. 137 *et seq.*; also p. 569 *et seq.*

equal tonnage, and the millstuff supplied by the mines comes from ore depositories of a parallel magnitude. New Zealand comes next, and our old friend the Gilpin County mill is last. And this, too, is not strange, for the mines of its particular habitat are restricted in the extent of their workings and always carry a certain proportion of ore sufficiently rich to warrant direct shipment to the valley smelter. Moreover, it treats an ore which in most districts would be considered hopelessly refractory and is rendered amenable to successful reduction under the stamps by a modification of the ordinary process which, anomalous as it often seems to the uncomprehending visitor from other districts, is yet remarkably adapted to the conditions of the case.

In the matter of screens there is a perplexing confusion, owing to the loose nomenclature and divergent types of the apparatus employed. The coarsest crushing is done at Clunes, where the practice is to use thick copper plate perforated with only 100 holes per sq. in. This lasts during the passage of 350 tons of ore. Since no mercury is put into the mortars of this district, the use of copper is not objectionable on the ground of its liability to amalgamation. Moreover, the coarse sizing of the pulp is permissible on account of the extremely simple character of the millstuff, the gold of which is readily loosened from the fractures and cavities in the quartz. Fine crushing is neither needed nor desirable in preparing such an ore for the blanket tables and wells which form the characteristic gold-saving apparatus of this old mining center.*

The finest pulverization is accomplished by the mills of Gilpin because the intimate association of the gold and pyrites requires such treatment in order to compel a separation. The screens of this district can hardly be considered in the nature of a sizing apparatus; they are made of iron plate punched with alternate burr slots of such a number and size that the chances of a particle of pulp, adequately pulverized, effecting an exit are as 1 in 34. This results in a degree of crushing far in excess of that indicated by the mesh of the screen, because particles once reduced so as to permit of their passage through the openings are thrown back for further comminution. The capacity of the mill suffers, but conditions are obtained suited to the separation of the fine gold from its envelopment of pyrites.†

It is a curious fact that in none of the districts quoted in the table are wire screens in the ascendant at the present time. In some instances they have been replaced, within recent years, by punched plate. This seems to me a curious and unfortunate retrogression in milling practice. Nevertheless woven wire cloth is destined to supersede punched or perforated iron plate. Wire screens have apertures approximately equal to the thickness of the wires of which they are made, and therefore offer equal chances for the discharge or retention of such particles of pulp as have been sufficiently crushed, as the discharge area depends upon the relation between the mesh and the thickness of the wire. With a 27 mesh and a 33 B. W. G. wire they are equal. They give conditions promoting uniformity of pulverization and a high crushing capacity. A recent test made at the Mammoth Mill, in Pinal County, Ariz., showed that as against a No. 6 angle slot screen and an equivalent wire cloth of 24 mesh and No. 26 wire, the

* For details of the Clunes practice reference should be made to the *Engineering and Mining Journal* of Jan. 28 and Feb. 4, 1893.

† See also *Transactions* American Institute Mining Engineers, Vol. XXIII., p. 139 *et seq.*

latter crushed 20% more. They are more liable to be choked by the pulp and weakened by wood chips from the mine timbers, and therefore in well-managed mills we find at least two sets for each battery, so as to permit of a regular substitution pending cleaning or repairing. This is urged against their usage, but surely it is a very foolish economy to sacrifice the proper operation of the mill in the effort to diminish this item of expenditure. The ordinary expense in screens per ton of ore is about 1c., so that even the doubling of this is no matter so long as conditions for good work are attained.

The life of the screens depends upon the hardness of the ore, the acidity of the battery water, the attention given to them, etc., but more than these it is chiefly regulated by the length of time which the superintendent considers it desirable to retain them in service. A screen will often actually last without breakage, at the Homestake, for instance, about 20 days, but its openings become so enlarged by abrasion as to permit of coarse crushing to an extent incompatible with successful extraction; therefore it is the practice of good mill-men to throw it out after an average, say, of 7 days. This is sensible. False notions of economy cause some men to lose ounces of gold in the effort to save a few cents. In Gilpin County the enlargement of the screen openings is allowed to go further than is customary elsewhere, and when the screen has had a good service in that part of the mill which is crushing ore from the company's mine, it is transferred for use to the section employed in treating custom ores.

The Thames and Charters Towers districts exhibit the briefest service, because the ores of these regions are rich in the sulphides of base metals whose partial oxidization gives an acidity to the water, causing a corrosion of the iron of the screens. The mills of Blackhawk exhibit a remarkable difference in wear of screens, with a rapid diminution of service as the mills succeed one another down stream, so that from a maximum of three months the average life of a screen dwindles to two weeks. This is due to the fact that the water which has been used in the batteries of one plant is reused in its next neighbor, with a consequent constant increase in acidity due to the decomposition of iron and copper sulphides.

The large percentage of these is indicated in the next column. In some instances the values saved by the mill are so largely in the pyrites collected on the shaking tables that the milling operation becomes more of a concentration than an amalgamation process. At Charters Towers the proportion of sulphides is also a heavy one, and the preliminary battery treatment is supplemented by regrinding in pans, followed finally by the chlorination or cyanidation of the richest portion of the concentrates. At the Thames the ores are equally loaded with refractory sulphides, but in that locality no adequate effort is made to prevent them from escaping with the tailings into the sea.* The saving of gold remaining in close association with the sulphides is also very inadequately attempted by the Homestake mills. The plant as yet erected for this purpose can only be considered an incompletely planned experiment.† The ores carry from 2 to 5% of pyrite, pyrrholite, and mispickel.

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*Discussed in the *Engineering and Mining Journal* of Dec. 10, 1892, p. 559, under "The Variations in the Milling of Gold Ores. No. 2—The Thames."

†See also *Engineering and Mining Journal* of Sept. 7 and 14, 1895.

The principal Australian and Californian gold-milling centers have ores giving an approximately equal percentage of concentrates. Thus we gradate from heavy sulphide ores of a very refractory character, for whose treatment stamp milling is only desirable on account of compulsory local conditions, to millstuff nearly free from admixture with minerals prejudicial to a very complete amalgamation of the gold which it contains.

The retort percentage is largely dependent upon the hardness of the mill-man's hands. Apart from this factor, it becomes proportioned to the coarseness of the gold particles and the thoroughness of their amalgamation, that is, the completeness of the alloying of the two metals, for an amalgam is an alloy formed by mercury with another metal in the cold.

The fineness of the bullion is an excellent index of the docility of the ores, because those which carry their gold within an incasement of pyrite yield retorts containing impurities, of which silver is the most frequent and least undesirable. It certainly does so happen that if you go through the list of these milling centers, taking them in the order of their bullion fineness, beginning with Clunes (975 per 1000) and ending with the Thames (640 per 1000), you will have the exact scale of their gradation from the most distinctly free-milling docile ore to the most decidedly difficult and refractory. Furthermore, speaking generally, I may mention, as a striking coincidence merely, that this figure will be roughly indicative of the percentage of extraction, because this last is a corollary from the fact just noted. Thus a Gilpin County mill will extract just about 78%, those of the Thames rarely reach 64%, those of Grass Valley usually exceed 84%. As a rough approximation of a probable extraction, the fineness of the retort gold affords in this way an interesting guide.

The variation in mercury consumption is the widest of all, from 5 grains to a pound per ton. The minimum figure at Clunes is traceable to the fact that no mercury is used in the mortar and blanket tables replace the copper plates ordinarily employed on the outside. Mercury is only used in wells and in the barrel which treats the blanketings. Rich ores entail a greater consumption than poor because more mercury is used. Charters Towers and the Thames give the maximum loss because of the addition of mercury in the pans, where it becomes floured and sickened* by being present while base sulphides are undergoing grinding.

Water consumption is primarily dependent upon the rate of crushing. It is increased by the addition of processes supplementary to the ordinary battery treatment. Blankets require more water than plates, hence the high figure at Clunes. Slow crushing needs a small supply, therefore the low consumption in Gilpin.

Finally, we reach that most important factor of all, the character of the ore. It is a cynical truism to say that the milling process should be adapted to the nature of the ore, because unfortunately it reminds one at once of the scores of expensive plants which are rotting upon the hillsides of our mining regions as the consequence of a perverse disregard of this obvious relation. Ordinarily it is best to have a mine possessing certain ore reserves before starting to erect a mill. Moreover, it is safer to have representative lots of ore tested at a neighboring re-

* See *Engineering and Mining Journal* of May 18, 1895: "The Flouring and Sickening of Mercury."

duction plant than to design a line of treatment on the insecure basis of a few laboratory experiments. The old folly still survives. Men of intelligence try a few grains of ore in a test tube and then hasten to telegraph the order for a $50,000 mill. English directors are particularly prône to placing blank orders for "a gold mill" in the hands of fashionable machinery firms. Many of the resultant failures are put upon the broad back of an old well-tried process which is further loaded with the incubus of incompetent management and incomplete equipment. The average mine owner not infrequently prefers fooling with "a man and a process" to spending a thousand dollars in properly directed experiments. Consequently there are many who, complaining of the unsatisfactory extraction in the batteries of a badly arranged or incompletely equipped stamp mill, rush headlong into the maze of complicated half-understood leaching processes. Their last end is often worse than their first.

In the above list of gold-mining centers there are at least two, both colonial, instances of the application of stamp milling to ores essentially unsuited to such a process of reduction. Some one put up a stamp mill long ago and the others have copied the first builder, because probably the ores that went to that first mill were so rich that in spite of an unsatisfactory percentage of extraction the mine paid dividends. After that no one wanted to be guilty of unprejudiced investigations resulting in a new departure. In other instances, as in Gilpin County, while the ores of most of the mines and most of the ores of any particular mine are susceptible of successful treatment by the process in vogue, there is much millstuff undergoing amalgamation and supplementary concentration which should be subjected to well-devised concentration accompanied by incidental amalgamation. This is being realized of late, so that the stamp mill, the concentrator, and the smelter in the valley will each receive that proportion of the ore production which is clearly designed, from a metallurgical standpoint, to go to them.

Incidentally mention may be made of the use of the stamp mill for the recrushing of the tailings from jigs. It has been generally supposed that jig sands are not suited to battery treatment. Their regrinding has been given over to rolls, Huntingdon mills, and a multitude of patent pulverizers. The successful work accomplished at several mills in the southwestern part of Colorado has shown that both the Huntingdon mill and the stamps are well adapted for this purpose; that the former is, because of its construction, suited for erection in mountainous regions; and that the stamp mill will treat jig sands satisfactorily when due regard is paid to regular feeding. Under such conditions it has a capacity and gives results rendering it suitable for such tailings coming from the jigs as consist of quartz sands containing free gold and have been previously deprived of those brittle sulphides which make slime. The crushing of ore preparatory to jigging is, on the contrary, a work which it is rarely advisable to give to the stamps, because, being badly adapted to sizing the pulp, they deliver it in a poor condition for concentration.

Certain districts in both hemispheres make only a lame effort to arrest the gold-bearing sulphides escaping in the tailings of the stamp mill. The ordinary practice is to employ two vanners per battery, because it is the ratio which has been found adequate to the treatment of the ores of the Californian mines, where the vanner first came into successful use. Guided by such a venerable rule of thumb, the mill owner equips his plant in a stereotyped fashion, regardless of the fact that his ore may carry a several times larger percentage of sulphides. As a rule, the number of vanners is insufficient because it is not recognized that they are machines which to do close work cannot be crowded. Nor, on the other hand, should it be expected that a delicate concentrator such as this can give satisfactory results when called upon to treat pulp varying in size from 30 mesh to impalpable slime. The importance of sizing, itself an inexpensive operation, is almost universally overlooked in English-speaking countries, to the heavy detriment of the work done by vanners and shaking tables.

The successful introduction of certain leaching processes, whether for the reduction of concentrates or the treatment of tailings, has caused many mill-men to lose sight of the desirability of extracting the values in the ore as soon as possible and not expecting to re-dress the unsatisfactory results of a poor battery amalgamation by a subsequent supplementary process. The pride of many mill-men over the obtaining of gold from tailings which have been permitted to go through the mill without yielding up a proper percentage of their contents and the satisfaction expressed over the work afterward done by the cyanide tanks or the chlorination vats is due to a disregard of one of the first postulates of good milling, namely, to catch the gold as soon as possible. Do not send specimen ore to the battery if it can be treated in a hand mortar; do not let the gold get into the outside plates if it can be arrested within the battery itself; get it on the amalgamating tables rather than on your blankets or in your wells; do not depend on your concentrators if you can save the values by amalgamation, nor neglect the care of the vanners because the tailings are to undergo further treatment. A sportsman is not considered a good shot because he misses the bird with his first barrel and brings it down with the second.

In the foregoing glance over the field of activity covered by the simple mechanism of the stamp mill the Witwatersrand has not been included because the practice of that region is yet in its formative stage and is destined to undergo important changes of development. At present it offers a magnificent opportunity for the utilization of the best experience of the older districts of the world. The application of the stamp mill to the conglomerates of the Rand serves further to accentuate its wide range of usefulness. It is this adaptability to ores of great diversity which enables it to hold its own in the face of the newer devices constantly offered by the restless inventive genius of the age. Between a simple white quartz carrying loosely attached particles of coarse clean gold and a compact pyrite wherein the gold is invisibly enveloped there is a divergence so great as to emphasize the elasticity of a process which, despite the encroachments of the smelter on the one hand and wet methods on the other, remains the simplest and cheapest way of extracting gold as yet devised by the ingenuity of man.

THE PRECIPITATION OF GOLD FROM CYANIDE SOLUTIONS.

BY WALTER RENTON INGALLS.

THE cyanide solutions drawn from the leaching tanks contain chiefly free cyanide of potassium, caustic potash, auro-potassium cyanide, argento-potassium cyanide, and more or less complex compounds of the base metals attacked by the solution. The next step in the process is the precipitation of the gold and silver. For the accomplishment of this two methods are in general use, viz., precipitation by finely divided zinc and precipitation by the electric current. Numerous other methods have been proposed, and certain have actually been tried on a working scale, but none of them finds application at the present time.

1. PRECIPITATION BY ZINC.—Metallic zinc being electrically positive to gold and silver has the property of throwing down those metals from their cyanide solutions. The voltaic order of the metals in solutions of potassium cyanide of different strength is given in the following table:

*0.625%	KCN	50° F.	+ Al, Mg, Zn, Cu, Cd, Sn, Co, Ni, Ag, Au, Hg, Pb, Fe, Pt, Sb, Bi, Te, C.—
*0.625%	KCN	100° F.	+ Mg, Zn, Cd, Al, Co, Cu, Ni, Sn, Au, Ag, Pb, Hg, Sb, Bi, Fe, Te, Pt, C.—
†12.5%	KCN		+ Zn, Cu, Cd, Sn, Ag, Ni, Sb, Hg, Pd, Bi, Fe, Pt, C.—
*30%	KCN	50° F.	+ Mg, Zn, Cu, Al, Cd, Au, Ag, Ni, Sn, Hg, Pb, Co, Sb, Te, Bi, Fe, Pt, C.—
*30%	KCN	100° F.	+ Mg, Al, Zn, Cu, Cd, Sn, Au, Ag, Ni, Hg, Pb, Co, Sb, Te, Bi, Fe, Pt, C.—

In practice it is found that the zinc must be in a fine state of division in order to present the maximum amount of surface to the gold-bearing solution. This object is undoubtedly best attained by zinc in filament form. The precipitation of the gold is easily effected by passing slowly the solution through a mass of filiform zinc arranged in a proper receptacle or trough. The gold and silver quickly come down on the zinc, usually in the form of a black or blackish-brown powder, while the zinc goes into the solution. The reaction is expressed as follows:

$$2KAuCy_2 + Zn = ZnCy_2, 2KCy + 2Au.$$
$$2KAgCy_2 + Zn = ZnCy_2, 2KCy + 2Ag.$$

The double cyanide of zinc and potassium is not a solvent for gold and silver, and so long as there is an excess of zinc present there will be no redissolving of the precious metals by the free potassium cyanide flowing through the boxes.

Although the precipitation of gold ‡ by zinc is theoretically so simple, the actual reactions which take place in the zinc boxes are complex and are by no means well understood. There is always during the precipitation an evolution of

* Gore, *Proc. Roy. Soc.*, XXX., 38.

† Poggendorf, *vide* Gore, *Electrolytic Separation of Metals*, p. 57.

‡ Silver behaves generally in cyanide solutions in the same manner as gold, but to avoid repetition of the phrase "gold and silver" and the duplication of reactions, gold only will be referred to unless some difference in behavior requires specific mention of silver.

hydrogen, which may be proved by igniting the gas bubbles on the surface of the liquor, and the development of a peculiar ammoniacal odor. Pure zinc is not so efficient in the precipitation as the commercial, which invariably contains lead, say in the proportion of 1%. The zinc should, however, be free from arsenic and antimony. In any case the precipitation proceeds slowly at first with fresh zinc, but as the latter becomes coated with gold a voltaic couple is formed and the action becomes rapid. This gold-zinc couple probably develops enough electromotive force to decompose water, thus:

$$Zn + 2H_2O = Zn(OH)_2 + 2H.$$

The nascent hydrogen may unite directly with hydrocyanic acid evolved by the atmospheric decomposition of the potassium cyanide, or otherwise, forming methylamine:

$$HCy + 4H = CH_3, NH_2.$$

The presence of methylamine may in part account for the ammoniacal odor always observable near the zinc boxes, but this may also be caused by hydrolytic decomposition. The zinc hydrate formed in the above reaction is at once dissolved by the free potassium cyanide:

$$Zn(OH)_2 + 4KCy = ZnCy_2, 2KCy + 2KOH.$$

The caustic potash thus produced, together with that formed during the reactions that take place in the leaching tanks, acts directly on the zinc to a certain extent in accordance with the well-known equation:

$$2KOH + Zn = ZnO, K_2O + 2H.$$

The zincate of potassium is probably converted into double cyanide of zinc and potassium by action of the free potassium cyanide in the solution:

$$ZnO, K_2O + 4KCy + 2H_2O = ZnCy_2, 2KCy + 4KOH.$$

N. Andersen* declares that zincate of potassium cannot exist in a cyanide of potassium solution, but even if it does exist it is an exceedingly unstable compound, and on contact with a fresh charge of ore is promptly decomposed into zinc hydrate and caustic potash.

The mill solution is therefore constantly made more alkaline. Without doubt, however, the caustic alkali is soon converted into carbonate by absorption of carbonic acid from the air, and in this way the percentage of free alkali in the mill solution is limited, which is unquestionably a matter of importance.

Experience has demonstrated that the precipitation of the gold is less rapid and complete when the free cyanide in the solution falls below a certain limit (say 0.20% or 4 lbs. per ton), while the decomposition of the zinc is also less.†

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* *Notes on the Precipitation of the Precious Metals from Cyanide Solutions by Means of Zinc*, Colorado Scientific Society, April 1, 1895.

† It is not meant that precipitation is impossible with more dilute solution; on the contrary, in certain instances this has been done effectually with solution containing only 0.10% KCN or 2 lbs. per ton, but the action is slower than with stronger solution and the precipitation not so complete.

Our present knowledge of the chemistry of the precipitation of the precious metals from cyanide solutions may then be summed up as follows:

1. The gold is thrown down by direct replacement of the zinc.

2. Hydrogen is evolved by the decomposition of water by the gold-zinc couple and by the action of caustic potash on zinc.

3. The zinc is decomposed by gold-potassium cyanide, caustic potash, and the voltaic action of the gold-zinc couple.

4. The potassium cyanide is decomposed by zinc hydrate and potassium zincate.

The gold-free liquor flowing from the zinc boxes is a solution of (*a*) uncombined cyanide of potassium, (*b*) double cyanide of zinc and potassium, and (*c*) caustic potash, or possibly zincate of potash. Theoretically 1 lb. of zinc should precipitate about 6 lbs. of gold; practically from 5 ozs. to 1 lb. of zinc are required for every ounce of gold recovered. A considerable part of this high consumption of zinc, however, is due to waste in refining the black slime.

The Preparation of Zinc Shavings.—Zinc shavings are generally prepared by turning down with a sharp chisel disks of sheet zinc revolved on a lathe. Sheet zinc of No. 9 gauge is the most suitable for this purpose. The disks can be obtained from the rolling mill already cut, 12 in. in diameter, with a 1-in. hole in the center. It is advisable to have the mandril of the lathe of 1 in. diameter, since otherwise it may be necessary to buy unpunched disks and subsequently punch them by hand. The 12-in. disks of No. 9 gauge weigh about half a pound and cost about 2c. per lb. more than the market price of spelter in New York, or say 6c. when spelter is quoted at 4c., to which must be added the freight to point of consumption; thus zinc disks laid down in Denver come to about 7c. per lb.

The lathe employed for turning the disks is very simple, consisting merely of a mandril, threaded at each end, supported on two bearings with a tight and loose pulley in the center and a set of cast-iron disks for each end, the whole being fixed on an ordinary bench. A lathe of this kind is illustrated by one of the photographs accompanying this paper. In operation a package of 20 disks—*i.e.*, 10 lbs.—placed between a pair of the cast-iron plates 10 in. in diameter is fixed on each end of the mandril and screwed tightly by a nut. The disks are then put in motion and thin shavings cut from them by means of a sharp chisel held firmly on an iron rest. The chisels should be of a very hard steel, like file-steel, and should be ground to a bevel edge of about 65°. The chisel is held at an angle so as to cut the sheaf of zinc disks at a bevel, first right and then left, the shavings streaming past the operator's elbow into a basket on the floor. When cutting the inner bevel a shield made of a piece of board or sheet iron should be placed over the mandril to prevent the stream of shavings from becoming entangled in the pulleys and belt. Another necessary precaution in setting the lathe is to have the driving belt in the quadrant opposite the operator, because if in the same quadrant it will interfere more or less with the freedom of his movements and consequently his efficiency.

The mandril of the lathe should not be driven at a less speed than 350 revolutions per minute, giving a peripheral velocity of about 1150 ft. per minute to disks 1 ft. in diameter. This is steadily lessened as the disks are turned down, and it is well to provide the lathe and driving shaft with conical pulleys in order to maintain a more uniform rate. However, this is not of great importance, the decrease in velocity in no way affecting the quality of the shavings, but merely reducing the rate of production.

As soon as the disks are turned down flush with the cast-iron holders a smaller pair is substituted, and so on until the disk becomes too small to turn further to advantage, this point being reached at a diameter of about 2¾ in. The operator turns alternately from the disk at each end of the mandril, changing from one to the other when it becomes too hot.

The shavings thus produced are fine threads of metal often 1 meter or more in length. They should be neither too coarse nor too fine, the consumption of zinc being unduly high when the shavings are very fine. A good kind of shavings consisted of threads or minute ribbons 0.1 mm. in thickness and 0.5 mm. in width. Shavings like this when packed in a spongy mass a little lighter than ordinarily in a zinc box weigh about 6 lbs. per cu. ft. They are so fine that they can be ignited by a lucifer match and with free access of air burn readily to zinc oxide.

An expert man with a lathe running 400 revolutions per minute can turn 8 lbs. of zinc per hour, but 6 lbs. per hour may be considered good average work. In a day's turning about 12 chisels will be used, and this number should be provided in order to avoid loss of time in sharpening. The whole lot, however, can be sharpened by the operator in about 15 minutes at the beginning of the day.

The small disks of unturned zinc, say 2¾ in. in diameter, are valuable only as scrap metal. This involves a loss of 4.5% of the metal purchased. The cost of zinc shavings turned by hand on a lathe may consequently be estimated as follows:

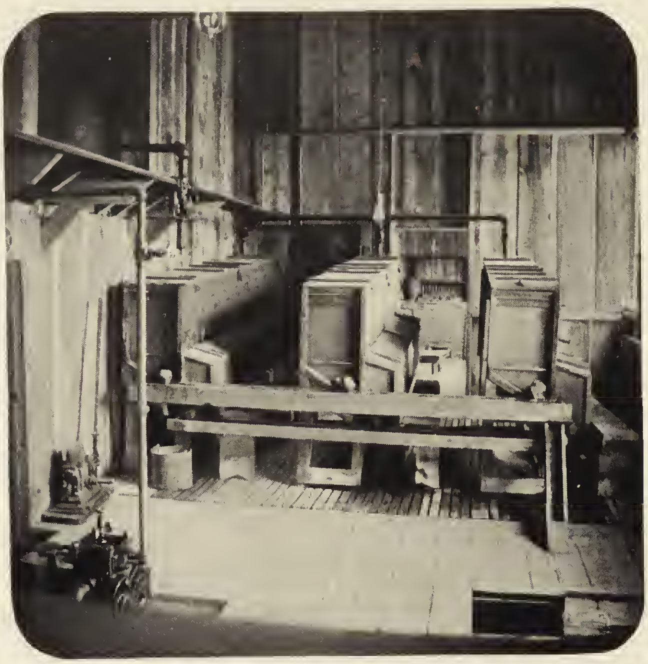
100 lbs. disks at 7c. per lb.	$7.00
Labor of turning, 16 hours at 30c.	4.80
95.5 lbs. shavings cost	$11.80

That is, 12.2c. per lb.

At the Mercur Works, in the Camp Floyd district, Utah, an automatic lathe for zinc turning has been introduced. The zinc is purchased in sheets 30 in. wide, and these are rolled tightly round a spool 6 in. in diameter, forming a shell of metal about 1 in. thick, the end of the sheet being soldered firmly to the underlying. The spool having been put in motion a cutting tool is set to work automatically against it. The lathe is erected in the engine room and is watched by the engineman, who also prepares the spool in his spare time. In many instances, as at Mercur, this scheme makes it possible to save the time of one man in the mill force.

Zinc Boxes.—The zinc box is a long trough inclined at a small angle and divided into a series of compartments by vertical partitions. Near the bottom of each compartment is fixed a horizontal screen which serves to sustain the zinc shavings, and below the screen in the bottom of the box is an outlet provided with a plug or cock through which the gold slime is drawn off. Between each compartment filled with zinc shavings there is a narrow compartment through which the liquor descends in order to rise through the shavings of the next one. In each of the compartments for precipitation, therefore, the current is from

PREPARING ZINC SHAVINGS.



PRECIPITATING TROUGHS.

bottom upward. This is necessary in order to maintain an unimpeded flow of the liquor, since with a downward current the decomposition of the zinc would proceed from the top of the mass of shavings downward, and the bulky precipitate would soon clog the openings; but with the precipitation taking place from the bottom the gold slime falls down against the current, passes through the screen, and accumulates in the pocket beneath it.

Zinc boxes are usually constructed of wood, though iron is sometimes employed. Many object to the use of iron in any connection with the zinc, asserting that the galvanic action set up between the two metals leads to an additional loss of potassium cyanide, and have gone so far as to reject steel-wire screens for the compartments, substituting perforated tiles of earthenware. While there is undoubtedly action of this kind between the iron and zinc, it is likely that its effect has been exaggerated, and earthenware tiles at the best have the disadvantage of offering only a small proportion of openings, thus rendering it less easy for the slime to fall into the pockets. At the Utica Works, Angel's Camp, California, zinc boxes entirely constructed of iron were used and no increased loss of cyanide was observable.* Iron or steel boxes have the advantage of easily being made absolutely water tight if built of metal thick enough to chip and calk the seams, say ¼-in. tank steel. Wooden zinc boxes must be put together very carefully in order to avoid leakages. However, if they are built of well-selected lumber, 2 in. thick for the main box, tongued and grooved, with pitch in the seams, no special danger is to be anticipated. Oak and yellow pine are good material; California redwood is also used, and in New Zealand kauri pine, which is said to be excellent, is commonly employed for this purpose. The boxes are of course put together with screws, and the pipe connections are made in the usual manner—*i.e.*, with nipples and lock nuts. Before using the boxes they should be kept filled with water for a week or two, when any small leaks will be closed by the swelling of the wood.

The zinc box thus described forms practically a continuous column filled with shavings through which the liquor passes. In point of size there is great variation. The cross section of the column depends, of course, upon the amount of solution to be precipitated, the length being fixed, or the cross section being fixed the length must be varied according to the amount of solution. At first the tendency was toward the use of very long troughs, even up to 40 ft., at the Mercur Works in Utah, while troughs 20 and 24 ft. long are still commonly employed in the Transvaal. Experience has shown, however, that this is unnecessary if the boxes are large enough, the precipitation of the gold taking place principally in the first part of the column, in the first 4 ft., for example; in which case a column 10 ft. long would be amply safe for complete precipitation, and a column of this length can easily be arranged in a trough 9 ft. long. This is illustrated in determinations by Dr. Scheidel at the Utica Works. Solution assaying 5.7 ozs. gold and 2.2 ozs. silver per ton was passed through a column 14x9x140 in., which contained 20 lbs. of zinc shavings, at the rate of 700 gals. (93.58 cu. ft. = 5850 lbs. approximately) per 24 hours. The column was divided into 10 equal sections or compartments. Assays of the solution flowing from each were as follows:†

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* A. Scheidel, *The Cyanide Process*, 1894, p. 32. † *Ibid.*, p. 91.

Compartment.	Column.	Gold.	Silver.
	Inches.	Oz. per Ton.	Oz. per Ton.
No. 1....................	14	0.800	0.260
No. 2....................	28	0.270	0.071
No. 3....................	42	0.130	0.035
No. 4....................	56	0.058	0.025
No. 5....................	70	0.052	0.023
No. 6....................	84	0.046	0.001
No. 7....................	98	0.032	....
No. 8....................	112	0.031	....
No. 9....................	126	0.027	....
No 10....................	140	0.025	....

The strength of the solution in potassium cyanide was 0.3185%, which remained constant during passage through the column.

The proper rate of flow of solution through zinc boxes can only be determined by experiment, assaying the outflow in each individual case. In providing precipitating capacity it may be safely assumed that a column 5 ft. long, 1 ft. wide, and 10 ft. high will precipitate the gold from 25 tons of 2-oz. solution per 24 hours—*i.e.*, from 50 tons of ore yielding 1 oz. gold per ton if the solutions used amount to 50% of the weight of the ore. The zinc column may be divided between any number of troughs that seems advisable. In general, however, there should be one set of boxes for strong solution and one set for weak solution, the object being to avoid mixture of solutions without the necessity of holding any back in reservoirs. The strong-solution boxes are not necessarily reserved for strong solution only and the weak boxes for weak, but either set may be used for either solution by diverting the outflow to the proper sump. There is no advantage in increasing the number of zinc boxes beyond two for steady service, though it is always well to have one extra box for emergencies, and the cleaning up of a large number of small boxes is a good deal more tedious than a few large ones.

The completeness of the precipitation in the zinc boxes depends not a little upon the attention devoted to them. The shavings should be placed evenly in the compartments, filling the corners closely, about 3 to 5 lbs. to the cubic foot, but never compressed so that the liquor will not flow easily through them as through a sponge. Channels must never be allowed to open through the mass, and as the latter has a tendency to rise it is well to wedge a few strips of wood across the top to hold it down. The gold-bearing solution having been turned into the box, the zinc in the first compartment soon begins to blacken and precipitation is then rapid. With ordinary solutions the gold comes down as a black or blackish-brown powder, but with rich solutions, assaying for example from 5 to 10 ozs. per ton, shining metallic particles can usually be easily recognized. When the decomposed zinc has sunk considerably in the first compartment it is filled again with black zinc from the second, the second being filled from the third, and so on to the end, where fresh shavings are supplied. The zinc is always transferred in this manner, since the blackened zinc being the most active precipitant it is desirable to have the first and second compartments at least filled with it. It is a good plan to have the zinc boxes attended to night and morning, though in many works they are left to themselves for much longer time. This may be one cause for incomplete precipitation. If the zinc boxes are to be left idle for some time they should be kept filled with solution or with water, to prevent the zinc from oxidizing, and needless to say the shavings that are used should be freshly turned and unoxidized.

Cleaning Up.—In cleaning up the zinc box the operator begins at the first compartment by transferring the blackened, undecomposed shavings to an enameled-iron pan or a similar suitable receptacle, previously shaking them in the solution filling the compartment to dislodge adhering particles of gold. The gold slime remaining on top of the screen is then stirred to make it pass through, after which the screen is removed and washed. The cock at the bottom of the compartment is then opened and the slime settled there is drawn off into a bucket or tub, small buckets made of No. 27 sheet iron answering very well for this purpose. The corners of the compartment are carefully washed out by means of a small stream of water, the screens are then replaced, the outlet cock closed, and the compartment is ready for refilling with shavings. The gold slime drawn off into buckets is allowed to settle, after which the clear cyanide liquor is decanted and returned to the zinc box. The collected slime is put upon a filter, preferably a vacuum filter, drained of cyanide solution, and washed with water. A Johnston filter press would answer admirably for this purpose and would save time, the gold slime being slow to filter and the richer it is the slower. The slime consists essentially of metallic gold, silver, and copper precipitated from the cyanide solution, lead, iron, and carbon resulting from the decomposition of the zinc in which they existed originally as impurities, small fragments of undecomposed zinc (which usually form a considerable percentage of the slime) and silica and alumina drawn through the filtering cloth of the leaching tanks and held in suspension by the solution.

Various methods are resorted to for the reduction of the washed slime. In South Africa it is generally roasted sufficiently to oxidize the zinc, after which it is fluxed and smelted directly in plumbago crucibles. In the United States it is commonly subjected to a sulphuric-acid treatment for removal of the zinc before smelting. With proper appliances the latter method is quite free from the objections which are often ascribed to it, and it is obviously preferable to smelt a product comparatively free from zinc to one rich in zinc. In adopting the sulphuric-acid method the slime is shoveled from the vacuum filter into a lead-lined tank, the filter and tank being for convenience placed side by side and the open spaces between them closed by a well-fitted bench to catch any accidental droppings in making the transfer. The slime is then stirred with dilute sulphuric acid, say 1 part acid to 3 of water, and heated by blowing in steam, which is simpler than arranging a steam-jacketed tank or a tank heated directly by a fire, as is done at some works. The gases given off by the action of the acid on the slime are exceedingly offensive; consequently the tank should be provided with a cover and an escape pipe leading to a chimney or to the open air. Also the effervescence is very violent, wherefore the tank has to be of comparatively large capacity. When the action of the acid has ceased an additional amount of water is added and the slime and solution are ladled on the vacuum filter, through which the solution is drawn off and the slime washed repeatedly with hot water, or until the filtrate shows no zinc when tested with an alkaline sulphide. No silver will go into solution. The filtering medium may be 10-oz. duck, which will last several clean-ups if the acid is sufficiently diluted. When the cloth shows signs of decay it is removed and burned on a roasting pan. The duck seems to be a better filter than asbestos cloth, not only in point of cheapness, but also in durability and ease in recovering the adhering gold.

The clean slime, which has the appearance of a fine black mud, with no metallic particles visible unless very rich, is transferred to a cast-iron pan and dried slowly, without stirring, in a muffle or over a small fire in the melting furnace, in which case it is desirable to have a closely fitting hood that may be drawn over it. The pans for this purpose are preferably of cast iron, a pan 2 ft. square and 3 in. deep, with bottom and sides ½ in. thick, being a convenient size, but since a pan of this size is very heavy, there should be a small crane or a block and tackle hung from a traveler for handling it. The same device may be made to answer for lifting the melting pots into and out of the furnace if very large pots are used. In drying the slime cakes and often the gold in it anneals so that the cakes show numerous shining yellow flakes, interspersed with white flakes if the slime is rich in silver. Often in treating tailings from amalgamation mills mercury, which is dissolved by the cyanide solution and precipitated on the zinc, sweats out of the slime during the drying if the temperature is high and collects in the pipe leading from the hood. Before fluxing the dry slime the lumps should be broken up in order to insure a good mixture. If the amount is small this may be done in an iron mortar provided with a cover, but if the amount is large a revolving iron drum will save a tedious operation, the flux being put into the drum together with the slime. The composition of the slime after treatment with acid is shown by the following analyses of slime produced at the Brodie Works, Cripple Creek, Colo.:

	Per Cent.	Per Cent.	Per Cent.
Au	49.85	26.18	23.60
Ag	9.54	6.84	6.00
SiO_2	15.60	10.00	6.60
Pb	3.00	Trace.	Trace.
CuO	5.58	8.11	6.40
ZnO	0.14	31.80	41.50
CaO	0.51	5.32	0.03
Fe_2O_3 / Al_2O_3	4.00	6.80	9.26
SO_3	11.32	4.80	6.45
Totals	99.54	99.85	99.84

In the second and third analyses the treatment with sulphuric acid was very incomplete. The lime and silica are probably entirely derived from the ore through particles in suspension, and the percentage of these elements in the slime is very variable on that account.

The flux for the acid-treated gold slime consists essentially of borax and sodium bicarbonate. For slime like that in the first analysis 50% soda and 25% borax will give a good slag; with the more zincky slime silica should be added, and a small amount of ferric oxide is not amiss; if the zinc is unoxidized niter should be used in the flux. The melting is done in plumbago crucibles as large as can be conveniently handled. The slime is very bulky, but a large charge may be run down in a comparatively small crucible by dividing it into two parts and introducing the second after the first has melted down in the furnace. A Dixon No. 40 crucible will hold easily 60 ozs. troy of slime, together with the requisite amount of flux, at a charge with no danger of boiling over. With a No. 125 crucible 300 ozs. of slime may be smelted at a charge, yielding 150 ozs. of fine bullion if the slime assays 50%. A charge can be brought to thorough fusion in a coke furnace in about 1½ hours. The slag and metal are poured into a large conical cast-iron mold from which the button is detached on cooling. The remelting and casting into bars will require about 30 minutes. The total time of smelting will be therefore about 2½ hours. The total time of a clean-up from the drawing of the boxes to casting the bar is from 12 to 18 hours, the most being consumed in filtering the slime.

The slag from the smelting is fluid and glassy, and if poured very hot contains only a few prills of gold. A good slag will not assay more than 20 ozs. gold per ton, but slags are often met with that assay 150 or 200 ozs. In any case, whether the slag is good or bad it is reserved for re-treatment. A good deal of value can often be recovered from very rich slags by a simple remelting. The second slag will best be sold to the lead smelters if there is a market near at hand; otherwise its gold may be recovered by any ordinary method—reduction with litharge and cupellation of the lead, amalgamation in a grinding pan, or by simple concentration in a gold pan.

A somewhat troublesome by-product in the smelting is the copper matte, which is formed by the copper almost always in the slime, and the sulphates, which it is almost impossible to wash out completely. The matte can be knocked off the first ingot, of which it may amount to 4 or 5% of the weight, but except by very tedious dressing there will always be enough adhering to form a thin black scum entirely covering the bar, which cannot be easily removed, even with strong acid. The composition of this matte is shown by the following analysis:

	Per Cent.
Au	3.57
Ag	16.10
Cu	33.29
Zn	8.97
Fe	1.80
SiO_2	0.70
Sulphur	35.37
Total	99.80

A simple method of obviating it is to use two or three strips of bar iron in the crucible during the smelting, whereby the copper matte is decomposed. The bullion, however, is more base, but this does not matter, especially since the impurities can be oxidized with niter and removed by skimming during the remelting.

The fineness of the bullion produced from the zinc-precipitated slime is very variable, ranging downward from 985 (gold and silver). The South African bullion usually assays about 600 to 700 gold and 70 to 100 silver. Mr. T. K. Rose* gives the following analyses of bullion from South Africa:

* *Metallurgy of Gold*, p. 305.

Gold	603	617	726
Silver	70	81	92
Zinc	150	95	71
Lead	70	164	49
Copper	65	40	48
Iron	22	3	14
Nickel	20	....	....

The bullion produced from sulphuric-acid-treated slime is usually finer than the South African. The bullion produced from the slime assaying 49.85% gold in the preceding analysis might be expected to go over 900 fine in gold and silver. Cyanide bullion, however, is almost always brittle, owing to the zinc it contains, and is not always easy to sample correctly, for no matter how thoroughly the zinc in the slime may be oxidized, a little is always reduced by the carbon of the crucible and will enter the bullion. Hence the bars should be cast at as low a temperature as possible in order to avoid liquation.

The common method of procedure in South Africa is to mix from 3 to 10% niter to the slime before roasting, the niter being added preferably in the form of a concentrated solution with which the slime is thoroughly drenched. The addition of the niter before roasting is thought to facilitate the oxidation of the zinc. The roasting lasts usually 3 or 4 hours at a dull-red heat. The slime thus oxidized is smelted directly, with the proper fluxes, in plumbago crucibles.

The precipitation by zinc is often set down as the weakest point of the MacArthur-Forrest cyanide process, especially in view of the tedious operations involved in a clean-up, but these have been much exaggerated; if the works are provided with proper appliances there is certainly no difficulty in carrying it out. The precipitation itself is practically complete, in many instances indeed absolutely complete, and the precipitate if handled with ordinary care is converted into marketable bullion with almost no loss. Nor is the cost excessive, as will appear from the following figures for 200 tons of ore assaying 1¼ ozs. gold per ton and yielding 1 oz. per ton in a works running at the rate of 50 tons per day:

Labor attending to zinc boxes, 8 hours at 30c	$2.40
Zinc shavings, 140 lbs. at 12.2c	17.08
Labor cleaning up, 15 hours at 30c	4.50
Acid, fluxes, and supplies	8.00
Coke, 400 lbs. at 7½c	3.00
	$34.98 = 17½c. per oz.

2. Electrical Precipitation.—It has long been known that gold can be precipitated from the cyanide solution by means of the electrical current, and moreover that the completeness of this precipitation is independent of the strength of the solution. Advantage has been taken of this property in the Siemens-Halske, Pelatan-Clerici, and other processes in which the gold is dissolved from the ore in exceedingly dilute solutions. It is not proposed to discuss the merits of a very dilute solution as a solvent in this paper, which is limited to the precipitation of gold alone, but it may be said that under suitable conditions it is an efficient agent, and the Siemens-Halske process has already come into general use in South Africa. It has previously been pointed out that with very dilute cyanide solution zinc cannot be depended upon to precipitate the gold with any degree of completeness. Especially does it fail when the solution contains a considerable

amount of copper, which comes down on the zinc before the gold, and coating it checks the precipitation of the latter. In certain instances this has been in a measure obviated by strengthening the solution to the mill standard before passing it through the zinc boxes, but this does not of course offset the high loss of cyanide by decomposition in cupriferous ores, whereas in the processes using very dilute solutions the entire decomposition of the cyanide may be contemplated without bringing the cost to a prohibitive figure. For this reason there are undoubtedly many ores which can be treated successfully by the Siemens-Halske or Pelatan-Clerici processes and cannot be treated by the MacArthur-Forrest. So far electrical precipitation has only been commercially applied to very dilute solutions; * it has been tried experimentally with the stronger solutions produced in the MacArthur-Forrest process, but nowhere has it yet been adopted in practice.

The electric current passed though a solution of auro-potassium cyanide decomposes that compound, precipitating metallic gold on the negative pole and setting free the metalloid at the positive, the quantity of metal deposited in a given time by a given current depending upon its electro-chemical equivalent. This holds good, however, only for solutions strong in metal; for solutions weak in metal, as in the cyanide process, there is not in an ordinary cell sufficient of the metallic compound present at the electrodes, and consequently decomposition of water takes place, to obviate which arrangement for the movement of solution past the electrodes is necessary. This is most economically effected by allowing the solution to flow steadily but slowly through the precipitation boxes. It is still more important to have electrodes exposing a very large surface, a better result being obtained, according to Mr. A. von Gernet, by doubling the electrode surface than by increasing the current tenfold. The electrical precipitation of gold takes place independently of the amount of free cyanide of potassium or caustic alkali that the solution contains, nor is it affected by acidity of the solution.

The cathode for the Siemens-Halske and similar processes must be a material to which gold will adhere, which is capable of being rolled into very thin sheets, and is not more electro-positive than the anode, in order to prevent return currents being generated when the depositing current is checked. Siemens and Halske have adopted lead as the most suitable material for the cathode, employing anodes of iron. Cathodes of amalgamated copper plates have been tried, but have failed to give good results, the action of the current producing a dry amalgam which does not adhere to the plate. By the action of the current a metalloid is liberated at the anode, and the latter when a metal oxidizes. If zinc be used as the anode the zinc oxide thus formed reacts with the ferrocyanide of potassium produced during the leaching and forms a white precipitate of zinc-ferrocyanide. Similarly the iron anodes form Prussian blue by the reaction of the ferric oxide and potassium ferrocyanide.† Carbon might be used as an anode

* The terms "concentrated" and "dilute," "strong" and "weak," applied to solutions are of course purely relative. Since a saturated solution of potassium cyanide contains about 50% of the solid salt at 15° C., a 5% solution might be considered dilute. In the cyanide processes, however, solutions containing more than 1% KCN are rarely used, and perhaps mill solutions are not commonly stronger than 0.5%. In this paper by "strong" solutions the strongest solutions used in practice are meant; by "weak" solutions those with 0.2 or 0.3% KCN are meant; and by "very weak" those with less than 0.2%. This division is, of course, purely conventional.

† Potassium cyanide can easily be recovered from the Prussian blue by dissolving the latter in caustic soda, evaporating to dryness, and melting with potassium carbonate.

if it could be obtained in a form to withstand the current, but ordinarily it rapidly crumbles to a powder, which decomposes cyanide and is so fine that it cannot easily be removed from the solution by filtration.

Only a very weak current is required to precipitate gold from cyanide solution, say about 0.06 ampère per sq. ft. With cathodes 1½ in. apart 4 volts is sufficient to produce this strength of current. With so weak a current the gold is deposited firmly upon the cathode, and the iron anodes last a long time, their waste being proportional to the strength of the current. The completeness of the precipitation depends upon the box capacity—in other words, on the speed of flow of the solution through the box. As carried out in South Africa it is stated that about 75% of the gold in the solution is precipitated.

At the Worcester Works, South Africa, where the Siemens-Halske process was first introduced on a large scale, the strong solution contains from 0.05 to 0.08% KCN and the weak solution about 0.01%. The precipitation plant originally installed consisted of four boxes 20x8x4 ft. The anodes were iron plates 7x3 ft., ⅛ in. thick. They stood on wooden strips on the bottom of the box and were kept in a vertical position by wooden strips fixed to the side. Each alternate plate was raised 1 in. above the bottom of the box, thus forming a series of compartments through which the solution was obliged to rise and fall, as in an ordinary zinc box. The plates were covered with canvas to prevent short circuits. The cathodes were suspended between the anodes. These consisted of sheets of lead weighing ⅙ lb. per sq. ft. fixed in a wooden frame 3x6 ft., the surface of each cathode, weighing 3 lbs., being 18 sq. ft. Each box had 87 cathodes, or 3132 sq. ft. of cathode surface.

In the Crœsus Works, the most recently constructed of the Siemens-Halske plants in South Africa, the precipitation boxes are 30 ft. long, 4 ft. 7½ in. wide, and 9 ft. high, containing 121 anodes 4 ft. 6 in. wide, 3 ft. high, and $\frac{3}{16}$ in. thick; and 120 frames for cathodes, each holding 4 sheets of lead 4 ft. by 2 ft., weighing 22 ozs. per sheet. The surface of the cathodes is therefore 7680 sq. ft., figuring both sides. Each box will precipitate 50 tons of solution per 24 hours from 0.1 oz. to a trace. The solution travels a distance of 120x8 ft.—*i.e.*, passing around each plate—or 960 ft. in 14½ hours, or about 1 ft. per minute, the box holding about 30 tons of solution. Consequently some 29 hours are required for the precipitation of 60 tons.

The following experiment on the rate of precipitation by the Siemens-Halske process is reported by Mr. John R. Williams, consulting metallurgist of the Crown Reef Gold Mining Company. A tank containing 56 cathodes 8x4 ft. was filled with 24 tons of solution assaying 0.125 oz. gold and 0.005% KCN, which was allowed to run out at the rate of 1 ton per hour:

Test.	Time.	Gold Assay.	KCN Assay.
	Hours.	Ounce.	Per Cent.
No. 1	3	0.0580	0.004
No. 2	6	0.0420	....
No. 3	9	0.0025	....
No. 4	12	0.0017	0.004
No. 5	15	0.0009	....
No. 6	18	0.0004	0.004
No. 7	21	0.0001	....
No. 8	24	Nil.	0.004

In clearing up the lead frames are taken from the box one by one, the lead is removed and replaced by a fresh sheet, the change being effected in a few minutes and the operation of the box not at all interfered with. The lead, which presents a gilded surface, bears from 2 to 12% of its weight in gold. It is melted into bars and cupelled. The consumption of lead in treating 3000 tons of tailings at the Worcester Works was 750 lbs.; of iron, 1080 lbs.; the power required was 2400 watts, equal to 3½ electrical horse-power, and actually consuming about 5 horse-power.

The Siemens-Halske process is now used in South Africa by the Worcester Works (started in May, 1894, capacity 3000 tons per month), the Metropolitan Works (started in November, 1894, 5000 tons per month), the May Consolidated Works (started in May, 1895, 6000 tons per month), the Crœsus Works (started in the autumn of 1895, 6000 tons per month), and the Robinson Works (8000 tons per month). The total capacity of works in South Africa now using the Siemens-Halske process is said to be 32,000 tons per month.

The Pelatan-Clerici Process.—This process has not been put in operation outside of the small demonstration plants erected by its owners, but at present writing (January, 1896) a large works for its application is being constructed at De Lamar, Idaho. The process consists in the treatment of fine pulp (passed through a 40-mesh sieve) mixed with a dilute solution of potassium cyanide (about 0.1%) by agitation in an electrolytic vessel. At the De Lamar Works the latter are to be rectangular vats of masonry lined with asphalt, the bottom covered by an amalgamated copper plate and a thin bath of mercury which serves as the cathode. A belt made of sheet-iron plates with projecting paddles travels longitudinally in the vat over horizontal rollers, and serves to agitate the pulp and at the same time as the anode of the cell. A single vat is to hold 25 tons of pulp and two charges are be treated per 24 hours, 18 horse-power being estimated as the requirement to keep the pulp in motion. The theory of this process is that the gold soluble in potassium cyanide will be taken up by the dilute solution, this action being hastened by agitation, and the auro-potassium cyanide will be at once decomposed by the electric current, the gold precipitated on the cathode being amalgamated by the latter. As an accessory reaction it is claimed that coarse gold which will not be dissolved by the cyanide solution will be amalgamated directly by the mercury with which it comes in contact. At the completion of the process the pulp, which is mixed with an equal weight of solution, is drawn off, the cyanide which it contains being ignored.

It is asserted that excellent results on a great variety of ores have been obtained by this process in the laboratory experiments made on somewhat large lots, and the names of the inventors guarantee intelligent and conscientious investigation. Extended comment on the process may best be deferred, however, until its results when applied on a large scale have been published. Messrs. Siemens and Halske, in experimenting with mercury cathodes, found that in order to precipitate 100 tons of cyanide solution assaying 0.25 gold per ton in 24 hours 10,000 sq. ft. of cathode surface was required; in order to maintain a bath covering the bottom ¼ in. of mercury was required, or 200 cu. ft., weighing 80 tons,* and the task of recovering the amalgam from this amount of mercury would be no small one.

* A. von Gernet, *Engineering and Mining Journal*, Nov. 3, 1894.

With a mercurial bath on an amalgamated copper plate fixed carefully at a level, it seems that a less thickness than $\frac{1}{4}$ in. would suffice, but since the cathode must fulfill the requirement of large surface exposure the amount of mercury required must in any case be large.

3. OTHER PROCESSES.—Besides the precipitation of gold from cyanide solutions by means of zinc shavings, various other purely chemical processes have been invented. In many of these zinc in a different form has been substituted for shavings—*e.g.*, zinc amalgam and zinc powder, zinc in sheets and granulated zinc. These have failed for purely mechanical reasons, zinc powder because it packs too tightly in the boxes, and amalgam, sheets, and granules because too little surface is offered in comparison with the weight of metal. It has been proposed, however, to precipitate the gold directly in vats by stirring in zinc powder, but at best there does not seem to be any advantage in this method aside from the numerous objections to it that may be raised. Other inventors have substituted for zinc sodium amalgam, aluminum, or carbon.

The Moldenhauer process consists in precipitation of the gold by aluminum in the presence of a free alkali. It is claimed that the aluminum separates gold very quickly from a cyanide solution without itself combining with the cyanogen, but simply reacting with the caustic alkali, forming alumina, while potassium cyanide is regenerated.

$6AuKCy_2 + 6KOH + 2Al + 3H_2O = 6Au + 6KCy + 6HCy + 6KOH + Al_2O_3.$

$6Au + 6KCy + 6HCy + 6KOH + Al_2O_3 = 6Au + 12KCy + 6H_2O + Al_2O_3.$

The discoverer claims that the quantity of aluminum required to effect a complete precipitation of the gold is only one-fourth the amount of zinc needed to produce the same result.

The Johnston process consists in the use of pulverized carbon, preferably in the form of charcoal. The carbon is arranged in a series of filters through which the solution is passed, the precipitated gold being recovered by burning the charcoal. The entire process is analogous to the carbon precipitation of gold from chlorine solution. The inventor claims that 95% of the gold in solution can be recovered in this manner.

The Molloy process, which was once tried in South Africa, but has now been discarded, consisted in the formation of a sodium or potassium amalgam by the decomposition of a carbonate electrolytically on a mercury bath, the alkaline metal thus formed decomposing the auro-potassium cyanide, regenerating potassium cyanide and setting free metallic gold which was amalgamated by the mercury.

$$K_2CO_3 = K_2 + CO_2 + O.$$
$$KAuCy_2 + K = Au + 2KCy.$$

The process was carried out in a vessel the bottom of which was covered with mercury, filled with the gold-bearing cyanide solution. The mercury was charged with the alkaline metal, and the amalgam coming to the surface of the mercury decomposed the gold-potassium cyanide according to the reaction previously stated.

The Parting and Refining of Gold and Silver and the Parting of Platinum and Gold.

By Titus Ulke.

Three general methods are in use for parting gold and silver, known as the nitric-acid, the sulphuric-acid, and the electrolytic process respectively. All of these methods are based on the insolubility of gold in the acids which dissolve the silver, and require that the gold present should not exceed 40% of the alloy to be parted. The separation of silver as well as copper and other impurities from high-grade gold alloys by means of chlorine gas (Miller process), sulphur (Roessler process), or by slagging with fluxes, belongs properly to the province of refining and not to parting. The parting methods will be treated in the following order:

I. The nitric-acid process. Philadelphia Mint.

II. The sulphuric-acid process. A. Ordinary method. New York Assay Office. B. Gutzkow method. Kansas City Smelting Works.

III. Electrolytic parting. A. The old Moebius process. 1. Frankfurt Refinery. 2. Pittsburg Refinery. B. Improved Moebius process. Perth Amboy Refinery.

In addition the separation of gold, platinum, and iridium will be treated; also the refining of gold with chlorine (Miller process). Sydney Mint.

I. THE NITRIC-ACID PROCESS.

This old method was already in use at Venice on a large scale in the fifteenth century. As now practiced at the Philadelphia Mint it is described in the report of the Director of the Mint for 1895 by Dr. D. K. Tuttle, whom we here quote:

"The nitric-acid process consists of the following seven operations: Assorting and proportioning the bullion; granulation of the same; solution of the silver in acid; treatment of the gold residue; precipitation of the silver as chloride; reduction of the chloride by zinc; washing, drying, and melting the parted metals.

"It is of course desirable that the bullion should be approximately free from base metals other than copper. Tin, antimony, and arsenic are especially objectionable, the two former not being soluble in nitric acid. They give insoluble oxides, which remain behind with the gold and must be removed in the crucible by suitable oxidizing fluxes. Copper, on the other hand, acts as a substitute for silver in the parting process, being, as it is, readily soluble in nitric acid. When silver deposits are scarce, therefore, such as contain considerable quantities of copper, whether of gold or silver, are not undesirable, although the copper requires more acid for solution than the silver which it replaces.

"It was originally thought that the proper proportion for parting was three parts silver to one of gold; hence the name 'quartation' given to the process. Experience has shown, however, that a lesser proportion of silver is quite as effective, and that the copper may be considered as silver for parting purposes.

The proportion of gold to silver (and copper) used at the Philadelphia Mint is 1 to $2\frac{1}{3}$.

"The necessary calculations having been made, the deposits are assorted into melts of about 4000 ozs. each, preferably by mingling gold and silver deposits. If the latter are not on hand in sufficient quantity fine silver is substituted. The melt is now brought to fusion in a large crucible, thoroughly mixed, and then by means of a dipping cup is poured into cold water from a height of some 3 ft. The cup is given a peculiar swirling, wavy motion, by which means the thin stream of molten metal is broken up when it strikes the water into leafy granules and hollow spheres to expose as much surface as possible for the action of the acid. These granulations are dissolved in porcelain vessels of about 33 gals. capacity. Twelve such vessels are placed in a large water bath in what is called the parting house. Provision is made for heating the water surrounding the jars, and a connection from the top of the house to a chimney serves to carry off the acid fumes.

"Each jar receives a charge of 190 lbs. of granulations and 175 lbs. strong nitric acid. When the first strong action has subsided steam is admitted to the water surrounding the jars. The metal and acid will about half fill the jar. At intervals of 20 minutes the contents are thoroughly stirred with a wooden paddle, the doors on the side of the house being raised for the purpose. The charge is kept boiling gently during 6 hours, by which time most of the silver will have been dissolved, leaving the gold as a granular sediment. The steam is turned off from the bath and hot water added to the jars to dilute the strong silver solution. After subsidence of the gold the clear solution, containing silver, copper, lead, etc., is siphoned off and transferred to the precipitation tank. The jars are again filled with hot water, the contents well stirred, and again allowed to settle. The clear liquid is added to the first and 50 lbs. of fresh strong acid added to each jar. The boiling is renewed for 5 or 6 hours, when washing of the gold by decantation is several times repeated. The gold sediment is now transferred to a lead-lined tub mounted upon a truck. This tub has placed in it a perforated false bottom, which is carefully covered with cotton cloth, the whole constituting a large colander or movable filter. Water is now passed through the gold until most of the silver has been removed, the wash waters being transferred as before to the large tank for precipitation.

"From this filter the gold is transferred to cast-iron pots, in which it receives a boiling in strong sulphuric acid to which a small quantity of niter is added. This treatment extracts an additional portion of silver and materially increases the fineness of the gold. The strongly acid liquor is ladled off into vessels partly filled with water. From this solution the silver and a little gold are periodically recovered as residues. The gold is thrown from the iron pots into water, washed a number of times by decantation, and then thoroughly sweetened on a portable tub filter such as has been described. It is now dried and melted. If a sample bar, upon trial, proves to be tough, the melt is now ladled into iron molds, giving bars of some 300 to 400 ozs. each. If the trial bar is brittle the molten mass is fluxed with niter through an 'eye' of boneash. The niter oxidizes lead, antimony, arsenic, sulphur, etc., the products being absorbed by the boneash cover.

About 6000 ozs. constitute such a melt, and we have some 15 bars of a fineness of 998 or 999, and worth, say, $8000 each.

"*Recovery of the Silver.*—The silver solutions, together with the wash waters from the gold treatment described, are transferred to a large precipitation tank having a capacity of some 2000 gals. This is never filled to its full capacity, since abundant room must be left for stirring and rousing the contents. Salt water is now run into the silver solution until a test shows that enough has been added to convert all silver present into chloride. An excess is avoided, since silver chloride is slightly soluble in salt water. The contents of the large tub are now drawn off through a filter. This is a wooden tank $6\frac{1}{2}$ ft. long, 3 wide, and $1\frac{1}{4}$ in depth, lead lined and provided with a perforated false bottom. The bottom and sides of this tank are carefully covered with cotton cloths as a filtering medium. The curd-like silver chloride is run into this filter through a large wooden stopcock. The liquid which drains off is returned to the filter until it runs clear, after which it is passed through several traps to the sewer. Fresh water is passed through the chloride until all soluble matters are removed, when it is allowed to drain. The filter tank is mounted on low wheels for convenience of moving the chloride to the reducing vat. This is again a lead-lined rectangular tank. The silver chloride is transferred to this tank by means of a copper scoop shovel. Hot water is run on and granulated zinc added in sufficient quantity to reduce the chloride to metallic silver. The addition of sulphuric acid hastens the action and serves to dissolve the slight surplus of zinc which it is necessary to use to insure complete conversion into metallic silver. The reduced silver is now taken out with a copper scoop having a shovel handle and put into a filter colander, such as was described previously when speaking of gold treatment. In this colander the silver is washed with hot water until entirely sweet. It is now ready for compression into solid cakes by hydraulic pressure. These cakes are dried in a current of hot air, when they are ready for melting. This is usually done without fluxes, and the resulting bars have a fineness of 998 to 999."

In addition to the above, it may be stated that the cost of parting gold and silver and delivering them in fine bars averages between $30 and $35 per melt of 2400 ozs. for material used in refining by the nitric-acid process.

II. THE SULPHURIC-ACID PROCESS.

As the silver sulphate formed in this process is reduced with metallic copper or iron or with ferrous sulphate, we may distinguish the ordinary method and the so-called Gutzkow method.

A. *Ordinary Method.*—Dr. Tuttle describes the New York Assay Office practice as follows: "Thoroughly satisfactory as is the nitric-acid process so far as its effectiveness is concerned and the high grade of gold and silver which it yields, yet the comparatively high price of nitric acid and the necessity of using either platinum or porcelain vessels led to its being superseded in modern plants by the sulphuric-acid parting process. Diluted sulphuric acid has no action on silver, but the strong acid when heated is decomposed by that metal, giving off sulphurous acid and forming silver oxide, which passes into solution in the excess of acid as silver sulphate. If gold is present in moderate percentage, say not to exceed one-third of the whole, strong sulphuric acid will extract the silver and leave the gold as a granular brown sediment. Should the bullion contain anything like one-half gold, the latter metal will protect the silver against acid attack and the result will be failure. It is therefore the business of the refiner to adjust for the melting pot gold deposits with those of silver carrying small quantities of gold, or failing such, to add fine silver so as to have from two to three parts of silver for each part of gold. Such an admixture is melted in a large crucible, thoroughly mixed, and then with a dipping cup is poured into cold water, as described in speaking of the nitric-acid process.

"But the proper adjustment of silver to the gold is not the only point requiring care. Most bullion coming to the refinery contains varying quantities of copper, and this metal works very badly in strong sulphuric acid, although it is the least objectionable metal in the nitric-acid treatment. While decomposing the acid with formation of copper sulphate, this latter, unlike the silver sulphate, is insoluble in oil of vitriol; hence if present in any considerable quantity copper soon acts as a protector to the bullion, and the chemical action either ceases or becomes tediously slow. Besides apportioning the silver to gold, it is necessary to so combine deposits that the granulations do not contain more than 6 to 8% of copper.

"*Dissolving the Silver.*—The success of this beautiful process really depends upon the happy observation that while weak sulphuric acid rapidly dissolves iron, yet if the acid be strong enough it has no appreciable action—just the reverse of its relations to silver. Cast-iron vessels may therefore be employed. A cast-iron kettle will last for years, during which time hundreds of tons of silver may be dissolved in it by boiling oil of vitriol. Large iron kettles 1.2 meters wide, 0.7 meter deep, and 0.04 meter thick are used, weighing half a ton, mounted over a furnace. Into the kettle a charge of 300 to 400 lbs. of the granulated bullion is placed and covered with three or four times its weight of acid of 66° B. Heat is applied, when a lively evolution of sulphuric acid sets in, which if too violent must be checked by the addition of a little cold acid and slacking of the fire. This boiling is continued for several hours, during which time the escaping and consumed acid are gradually replaced. When the solution is complete the fire is withdrawn and the contents of the kettle allowed to settle quietly. A little cold acid is added to aid the precipitation of any suspended gold. Hoods over the kettles carry off the fumes to condensing and suppression apparatus. The strongly acid solution while still hot is siphoned into the reducing houses. These are long rectangular vats lined with lead and provided with sloping covers like the roof of a house. These covers are hinged to what would be the ridge pole and are counterbalanced so as to be easily raised. Slabs or ingots of metallic copper are placed on the bottom and sides of these vats, which are then partly filled with cold water. The hot silver solution is then run in. A lively commotion ensues, as will readily be imagined when one recalls the heat evolved by the mingling of cold oil of vitriol with water. In this case the acid is nearly at its boiling point. The result is a weak solution of silver sulphate, rendered milky by the separation of fine crystals of that salt, the solubility of which is very slight in pure water. The copper immediately begins to precipitate the silver as a beautiful crystalline moss, easily detachable from the plates when the operation is complete. This requires about 24 hours. Meanwhile the copper has taken the place of silver, and we have now a strong solution of copper sulphate (blue vitriol). This blue solution is drawn off for crystallization and the spongy silver carefully transferred to leaching tubs for thorough sweetening with fresh water. The silver, now in the form of minute flaky crystals, is compacted into cakes by means of hydraulic pressure and these cakes dried in a current of warm air, after which a simple fusion in a black-lead crucible without fluxes gives a bullion 998 or 999 fine. If selenium or tellurium is present in the bullion it will pass into solution with the silver and be deposited with it by the copper plates. In this case the spongy silver will be dark-colored and the melt will be brittle. It must then be fluxed with niter. The sulphate of copper is a staple article of commerce and is carefully prepared for the market.

"We left the gold as a sediment in the large iron dissolving kettle. A small quantity of fresh acid is added and the gold then removed to a smaller vessel by an iron ladle perforated with holes. It is transferred to another iron pot, in which it receives a number of repeated boilings with fresh strong acid. There are not less than five such boilings. The finishing acids are siphoned off and used upon fresh charges of bullion. The gold is now transferred to a tub, in which it is washed, first with cold water and then with hot. These washings find their way to the silver-precipitating tanks. It is now transferred to a lead-lined vat mounted upon a truck. This vat has a perforated false bottom, which is carefully covered with cloth, the whole constituting a large movable filter. Water is now passed through the gold in this filter until it is entirely sweet. If the gold is in coarse particles it may be dried and melted without danger of its being mechanically carried off while placing it into crucibles, but if very fine it is compacted into cakes while wet by hydraulic pressure. These cakes are dried, as were those of silver, in a current of warm air and melted in a graphite crucible. A trial sample is taken to see if the metal is tough. The presence of even small quantities of lead will render the gold brittle, in which case it is fluxed with niter through an 'eye' in a cover of boneash. When tough it is ladled into an iron mold. About 6000 ozs. constitute such a bar melt. The bars are worth about $8000 each."

B. *The Gutzkow Method.*—The Gutzkow method, as introduced in 1867 into the San Francisco Assaying Works, effects the recovery of the silver from the sulphate solution obtained in dissolving bullion by sulphuric acid with ferrous sulphate. This reduction is preceded by the separation of monosulphate of silver by introducing steam into the sulphate solution until the free acid present is diluted to about 62° B., followed by cooling to, say, 80° F. The yellow crystals of monosulphate thus secured only block up about half as much sulphuric acid for the same weight of silver as the greenish-white bisulphate, obtained by the ordinary method of parting. According to the well-known reaction $Ag_2 + 2H_2SO_4 = Ag_2SO_4 + 2H_2O + SO_2$, one part by weight of silver in forming Ag_2SO_4 requires about one part by weight of H_2SO_4. An additional portion (from one to one and one-half parts by weight) of H_2SO_4 is required to hold the Ag_2SO_4 in solution. In the Gutzkow process this last acid is replaced by the mother liquor from a previous silver-sulphate crystallization. This process, therefore, only requires from one-half to two-thirds the total quantity of acid consumed by the ordinary method, in which the mother liquor from the silver sulphate, after the blue vitriol has been taken out, is so dilute that it is not further utilized. From these and other considerations it appears that the Gutzkow method is more expeditious and less expensive than the ordinary method of sulphuric-acid parting.

In the *Engineering and Mining Journal* of February 28, 1891, and May 7, 1892, Gutzkow described certain modifications of his process by which he claimed to have greatly cheapened and simplified the apparatus and manipulations. Two of these so-called improvements relate to the reduction of silver sulphate with iron and with charcoal. In the latter process, according to Gutzkow the sweetened crystals from 400 lbs. of bullion, which measure about 3 cu. ft., are dried and mixed with about 5% of charcoal and charged into a hot crucible in the melting furnace. The silver sulphate is reduced to metallic silver at a red heat, with the evolution of sulphurous and carbonic acid gas. It is stated that the escaping gases cause but little trouble, as no traces of them are left by the time the temperature of melting silver is reached. The silver is finally toughened with niter in the usual way.

In commenting upon the above, we may state that the reduction of the silver sulphate by means of metallic iron is accompanied by the formation of basic salts of iron, which can only be removed from the reduced silver with difficulty by fluxing. Secondly, the reduction of silver sulphate by charcoal is impracticable, owing to the great volume of objectionable gases evolved, probably accompanied by heavy losses of silver. Both of these so-called improvements were tried by the Consolidated Kansas City Smelting and Refining Company and abandoned. Gutzkow's original method of reducing the silver sulphate with a solution of green vitriol, according to the reactions $Ag_2SO_4 + 2FeSO_4 = 2Ag + Fe_2(SO_4)_3$ and $Fe_2(SO_4)_3 + Fe = 3FeSO_4$, has given the best results from a business standpoint. It has been worked out in all its detail and is used on a very large scale at the works of the Consolidated Kansas City Smelting and Refining Company, at Argentine, Kan. Prof. W. Jones, late superintendent of the refining department, has kindly furnished the following description:

The original parting plant at Argentine, Kan., had a daily capacity of 12,500 ozs. of doré bullion and occupied a building 40x40 ft. and two stories high, the upper floor being only used as a storeroom and for condensing the acid fumes from the dissolving kettles. The expense of parting was 0.35c. per oz.

During the spring of 1895 the plant was rebuilt for a capacity of 36,000 ozs. per day of 12 hours, as no work is done in this department at night. The building now covers an area of 100x40 ft. There are 6 dissolving kettles, arranged in pairs, so that either 2, 4, or 6 can be used at the same time. The tanks, arranged to correspond in position and capacity, comprise 2 settling tanks and 3 crystallizing tanks, all of cast iron; then there are 2 lead-lined wooden tanks for holding the ferric sulphate, 3 for holding the wash waters, 1 large tank for holding the ferrous sulphate, and the necessary acid tanks.

The process is carried on as follows: The doré is cast into slabs 12x12x¼ in. These are weighed up into 6000-oz. charges for each kettle and are charged at 6 A.M. The supply of acid for each pair of kettles is drawn from the storage tank into an iron tank immediately back of the kettles. This is supplied with a gauge tube, which shows the amount of acid used. The dissolving takes about 2 to 3 hours and is accomplished with the use of about one and a half times the weight of the doré in strong acid. As soon as the silver is dissolved the mother liquor from the previous crystallization is slowly run in. After allowing the kettle to stand a few minutes for any fine gold to settle, the solution is siphoned off into a settling tank, in which any gold which might come over is retained. From this tank the solution is siphoned into the crystallizing tank. The latter is made double and so connected that either steam or hot water can be run between the inner and outer walls. Steam is run in to heat the tank before the liquor is brought into it, to prevent the deposition of bisulphate of silver, which is very objectionable. Into the solution in this tank dry steam is injected through a lead pipe. The steam being at once taken up by the acid produces a large amount of heat and at the same time dilutes the acid, while holding the silver in solution. The steam is not shut off until a cooled sample of the solution shows only the monosulphate of silver in yellow arrow-shaped crystals, and not the bisulphate, which is white, crystallizes in star shape, and is troublesome to reduce by ferrous sulphate. The solution now being exceedingly hot, even steam run through the double tank has a cooling effect. The tank in time becomes cool enough to allow cold water to be turned on to hasten the cooling, and then it is left to itself until the next morning.

Returning to the kettles, the condensation of the acid fumes, which have been found from experience to carry a large amount of silver, is accomplished as follows: A 10-in. lead fume pipe about 12 ft. high leads from the kettle to the floor above, where it enters a lead chamber 80 ft. long immersed in a tank of cold water through which a circulation is kept up. The fumes passing through here enter a series of 3 chambers each 7x7x6 ft. and finally pass to the flue. The condensed acid from these various chambers is collected in a small tank and is used in many places where a weak acid is needed, such as in washing the reduced silver to free it from iron. After the introduction of this system of condensation there were no longer any appreciable losses in silver.

The gold remaining in the kettle, still very hot, is now treated as follows: First 10 to 20 lbs. of strong acid are added, which cools it and keeps the silver from settling out as bisulphate. This small amount of acid is added to the next charge and so makes no extra cost, and at the same time leaves the gold quite free from silver, so that the gold can be well sweetened in about 2 hours. This sweetening takes place in a circular tub containing a filter about 2 in. from the bottom. The gold is placed on this filter and boiling water is run in from the bottom and overflows through an outlet near the top. This method, it is believed, does the work quicker and carries off less of the fine gold than when the water is run in from the top. The gold is then dried in steel pans on the back of the melting furnace and is at once charged into a graphite crucible in which some borax has previously been melted. The gold is cast into bars of the required size and is shipped on the same day, usually in less than 10 hours from the time the doré is charged into the kettles. It averages 990 fine, the impurity being chiefly silver. No attempt is made to have the gold any finer, as it is only boiled once with acid, so as to permit of its being shipped in the above time.

The next morning the mother liquor is drawn off from the silver-sulphate crystals by a vacuum pump into a large storage tank ready for use in the kettles.

The crystals of monosulphate of silver are gathered into a reduction box. This is a lead-lined box 2½ ft. square and 1½ ft. deep, with a false bottom about 2 in. from the real bottom and an outlet between the two. A small quantity of cold water is run through the crystals to remove the free acid and any sulphate of lead that may have been formed. The crystals are now ready for reduction with a practically neutral solution of ferrous sulphate at 20° B. and 100° F. This is run over the crystals until they are entirely reduced to metallic silver. The latter is well washed with water and dilute acid to remove all iron salts, dried, and melted in a retort to fine silver 999 fine. It is usually shipped on the second day following the one on which the doré is charged. The iron solution, which is now in the shape of ferric sulphate, holds in solution any copper which may have been present, as well as considerable silver (3 to 5%). By the introduction of metallic iron we reduce the liquor back to ferrous sulphate and at the same time precipitate the silver and copper. This precipitate is added to the next day's run, the copper being dissolved by the ferric sulphate formed. A certain amount of this solution is drawn off each day and, together with the various wash waters, thoroughly reduced with iron, the resulting ferrous sulphate solution now free from silver or copper being thrown away, so as to keep all of the solutions down to the proper bulk. The precipitate from the wash-water tanks contains practically all the copper which enters the plant, together with some silver; this is returned to the refinery and cupelled to fine silver along with the regular work.

The daily cost of parting 36,000 ozs. of doré (containing on an average 4% of gold and 95% of silver) in the above plant is as follows:

Labor:	
1 foreman	$2.50
1 second man	2.25
4 helpers at $2.00	8.00
Total labor	$12.75
Fuel (including 100 gals. oil at 3.15c. per gal.)	7.00
Acid (3600 lbs. at 1c. per lb.)	36.00
Scrap iron (600 lbs. at 0.4c. per lb.)	2.50
Repairs	2.00
Contingencies	5.00
Interest on $15,000 plant at 6%	2.50
Interest on stock at 6% (100,000 ozs. of doré at 70c. per oz.)	11.66
Daily cost of parting 36,000 ozs	$79.41

Or 0.2206c. per oz. This does not include superintendency and office charges.

In nearly all American refineries the bullion to be parted is not granulated, but is charged in the dissolving kettles in the shape of thin plates or bars, a charge weighing about 250 kgms. In this way there is less foaming of the solution than when granulations are used, and the solution can therefore be kept boiling more steadily and the dissolving be accomplished more rapidly.

In certain European refineries (Lautenthal, Frankfurt-am-Main) the gold residue, instead of being refined by acids and fluxing as above described, is dissolved in aqua regia and the gold reprecipitated by a ferrous salt. The gold is then filtered off, washed until sweet, and after melting with a suitable flux cast into bars. At Freiberg the gold residue is fluxed with bisulphate of soda and afterward with niter. Scrap iron instead of copper is used at Lautenthal to reduce the silver sulphate to metal.*

III. ELECTROLYTIC PARTING.

In the electrolytic parting of silver and gold it is not necessary to obtain the deposited metal in sheet form, as silver in crystals is readily melted into bars. Owing to the great value of the metals treated, the chief aim is to secure a rapid output. As high a current density is therefore employed as is possible without unduly heating the electrolyte or carrying over impurities from the anode. Short circuits produced by the bridging over of silver crystals from cathode to anode when high-current densities are used can be avoided by scraping off the silver crystals. These fundamental principles were first recognized and commercially applied by B. Moebius, who in 1884 and in 1895 respectively patented the two forms of apparatus described below. Thus far no other inventor seems to have been commercially successful in this field. As the process involves the use of a fixed or rotating cathode, we may distinguish, 1, the old Moebius process, in operation at the Deutsche Gold- und Silber- Scheide Anstalt of Frankfurt-am-Main, Germany, and at the Pennsylvania Lead Company's works, near Pittsburg, Pa., and, 2, the improved Moebius process, in successful operation at the Guggenheim Works, Perth Amboy, N. J.

A. *The Old Moebius Process.*—1. To the information contained in THE MINERAL INDUSTRY, Vol. II., pp. 279, 280, and Vol. III., p. 191, we may add the following detailed description of the electrolytic refinery at Frankfurt-am-Main, a general view of which is shown in the accompanying engraving from a photograph. For Figs. 1 to 5 and the accompanying text we are indebted to Borcher's *Elektrometallurgie*, 1896, and to the kindness of Dr. B. Moebius, of New York:

The electrolytic vats consist of tarred pitch pine tanks, about 0.6 meter wide and 3.75 meters long, partitioned off into 7 cells. Each cell is provided with 3 rows of anodes which hang in cotton sacks and 4 cathodes. To a frame running on the tank sides are fixed a number of wooden scrapers for breaking off the silver crystals from the cathodes. Beneath the electrodes is a box-like frame, over which a cloth is stretched to catch the silver broken off by the scrapers. When cleaning up the silver this entire apparatus, including box, electrodes, and scrapers, is raised out of the tank by means of a large frame and windlass. The anodes *a* are cast doré-silver plates of the form shown in Fig. 1 and are of about 6 to 10 mm. in thickness. By means of double hooks (*h*, Fig. 3) resembling miniature ice tongs these plates are suspended from a metal frame, *R* (Figs. 1, 3, and 4), which not only serves as anode holder, but also conveys the current from the conductor *P* to the anodes. The frame *R* is insulated from the negative conductor *N* by rubber, *I*. To keep the gold residue at the anodes from mixing with the silver dropping from the cathodes, the former are inclosed in cotton sacks, *B*, stretched on wooden frames, *G* (Figs. 1 and 3), suspended from the metal frame *R*. The cathodes *k* consist of thin plates of sheet silver soldered to a horizontal bar of copper. The projecting ends of the bars are provided with

* For details of the European practice see the excellent *Handbuch der Metallhüttenkunde*, by Dr. C. Schnabel, Berlin, 1894.

supporting clamps, hanging on the two conductors P and N running above the tanks, and in circuit with $-N$, but insulated from $+P$. The conductors consist of rods of copper, brass, or bronze strong enough to safely carry

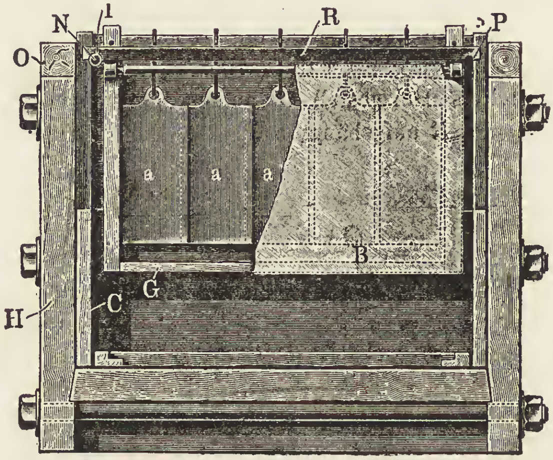


FIG. 1.—SECTION OF ANODE COMPARTMENT.

the weight of the electrodes. The 7 cells of a tank are in series circuit, as is shown by diagram (Fig. 5). The scrapers consist of wooden slats, *s* (Figs. 2, 3, and 4), two for every cathode, attached to the movable frame *F*. The latter

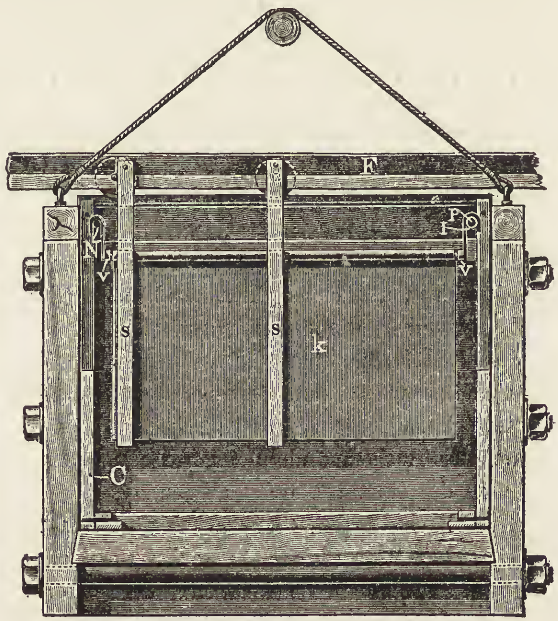
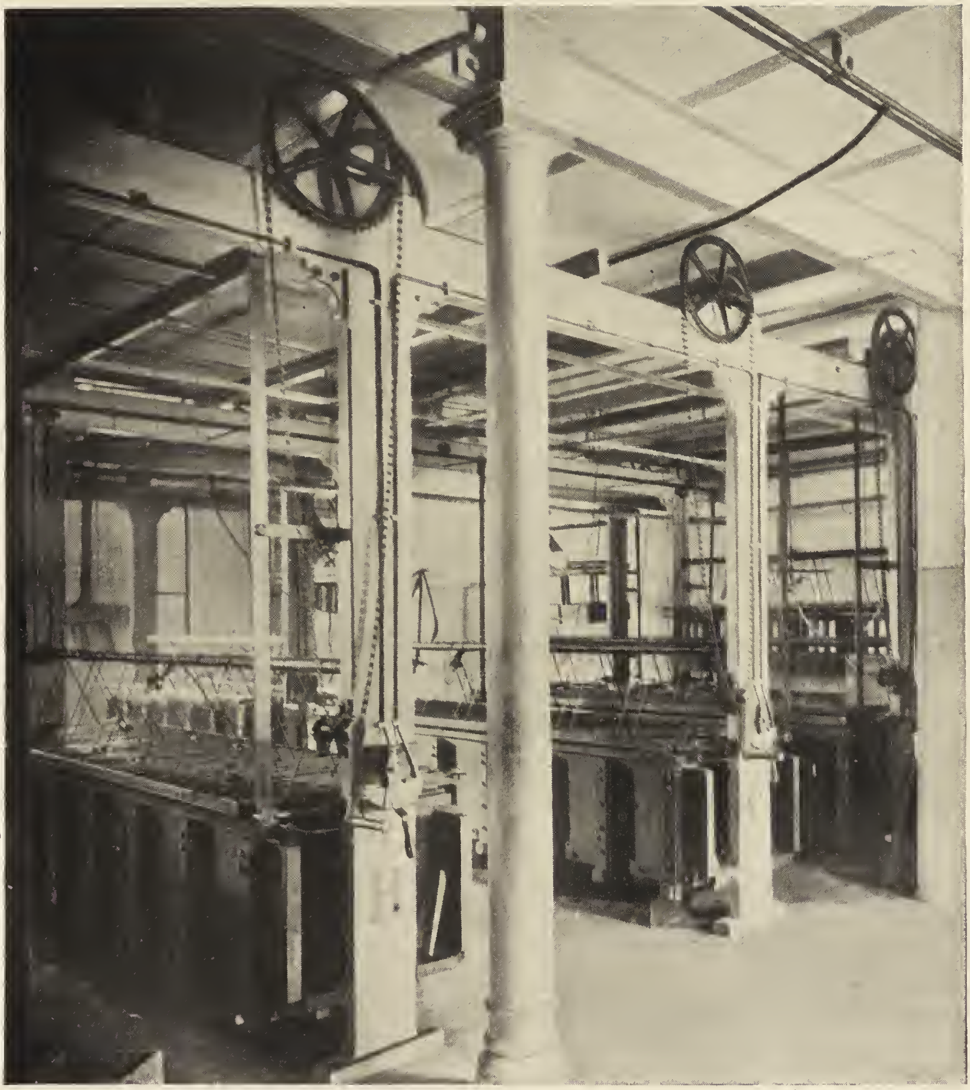


FIG. 2.—SECTION OF CATHODE.

runs on the track *n*, supported on stringers forming part of the frame *O*, which rests on top of the tank walls. The frames *F* receive their motion from a sliding



ELECTROLYTIC PARTING, MOEBIUS PROCESS.

DEUTSCHE GOLD UND SILBER SCHEIDEANSTALT, FRANKFURT, A/M.

cam rail moved back and forward by means of an eccentric. The frame *O*, to which is attached all the apparatus suspended in the solution, can easily be raised or lowered by a windlass. The collecting box *C* for the loose silver finally is a flat box loosely fitting into each tank cell. By means of slats attached to its sides the box can be fastened to the electrode frame and thus be lifted out of the solution. The bottom of the collecting box is formed by a wooden grid fastened to the box frame by means of bolts and hinges, and over which is stretched coarse sack linen to hold back the silver mud when the collecting box is lifted out of the tank. When the bolts are pushed back the grid bottom opens and drops its load of silver crystals into a shoot and receiving tank.

The apparatus is operated as follows: The tanks are filled with an acidified weak solution of silver and copper nitrate. After lowering the movable apparatus into position it is connected with the dynamo by automatic switches. At the

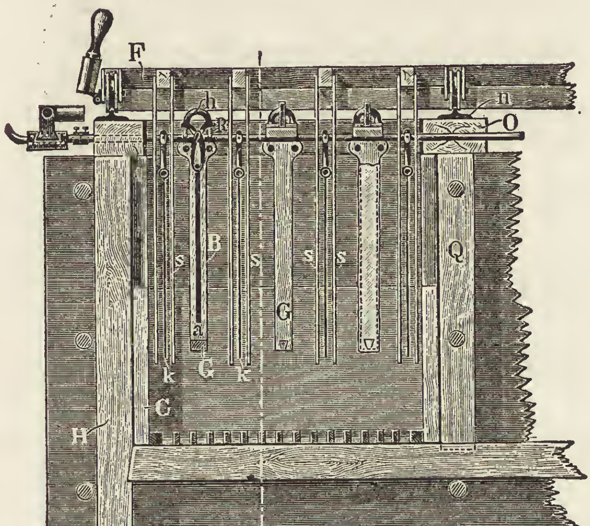


FIG. 3.—SECTION ALONG LINE A, B, C, D, E.

start, and as long as the solution is relatively poor in copper, the density of the current may be as high as 250 ampères for the total cathode surface in each cell, which equals 0.5 sq. meter. But eventually the electrolyte is enriched in copper (coming from the anodes, which vary from 950 to 980 in fineness) to such an extent that the current density must be lowered to about 180 ampères per 0.5 sq. meter and more nitric acid must be added. The solution naturally varies in composition with the bullion treated. It averages 0.5% Ag and 0.1% free nitric acid, and may contain as much as 5% Cu without causing the latter to deposit with the silver. The electromotive force required for each cell is about 1.4 to 1.5 volts. In each cell (Figs. 1–5) from 22 to 26 kgms. of fine silver are deposited on the cathodes in 36 hours with a current of 150 to 180 ampères. If 3 rows, each of 5 anodes of the above dimensions, are placed in every cell, the soluble quantity of each anode being taken as weighing 1.5 kgms., the entire doré-silver charge may be deposited in 30 to 36 hours. It is possible, therefore, to refine and part a very large quantity of doré in very limited room and in a short time.

The operating costs are low, the gold extraction is nearly perfect, no obnoxious gases are evolved excepting when boiling the gold, and the mechanical losses of parting are reduced to a minimum.

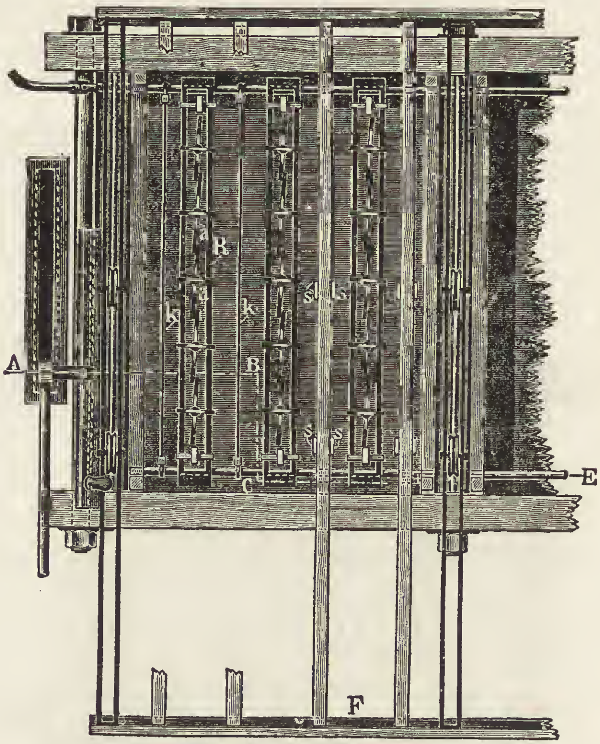


Fig. 4.—Plan View.

Notwithstanding the high density of current used, the temperature of the solution is but slightly raised, partly because of the excellent conductivity of the electrodes and electrolyte, and partly on account of the good circulation of the

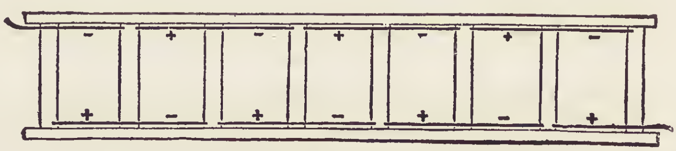


Fig. 5.—Diagram of Current in Tank.

latter produced by the scrapers. Once in 24 hours the main frames on the tanks are raised and the silver removed from the collecting boxes. To accomplish this the latter are drained from surplus solution, lifted from the electrode frame, and their silver contents finally emptied into a movable washing tank, through shoots fixed to the latter, by pushing back the bolts in the bottom of the collecting box as previously described. The silver crystals are washed, dried on the filter bottom of the washing tank by air exhaustion, and melted in the usual way. According to the percentage of gold in the anodes, the residues from the latter contained in the anode sacks are emptied once or twice per week. The mode of treating the gold residues, which average from 600 to 800 fine in gold, depends largely upon their chemical composition. The Frankfurt plant occupies an area of 40x45 ft. (13x14 meters) for a parting capacity of 30,000 ozs.

2. The Pittsburg parting plant of the Pennsylvania Lead Company has been operated since 1886, and with 84 electrolytic cells running continually out of a total of 98 produces 1244 kgms. fine silver daily.* The doré to be parted is refined on the cupel until it contains not over 2% of impurities (lead, copper, bismuth). If more impure silver is treated there is more or less trouble with accumulations of copper and lead in the solutions, with consequent large amounts of by-products and also increased difficulty in turning out a pure product. The anode plates are cast 45x25x1.3 cm. in size and weigh 13 to 15 kgms. Each plate has three projections or lugs on one of the long sides. Holes are punched in these lugs to receive the wires which suspend the plate in solution. The three supporting wires (5 mm. in diameter) are attached to a copper rod 73 cm. long and 1.3 cm. in diameter. The cathodes are rolled fine silver sheets, 33x55x0.2 cm. There are 14 tanks, each containing 7 cells. The tanks are made of California redwood plank joined together very carefully. The bottom is lined with sheet rubber. Each tank is 305 cm. long, 61 cm. wide, and 55 cm. deep (inside measurement), the separate cells or baths being about 61 cm. long by 46 cm. wide.

The electrolyte is a solution of silver and copper nitrate, acidified with ½ to 1% free nitric acid to prevent the copper from being deposited with the silver. The consumption of nitric acid is less than ½ liter every 24 hours. In every cell 4 cathodes alternate, with 3 anodes with a space of 4.3 mm. between the electrodes. The current, which is conducted to the baths through copper rods 1.6 cm. in diameter, has usually a density of 18 ampères per sq. ft. (0.093 sq. meter) of cathode surface. The details of the Pittsburg plant are very similar to those of the German refinery described above.

According to Mr. Faunce, each kilogram of silver deposited consumes about ⅖ horse-power per hour. Although, theoretically, 70 baths should deposit 1219.3 kgms. (39,205 ozs.) of silver per day, in practice this yield is not obtained for several reasons:

(1) The anodes have to be drawn up out of the baths for the purpose of cleaning up the gold and silver. This consumes considerable time each day.

(2) Shorter interruptions of the deposition are necessary for replacing anodes, cleaning connections, examining insulations, etc.

(3) With the small machine used, which is not quite large enough for the work put upon it, constant vigilance is necessary to keep the current up to 180 ampères throughout the 24 hours, and of course any lowering of the intensity of the current means a proportionate decrease in the output. The actual working results day in and day out will average 33,000 ozs. per day for the 70 baths. They could for a short time deposit in the whole plant 45,000 to 50,000 ozs. per day, but in the long run it will be found necessary to keep about one-seventh of

* See description of this plant by George Faunce in the *Journal of the Franklin Institute*, October, 1895.

the tanks under repair all the time. The labor required in the process is slight. A carpenter is employed constantly in repairing and rebuilding tanks, making brushes, boxes, etc. A mason and a machinist are needed about one day each week for other repairs. Three men on day turn and one at night are all that are required to do the regular work, which consists of cleaning up and melting the fine silver, preparing the anodes and placing them in the bath at the proper time, cleaning up and refining the gold slimes, melting scrap silver, keeping connections clean and insulations perfect. Each tank is cleaned of silver every other day and of gold once a week. A full-sized anode is dissolved in about two and one-half days.

The deposited silver as soon as it is taken from the tanks is washed thoroughly with hot water, in order to rinse out the copper-bearing solution. It is then melted down in a large plumbago retort which is capable of holding 18,000 ozs. (or 1200 lbs. avoirdupois). Each retort melts on the average about 5 tons before breaking. The fineness of the silver produced is 999, often 999½. By repeated washings it is possible to obtain silver as fine as 999.85. The gold slimes are melted, granulated, and parted by nitric acid. The resulting gold is 996 to 998 fine.

The electrolyte is of a beautiful green color, due to the presence of 4 or 5% of copper. It also contains a small percentage of lead. When these three metals are in nitric solution the silver (being the most electro-negative) is deposited before the others. So long as the copper and lead are not present in too large quantities and so long as a proper amount of acid is used, the silver will be deposited in a state of almost absolute purity. As the copper and lead accumulate to a dangerous degree, it becomes necessary to withdraw part of the solution, and after throwing down the silver with salt to precipitate the copper and lead. If the anodes are too rich in copper the silver deposited is not fine. The necessity of previously removing the excess of copper by cupellation or other means is therefore evident.

It may be well to remark here that light and thin anodes (0.6 cm. thick and weighing 1.5 kgms. used at Frankfurt) are much to be preferred to thick and heavy anodes, such as are used at the Pittsburg Refinery, where they are 1.3 cm. thick and weigh about 13.6 kgms., for the following reasons: The former are cast in open molds, are suspended on a single hook, are dissolved more completely and therefore leave less scrap, and are handled easier than the large anodes, which are cast in closed molds, are suspended at three points, are more likely to cause damage in falling, leave a much greater amount of anode scrap than the lighter anodes, and which also represent a greater investment for the same output.

In 1895 the production of electrolytic silver in the United States was about 10,000,000 ozs., or about one-seventh of the total silver output.

B. *The Improved Moebius Process.*—This process represents the latest improvement in electrolytic refining. An improved form of the apparatus, described in THE MINERAL INDUSTRY, Vol. III., pp. 189, 190, is now in successful operation in the parting plant of the Guggenheim Smelting Company, Perth Amboy, N. J. The following is the first detailed description of it that has been given:

The silver refinery, which is 40 ft. wide by 80 ft. long, exclusive of the melting and weighing room, was built large enough to allow ample room for increasing the plant to twice its present capacity. It contains 48 electrolytic tanks, arranged in 8 groups of 6 each. Every group is surrounded by an aisle about 4 ft. wide and consists of 2 sets of 3 tanks placed one above the other at intervals of 18 in. The two sets of every group are 15 in. apart and are 5 ft. 6 in. high from floor to top of the uppermost tank. The tanks are constructed of 2-in. pitch pine coated with acid-proof paint and measure 14 ft. 3 in. long, 16 in. wide, and 7 in. high. The floor of the building is of cement, made sloping so as to drain to a cemented collecting pit 30 ft. long by 4 ft. wide and deep. The electrolytic solution is prepared in a tank placed in this pit by dissolving granulated silver in nitric acid (38° B.) and adding water, soda nitrate, and some nitrate of copper to start the deposition. When normal it contains about 0.1% of free acid, with 4 to 5% of copper and about 12 ozs. of silver per cu. ft. of electrolyte. Sulphuric acid is occasionally added to precipitate any lead present. The solution is gradually enriched in copper as the electro-deposition proceeds, and a portion is finally rejected, say once in four months, and fresh solution added to prevent copper from being deposited with the silver. Copper in dissolving to cupric nitrate requires nearly three and a half times as much nitric acid as is required by the same weight of silver; nitric acid must therefore be added more frequently with doré rich in copper than with doré comparatively free from this metal. The consumption of nitric acid is about 1½ lbs. for every 1000 ozs. of doré parted.

In each tank are placed 6 frames (18 in. square and 1 in. deep) over which muslin diaphragms are stretched. The frames are divided by strips into four sections, in each of which an anode is placed. These doré anodes contain about 980 parts of silver and 3 to 8 parts of gold and are 15x3½x½ in. in size. Running underneath and within ½ in. of the muslin diaphragm is a belt 31 ft. long by 15 in. wide, which was originally made of rubber-lined silver. Owing to the buckling of the rubber exposed to the solution, belts of rolled sheet silver $\frac{1}{32}$ in. thick were substituted. At first the silver belts were coated with an insulating layer of gutta-percha on their under side to prevent the unnecessary deposition of silver thereupon. This is not done at present, but the upper or outer side of the belt is painted with a graphitic composition. Such a preparation of the surface of the belt once every two weeks after the first month's run is deemed necessary in order to facilitate the scraping off of the silver by the fixed brushes used for that purpose; otherwise the silver adheres too firmly to the belt, causing a rapid increase in thickness, brittleness, and eventually a rupture of the same. The belt is moved at a speed of about 3 ft. per minute over gutta-percha rolls. About 3 horse-power are required to drive the chain and gearing which move the belts. The scraper or knife edge of hard rubber formerly used has now been discarded in favor of thin rush-wood brushes placed outside of the solution and easily adjustable.

The circulation is effected by overflow from one top tank to the next across and down. The lowest tank empties into the collecting reservoir, in which the solution is standardized by the addition of acid, water, and silver nitrate. From the collecting reservoir an acid pump made of stoneware forces the solution into a distributing tank, which supplies the electrolytic cells with fresh solution.

A 40 horse-power Westinghouse engine, amply large enough for an eventual increased capacity of plant, drives a General Electric generator capable of delivering 300 ampères at 150 volts, but at present furnishing 220 ampères at 90 volts for depositing 24,000 ozs. daily. By means of a plate-current regulator the voltage is adjusted to the number of tanks in circuit. The current reaches the anodes through platinum-tipped contact levers and passes to the belt, which is placed in circuit by means of silver contact brushes. The tanks are electrically connected in series, and require each about 1½ to 2 volts to overcome the resistance to the passage of the current. In order to take up the pressure of the contact lever upon the diaphragm when the anode is nearly all dissolved, the diaphragm is strengthened by an extra thickness or bridge of muslin in its middle portion, or a pin or lever rest is employed.

The fine silver crystals scraped from the belt drop through a closed shoot into a bin placed at the end of each set of tanks. They are washed in a double-bottomed vat by exhausting the air underneath the false bottom, and while still in a moist condition charged into graphite retorts and melted into bricks weighing each about 70 lbs. Scrap copper is added during melting in order to bring down the percentage of silver in the bricks to 998 parts in 1000, as any excess of silver is not paid for by English purchasers. Usually not even a trace of gold can be found in the fine silver. The anode residue contains besides the gold considerable superoxide of silver, bismuth, lead, and antimony. It is washed, dried, charged into a graphite retort, and melted. By skimming off the slag the main bulk of the impurities may be removed. The metal then is either alloyed with silver and granulated for final parting or it is cast into bars and again subjected to electrolysis to concentrate its contents in gold. The granulated alloy, containing about 3 parts of silver to 1 of gold, is parted with nitric acid in the usual way. The nitrate of silver is added to the silver electrolyte and the gold cast into bars. About 660 to 700 ozs. of fine silver are deposited per tank in 24 hours. The entire plant only requires an attendance of two or three men per shift. The apparatus, exclusive of engine and dynamo, for refining more than 30,000 ozs. of doré silver in 24 hours need not cost over $6000.

Absolutely reliable figures of the cost of parting by this process have not yet been reached, as the above plant has only been in operation for a few months, during which time many difficulties, such as are encountered by every new plant, had to be overcome and many changes and improvements were made. The principal items of daily operating cost, exclusive of general expenses, superintendency, and royalty, are about as follows:

Labor:	
3 men on day shift at $2.25	$6.75
2 men on night shift at $2.25	4.50
1 melter at $2.25	2.25
Coal, ¾ ton at $4, for engine	3.00
Coke, ½ ton at $6, for retort	3.00
Retorts	2.60
Nitric acid, commercial, 45 lbs. at 2c	.90
Repairs	5.00
Interest on metal at 6%	8.75
Interest on plant at 6%	1.75
Cost of parting 30,000 ozs. of doré	$38.50

Or about ⅛c. per oz.

The advantages of the Moebius process are the low cost of plant and parting, total absence of noxious gases except during acid treatment of the gold residues, the small amount of labor and chemicals required, the cleanliness and rapidity of working, and the fact that as practically no by-products are produced, the chance of loss of metal is reduced to a minimum.

SEPARATION OF GOLD, PLATINUM, AND IRIDIUM.

Various methods are used for effecting the separation of gold, silver, platinum, iridium, and allied metals on a commercial scale. The method most suited to any particular alloy depends chiefly on the relative proportion of the metals in this alloy. We will briefly consider four cases:

1. The parting of gold, platinum, and iridium.
2. The separation of so-called iridium (osmiridium, etc.) from gold bullion.
3. The refining of platiniferous gold.
4. The separation of platinum, gold, and silver.

1. *The Parting of Gold, Platinum, and Iridium.*—The separation of these metals may be accomplished by one of the following methods: A. Solution of the alloy and separate precipitation of the metals. B. Electrolysis.

A. Baker & Co., platinum manufacturers of Newark, N. J., report that they treat gold bullion containing platinum and iridium in the following manner: After completely dissolving the gold bullion containing platinum and iridium in aqua regia, the filtered solution is evaporated to dryness upon a water bath, with the occasional addition of hydrochloric acid, until all the nitric acid has been expelled. The crystallized salt containing the chloride of gold, platinum, and iridium is then dissolved in a minimum amount of distilled water and filtered. To the filtrate a concentrated solution of ammonium chloride is added until a precipitate no longer forms and the precipitate with the mother liquor is allowed to stand for at least 24 hours while heated to about 80° C. The liquor is then siphoned off and the precipitate of ammonium platinic chloride, after being washed by decantation with a concentrated solution of sal-ammoniac diluted one-third with distilled water, is thrown upon a filter and washed with dilute hydrochloric acid. The mother liquor which was siphoned off and the wash solution from the precipitate are evaporated on a water bath until ammonium-chloride crystals separate and the violet-colored salt containing whatever iridium may be present appears; these are then collected upon a filter moistened with a solution of ammonium chloride. The contents of both filters are carefully dried and ignited in a platinum crucible, so as to collect the platinum and iridium present in the bullion in a so-called "sponge." The platinum may be separated from any iridium present in this sponge by treating the latter with aqua regia diluted with four or five times its volume of water and heated to a temperature not exceeding 40° C. By repeating the application of aqua regia from time to time until the same ceases to be colored with solution of platinum, and by taking care to keep the temperature low and the aqua regia weak, the complete separation of platinum and iridium may be accomplished. The difference in weight of the original sponge and the insoluble residue in aqua regia gives the weight of platinum present. The mother liquor from the precipitated ammonium platinic chloride and ammonium iridic chloride contains all the gold present, and this metal may be separated by the addition of ferrous sulphate. If care is exercised in thoroughly washing the precipitates of platinum and iridium with ammonium chloride a complete separation of gold platinum and iridium may be effected by the above-described method. This process is the one most generally in use and one which gives accurate results with minimum care.

B. The Norddeutsche Affinerie of Hamburg, according to Bock, refines gold bullion and separates the gold from platinum and other metals by electro-deposition. The electrolyte is a dilute solution of gold chloride. Anodes of gold bullion alternate with cathode sheets of pure gold. The metals of the iridium group separate as a grayish-black slime at the anodes and drop to the bottom of the depositing vessel or are caught in anode sacks. A low-current density must be used in order to obtain the fine gold in coherent form. This method is now (1896) being introduced into the German Gold and Silver Refinery at Frankfurt-am-Main, Germany.

Platinum may be separated from iridium (and rhodium), according to Borchers, by electrolysis of a solution of platinum chloride, with anodes of the alloy containing the platinum and iridium.

2. *The Separation of So-called Iridium from Gold Bullion.*—Osmiridium, platiniridium, and allied metals of the platinum group, designated in mint usage by the general term "iridium," are occasionally found in mint deposits of gold and sometimes, though rarely, in silver. As they are not alloyed with the precious metals, but are mechanically mixed with them in the shape of grains or powder, their presence renders impossible the production of a perfectly smooth and polished surface.

Iridium is separated from gold by so-called "settle-melting." This consists briefly in alloying the bullion with two or three times its weight in silver in order to so diminish the specific gravity of the molten mass that part of the silver and all of the heavy iridosmine grains, or "iridium-king," will settle as a viscid mass to the bottom of the crucible. The silver and gold are then carefully poured off and parted in the usual way. The details of this method, as practiced at the New York Assay Office and described in a paper on "Iridium in Mint Deposits" by B. F. Martin in the *Report of the Director of the Mint for 1885*, may be illustrated by the following example:

The gold bar weighs after melting, say, 100 ozs. The assay cornets show no iridium, but the bar is strongly marked. The fineness is reported at 800, which at the weight indicated would credit the depositor with 80 ozs. of pure gold. A correct report would be that amount less the weight of iridium contained. Two hundred ozs. of silver are added, the weight being then $100 + 200 = 300$ ozs. This is melted and after stirring is permitted to stand for 30 to 45 minutes. The crucible is then lifted from the fire, its contents, with as little disturbance as possible, poured off to within, say, 20 ozs. of the entire amount contained. The crucible is replaced in the fire and heated until all the particles of metal on the sides and rim are sweated down into the king at the bottom. It is then taken out, and after cooling the king is removed and weighed. The bars, previously poured off, are weighed and tested for iridium, and being found free are assayed for gold. The king after weighing is tested for gold. If free from that metal the operation is complete. The showing would then be as follows: Weight of bar equals 280 ozs., at 0.284 = 79.52 ozs. fine gold; weight of king equals 20 ozs.; weight of iridium equals 0.48 oz.

In practice, if the bars are not free from iridium a resettling is given, sometimes with the further addition of silver. If the king contains gold, silver is added to it and it is settled until the gold is practically eliminated, or the traces which remain are determined by assay. The results are added to the first settling. The kings from a number of settlings are allowed to accumulate until a convenient opportunity, when they are operated on in mass. The silver is dissolved out by nitric or sulphuric acid. The residual grains are treated with aqua regia. The gold (if present) and the platinum are precipitated. The final grains are washed and dried. They consist of impure iridium, the further treatment of which is not attempted at the New York Assay Office.

3. *The Refining of Platiniferous Gold.*—This may be accomplished in two ways: A. Slagging with sodium bisulphate and saltpeter. B. Solution and separate precipitation.

A. *Slagging with Sodium Bisulphate and Saltpeter.*—At Freiberg, Saxony, the platiniferous gold residue from the sulphuric-acid parting process is treated as follows: The gold, in portions weighing 2 kgms., is melted with 4 kgms. of sodium bisulphate in an iron crucible for 2 to 3 hours. The molten mass, possessing a yellowish-green or brownish color, is dumped on an iron plate, and after cooling washed in porcelain vessels with hot water. The gold is now dried on a graphite disk and treated with saltpeter in order to remove the last traces of impurities and the rest of the platinum. From 3 to 4 kgms. of the gold are slowly heated with $\frac{1}{2}$ to $\frac{1}{3}$% of saltpeter in a graphite crucible for 5 to 6 hours, and subsequently kept in a molten state for the same length of time. The resulting gold king, being free from platinum, is remelted and cast into a bar from 997 to 998 fine. The slags obtained by fluxing the impure gold with sodium bisulphate and with saltpeter are platiniferous. To extract the contained platinum they are mixed with litharge and carbon and reduced to platiniferous lead, which is cupelled. The resulting button is dissolved in aqua regia, the platinum precipitated with sal-ammoniac, and the metal secured by heating this precipitate.

B. *Solution and Precipitation.*—After dissolving the gold-platinum alloy in aqua regia, sufficient alcohol is added to hold the gold in solution, while the platinum is precipitated with sal-ammoniac. The gold in the filtrate from the platinum salt is obtained by precipitation with a ferrous salt.

4. *The Separation of Platinum, Gold, and Silver.*—At the Balbach Works in Newark, N. J., platiniferous alloys, obtained by melting the anode residues resulting from the electrolysis of copper-nickel mattes, are treated, it is said, with nitric acid. Platinum goes into solution with the silver and is precipitated by means of zinc, the silver having previously been removed by precipitation as chloride.

REFINING OF GOLD WITH CHLORINE (MILLER PROCESS).

This process is based on the fact, recognized by Thompson in 1838, that gold does not combine with chlorine like silver and other metals at a red heat. It was first practically applied by B. F. Miller, assayer of the Sydney Mint, Australia, in 1867. The cause of its introduction in Australia was the prevailing high price of acid, as well as the important feature of having no crude silver to alloy with the base gold for the acid-parting process. It is occasionally used in the Royal Mint of London in toughening extremely brittle gold. Miller describes the process and apparatus as follows:

The melting furnace used has the flue as near the top as possible, so as to allow of the crucible standing high up in the furnace, without being cooled by the draught, and has such a depth that the bottom of the crucible, when it is placed in the fire, is not more than 3 in. above the grate bars. The furnace is generally 12 in. square. The covering of the furnace consists of two fire tiles, $7\frac{1}{2}$ in. wide and 15 in. long, one of which has a slot or hole in the center to allow the chlorine tubes to pass through. An iron cover would become too hot for the convenience of the workmen.

French white fluxing crucibles are employed for the refining. They are prepared for use by filling them with a boiling aqueous solution of borax, which is allowed to stand in them for 10 minutes and is then poured off, the crucibles being afterward set aside to dry. The crucibles are then heated to redness, whereby the borax forms a glaze on their inner surface and renders them impervious to the infiltration of the very liquid chlorides of silver. When used for refining these French clay crucibles are placed within black-lead pots as a precaution against loss should the former crack, which, however, seldom happens. The crucibles are covered with loosely fitting lids, with the requisite holes through them for the passage of the clay chlorine pipes, etc. Ordinary clay tobacco-pipe stems, $\frac{1}{2}$ in. in diameter, 22 in. long, $\frac{3}{16}$-in. bore, have been found to answer well for the purpose of passing the gas through the molten gold. (Pipes are now expressly furnished for this purpose by the Battersea Crucible Works in England.) Two pipes are used at a time in one crucible. The lower end of the pipe should be heated for about 10 minutes before using, or it is liable to split.

The chlorine generators consist of the best stoneware acid jars, capable of holding 10 to 15 gals. and furnished with two necks. One of these openings is stopped with a vulcanized India-rubber plug, through which two glass tubes pass tightly—the eduction tube and the safety or pressure tube, the length of the former being a few inches and the latter from 8 to 10 ft. The other opening is intended for introducing oxide of manganese, etc., and is closed with a leaden plug covered with a stout piece of India-rubber and well secured. On the bottom of the generator is placed a so-called draining layer of small quartz pebbles, down nearly to the bottom of which the pressure tube should extend. On this layer should be placed from 70 to 100 lbs. of binoxide of manganese in cubes of about $\frac{1}{4}$ in. square. This quantity will be sufficient to effect many refining operations and will obviate the necessity of repeated dismantling of the apparatus. Each generator should be suspended to about half its height in a galvanized-iron water bath.

The chlorine gas is produced when required by pouring common hydrochloric acid down the safety tube, the apparatus being warmed by means of gas burners beneath the water baths. The gas is conveyed from the generators by means of a leaden pipe fitted with branches to supply the several furnaces, all intermediate connections being formed by means of vulcanized India-rubber tubing, which if screened from direct radiation from the fire stands the heat well, even immediately over the furnace. All joints between the various pipes and India-rubber tubes are easily secured and rendered perfectly gas tight with a cement consisting of a thin solution of India-rubber in chloroform. Screw compression clamps on the India-rubber tubes give the means of regulating the supply of gas as required and enable the operator to shut it off entirely as soon as the refining is over. In the latter case the chlorine, having no other means of escape, accumulates in the generator, and soon forces all the acid up the safety tube into a vessel placed above to receive it; and as the acid no longer acts on the oxide of manganese, the supply of gas of course ceases. Two such generators as are here described and three ordinary gold-melting furnaces have been found capable of refining daily about 2000 ozs. of gold, containing about 10% of silver, between 9 A.M. and 2 P.M.

The French crucibles, duly prepared with borax, having been placed in the cold furnace and slowly and carefully heated to dull redness, the gold, from 600 to 700 ozs. to each crucible, is introduced and the fire urged until the metal is melted. Meantime the necessary generation of chlorine is started by pouring a little hydrochloric acid down the safety tube into the generators. As soon as the gold is melted, from 2 to 3 ozs. of borax, in a state of fusion, are poured upon its surface. If the borax is added sooner it acts too much on the lower part of the crucible, and if thrown in cold is apt to chill the gold. The clay pipe which is to convey the chlorine to the bottom of the molten gold is now introduced. At the moment of its entering the molten gold the screw compression clamp is slightly loosened so as to allow a small quantity of gas to pass through it, and thus prevent any metal rising and settling in the pipe, which is then gradually lowered to the bottom of the molten gold, where it is kept by means of a few small weights attached to the top. The compression tap is now loosened and the gas is heard bubbling up through the molten metal, which it does quietly and without projection of globules from the pot.

Sufficient hydrochloric acid must be added to the generators from time to time to keep up a rapid evolution of chlorine. The column of liquid in the safety tube acts as a barometer and thus affords a ready means of knowing the pressure in the generator and of judging of the rate of production of the gas, as well as at once showing by its fall if anything irregular has occurred, such as a leak or a crack of the chlorine pipe or crucible. From 16 to 18 in. in the safety tube correspond to and balance 1 in. of gold in the refining crucible. When the chlorine is first introduced into the molten gold a quantity of fumes is seen to pass up from the holes in the crucible lid; these are not chloride of silver, but the volatile chlorides of some of the baser metals, and they are especially dense when much lead is present in the alloy under treatment, forming a white deposit on any cold substance presented to them. After a time, longer or shorter according to the impurities in the gold, the fumes cease. So long as any decided quantity of silver is present in the molten gold, the whole, or nearly the whole of the chlorine is absorbed, little, if any, appearing to escape and to be thus wasted, and it is found that the better the supply of chlorine the quicker is the operation. It is essential in using chlorine that the gas should pass to the very bottom of the crucible to effect a complete refinage.

When the operation is nearly finished fumes of a darker color than those observed at the commencement make their appearance, and the end of the refinage is indicated by a peculiar flame or luminous vapor of a brownish-yellow color, occasioned by the free and now waste chlorine escaping, which can be seen on removing a small plug which fits into a hole in the lid of the pot. This, however, of itself is not a sufficient indication. The process is not complete until this flame imparts to a piece of white tobacco pipe or similar substance, when held in it for a moment, a peculiar reddish or brownish-yellow stain; so long as it gives any other color the refinage is unfinished.

When these appearances are observed, usually for gold containing about 10% of silver, in about 1½ hours from the introduction of chlorine, the gas is shut off and the crucibles removed from the fire; the white crucibles is lifted out of the black one and, together with its contents, allowed to stand for several minutes until the gold becomes cool enough to set or solidify. The chloride of silver, which remains liquid much longer, is poured off into iron molds. The crucible is then inverted on an iron table, when the still hot gold falls out in the shape of a cone. This is slightly scraped and thrown hissing into a concentrated solution of common salt to free it from any adherent chloride of silver. An alloy containing originally 89% of gold, 10% of silver, and 1% of base metal will yield, on an average, a cake of chloride weighing, with a little adherent borax, 15 ozs. for every 100 ozs. operated on.

It is necessary to very carefully dry and heat the molds into which the chloride of silver is poured, as the slightest moisture causes the latter to be violently dispersed, to the great risk of the bystanders. The gold is now fine and simply requires melting into ingots. As before stated, it is found that all these operations can readily be performed and about 2000 ozs. refined per day in three common melting furnaces in 5 hours; 98% of the gold originally contained in the alloy operated on is then ready for delivery. The other 2% remains with the chloride of silver.

The silver chloride was formerly freed from gold by melting it with silver, which alloyed with the gold and formed a button in the bottom of the crucible. The separation, however, was incomplete and has been replaced, according to Leibius, * by melting the silver chloride with soda under a cover of borax. To avoid losses of metal, the chloride is first covered with a layer 1 cm. thick of borax; the soda is then added, in small portions at a time, until it is present in the proportion of 0.5–0.6 kgm. to 7 kgms. of silver chloride. By repeating this melting operation the gold can be removed quite completely and is obtained in a button combined with a portion of the silver.

The final reduction of the silver chloride to metallic silver is accomplished by electrolysis, as suggested by Leibius. Zinc and silver plates are used as electrodes in a solution of the silver chloride in salt or zinc chloride. The metallic silver thus obtained is remelted in graphite crucibles. If the gold alloy treated contains much copper, the greater part of this goes with the silver. By-products containing silver are ground fine in a Chile mill and treated by amalgamation. Besides the separation of the silver as above described, another useful end is gained by the chlorine process—that of having converted the "brittle" into "tough" gold.

* *Dingler's Journ.*, Vol. 197, p. 55.

In the metallurgic treatment of the precious metals some loss is always sustained, but that in the process here described is found to be very small. The average loss of gold in operating hitherto has been found to amount to 19 parts in every 100,000 of alloy treated, which is considerably less than would be met with in toughening an equal amount of gold with corrosive sublimate in the ordinary manner. The loss of silver has amounted to 240 parts in every 100,000 of alloy operated on (containing originally, say, 10% of silver). There is no doubt that a considerable portion of both these losses would be recovered on further treating the crucibles and ashes remaining after the operation. In refining on the large scale gold containing 10% of silver, the cost of the operation in Sydney is about 5 farthings per oz. The fineness of the gold produced by this process varies from 991 to 997 in 1000 parts, the average being 993.5 and the remaining 6½ thousandths silver.

The Miller process has not been introduced into the mints of the United States because the bullion parted and refined there carries too much silver to make treatment by the chlorine process profitable.

COMPARISON OF THE DIFFERENT PARTING PROCESSES.

The choice of the most suitable process for a new parting plant depends upon the following considerations: The chemical composition of the material to be parted; the rapidity of treatment; the comparative efficiency of the process; the cost of plant and of operating same.

Composition of the Material to be Parted.—Doré bullion carrying over 5% of impurities (lead, copper, bismuth, etc.) is treated by the acid-parting processes in preference to the electrolytic in works like the mints, not generally provided with facilities for wholesale cupellation. When the bullion is rich in copper (over 7½%) it is parted more readily by the nitric-acid than by the sulphuric-acid process, but the latter process is cheaper and is generally adopted when the bullion to be treated varies greatly in composition and fineness. Bullion carrying comparatively little silver, but considerable gold, is advantageously treated by the Miller process, where crude silver to alloy with the gold can only be obtained with difficulty or the price of acid is high. Lastly, doré bullion not carrying over 5% of impurities nor very rich in gold is best parted by the Moebius process.

Rapidity of Parting.—The amount of bullion that can be parted daily depends upon the thoroughness of the parting operation and the tank capacity. In parting doré by sulphuric acid, as many as four bullion charges of at least 400 lbs. each can be dissolved in a single kettle in 24 hours. The time required for the reduction of the silver sulphate varies from 3 to 24 hours, according to the method employed. The tedious bluestone recovery generally connected with sulphuric-acid parting may be obviated and time saved by reducing the silver sulphate with iron or ferrous sulphate. In electrolytic parting it usually takes from 30 to 60 hours to deposit the entire doré charge. The time necessary for this operation, however, only depends upon the thickness of the anodes and the frequency with which the deposited silver is cleaned up. These factors likewise govern the amount of silver blocked up in the plant, which averages about two and a half times the daily silver output. With a current equivalent to 17 horse-power 30,000 ozs. of doré can be parted daily; yet the actual average output at Pittsburg, for example, is only 85% of the theoretical yield of the dynamo. The loss in time efficiency due to stoppage for cleaning up and repairs can therefore be taken at about 15%.

Efficiency of Parting.—From the economy with which the sulphuric-acid process is conducted and the low price of sulphuric acid, as well as the return of the copper and sulphuric acid in the shape of bluestone, it admits of being profitably applied to the parting of silver containing as low as 0.02% of gold, while silver containing as much as 0.05% of gold cannot be economically parted with nitric acid. The consumption of acid is generally from two to four times the weight of the bullion treated. Electrolytic parting permits the profitable treatment of doré only carrying 0.01% of gold.

Cost of Plant and Operating Expenses.—The comparatively high price of nitric acid and the necessity of using either platinum or porcelain vessels make the nitric-acid parting process more expensive than the sulphuric. The first cost of an electrolytic parting plant of large capacity is about equal to that of an acid parting establishment in which the same quantity of doré bullion is treated. The contract price for a Moebius plant with a daily parting capacity of 30,000 ozs., put up and in complete running order, is $7500. The parting expenses are included in the cost of parting and will be considered under that caption.

Cost of Parting.—The expense of refining gold containing 10% of silver by the chlorine process used at Sydney, Australia, is stated to be a little over 1c. per oz. Parting doré bars by sulphuric acid in private refineries generally costs about 0.4c. per oz. of metal contained, and under exceptionally favorable conditions is as low as 0.3c. per oz. The expense of parting doré bullion by the Moebius process is less than 0.2c. per oz., or at least 0.1c. below the cost of sulphuric-acid parting under equally favorable conditions. As the operating cost is largely dependent upon the location and capacity of the works and the composition of the alloy treated, the general figures given above can only be approximate and must be modified where unfavorable conditions prevail, as at the United States Assay offices and mints. It is safe to say that the production of refined metal from all bullion received costs the Government from 1¼ to 1½c. per oz. of refined metal and 1c. per oz. for parting doré bars. This is much higher than private parting and refining costs, for the following reasons: The government hours of labor are much shorter and the cost of labor double. Private refiners can turn all the by-products to their advantage and profit. Private refiners are able to continue refining operations longer than eight hours at one time. Government officers, while admiting the above facts, claim that this is as it should be, for the Government should not compete with outside refiners, but should simply serve as a check on private refiners in case in any way they should overreach.

DITCH CONSTRUCTION IN IDAHO.

By Augustus J. Bowie.

The Leesburg mining district, in Lemhi County, Idaho, has since its discovery been noted for the production of its gold placers. Situated in the heart of rugged mountains, until the last two years it has been practically inaccessible. Now, however, a wagon road has been built into the district, and larger operations than could be carried on by individual miners are possible. The greater part of this region is drained by Napias Creek, which receives the waters from tributary creeks as well as from rains and melting snow from the surrounding mountains. These topographical conditions necessarily cause heavy floods during periods of warm weather and rain, when the discharge of the creek at California Bar has been as high as 700 cu. ft. per second.

The California Bar claims are situated in Napias Creek, about 3 miles south of the town of Leesburg and below the principal tributaries of the creek. In the fall of 1892 some Colorado speculators prospected these claims and in the spring of 1893 determined to hydraulic them. Early in the 60s attempts had been made to bottom this channel, and in one instance $60,000 were lost in endeavoring to reach it by means of a tunnel. Chinese miners subsequently leased the ground, and thinking that they could control the surplus water and drift the gravel, constructed along the west side of the creek bed a canal about 2½ miles in length. The enterprise was a failure, but the property maintained its reputation for richness, although its opening was considered by all in these regions as an impossible feat. An examination showed, however, that it was perfectly feasible, although the grade was only 1.55%.

The bar claims referred to approximate 4500 ft. in length by 300 to 800 ft. in width of the creek bed, contracting at the upper as well as at the lower end. Alluvia occur on the west side of it, but none on the east. The depth of the deposit in the creek bed, demonstrated by prospecting shafts, was 57 ft. at the lowest end and 18 ft. at the upper. The bed rock is a metamorphosed rhyolite. The creek bed has been tailed through for years and contains a large amount of sand and refuse material covering the gold-bearing gravel deposit which lies on bed rock.

The early miners ran a little ditch from Napias Creek above Rapp's, which delivered a few hundred inches of water at the lower end of the bar under a pressure of 100 ft. The ditch was practically of no value and a larger one was therefore projected for hydraulic mining purposes. The new line was surveyed and located to draw the water directly from Napias Creek, about a mile above Rapp's Creek. Work was started in October, 1894, on the line, but extreme cold weather and snow closed the operations. In the latter part of May, 1895, instructions were given to push the work and complete it. Between 1894 and 1895 considerable information was gathered as to the discharge of this watershed, and it had become very apparent that any ditch with its head in this portion of Napias Creek would in all probability be destroyed during times of flood. Moreover, it was noticed that the flow of water from Rapp's Creek was more desirable and as continuous as that from Napias Creek, and should there be only this one source of supply for both ditches, mining operations were liable to be indefinitely suspended during the water season. Rapp's Creek was selected for the location of the head of the new ditch, necessitating a total change of plan and the construction of 3400 ft. of flume and trestle work. On account of the steep rise of the hills there are no available sites for storage reservoirs in the vicinity of California Bar.

A distributing reservoir can be constructed about a mile above the present head of the new ditch which would impound a few weeks' water for mining during the dry season. The capacity of the new ditch and that of the old ditch (enlarged to carry 1500 in. of water), with the assistance of the China ditch to handle the surplus water beyond the head of the sluices, will enable very extensive mining operations to be carried on during the entire water season, and should developments justify it a larger supply can be obtained.

The Rapp's Creek ditch and flume were constructed in the summer and fall of 1895 by the Leesburg Gold Mining and Milling Company (Limited) to supply water for the mining operations at California Bar, as above described. The line was surveyed in July, 1892, and staked in the fall of 1893. Preliminary work for the purpose of estimates was carried on spasmodically during 1893–94, up to May, 1895.

The following figures show the total expenditure from October 1, 1894, to May 23, 1895: Labor clearing out stumps and grading, $1059.77; team work, $426.87; powder, caps, and fuse, $41.87; tools, $12.35; total, $1540.86. For all this work wages were at the rate of $3 per diem for labor.

The ditch (see Fig. 1) is 7 ft. wide on top, 4 ft. at bottom, and 3½ ft deep.* In its construction the bank was cut horizontally from the grade stakes a distance of from 13 to 15 ft. The outside bank of the ditch is 3 ft. wide on top in solid ground. The side slopes along the mountain are exceedingly steep and in places composed solely of *débris*, making ditching impossible. On all the curves the ditch is enlarged from 1 to 1½ ft. in the bottom with a corresponding increase on top. The material from the excavation was placed on the outer bank and sloped back to prevent any sliding into the ditch. After the ground is thoroughly soaked, calked, and consolidated, the carrying capacity of the ditch can be readily increased 1 ft. in depth.

In the rock cuts, through a species of rhyolite badly fissured, boxes have been placed wherever it was necessary. In constructing the ditch manual labor, teams

* Capacity, 2500 N. B. standard miner's inches; 1 miner's inch = a discharge of 1.5 cu. ft. per minute.

with plows, "go-devils," and scrapers were employed. This is a new departure in mining work, but here has been most successfully used even on the steepest side hill. After the grade pegs were set an outside stake 3 or 4 ft. high was placed immediately opposite to them so that they could be readily found (Fig. 1). The first furrow was started from 4 to 6 ft. inside of the grade peg. A team with a go-devil having an adjustable side followed the plow, removing the ground broken. According to circumstances the ground was excavated for a width of 12 to 13 ft. to a level with the top of the grade. In a word, a road was built around the side hill on the grade of the ditch.

When a stretch of road was completed a team with a plow was set to work, about 4½ ft. inside of the grade peg, plowing the ground the top width of the ditch. As the work progressed the go-devils were abandoned and scrapers substituted, in the employment of which great care was necessary to preserve the outside bank intact. To insure against such accidents, where the teams entered

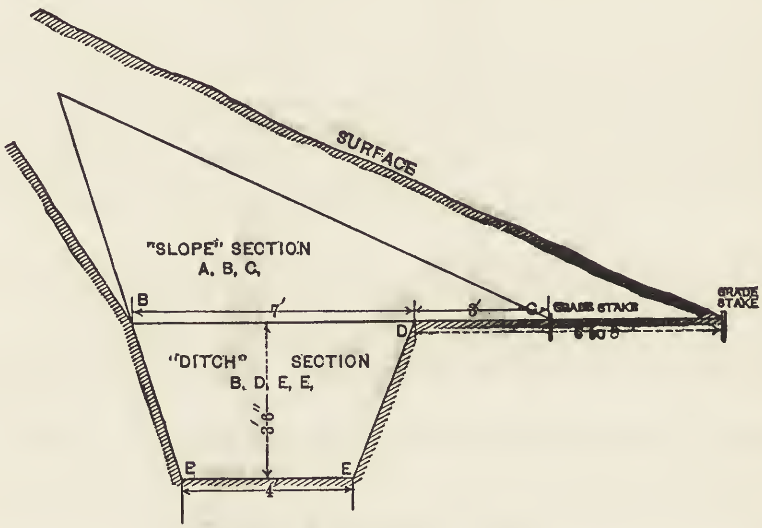


Fig. 1.—Cross Section of Ditch.

and left the ditch the ground was gently sloped and left solid. The excavated material was deposited along the top and side of the outer bank, where it was tramped down by the teams as they returned to enter the ditch. Teams were used to within a foot of the bottom of the ditch, from which point the ground was worked down with pick and shovel to grade and the sides properly sloped. The grade of the ditch is 10.5 per mile.

Blasting was avoided as far as possible. The greater part of the work was done with picks, gads, sledges, and crowbars. The outer bank has been kept practically intact, great care being taken not to have it shattered. The removal of heavy bowlders was effected by means of giant powder, most carefully applied in very small quantities. The rhyolite rock through which the ditch runs, although compact, is disintegrated on the surface, but badly fissured. It was readily handled by means of sledges and gads. There are five wasteways, but two more are projected to insure safety in case of accident.

In Fig. 1 the dotted line shows a section of the ditch with the bank cut 10 ft. horizontally from grade stakes. Solid lines indicate the section as actually constructed, with the bank 13 to 15 ft. from the stakes and sloped back further than the dotted line shows. The area inclosed in the solid lines has been used in calculating the number of cubic yards excavated, but no allowance has been made for the extra amount of ground removed in giving the inner bank its greater slope as required in the general construction of the work. The volume of earth removed was calculated from slopes taken every 50 ft. along the line of the original survey.

The total length of the line from the measuring box at California Bar to the head of the ditch at Rapp's Creek is 15,105 ft., divided as follows: Ditching,

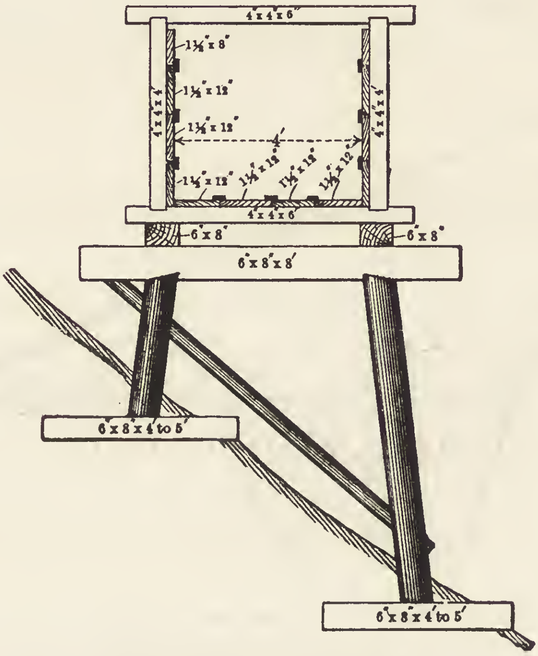


FIG. 2.—FLUME AND TRESTLE.

11,633 ft.; fluming, 3472 ft. Amount of work required was: Earth and solid ground removed, 20,456.25 cu. yds.; rock removed, 4134.16 cu. yds.; rock removed for flume bed, 552.27 cu. yds.; total, 25,142.68 cu. yds. Of this there were in the ditch section 7748.90 cu. yds.; in the slope section, 16,841.51 cu. yds.; and in the flume bed, 552.27 cu. yds.

The total cost of the construction of the ditch, including labor, side lining, and ditch at head gate, was $10,309.86, divided as follows: Labor and material, $9448.28; lining materials and labor, $805.33; head ditch, $56.25. Exclusive of the ditch lining, but including the proportionate charge for superintendence, the cost of this work was as follows: Labor, etc., $9448.28; superintendence, $365; total, $9813.28.

The timber for the trestle was hewn from spruce trees on the hillside above

PLOWING ON GRADE LINE.

COMPLETED DITCH AT HORSE-SHOE BEND.

TRESTLE CONSTRUCTION, RAPP'S CREEK DITCH, IDAHO.

the line of construction. The character of this ground precluded any possibility of ditching. It was hazardous to break the steep hill slopes any further than was absolutely necessary to anchor in the posts and sills. The trees and brush for 40 ft. above and below this trestle were cleared and burned, to protect the flume against accident and fire. Stumps on the upper hillside are numerous, and a few small poles placed against them parallel with the trestle will afford protection against rolling rocks, while the many growing trees higher up give the best security against snow slides.

The average height of the inner posts approximates 3 ft. and the outer posts average about 6 ft., both being 7 in. in diameter. The posts are stripped of their bark and set on sills of hewn timber 6x8 in. with a length corresponding to the requirement. On the inner side only sufficient ground was excavated to permit the placing of a 3 or 4 ft. sill, as might be necessitated. The outer post is set on a sill securely placed on the ground purposely excavated and leveled for it. A slope of 1½ in. to the foot is given to the posts, which are held to the sills with 60-penny nails. The caps are fitted with a gain to each post and nailed on both sides. The stringers (18 ft. long each), of 6x8-in. timber, are hewn on both sides, gained on the lower side to the caps, and notched where they are nailed to them. They lap on both ends over every three bents. The bents are placed 8 ft. from centers and are braced crossways with 3 and 4 in. diameter round poles, spiked to the posts and caps. The structure is so strong as not to require any longitudinal bracing. This work was commenced July 15, 1895, and finished August 15, 1895. The total number of hands employed was 13, and the entire cost, including labor, timber, tools, and nails, was $1109.69.

The drawing shows the construction of the flume and trestle in detail, and the following figures give the respective amounts of timber each contains, exclusive of braces, in ft. B. M.: Posts, 7 in. diameter by 6 and 3 ft., 10,395; caps, 8 ft. by 6 by 8 in., 12,320; sills, 8 ft. by 6 by 8 in., 12,320; stringers, 18 ft. by 6 by 8 in., 27,970; total, 62,955.

The lumber for the flume was cut at the company's sawmill, about 3 miles by wagon road from the present head of the ditch. It is a red fir of ordinary quality, such as is usually found in this country. The logs were cut during the fall and winter of 1894 and were fairly seasoned, but somewhat checked. On account of the scarcity of ready material about one-half of the caps on the flume were made of two pieces of 2x4-in. scantling, spiked together and then gained. All lumber used in the ditch and flume construction has been charged for at the rate of $14.05 per 1000, the mill charge. The greater part of the lumber used had been culled over and the best planks selected for sluices.

The flume at the head below the main gates is 6 ft. wide and 4 ft. deep. This size runs for a distance of 150 ft., tapering into a 5-ft. sluice 4 ft. deep running a similar distance and tapering into the regular size flume as given in annexed table. The lumber, sawed but not planed, was carefully put together, all joints being closely battened. The posts were gained 1 in. into the sills and caps respectively and nailed. No side braces were used on the flume. The flume lumber per box was as follows for a flume 4 ft. wide, 42½ in. deep, 12 ft. box in the clear: 6 posts 4 by 4 in. by 4 ft., 32 ft.; 3 caps 4 by 4 in. by 6 ft., 24 ft.; 3 sills 4 by 4 in. by 6 ft., 24 ft.; 4 bottom planks 1½ by 12 in. by 12 ft., 72 ft.; 6 sides

$1\frac{1}{2}$ by 12 in. by 12 ft., 108 ft.; 2 sides $1\frac{1}{2}$ by 8 in. by 12 ft., 24 ft.; 9 battens $\frac{1}{2}$ by 4 in. by 12 ft., 36 ft.; total, 320 ft.

Hauling and delivering of material at the head of the ditch was done by contract. Whenever the company's men or teams were employed on the ditch construction the ruling rates have been charged to this account. As the flume progressed the lumber was floated to the work as required. Labor rates per day of 10 hours were as follows: Laborers, $2.50; carpenters, $3.25 to $3.50; teamsters, $2.50; two-horse team, $3. Teamsters supplied plows and scrapers, did their blacksmithing, and furnished their own horse feed. All the men were boarded by the company's contractor at the rate of $1 per day per man, the company receiving 10% on all accounts. No credit for profits has been given in any statement of costs.

The cost of the flume was as here given: Labor, $879.50; lumber, $1202.03; hauling, $191.23; tools, $7.66; nails, $176; superintendence, $125; total, $2581.42.

The total amount of lumber charged above is 85,534 ft. B. M. In the side lining and intermediate boxes between the main flume and measuring box 23,769 ft. of lumber additional were used. The details of this cost will be found in the table. The pressure box, measuring box, and wasteway from pressure box contain 12,015 ft. of lumber. The sand box connects the measuring box with the pressure box, which latter is protected from overflow by means of a wasteway. The measuring box has sufficient capacity to gauge 3000 miner's inches and can be increased if desirable. The details of cost are given in the table. In the gates and boxes at the head of the ditch 3310 ft. of lumber were used. Four small timber cribbed dams (loaded with rocks), 4x6 ft. in size angling up stream, sunk $3\frac{1}{2}$ ft. for the grade and rising 4 ft. high above creek bottom, hold the gates through which the water supply from Rapp's Creek is drawn. A temporary obstruction has been thrown across the bed of the channel of Rapp's Creek to direct the water into the ditch. The gates at the head are provided with a wasteway 10 ft. wide to regulate the height of the water entering the ditch. To thoroughly protect the flume from being destroyed by an overflow of the creek, or back water, another set of gates and wasteway, firmly set in the ditch against a bluff of rocks, have been placed about 50 ft. below the main head gates. The main flume several hundred feet below the head has been fitted with a large sand box, 48 ft. long.

The cost of tools in the construction of this ditch and flume, as shown by the final statement, is insignificant. This is due to the fact that the plows, scrapers, and go-devils were supplied by the men owning the teams, and the company had on hand a supply of tools left over after the building of the Leesburg road. Hence the only charge is for the material consumed and a few necessary articles purchased.

The entire ditch and flume were completed and water delivered at the mine September 29, 1895. The ditch will bear comparison with any first-class mining work of this character. The actual cost per cubic yard of material moved was $0.462.* The cost per foot of 388 linear ft. of lining, including material.

* The cost per cubic yard, as per tabulated statement, is $0.399. To this may properly be added all expenditures prior to May, 1895, which aggregate $1540.86, making the total cost per cubic yard $0.462.

was \$2.07. The cost of the flume per linear foot was \$0.837. The cost of trestle per linear foot was \$0.359. The total cost of the entire work was \$5799.30 per mile, including superintendence, surveying, measuring box, pressure box, wasteways, head gates, cribs, etc., and all moneys expended from 1893 to October 31, 1895, which is materially less than any structure of similar size built in the mining regions on the west coast with the same rate of labor.

LEESBURG GOLD MINING AND MILLING COMPANY—CONSTRUCTION OF RAPP'S CREEK DITCH.

	Grading and Excavating Ditch.	Trestle.	Main Flume on Trestle, Two Switches, 257 Boxes.	Pressure Box, Measuring Box, and Wasteway.	Side Lining and Intermediate Boxes Between Main Flume Measuring Box.	Gates, Boxes, etc.	Roads and Trails.	Totals.
Labor	\$7,647.72	\$1,051.00	\$879.50	\$148.18	\$347.69	\$30.00	\$67.25	\$10,171.34
Foreman	365.00	....	125.00	....	70.00	5.00	....	565.00
Surveying	162.00	....	....	....	....	....	....	162.00
Grading (teams)	1,728.87	....	....	....	....	....	....	1,728.87
Hauling lumber	....	....	191.28	9.00	24.00	8.00	....	232.23
Tools, steel, iron, and coal	94.85	3.79	7.66	....	....	....	....	106.30
Powder, caps, and fuse	33.09	....	....	....	....	....	....	33.09
Nails (51½ kegs)	....	54.90	176.00	29.13	29.69	6.27	....	295.99
Lumber (124,638 ft. at \$14.05)	....	....	1,202.03	168.81	333.95	46.37	....	1,751.16
Totals	\$10,031.53	\$1,109.69	\$2,581.42	\$355.12	\$805.33	\$95.64	\$67.25	\$15,045.98

Lumber used in flume and trestle, 85,544 ft.; in pressure and measuring boxes, 9090 ft.; in wasteways, 2925 ft.; in side lining and intermediate boxes, 23,769 ft.; in gates and boxes, 3310 ft.; total lumber used, 124,638 ft. Timber in trestle reduced to B. M., 62,955 ft., is included in total cost of trestle under labor account, which represents the cost of hewing and setting, and also the excavation of 552.27 cu. yds. of rock.

Hanging Flumes for Hydrostatic Ditches.

There are certain cases where a flume passes through a canyon or along the face of a cliff where it would be impossible to cut out a channel in the rock and difficult or very costly to support it by trestles from below. In several instances the expedient has been adopted of suspending the flume, and this method has proved very successful.

An example of this is found on the line of a ditch built by the Miocene Mining Company in Butte County, Cal.,* where a work of this class was designed and carried out by Mr. W. H. Bellows to avoid the construction of a trestle 186 ft. in height. The line of ditch was run some 600 ft. up the canyon, abutting against a perpendicular wall of basaltic rock, along the face of which, 118 ft. above the bed of the ravine and 232 ft. below the top of the cliff, the flume was carried on brackets for a distance of 486 ft. The approach to this section is on a trestle 86 ft. high at the highest point. The flume itself is 4 ft. wide and 3 ft. deep, inside measurements. The brackets were made of old iron rails, 30 lbs. to the yard, of the usual T-section. These rails were bent at right angles in the form of an L. The long arm, 10 ft. in length, was placed horizontally for the bed of the flume to rest on, its end being supported in a hole drilled in the rock. The end of the shorter arm, which is 2 ft. in length and stands vertically when in position, was forced into an eye, into which hooks a suspender of ¾-in. round iron. The other end of the suspending rod is fastened to the rock above by means of a ring bolt soldered into a hole drilled for the purpose. The brackets were set 8 ft. apart and were tested to sustain a weight of 14½ tons each.

* Bowie's *Hydraulic Mining*, pp. 150–153.

The construction of this ditch involved some expensive work. It is $33\frac{1}{3}$ miles long, and besides the work just described there are on its line a trestle 1088 ft. long and 80 ft. high, and another trestle 136 ft. in height. The capacity of the ditch is 3000 miners' inches.

Another example of the suspended flume is found in the ditch of the Montrose Placer Mining Company in Southwestern Colorado.* The flume runs through the Dolores Canyon for about 4 miles, and at some points is 400 ft. above the river. It is carried on benches where possible, but at many points is suspended on the wall of the canyon. In this case the horizontal supporters are timbers anchored to the rock by bolts $1\frac{1}{4}$ in. in diameter and driven 18 in. into the rock, and are supported by braces which are gained into the horizontal timbers near the outer end and rest at the lower ends on steps or pockets cut in the rock; these are also further secured by bolts to the rock. At one point on the line for about 200 ft. the rock projects out, forming a sort of canopy so shaped that it was impossible to support the flume on brackets. At this point it is hung in iron supporting frames secured above to bolts driven in the rock.

While this flume was under construction a rock weighing many tons fell from the top of the cliff, but only tore off a small section of the flume about 20 ft. long. It snapped off the heavy timbers where it struck, without loosening or apparently straining the supports a few feet distant. The break was repaired in two hours.

These two examples show different plans of construction of hanging flumes. Both have their advantages, but on the whole the iron supports seem to be preferable. This is a question, however, which would in most cases be decided by the comparative cost of lumber and iron at the place where the flume is to be built.

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* *Engineering and Mining Journal*, Vol. XLIX., pp. 563–565.

GRAPHITE.

Graphite, or plumbago, is a mineral which is found in many countries, but comparatively few deposits are known of sufficient purity and abundance to be commercially available. The impure graphite, which is of the most common occurrence, is useful only for a few purposes. Very little is to be said of the production of graphite in this country, the particulars of which are given in the following table for the five years ending with 1895. It will be seen that the production has been decreasing rapidly and in 1895 was not much over one-quarter of that reported in 1891. The industry in the United States is entirely in the hands of a few companies, who use the product themselves and market it only in the finished or manufactured form. The imports increased largely last year over those of 1894, and the consumption showed a corresponding gain, but the total supply was less than that of any year since 1890 with the exception of 1894.

GRAPHITE INDUSTRY IN THE UNITED STATES.

Year.	Production.		Imports.		Consumption.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1891	1,506,065	$75,350	21,236,000	$555,080	22,742,065	$630,430
1892	1,298,363	64,920	23,354,000	667,775	24,652,363	732 695
1893	882,912	39,731	28,882,000	865,379	29,764,912	905,110
1894	770,846	34,689	11,640,000	225,720	12,410,846	260,409
1895	392,008	17,640	19,745,600	454,145	20,137,608	471,785

The average price of the graphite mined is given at somewhat over 4c. a pound, which is necessarily only an approximation, since, as we have said, none of it is marketed in a crude form. The only mines at present worked to any extent are those at Ticonderoga, N. Y., which are controlled by the Joseph Dixon Crucible Company of New Jersey, and their output is decreasing. Other deposits have been reported from time to time, but none has been worked to any extent.

In addition to the graphite properly so classed, some amorphous graphite has been mined in Rhode Island from the so-called coal deposits of that State. This graphite has been chiefly used in foundry facings, and the production has been decreasing; none was mined in 1895.

The following table gives the world's production of graphite for the five years ending with 1894:

WORLD'S PRODUCTION OF GRAPHITE. (IN METRIC TONS.)

Year.	Austria.	Canada.	Ceylon.	Germany.	Italy.	Japan.	United States (a)	Totals.
1890	23,728	159	32,225	4,355	1,735	4,573	272	67,047
1891	21,346	236	21,026	3,824	2,415	2,464	707	52,018
1892	20,978	151	21,300	4,036	1,645	601	634	49,345
1893	23,807	20	21,900	3,140	1,465	3	400	50,735
1894	24,121	350	20,400	3,133	1,575	....	349	49,928

(a) Refined graphite.

It will be seen that the chief producers in the world are Austria and Ceylon. In Austria deposits are worked in Bohemia, Moravia, Styria, Carinthia, and Lower Austria. The largest mines in Austria are in Bohemia, and these furnish the greater part of the European supply. The mines of Styria are much smaller, but their output is in demand for the manufacture of crucibles, for which its purity especially adapts it.

The largest producer outside of Austria is Ceylon, from whence the greater part of the mineral used in this country is brought. The deposits of graphite in that island are extensive. There are many small workings, but none which are carried on on a large scale, the industry being entirely in the hands of the natives, who mine and clean the graphite and prepare it for market in a somewhat primitive manner. Owing to the cheapness of labor and the good quality of the graphite the industry as it is carried on is a profitable one, and no attempt has been made to change the methods which have been pursued for many years.

One of the most notable mines of graphite in existence is that at Passau, Germany, which has been worked for several hundred years and still shows no sign of exhaustion.

The uses of graphite are well known. It is employed for making lead pencils and refractory crucibles, for stove polish, as a pigment, and as a lubricant. Its use for the last-named purpose is increasing, as graphite compounds have been found specially adapted for the bearings of high-speed engines and for similar purposes. The use of the mineral in making paint especially adapted for covering metallic surfaces and protecting them from oxidation when exposed to the weather is also rapidly extending. In making crucibles for certain special uses no efficient substitute has ever been found for graphite, and the demand for this purpose, although not very large, is a steady one.

Several discoveries of graphite in this country have been reported during the past two years, but as yet no steps have been taken toward working any of them, owing to the cost of erecting the proper plant for cleaning and preparation, and partly also to the uncertainty as to whether the product could be furnished at a sufficiently low price to compete with the Ceylon mineral.

GYPSUM.

GYPSUM is a hydrous sulphate of lime, the color varying according to the purity from white, gray, red, brown, and even black. It occurs in various forms, sometimes in the transparent and crystallized form called selenite and sometimes of exceptional purity in masses and of fine grain, more commonly known as alabaster. It is usually found in large beds, which are occasionally of great thickness, but inter-stratified with clay and limestone. The gypsum itself is frequently mixed with these substances, which constitute impurities. Its most usual occurrence is in the Cretaceous, Silurian, and Subcarboniferous formations, but it is also found in the Triassic formation of the Rocky Mountains.

The following table shows the production of gypsum in the United States for the years 1894 and 1895, arranged by States. The statistics for the years previous to 1894 will be found in THE MINERAL INDUSTRY, Vols. I., II., and III.:

PRODUCTION OF GYPSUM IN THE UNITED STATES.

(In tons of 2000 lbs.)

States.	1894.			1895.		
	Tons.	Value.		Tons.	Value.	
		Total.	Per Ton.		Total.	Per Ton.
California	1,630	$16,664	$10.22	1,230	$12,300	$10.00
Iowa	20,000	47,000	2.35	18,600	43,710	2.35
Indian Territory	1,000	8,000	8.00	1,000	8,000	8.00
Kansas and Missouri	57,675	292,068	5.06	74,163	380,929	5.14
Michigan	98,319	242,848	2.47	95,376	236,532	2.48
New York	67,743	119,038	1.76	55,323	109,281	1.98
Ohio	33,571	100,441	2.99	33,510	101,107	3.02
South Dakota	487	2,922	6.00	....	....	....
Texas	3,605	21,725	6.03	5,670	32,045	5.56
Utah	1,400	11,200	8.00	1,265	10,120	8.00
Virginia	15,856	46,425	2.93	12,435	40,195	3.23
Wyoming	250	2,500	10.00	....	....	....
Total short tons	301,536	$910,831	$3.02	298,572	$974,219	$3.26
Total metric tons	273,553	Per met. ton..	3.33	270,861	Per met. ton..	3.60

The production for 1895 shows a very slight decrease from that of 1894 in quantity, but an increase in value, the average price obtained for the gypsum mined having somewhat increased. The principal changes to be noted were a considerable increase in the Missouri district, a slight decrease in Ohio, and a larger one in New York. No new producing districts were developed during the year.

As will be seen from the table, gypsum is found in many parts of the country and is mined or quarried in a number of different States. Michigan is the largest producer at present, but New York, Missouri, Kansas, Ohio, and Iowa also mine very considerable quantities, while Virginia, Utah, Texas, California, and the Indian Territory are also producers. It may be noted that gypsum deposits are almost always found in the neighborhood of those of salt, as is the case in New York, Michigan, and Kansas.

The gypsum deposits of New York, which are the oldest and best known and which have been the longest worked, and those of Iowa, which are of great extent and value, but as yet hardly touched, are very fully described in the following pages.

Besides the gypsum beds which are at present worked and furnish a supply, many others are known to exist which are not at present exploited, owing either to their location or to the absence of demand. The supply of this mineral can readily be increased to almost any extent necessary to meet the requirements of the country.

The chief industrial uses of gypsum are in making plaster, especially the form known as plaster-of-Paris, which is used for making molds, casts, and many other articles, and occasionally in preparing artificial stone. The best quality of gypsum and that most free from impurities is used for this purpose. A large quantity is used also for agricultural purposes in the form commonly known as land plaster, for which sale is found all over the country. The greater part of the New York gypsum is sold for this purpose and is not transported very far from the points where it is mined. A much larger proportion of the gypsum obtained in Missouri and Kansas is used in making plaster, owing to its comparative freedom from impurities and the consequently lower cost of preparing it for market. That used in agriculture is usually sold in crude form much as it is taken from the quarry; large quantities are disposed of in this way at prices not over $2 or $2.50 per ton.

Throughout the greater part of the country the demand for this mineral is met by the domestic mines, but a considerable quantity of gypsum is imported from Canada, the product obtained in New Brunswick and Nova Scotia being very pure and well adapted for the manufacture of plaster. The greater part of these imports is made in crude form and the gypsum is calcined and prepared in this country, chiefly in Maine. The low value and bulk of the gypsum forbid its transportation over any considerable distances.

Among the deposits above referred to which are not worked at the present time are those of Louisiana, which are known to be of very considerable extent, of Alabama, where extensive beds also exist, and of Arkansas. In addition gypsum has been found in Colorado, Utah, Wyoming, and Montana, although it is not worked in those States at present, with the exception of a small quantity which is mined for local use in Wyoming. California is the only State west of the Rocky Mountains which reports any production, and that is a comparatively small one.

Iowa Gypsum.

By Charles R. Keyes.

Although the occurrence of "plaster stone," or gypsum, has been known in Iowa for many years, it has only been very recently that its great extent and value have been recognized. It may now be considered as forming one of the deposits of the greatest value among Iowa's mineral resources. While the substance is widely distributed in small quantities throughout the region and occurs in nearly every geological formation having a surface exposure within its limits, the chief deposits of commercial value are those which exist in Webster County, in the north-central portion of the State. The gypsum of this locality is not only the most extensive occurrence in Iowa, but it may be regarded as one of the most valuable formations of the kind in the United States. Furthermore, its geographical position makes it the most important deposit in the entire Mississippi Valley.

A district of nearly 50 sq. m. is now known to be covered by the gypsum beds, and late investigation indicates that this is not the limit of their extent. The deposits form an irregular triangular or rectangular area lying chiefly to the south of the town of Fort Dodge, in the central portion of Webster County. The tract occupied by the gypsum trends approximately northeast and southwest, a direction nearly at right angles to the valley of the Des Moines River.

The area containing the gypsum deposits is a part of a level stretch of prairie, whose surface is so slightly rolling that the drainage is very imperfect, and the depressions are occupied for the greater part of the year by wet sloughs, often impassable by vehicles of any kind. Traversing the district in a southeasterly direction and cutting it into two nearly equal portions is the Des Moines River. While a few miles back from the stream on either side the surrounding country is quite level, with no marked contrasts of elevation, toward the chief watercourse deep ravines begin to appear, sloping steeply toward the river, whose bed is 130 to 150 ft. below the general level of the upland plain.

In Webster County the Des Moines River valley is very narrow, with scarcely any alluvial flood plain. The sides of the valley are very steep, even precipitous. All the minor tributaries of the chief watercourse likewise flow in narrow steep-sided ravines, very deep toward their lower extremities, but in the opposite direction spreading out into small broad, shallow drainage basins. The ravines are numerous, close together, and tortuous. They are separated from one another by sharp, narrow ridges.

Glacial deposits cover the entire region, often to a very considerable depth; these, therefore, have had an important influence in the molding of the topographical types, which are characteristically drift in aspect, except in the immediate vicinity of the larger watercourses. Chiefly on account of the many steep-sided valleys and ravines, the outcrops of the different formations and the various beds occur with great frequency. The district may therefore be regarded as a broad, level plain, deeply trenched through the middle by the Des Moines River.

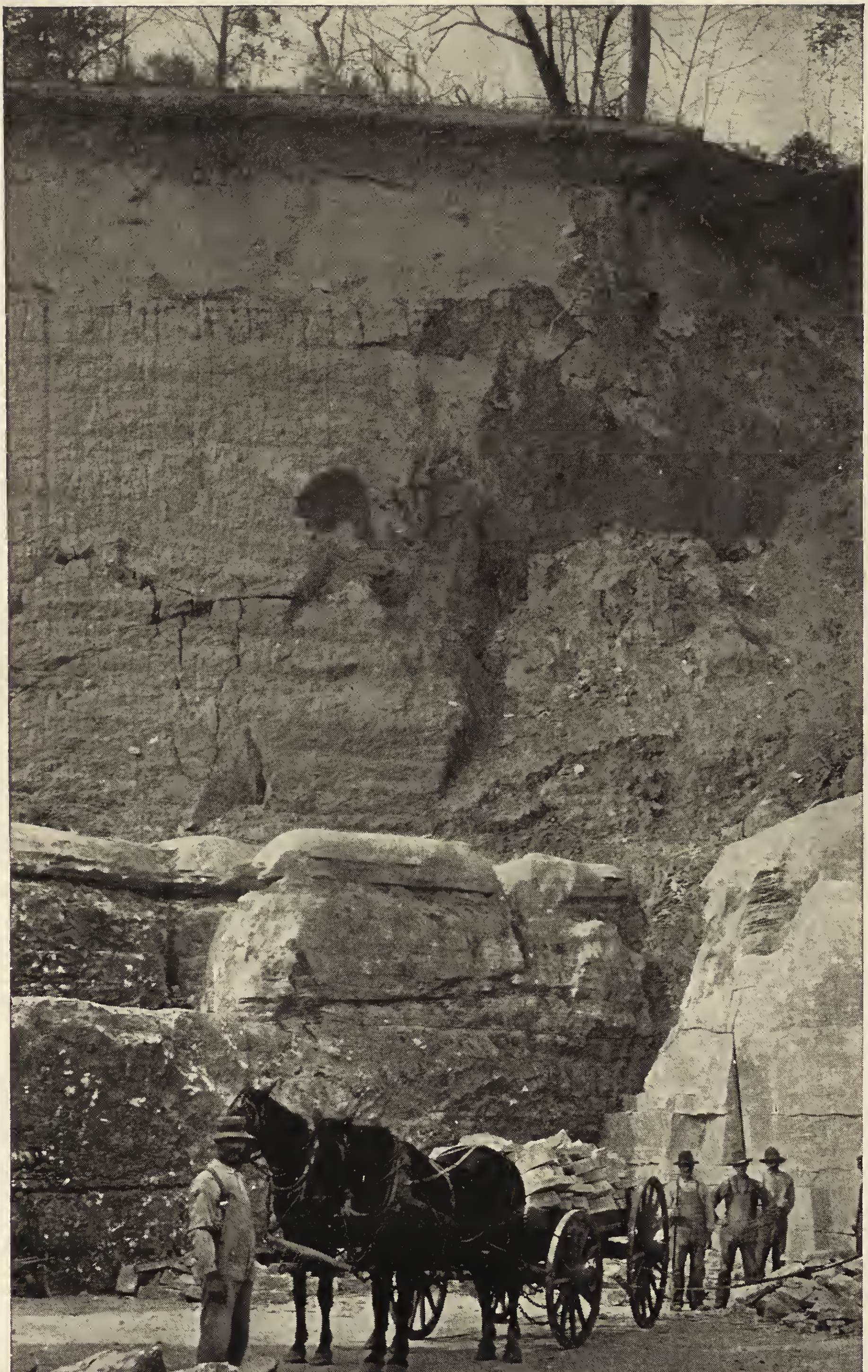
The Fort Dodge gypsum region is remarkable geologically in having present in so small an area four distinct geological formations. Between the periods of their deposition there elapsed long intervals of time. They are:

4. Drift (Pleistocene).
3. Gypsum beds and associated deposits (probably Cretaceous).
2. Lower coal measures (Des Moines formation, Upper Carboniferous).
1. St. Louis limestone (Lower Carboniferous).

In the present connection no other formations except those classed as No. 3 need be considered. The gypsum and the deposits genetically associated with it comprise several kinds of strata. At the base everywhere, so far as has been observed, there appears to be a layer of red ferruginous, clayey, and sometimes sandy nodular shale, variable in thickness, usually from a few inches to 2 or 3 ft., and resting directly upon the Carboniferous beds. Upon this stratum lie the gypsum deposits, which vary in thickness from 3 or 4 to 30 or more ft., the average measurement being about 16 ft. The gypsum is the perfectly massive variety, made up of numerous thin alternating bands of white and gray calcic sulphate, the differently colored layers measuring from $\frac{1}{8}$ to $\frac{1}{2}$ in. in thickness and finely corrugated. The lower part of the deposit, though not strikingly different from the upper portion, often contains some impurities, and on that account this part is usually ground into land plaster, while the upper portion is made into stucco. The gypsum beds appear to be thoroughly crystalline throughout, the individual crystals being columnar or needle-like, arranged closely together with their long axes at right angles to the sedimentation planes. This arrangement seems to be uniform throughout the entire deposit.

Nearly everywhere glacial detritus immediately covers the massive gypsum layer, but above the main bed in certain places—as along Soldier Creek, for example—there are exposed beds which were manifestly deposited at the same time as the principal gypsum mass. These are chiefly red and often somewhat sandy shales which pass upward into friable massive sandstone. At various levels throughout a vertical height of 25 or 30 ft. there are thin layers of typical gypsum, from $\frac{1}{4}$ to $\frac{1}{2}$ in. in thickness, widely separated both from each other and from the massive beds below. These thin gypsum layers are highly corrugated, broken portions appearing like a letter ∞ with a width often of fully 3 in. At first glance the beds immediately overlying the gypsum appear to have been deposited unconformably, but closer investigation shows plainly that such is not the case. Percolating waters have dissolved and carried away portions of the upper part of the great gypsum bed, allowing the superimposed beds to settle down on an apparently uneven surface. The shales, which are commonly light reddish in color, are friable and present few indications of bedding planes. Upon exposure they break down and crumble into a fine, dry, incoherent mass, which rapidly hides the gypsum from view, except where the streams are constantly sweeping away the talus. Upward the reddish shales give way to similar layers of a brownish or drab color, acquire more and more fine sandy material, and soon pass into a massive yellowish sandrock.

The exposure showing the fullest vertical section of the gypsum is near the mouth of Soldier Creek, in North Fort Dodge. The place is a quarry face at Kohl's brewery, and a section shows as follows:



GYPSUM QUARRY FACE, IOWA PLASTER CO., FORT DODGE, IOWA.

	Feet.
8. Drift	30
7. Sandstone, soft, friable, buff, heavily bedded	5
6. Shale, argillaceous and sandy, alternating	25
5. Sandstone, buff, massive, quite friable	2
4. Shale, blue, argillaceous	2
3. Gypsum, thin, undulatory band	0⅛
2. Shale, brown and reddish, with sandy layers, and white and gray bands of gypsum from 4 to 6 in. thick and very undulatory	7
1. Gypsum, massive, gray and white (exposed)	10

No. 1 of this section is doubtless thicker than shown in the exposure. It probably rests directly upon the St. Louis limestone, which is exposed in the creek bed a short distance away. A noteworthy fact in this section is the superposition immediately above the massive gypsum of sandy shales with thin bands of gypsum intercalated. These shales are of such character lithologically as to render favorable the finding of leaves of plants, whereby the exact age of the deposits may be determined with certainty.

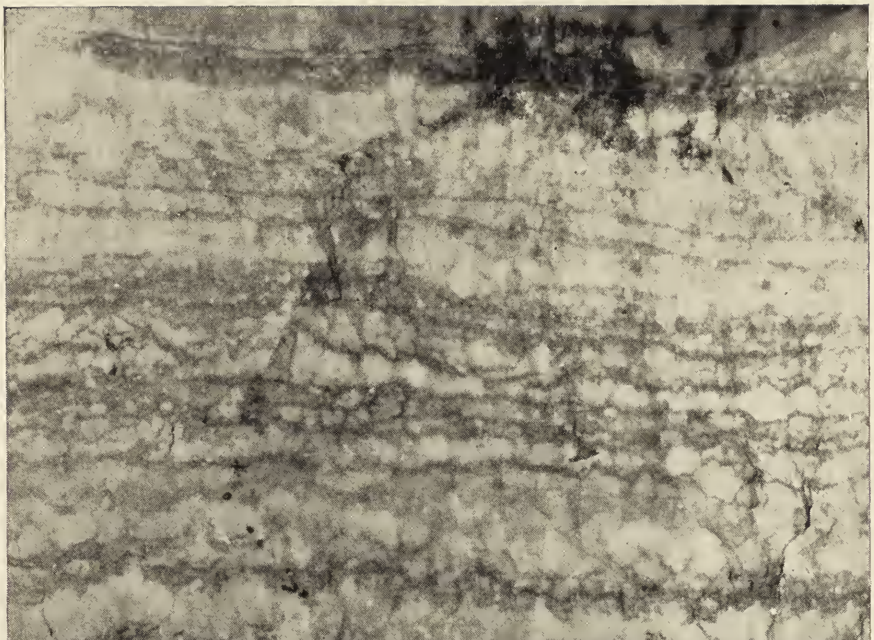
To recapitulate, the gypsum beds of Iowa form a broad plate at least 10 or 12 miles in length and about 6 miles in breadth, with a thickness varying from a few to 30 or more ft. Through the middle of the area the Des Moines River has cut a deep trench, removing a narrow belt of gypsum half a mile in width, yet at the same time exposing the deposit in its best development and making it more accessible than would have been otherwise possible.

Taking into consideration the results of the recent geological investigations in north central Iowa, it may be inferred that the gypsum has a much greater extent than is at present known. To all appearances the deposit lies in a long but narrow area not very unlike what would have been laid down in a shallow estuary stretching out into a broad open sea. The gypsum area has its long axis directed nearly northeast and southwest, a direction at right angles to that which has always been supposed. Starting upon the hypothesis that this was the true direction of a long estuary deposit, as all facts seemed to indicate, and that in geological age it was probably Cretaceous, outcrops of the latter formation were looked for beyond the borders to the southwest of any heretofore known exposures. The result was the finding of extensive chalk beds east of Auburn, in the extreme southeastern corner of Sac County, a locality 80 miles further east than any other previously reported Cretaceous chalk outcrop and within 30 miles of the Fort Dodge gypsum area. Moreover, it was directly in line with the prolonged axis of the gypsum deposit as determined some months before. Should these observations be correct, it is to be expected that extensive gypsum beds will eventually be found to exist at very moderate depths for considerable distances to the northeast and southwest of the present known limits of the Fort Dodge gypsum district.

The Iowa gypsum has been formed through chemical precipitation. At the time of deposition the area within the present boundaries of Iowa had been depressed, allowing the Cretaceous sea to invade the northwestern half of the territory. Owing to another slight oscillation of the land the waters rapidly retreated. Depressions in the old land surface would be occupied for a time by saline lakes of greater or less extent, cut off more or less completely from the ocean. As evaporation went on rapidly in these land-locked bodies of salt water they would become more and more dense and assume greater salinity, until finally the various salts would be precipitated one after another. Now, these salts fall in the inverse order of their solubility: anhydrite, gypsum, rock salt, and the others still more easily soluble. The process is not unlike that now going on in existing saline lakes, where it has been found that the gypsum is formed where the degree of saturation of the water is such that 35 to 40% of the ordinary sea water has been driven off. When more than twice this amount of water is evaporated common rock salt begins to crystallize out. With the deposits of gypsum and common salt so closely associated, it seems not improbable that the latter may be discovered sooner or later in the neighborhood of the Iowa gypsum area. Rock salt, however, is not a necessary accompaniment of the gypsum, as the waters originally may never have become so concentrated as to allow this mineral to be thrown down. Or if it had once been deposited upon the gypsum, percolating waters may have removed all the sodium chloride, for the reason that it is very much more soluble than the gypsum.

The gypsum deposits form one of the few formations of Iowa whose geological age has long remained undetermined. Recent investigations have practically settled this question, so that now there is but small doubt that it is Cretaceous in age. As remarked by White, neither in the gypsum nor the associated shales have any traces of organic remains been found. All considerations as to relative age must therefore be based upon the evidence derived from a comparison of the relations of the different formations to one another, taken in connection with the general geology of the region. Recent geological observations in northwestern Iowa indicate that exposures which are undoubtedly Cretaceous occur much further eastward than had hitherto been regarded, and it would appear that the gypsum beds and the accompanying overlying shales may be considered as Cretaceous in age and that they were probably deposited at the same time as the Niobrara chalks along the Missouri River near Sioux City. The Cretaceous deposits of Iowa were laid down on a gradually sinking shore. Cretaceous sediments, Dakota sandstones and Benton shales, were deposited at the beginning of the period of depression and were afterward covered by the Niobrara chalk. But eastward from the open-sea deposits of the last-named stage shore depositions were also formed. The Niobrara stage thus represents the greatest expansion of the Cretaceous waters within the present limits of Iowa. As already stated in regard to the origin of the gypsum, there is no reason for doubting that all the gypsum deposits of the region are to be considered as chemical precipitations in saline lakes which had originally been cut off from the sea during a period of land elevation. This being the case, it would be only during the retreat of Cretaceous waters in the Iowa territory that such salt or land-locked lakes could be formed.

For so thick and so extensive a deposit of this mineral the Fort Dodge gypsum is remarkably pure chemically. The whiter portions show considerably less than 1½% of impurity, while the darker portions, which are taken from near the base and which are used for land plaster, give only 10 to 15% of impurity. The largest proportion of the impurity is probably clay, which, however, is usually concentrated more or less into narrow bands. The argillaceous matter, even in its most concentrated form, seldom amounts to more than one-tenth of the entire portion of the thin zones, which are called the impure parts. The other impuri-



STRUCTURE OF IOWA GYPSUM DEPOSIT.

ties are minute quantities of silica in a finely divided condition. Of lime and iron there are commonly but small quantities, amounting to only a fraction of 1%.

Analyses of a number of samples of the Fort Dodge gypsum were recently made by Prof. G. E. Patrick. A selected piece which was slightly weathered and taken from the quarry which supplies Mill No. 3 of the Iowa Plaster Company showed only 0.65% of impurities. This analysis gave:

	Per Cent.
Calcium sulphate, $CaSO_4$	78.44
Water of crystallization (calculated)	20.76
Insoluble matter (impurities)	0.65
	99.85

Three samples from the top, middle, and bottom of the quarry face at the same locality gave the following results:

	Top.	Middle.	Bottom.
Calcium sulphate, $CaSO_4$	78.37	78.54	78.44
Water of crystallization	20.75	20.79	20.76
	99.12	99.33	99.20

Specimens from the Duncomb Quarry, on the opposite side of the river, yield very similar results, with the indications that the gypsum is a trifle more pure. Two analyses by Emery of light and dark bands of the gypsum, probably from the lower portion of the deposit, which is ground into land plaster, gave 98.63 and 85.53% of gypsum.

A fresh sample from the middle of the quarry ledge above Mill No. 3 showed:

	Per Cent.
Calcium sulphate, $CaSO_4$	79.23
Water of crystallization (determined)	20.23
Insoluble matter	0.84
	100.30

It will be noticed that the amount of water of crystallization in this sample, which was accurately determined, was considerably lower—0.70%—than the theoretical amount of water in pure gypsum. This, taken in connection with the fact that there is a slight excess of lime and sulphuric acid in the different analyses, would indicate that a small amount of calcium sulphate in the form of anhydrite is present in the gypsum. In this connection it would also be of interest to know whether or not the ordinary gypsum crystals which are so abundant in many of the formations have always the theoretical amount of water of crystallization.

Uses of Iowa Gypsum.—Nearly all of the gypsum produced in Iowa is converted into stucco, or plaster of Paris. The processes involved from the time the material leaves the quarry until it appears as the finished product ready for shipment are fully described further on.

The most extensive use to which the stucco is put is in the finishing coat of the inside of buildings. Hard plaster for walls also consumes considerable amounts. Fertilizers are used so sparingly in Iowa at present that very little gypsum is ground for this purpose. The total amount used in this way for one year was valued at only $4845. Thirty years ago, before railroads were constructed through the Fort Dodge region, gypsum was quarried largely for building purposes. Not only were foundations and retaining walls built of it, but houses and culverts. Split up into large slabs, it also served as flagging for sidewalks on some of the principal streets. Of recent years comparatively little of the material has been used for construction purposes. Of the buildings erected with it the most prominent is the Illinois Central Railroad station at Fort Dodge; several residences were also built largely of it. As a facing for buildings and for cut stonework it retains its primitive freshness only for a few years, a decade or more perhaps. Generally the exposed surfaces become bleached and finely cracked as in the natural ledges. Notwithstanding this, the blocks do not crumble or become parted and the appearance of the building is unimpaired.

Quantity of Gypsum Available in the Iowa Deposits.—Recognizing the excellent character of Iowa gypsum, it becomes a matter of considerable interest and importance to determine, approximately at least, both the areal and vertical extent of the beds and the amount of material that is practically available. While, as already said, the deposit is variable in thickness, ranging from a few feet to upward of 30 ft., it is not an unusual thing to find the maximum measurement exhibited in numerous sections. Most of the many exposures show the mean vertical measurement of the gypsum, so that it would probably be no overestimation to place the average thickness of the entire bed at 16 ft. Although a part of the gypsum has been removed through the erosion of the Des Moines valley and its tributary ravines, and a still larger portion has been carried away through solution since its original deposition, there yet remains an amount which is sufficient to supply all demands for many years to come.

Careful mapping of the gypsum area, accurate measurements of the outcrops, and comparisons of boring records have enabled the areal extent of the deposits to be made out with considerable detail. In making the various estimates regarding the quantity of material which is available all figures are low, so that a wide margin is left, which will amply make up for any minor discrepancies in the calculations.

The amount of good gypsum which different parts of the field will yield is of course variable. In the thinner portions only 10,000 or 20,000 tons to the acre can be relied upon; on an average the yield would probably be in the neighborhood of 50,000 tons for the same area; while at those points where the best sections are exposed, with the bed 30 ft. and over in thickness, the yield per acre would be nearly 100,000 tons.

The known areal extent of the gypsum is in the neighborhood of 55 sq. m. But this doubtless is not one-half of the entire deposit. On the basis of the average thickness, the total amount of available gypsum on the known area is something more than 40,000,000,000 tons. At the present rate of production it would require not less than 800,000 years to exhaust it. Although the present condition of the industry appears to be quite flourishing and important, no adequate idea of the immense actual extent and value of the Iowa gypsum deposits can be acquired without making some comparison of what is now being done with what a full development would make possible.

The conditions for obtaining the gypsum are exceptionally favorable. Instead of its being necessary to mine the mineral, or in quarrying it to remove large quantities of hard rock, only a soft, incoherent covering is present. This covering, though sometimes 30 to 60 ft. thick, is easily disposed of, since the position of the gypsum high up in the hills enables it to be reached readily. At the present time the stripping is done by scrapers after the manner of ordinary highway work. The introduction of hydraulic apparatus for the removal of the drift material overlying the gypsum would greatly facilitate stripping and at the same time very materially reduce the cost. Carefully made estimates indicate that the removal of the covering of the gypsum could be accomplished at somewhat less than one-fifth of the present expenditure for this purpose. The deep gorges and ravines which intersect the region in all directions, especially near the principal watercourse, with the gypsum lying high above the creek beds, make this method of stripping particularly commendable.

The gypsum is not only readily removed from the natural bed, but the facilities for transportation are unusually good. Four railroad lines give outlets in several directions with good connections, affording means of reaching every part of the surrounding country and all the larger cities of the Northwest. These railroads are the Illinois Central, the Chicago, Rock Island & Pacific, the Minneapolis & St. Louis, and the Mason City & Fort Dodge. The annual production has been over 50,000 tons. The production of gypsum has rapidly increased during the last few years, nearly all of the amount quarried being converted into stucco. In the manufacture of plaster of Paris Iowa ranks second and in the total production of gypsum third among the States of the Union.

Preparation of Gypsum for Market.—The gypsum mills are four in number. Three of them are situated 3 to 4 miles south of Fort Dodge, on the Minneapolis & St. Louis Railroad; the fourth is only a short distance away on the Illinois Central Railroad. The mills consist of large sheds, where the gypsum blocks are piled as they come from the quarry; the mills proper, which are tightly closed buildings containing all the machinery, boilers, and kettles; and storage sheds, which are rather open structures, but protect the stucco effectually from the weather until shipment. All the mills have private switches from the railroad, so that the coal used is brought in and unloaded directly in front of the furnace openings and the output is loaded from the storerooms.

The gypsum is quarried in the same manner as ordinary building stone. The stripping, which is from 10 to 50 ft. thick, is removed by iron grading scrapers, each worked by two horses. The covering is removed for a considerable distance and the upper surface of the gypsum made as clean as possible. The immediate quarry faces are not very large, usually not more than 50 or 60 ft. across, though several of them may be driven forward close together in a single ledge. A number of holes are made near the edge of the ledge by means of ordinary hand drills and large masses blasted from the bed. Further breaking, for ready handling, into sizes about as large as paving blocks is accomplished by means of sledges. The material is then loaded on wagons and transferred to the sheds near the crusher, where it accumulates in large piles. The blocks are then fed to the crusher, which consists of a heavy steel jaw working horizontally against a large thick anvil, allowing the small fragments to drop beneath. After passing through the crusher the small gypsum fragments are conveyed to the grinder, modeled after flouring buhrs, but somewhat coarser. Coming out as a flour-like product, it is carried to the kettles, which are large iron vats under which heat may be applied and which hold about 6 tons each. Here the gypsum is heated or "boiled," by which process the water is driven off. The heating process takes about 1½ hours and the filling of the kettles about as much more time. Considerable fine gypsum goes off with the steam, and passing up the tall smoke-stack spreads out and settles upon every object within a radius of a quarter of a mile. The mills, sheds, trees, and ground have the appearance of being covered with snow, forming in summer time a very striking effect. After "boiling" sufficiently the stucco is allowed to cool and is transferred to barrels or bags and made ready for shipment.

When the industry of manufacturing stucco on a large scale had become well established much dissatisfaction was found with all the ordinary methods then employed in the calcining process. Various experiments were tried by the several companies engaged in the business. Finally an improved method was perfected which was patented by the Fort Dodge Gypsum Company and known as the Marsh process. Up to this time the gypsum or plaster had been calcined by placing the material in a metallic vessel, which was provided with flues extending upwardly from different points in its bottom or horizontally from different points in its sides, to heat the plaster in the body of the kettle. The kettle or vessel was heated by fire beneath and about its bottom in the usual way. This process was liable to several objections. First, it was expensive, because the bottoms of the kettles were costly, and as they burned out rapidly required frequent replacing by new ones, occasioning much expense as well as loss of valuable time; secondly, the process was wasteful, owing to leaks through the bottoms, which frequently and unavoidably cracked when the kettle was full of plaster and under a full head of fire, thus causing much loss of plaster as well as delay for repairs; thirdly, the process was generally unsatisfactory, for the reason that it was impossible to maintain uniformity of heat in boiling kettle after kettle or in several kettles run at the same time, which resulted in giving a product differing in quality according to the difference or irregularity of heat with which it was treated.

The main advantage claimed for the new method was to overcome the defects mentioned, to secure perfect uniformity in the application of heat and in the quality of the product, as well as generally to improve the method of calcining gypsum. The invention consists essentially in employing steam to expel the water from the gypsum and reduce it to a friable state, and in the construction and arrangement of a mechanism by which this result is accomplished. The apparatus embraces a kettle with an agitator and coils of pipe instead of a steam jacket about its inside. The kettle may be of any desired size, but one 6 or 7 ft. high and about 8 ft. in diameter is to be preferred.

Gypsum in New York.

Occurrence.—Gypsum is found in the Salina of the Upper Silurian in New York State. In the crystallized form it is called selenite; in the anhydrous form it is known as anhydrite. Pure gypsum has a sp. gr. of 2.6 to 2.8 and contains lime, 32.6%; sulphuric acid, 46.5%; water, 20.9%. The beds were referred to the Lower Heidelberg by Williams, but he overlooked a low fold at Union Springs. The gypsum deposits are found in New York State from Genesee County eastward as far as Madison County, and are, in a general way, limited on the north by the line of the Erie Canal.

Deposits have been found and opened at Alabama Falls and Oakfield, in Genesee County; Mumford and Garbutt, in Monroe County; Port Gibson, in Wayne County; Victor and Phelps, in Ontario County; Union Springs, in Cayuga County; Marcellus Falls, Halfway, Fayetteville, Jamesville, and Syracuse, in Onondaga County; Cottons and Hobokenville, in Madison County. The most extensive of these are at Oakfield, Mumford, Garbutt, Union Springs, and Fayetteville. The Union Springs Quarry is the only one conducted on a commercial scale, with shipments of products and milling facilities.

The stone is usually of a gray color, which is probably due to carbonaceous matter and not to metallic oxides. The color varies, running from the dirt-colored variety found in Madison County to whitish in Monroe County, the purity of the stone increasing toward the west. Two and sometimes three beds are known in places; usually the deeper the material the better. Rises or knolls of ground are considered favorable points of attack for opening new quarries. Accompanying the gypsum rock and more or less intermingled are found water lime, shale, and dirt. Numerous cavities are found filled wholly or partly with "ashes," a coarse sediment of shale and dirt, illustrating the original deposition from a body of water.

Mining and Preparation.—Underground work is in vogue in the western part of the State. On Cayuga Lake and to the east open quarrying and stripping of the top covering of earth is usual. The work is carried on largely by farmers and local merchants, the farmers working the deposits in the dull season. In mining a shaft about 8x12 ft. is sunk to the bottom of the gypsum bed, the shafts being generally 25 to 50 ft. deep. Tunnels are then driven in the deposit and the material obtained by cuttings, no systematic method of exploitation being employed. For maintenance occasional pillars or crib work are used. To mine the stone short drills are struck by sledges, the holes being loaded with black powder. In this way the material is obtained in different sizes, which can be loaded on a barrow or on small flat cars running on wooden rails with a light hoop rim. The stone is loaded in buckets and hoisted to the surface by a derrick or whim operated by horses. The methods are of the simplest kind and involve considerable handling of the products. The beds vary in thickness from 4 to 6 ft., the first bed only being worked. The pay of miners is $1 to $1.50 per day; in one case contracts were made at 60c. per ton brought to the surface, powder provided.

In open quarrying the top earth is stripped off to the gypsum bed, a black earthy gypsum being found above the working bed which is of little value. The stone is blasted with powder and hauled to the mill on one-horse carts, the refuse being used on the roads. Quarrymen receive about $1.50 per day. Quarries run up to 40 ft. thick, with more or less non-workable layers.

In milling the material is first crushed in a Blake crusher, from which it goes to a cracker. It is then elevated by conveyers of the link-belt type to a hopper leading to the mill, where it is crushed to a fine powder between buhr stones revolving in opposite directions. From these it is conveyed to and loaded in cars or put up in bags for shipment.

Uses.—The principal use of gypsum is as land plaster. It is also marketed in various other forms. Keen's cement is composed of gypsum with 1 part alum and 12 parts water. Parian cement is plaster with some borax and water. Stucco is a mixture of plaster and glue. Another form is known as imitation meerschaum. When heated to about 250° F. gypsum loses its water of combination. It has the property of recombining with water when mixed with it and setting from a thin paste into a solid mass, this phenomenon being accompanied with some expansion and evolution of heat. When gypsum is burned to over 480° the sulphate rehydrates only with difficulty; at still higher temperatures it loses all power of absorbing water, and in this respect resembles anhydrate. In this form it is used for making copies of statuary, coins, medals, sculpture, and carvings; also casts of natural objects, molds for electro-deposits, pressed and embossed pottery ware. Plaster casts made with water alone are soft and somewhat soluble in water. The most extensive use is as a fertilizer. It is claimed that it not only furnishes food for plants, but also absorbs ammonia and other gases from the air and transfers them to the soil. It is employed as a top dressing for wheat, potatoes, clover, corn, etc. It is also largely used in the manufacture of commercial fertilizers. None of the gypsum quarried in New York State is used in making plaster of Paris, although experiments have been made in Western New York with some degree of success. The trouble appears to be on account of the color of the gypsum and the impurities which it contains. Three companies in New York are now manufacturing plaster for walls and ceilings, but the raw material is obtained from quarries or deposits outside the State.

Price.—The price ranges from $2.50 to $3 per ton. The market is chiefly local, although the Cayuga Plaster Company ships some out of the State, as well as to different points in the State. The "Cayuga" and "Onondaga Chief" brands of plaster are made by this company. The cost of mining varies from 15c. to $1 per ton, according to the circumstances—thickness of bed, facility of mining, etc.

Literature.—Kemp, *Economic Geology;* Williams, *A. J. S.*, Pt. III., pp. 30, 252; Gesner, A., *I. J. G. S.*, p. 129, 1849; Hunt, *A. J. S.*, Pt. II., Vol. XXVII., pp. 170, 365; Hunt, S. T., *A. J. S.*, Pt. II., Vol. VII., p. 157; Williams, S. G., *A. A. A. S.*, Vol. XXXIII., p. 402, 1884, Cayuga County; Tyrell, *Can. Rec. of Science*, July, 1889.

IRON AND STEEL.

By Frederick Hobart.

The record of the iron industry of the United States in 1895 shows a very large, though somewhat irregular production, accompanied by a steady increase in capacity of plants and minor improvements in working methods, though no important changes were made. It was a period of recovery from depression, when the course of the industry was entirely dependent on the changing conditions of trade.

The production of pig iron was the greatest ever made in one year in the United States, or, indeed, in any country in the world; and the same statement is to be made of the output of steel and of nearly all kinds of finished material, though there were a few notable exceptions. The quantity of pig iron made in this country was 9,446,308 long tons, which was 1,550,633 tons more than was made by Great Britain, and very far in advance of the amount reported by any other nation.

The results of the year showed an increased tendency to the centralization of the trade in a few districts; a growth in the business and strength of the larger concerns at the expense of the smaller producers; and they emphasize the fact that under the stress of modern competition and the improvement in processes, it is only the largest and best-equipped plants which can expect to prosper and to hold their position in this trade.

We are fortunate in the United States in possessing very complete and reliable statistics of the iron industry. This is due to the thorough organization of the American Iron and Steel Association and to the excellent work done by its secretary, Mr. James M. Swank, whose thorough knowledge of the trade and many years of experience have enabled him to collect and present the statistics of production with a degree of method and completeness which are not equaled in any other important industry. The figures given below are chiefly taken from the reports of the association.

IRON-ORE PRODUCTION.

The production of iron ore in the United States showed a great increase, the activity at the mines naturally following that of the furnaces. The table below gives the production and imports for the five years ending with 1895 in long tons:

IRON-ORE PRODUCTION OF THE UNITED STATES.

Year.	Red Hematite.		Brown Hematite.		Magnetite.		Carbonate.		Total Production.		Imports.		Total Supply.
	Tons.	Per Cent.	Tons.	Per Cent.	Tons.	Per Cent.	Tons.	Per Cent.	Tons.	Per Cent.	Tons.	Per Cent	Tons.
1891..	9,327,398	60.2	2,757,564	17.7	2,317,108	15.0	189,108	1.2	14,591,178	94.1	912,864	5.9	15,504,042
1892..	11,646,619	68.1	2,485,101	14.5	1,971,965	11.5	192,981	1.2	16,296,666	95.3	806,585	4.8	17,103,251
1893..	8,272,637	68.3	1,849,272	15.3	1,330,886	11.0	134,834	1.1	11,587,629	95.7	526,951	4.3	12,114,580
1894*a*.	8,660,000	71.9	1,820,000	15.1	1,280,000	10.6	120,000	1.0	11,880,000	98.6	168,541	1.4	12,048,541
1895*a*.	12,426,000	71.1	2,536,000	14.5	1,860,000	10.7	128,000	0.7	16,950,000	97.0	524,153	3.0	17,474,153

(*a*) Distribution estimated.

The following additional table shows the total production, the approximate consumption, and the values of iron ore for the years 1894 and 1895:

IRON-ORE PRODUCTION AND CONSUMPTION.

Year.	Production.				Imports.				Consumption.				Tons Ore to Ton Pig Made.
	Long Tons.	Metric Tons.	Value.		Long Tons.	Metric Tons.	Value.		Long Tons.	Metric Tons.	Value.		
			Totals.	Per Ton.			Totals.	Per Ton.			Totals.	Per Ton.	
1894	11,880,000	12,070,080	$20,790,000	$1.75	168,541	171,238	$267,241	$1.59	12,048,541	12,241,318	$21,057,241	$1.75	1.81
1895	16,950,000	17,221,200	29,662,500	1.75	524,153	532,539	786,207	1.50	17,474,153	17,753,739	30,448,207	1.74	1.85

Lake Superior Iron Ores.—The iron ores of the Lake Superior region in 1895 continued to be the main source from which nearly all the furnaces north of the Ohio and west of the Alleghanies drew their supplies. The production in this region was very largely increased, reaching a total of 10,429,037 tons, an increase of 2,680,105 tons, or 34.7%, over 1894. This was 61.5% of our total production of ore for the year. In the following table we give the shipments of iron ores by ports for the five years ending with 1895, the figures for the latter year being taken from the carefully prepared statistical tables of the Cleveland *Iron Trade Review:*

SHIPMENTS OF LAKE SUPERIOR IRON ORE BY PORTS.

(In tons of 2240 lbs.)

Year.	Marquette.	Escanaba.	Gladstone.	Ashland.	Two Harbors	Duluth. (*a*)	Total Lake.	Rail.	Totals.
1891..	1,056,027	3,058,590	177,866	1,261,658	890,299	....	6,444,440	651,541	7,095,981
1892..	1,026,338	4,010,085	115,886	2,223,683	1,165,076	4,245	8,545,313	528,930	9,074,243
1893..	1,086,934	2,048,981	203,585	1,117,524	903,329	520,565	5,880,918	178,037	6,058,955
1894..	1,424,409	1,657,240	79,109	1,731,703	1,373,344	1,367,286	7,633,091	115,841	7,748,932
1895..	1,079,485	2,860,172	109,211	2,350,219	2,119,156	1,716,667	10,234,910	194,127	10,429,037

(*a*) Superior shipments are included in Duluth.

The table below shows the output of iron ore from the region by ranges, also for the five years ending with 1895, the last line in the table showing the total shipments from each range from its first opening up to the close of 1895:

SHIPMENTS OF LAKE SUPERIOR IRON ORE BY RANGES AND TOTALS FROM OPENING OF THE MINES.

Year.	Marquette.	Menominee	Gogebic.	Vermilion.	Mesabi.	Totals.
1891	2,511,395	1,843,326	1,848,721	891,539	....	7,094,981
1892	2,666,856	2,261,499	2,973,993	1,167,650	4,245	9,074,243
1893	1,829,053	1,466,197	1,329,464	820,621	613,620	6,058,955
1894	2,058,683	1,139,273	1,810,290	948,514	1,792,172	7,748,932
1895	2,097,838	1,923,798	2,547,976	1,077,838	2,781,587	10,429,037
Totals from opening of ranges....	43,906,131	21,308,618	18,934,952	8,132,146	5,191,624	97,473,471

The most marked feature in the region has been the rapid development of the Mesabi range, which rose from a few thousand tons in 1892 to the position of the largest shipper in 1895. This development still continues, and recent discoveries have proved that the ore-bearing territory extends very much beyond the limits which were originally assigned to it. The higher-grade ores of the Mesabi also form a fair proportion of the total.

The production of all the ranges in 1895 was for the first time in excess of 10,000,000 tons in one year.

Southern Iron Ores.—Mr. W. M. Brewer reports specially for this work that in Alabama the output of iron ore from the Red Mountain district, which comprises properties of the Tennessee Coal, Iron and Railroad Company, the Sloss Iron and Steel Company, the Woodward Company, and the Pioneer Mining and Manufacturing Company, was greater than during any year since 1890, and almost equaled the aggregate of that year, which was the largest in the history of the State.

One of the most important questions in relation to the iron-ore industry has been the experiments made by Dr. Wm. B. Phillips in magnetizing and concentrating the low-grade fossiliferous ore which has heretofore been left unmined in the Red Mountain vein. This forms the lower portion of the seam and is reported as averaging from 8 to 10 ft. in thickness and having a sufficient area uncovered at the present time to leave in sight some 5,000,000 tons. While a certain degree of success has been attained in these experiments, the newer Wetherill process for concentrating these ores raw by magnetic machines will probably prove more economical and more efficient. Experiments are being made to test this.

The persistency of the larger and more important deposits of limonite in Alabama and Georgia is in many cases really surprising to the owners themselves. Take, for instance, the Champion Mine, owned by the Tennessee Coal, Iron and Railroad Company, the mines owned by the Pioneer Mining and Manufacturing Company, the Baker Hill, owned by the Tecumseh Iron Company, the Big Bank, owned by the Georgia Mining, Manufacturing and Investment Company, the Reed Bank, owned by the Augusta Mining and Investment Company, and the Ledbetter Bank, leased by the North Georgia Mining Company, which may be considered the more important of the Southern brown ore mines, and we find that new pockets are discovered about as fast as the old ones are worked out. Within the last five years it has seemed several times that the minimum limit had been reached in the cost of mining and washing brown ore, and yet each year sees a further lowering of some item. In 1891 the price per ton of brown ore, taken as run of mine, was greater than the price paid in 1895 for the ore from the same district purchased on analysis with 50% iron as the minimum. Of course during each year since 1891 operators with small means have been obliged to drop out of the business, because as the furnaces demanded a better and cleaner grade of ore it became necessary to throw aside the old screens and replace them with a modern washing plant. To do this required capital, and consequently the mining of limonite is now in the hands of corporations whose profit is chiefly from the transactions in the commissary store, which in this section is apparently necessary for carrying on of iron ore-mining profitably.

The decrease in the demand for ores for the production of charcoal pig iron in Alabama was quite noticeable during 1895. In fact, this decline has been marked since 1892, but until last year the list of charcoal furnaces in blast included the Shelby, the Ironton, the Jenifer, the Rock Run, and the Round Mountain in Alabama, and the Rome Furnace in Georgia. During 1895 the Round Mountain was the only one in blast during the entire year. Late in the spring Shelby was blown in and still later Rock Run, while at Ironton the furnaces were changed for coke, and Jenifer was practically out of blast the entire year. In Georgia the Rome Furnace was kept in blast throughout the year.

Owing to the increased production of pig iron during 1895 there was an increased demand for limonite, and in consequence work was resumed at several properties which had been idle for several years. New mines opened in 1895 are the May and Linsey, in Cedartown district; and among older properties on which operations were resumed during the year are the Pittman and the Vandeventer, near Exom Hill, in Polk County, Ga.; the Big Bank, in Bartow County, Ga., and several less important occurrences of a high-grade low-phosphorus ore, which, because of their apparently limited extent, had not received the attention they deserved in the past. All the mines which have been regular producers since 1890 were active in 1895, and all of them produced more ore than in any previous year. Such properties as the Cochrane, in Polk County, Ga., the Rendalia, in Talladega County, Ala., the Alexander, in Cleburne County, Ala., where large amounts were invested in modern plants which have never been in operation because of the unsatisfactory supply of ore, ranked among the non-producers during the year, as also have the Grady Banks, in Polk County, Ga., and the Seney Banks, in Floyd County, Ga.

The Red Ore district of Georgia, which is situated in the southwesterly extension of the Cumberland Mountains, locally known as Pigeon Mountain, Broncho Mountain, and Dirtseller Mountain, and which crosses Walker and Chatooga counties, was especially active during 1895. The product from the Dirtseller Mountain, where the seam of red fossiliferous ore only reaches an average of about 13 in. in thickness, has been used in the charcoal furnaces at Rome. The product from the Broncho Mountain mines, where the seam of ore has almost a vertical dip and is mined from a depth of nearly 200 ft., is used by the Dayton Coal and Iron Company. This vein of ore has an average thickness of about 3 ft. and is mixed on the full-room system at the rate of about 100 tons per day. The product from the Estelle Mines, in Pigeon Mountain, is also shipped to Dayton, Tenn. The ore body in these mines is very similar to that at Dirtseller Mountain, only averaging somewhat thicker, and is mined from under cover. At Dirtseller the thickness of the seam is not too small nor is the overburden too heavy at present to make stripping unprofitable.

Imports of Iron Ore.—Of the iron ore imported in 1895 about 98% came to the ports of Baltimore and Philadelphia. Of the total imports 386,044 tons, or nearly three-fourths, came from the island of Cuba. The greater part of the remaining fourth was from Spain, though a few cargoes were received from Algeria.

The production of iron ore in Canada in 1895 is reported by the Geological Survey of the Dominion at 102,797 tons, showing an increase of 4591 tons over 1894. Very little of this ore came to the United States.

PIG IRON.

The course of pig-iron production in the United States is shown in the following table, which gives the approximate production by months in long tons, with the number of furnaces in blast at the opening of each month:

PIG-IRON PRODUCTION IN THE UNITED STATES.

Month.	1893.		1894.		1895.	
	Furnaces.	Production.	Furnaces.	Production.	Furnaces.	Production.
	Number.	Tons.	Number.	Tons.	Number.	Tons.
January	250	766,225	137	447,723	185	762,474
February	250	719,675	128	406,443	181	641,550
March	256	746,151	134	515,137	172	688,170
April	259	766,388	144	571,784	171	666,315
May	255	786,470	124	472,893	175	664,600
June	243	778,009	91	304,003	172	664,449
First half-year	....	4,562,918	....	2,717,983	....	4,087,558
July	230	634,165	109	411,500	187	730,156
August	174	497,067	136	539,540	203	780,855
September	126	381,340	169	694,974	219	899,400
October	116	325,826	172	717,691	228	940,630
November	122	351,590	186	761,251	238	979,933
December	130	371,596	188	814,449	244	1,027,776
Second half-year	....	2,561,584	....	3,939,405	....	5,358,750
Totals for the year	....	7,124,502	....	6,657,388	....	9,446,308

Fuel Used.	1893—Tons.	1894—Tons.	1895—Tons.
Anthracite	1,347,529	914,742	1,270,899
Coke	5,390,184	5,520,224	7,950,068
Charcoal	386,789	222,422	225,341
Totals	7,124,502	6,657,388	9,446,308

The figures include the production of spiegeleisen and ferro-manganese, which amounted to 171,824 gross tons in 1895 and 120,180 tons in 1894. Of the total production in 1895 there were 5,623,695 tons (59.5% of the total) classed as Bessemer pig, against 3,808,567 tons (57.2%) in 1894 and 3,568,598 tons (50.1%) in 1893.

The following table shows the production of pig iron by States for the five years ending with 1895:

PRODUCTION OF PIG IRON IN THE UNITED STATES BY STATES.

States.	1891.	1892.	1893.	1894.	1895.
Alabama	795,673	915,296	726,888	592,392	854,667
Colorado	18,116	32,441	45,555	73,669	58,508
Connecticut	21,811	17,107	12,478	7,416	5,615
Georgia	49,858	9,950	39,675	40,268	31,034
Indiana	7,729	7,700	5,567	....	....
Illinois	669,202	949,450	405,261	604,795	1,006,091
Kentucky	44,844	56,548	47,501	33,854	63,780
Maryland	123,398	99,131	151,773	5,600	10,916
Massachusetts	8,990	7,946	7,853	156	4,710
Michigan	213,145	184,421	117,538	95,171	91,222
Minnesota	1,226	14,071	10,373	....	....
Missouri	29,229	57.020	32,360	6.522	27,518
New Jersey	92,490	87,975	74,305	63,273	55,502
New York	315,112	310,295	191,115	175,185	181,702
North Carolina	3,217	2,908	2,843	....	323
Ohio	1,035,013	1,221,913	875,265	900,029	1,463,789
Oregon	9,295	7,628	4,739	1,000	....
Pennsylvania	3,952,387	4,193,805	3,643,022	3,370,152	4,701,163
Tennessee	291,738	300,081	207,915	212,773	248,129
Texas	18,662	8,613	6,257	4,671	4,682
Virginia	295,292	342,847	302,856	298,086	346.589
West Virginia	86,283	154,793	81,591	80,781	141,968
Wisconsin	197,160	174,961	131,772	91,595	148,400
Totals	8,279,870	9,157,000	7,124,502	6,657,388	9,446,308

Pennsylvania maintained the first position as an iron producer, making very nearly one-half of all the pig iron. Ohio was second in order, Illinois third, and Alabama fourth. No other State made over 500,000 tons. Oregon dropped out of the list of producers, while the furnaces of Indiana and Minnesota remained inactive.

The following table shows, in addition to the production of pig iron, the imports, exports, stocks on hand at the close of each year, and the approximate consumption, in long tons:

PRODUCTION AND CONSUMPTION OF PIG IRON IN THE UNITED STATES.

Year.	Production.	Imports.	Exports.	Stocks.	Consumption.	
					Totals.	Per Capita. Pounds
1891	8,279,870	67,179	14,945	596,421	8,341,603	293
1892	9,157,000	70,125	15,427	506,116	9,302,003	320
1893	7,124,502	54,394	24,570	662,068	6,998,374	237
1894	6,657,388	15,582	24,480	597,688	6,648,490	241
1895	9,446,308	53,232	26,164	444,332	9,626,732	315

The demand for iron not only absorbed the entire output of the year, but also brought the unsold stocks at the close of the year down to an unusually low point. The imports and exports of pig iron have a very insignificant relation to the production.

STEEL AND FINISHED IRON.

Even in the depression of 1894 there was an increase in the production of steel over that of the preceding year, and it was to be expected that in a period of renewed activity there would be a still further gain. The following table shows the total production of steel in the United States for the five years ending with 1895:

STEEL PRODUCTION IN THE UNITED STATES.

(In tons of 2240 lbs.)

Kinds.	1891.	1892.	1893.	1894.	1895.
Bessemer	3,247,417	4,168,435	3,215,686	3,571,313	4,909,128
Open-hearth	579,753	669,889	737,890	784,936	1,137,182
Crucible	72,586	84,709	63,613	51,702	67,666
Miscellaneous	4,484	4,548	2,806	4,081	858
Totals	3,904,240	4,927,581	4,019,995	4,412,032	6,114,834

This steel production exceeds by no less than 1,187,253 tons the greatest ever reported in any previous year. The table shows the steady progress made by the open-hearth process; in 1892 the Bessemer steel was 84.6% of the total and the open-hearth 13.6%, while the proportion in 1895 was 80.3% Bessemer and 18.6% open-hearth. The change is further shown by the fact that the increase in capacity of the Bessemer steel works in this country in the years 1894 and 1895 was 22.4%; that in producing capacity of the open-hearth plants was 40%. Rapid progress has also been made in the introduction of the basic process, and it is estimated that nearly one-half the open-hearth steel works in the country now use that process. The introduction of the open-hearth furnace has largely increased the number of plants making direct steel castings.

The use of steel in place of iron continues to increase, as is shown by the fact that in 1895 the number of puddling furnaces actually decreased, in spite of the greater demand. The almost total disappearance of a once important branch of the iron industry is shown by the statement that there was in operation in 1895 only one forge making blooms directly from the ore. This was the Helton Forge, in Ashe County, N. C., and its total output for the year was only 40 long tons of blooms and bars. As late as 1890 there were 11,089 tons of this class of iron made.

While the railroad demand is no longer the chief support of the rolling mills, we give as a matter of interest below the production and consumption of rails in the United States for five years:

PRODUCTION AND CONSUMPTION OF RAILS.

(In tons of 2240 lbs.)

Year.	Production.	Imports.	Exports.	Consumption.	Railroad Mileage.	
					Totals.	Increase.
1891	1,307,176	253	11,239	1,296,190	170,795	4,089
1892	1,551,844	347	7,982	1,544,209	175,233	4,438
1893	1,136,458	2,888	19,876	1,119,470	177,862	2,629
1894	1,021,772	300	13,556	1,008,516	179,812	1,950
1895	1,306,135	1,447	204	1,307,378	181,612	1,800

No iron rails were made in 1894 or 1895.

The following table shows the production of various forms of rolled iron and steel as reported by the American Iron and Steel Association for the years 1894 and 1895:

PRODUCTION OF FINISHED IRON AND STEEL.

Articles—Gross Tons, Except Nails.	1894.	1895.
Structural shapes, not including plates	360,305	517,920
Plates and sheets	682,900	991,459
All rolled iron and steel except rails	3,620,439	4,883,438
Bessemer steel rails	1,016,013	1,299,628
Total production of rails	1,021,772	1,306,135
Street rails, included above	157,457	163,109
Iron and steel cut nails, in kegs	2,425,060	2,129,894
Iron and steel wire nails, in kegs	5,681,801	5,841,403
Iron and steel wire rods	673,402	791,130
Total rolled iron and steel, including rails	4,642,211	6,189,574

The foreign value of all the iron and steel and manufactures thereof which were imported into the United States in 1895 was $25,772,136, against $20,843,576 in 1894, an increase of $4,928,560. In the above figures are included imports of tin plates, which in 1895 amounted to 219,545 gross tons, against 215,068 tons in 1894, 253,155 tons in 1893, 268,472 tons in 1892, 327,882 tons in 1891, 329,435 tons in 1890, and 331,311 tons in 1889, when the maximum of imports was reached.

The imports of pig iron in 1895 amounted to 53,232 gross tons, against 15,582 tons in 1894, an increase of 37,650 tons. The imports in 1894 were the smallest of which we have any record.

The exports of iron and steel from the United States in 1895, including all manufactures of iron and steel except agricultural implements, amounted to $35,062,838, against $29,943,729 in 1894, an increase of $5,119,100. In both 1894 and 1895 the exports of iron and steel greatly exceeded the imports in value.

Except in a few special lines of machinery, our exports of iron and steel and their manufactures increase slowly.

An account of the course of prices and the market conditions of the year will be found in the following pages.

IRON PRODUCTION OF THE WORLD.

The production of pig iron for 1895 reached the great total of 29,868,239 metric tons; it shows the very decided increase of 3,809,269 tons, 14.6%, over 1894, which was due chiefly to the increases in the United States and Great Britain, though there were very considerable gains in other countries. The iron industry of Russia, for example, shows a great proportional increase, though the total made is still small when compared with the iron resources of the country and its great population.

The United States in 1895 made 32.1% of the total pig iron produced and stands far in advance of any other nation. Great Britain, which comes next, made 26.9% of the total, and Germany held the third place, with 19.3% of the supply. These three countries together supplied 78.3% of all the pig iron made.

If we compare the production of the three chief iron-making countries—the United States, Great Britain, and Germany—we find that of the three Germany shows the steadier progress. The iron production of that country has advanced with few of the fluctuations which have marked our own output, and this is due in great part to the persistency and method with which German exports have been pushed.

The following table shows the iron production of the world for the five years ending with 1895. In all the leading iron-producing countries the figures are from official returns, but in some countries it has been necessary to estimate the quantities produced in 1895:

PRODUCTION OF PIG IRON AND STEEL IN THE PRINCIPAL COUNTRIES.

(In metric tons.)

Year.	Austria-Hungary.		Belgium.		Canada	France.		Germany.		Italy.		Russia.	
	Pig Iron	Steel.	Pig Iron.	Steel.	Pig Iron.	Pig Iron	Steel.	Pig Iron	Steel.	Pig Iron.	Steel.	Pig Iron.	Steel.
1891	921,846	a475,000	684,126	243,913	21,697	1,897,387	638,530	4,631,218	2,562,549	11,930	75,925	1,004,745	433,487
1892	940,284	a480,000	753,268	260,037	38,514	2,057,300	682.000	4,937,461	a2,600,000	12,729	56,543	a919,614	371,199
1893	982,707	a485,000	745,264	273,058	50,754	2,003,100	664,000	4,986,030	a2,600,000	8,038	71,380	1,160,737	390,000
1894	1,054,520	a490,000	810,940	396,914	45,327	2,077,647	663,264	5,559,322	a2,700,000	10,329	54,614	1,312,760	422,500
1895	1,075,000	a495,000	829,135	455,550	38,434	2,005,889	716,931	5,788,798	a2,825,000	a10,500	a55,000	1,454,298	574,112

Year.	Spain.		Sweden.		United Kingdom.		United States.		All Other Countries.		Totals.	
	Pig Iron.	Steel.	Pig Iron	Steel.	Pig Iron	Steel.	Pig Iron	Steel.	Pig Iron	Steel	Pig Iron.	Steel.
1891	278,462	69,972	490,913	172,774	7,525,301	3,207,994	8,413,176	3,962,804	a350,000	a250,000	26.230,081	12,092,948
1892	247,329	56,490	485,664	158,978	6,817,274	2,966,522	9,304,428	5,001,494	a350,000	a250.000	26,863,865	12,883,263
1893	260,450	71.200	453,421	221,780	7,089,318	2,983,000	7,239,806	4.084,305	a350,000	a250,000	24,229,025	12,093,963
1894	260,000	70,000	459,132	205,865	7,364,745	a3.050,000	6,757,248	4,482,592	a350,000	a250,000	26,058,970	12,785,749
1895	206,430	65,000	a465,000	a230,000	8,022,006	a3,150,000	9,597,449	6,212,671	a375,000	a275,000	29,868,239	15,053,864

(*a*) Estimated.

Both Great Britain and Germany are relying each year more and more on imported ores, and in both countries the question of ore supply is becoming a serious one. Spain has been the great source of supply for the British furnaces, but during the past two or three years the Swedish mines have furnished an increasing supply. Spain, though comparatively a small producer of pig iron, mines a large quantity of iron ore, and the exports reached 5,248,192 metric tons in 1895.

The total production of pig iron in Great Britain in 1895 was 7,895,675 long tons (8,022,006 metric tons), showing an increase of 530,930 long tons, or 7.2%, as compared with the previous year. The greater part of this increase was in Scotland, where labor troubles seriously restricted the output in 1894. Of the production in 1895 there were 3,917,915 tons, or 49.6%, classed as Bessemer and basic pig, the remaining 3,977,760 tons being forge and foundry iron.

The total production of pig iron in Germany in 1895 was 5,788,798 metric tons, of which 2,898,476 tons were classed as Thomas pig, 444,495 tons as Bessemer pig, and the remaining 2,444,827 tons as forge and foundry iron. The total production showed a gain of 229,476 tons, or 4%, as compared with the previous year. The growth of the industry is shown by the statement that in 1870 the output was 1,391,124 tons; in 1875 it was 2,029,389 tons; in 1880 it was 2,729,038 tons; in 1885 it was 3,687,434 tons; in 1890 it was 4,658,450 tons; while last year it reached the total given above of 5,788,798 tons.

In France there was in 1895 a slight decrease, the total of 2,005,889 metric tons being less than that of the previous year by 72,756 tons, or 3.5%. Of the total in 1895 there were 489,721 tons of foundry iron, the remaining 1,516,168 tons including Bessemer pig, basic pig, and forge iron, which are not reported separately. The total production of wrought iron in bars, plates, and other finished forms in 1895 was 743,671 tons. The output of steel for the year was 716,931 tons, of which 693,290 tons were Bessemer and open-hearth steel, the remaining 33,641 tons being made up of crucible, blister, and other special steels. The production of steel rails was 160,117 tons. The steel output showed an increase of 53,797 tons, or 8.1%, notwithstanding the decrease in pig iron.

In Belgium 414,034 tons of the pig iron made in 1895 were Bessemer and Thomas pig, 329,651 tons forge iron, and 85,450 tons foundry iron. The total of 829,135 tons showed an increase of 18,195 tons, or 2.2%, over 1894. The production of wrought iron was 453,380 tons, of which 101,479 tons were plates. The output of steel ingots, including castings made direct, was 455,550 tons, while the production of finished forms—rails, bars, plates, etc.—was 392,332 tons.

The production of 206,430 tons of pig iron in Spain makes an insignificant showing in comparison with the large quantity of iron ores mined, most of which was exported. The Spanish iron ores are in demand in Europe owing to the small amount of phosphorus which they carry. Their chief competitors are the Swedish ores, which are now being mined in increasing quantity, although Greece and Algiers also furnish some supply.

In Austria the production increased in 1895 by 23,410 tons, or 2.2%, over 1894. It does not grow as rapidly as in some other countries, but the output of raw iron shows a very fair gain. Both Austria and Hungary possess considerable resources in iron ores, and both also possess coal of fair quality.

Among the Eastern nations iron production is still limited, and in most of them it is but little developed on modern lines. In Japan the industry has been fairly established and is being developed with the energy and intelligence characteristic of that nation. British India possesses both iron ores and coal, but makes as yet little use of them.

Very little is known of the iron manufacture in China, though it is carried on in various parts of the country.

Korea is said to have fine iron ores and excellent iron is made, but in small quantities only.

The Canadian iron industry grows slowly, and in 1895 there was a decrease of 6962 tons, or 15%, in the output of pig iron. The establishment of one or two new blast furnaces did not seem to increase the production, and a large part of the iron and steel used is still imported.

In all the iron-making countries we find a rapid increase in the production of steel. This growth in the United States is referred to above; in other countries it is almost as strongly marked. In Germany, where the Bessemer steel process has not found favor, owing to the nature of the iron ores chiefly found in that country, the basic open-hearth process is the one mainly in use, and we find that in 1895 over 50% of all the pig iron made was classed as "Thomas pig"—that is, iron intended for steel making by the Thomas-Gilchrist process. The same condition is found in Belgium. The French steel makers use the Bessemer process and its modifications to a much greater extent, though the basic process is gaining in that country also.

The Course of the Iron Trade in 1895.

The history of the iron trade in the United States in 1895 shows a period of agitation and of sharp fluctuations, the changes being quite as marked as in 1893 and 1894, but in the reverse direction. In 1893 the first half of the year showed a large production, but a somewhat halting and uncertain market; the second half, after the beginning of the currency panic in June, showed a rapid and continuous fall in demand, in prices, and in output as furnaces and mills closed down, one after another, under the stress of the times. In 1894 the depth of the reaction of prices was reached, and about the middle of the year production was at its lowest level. In the latter half of the year a somewhat slow and hesitating recovery began, which gradually gained impetus, and the year closed with a marked improvement and the promise of continued gain in the future.

The year 1895 opened with less activity and more uncertainty as to the future than had been anticipated in the closing months of its predecessor. The tariff question had been settled and taken out of the way, but the continued delay of Congress in acting upon the currency question and the uncertainty as to future values depressed business generally, and in the earlier months of the year there was a slight decline in production, while prices gained either very slowly or not at all. The revival of confidence which followed the closing of the Syndicate contract for the government bonds at the close of February, when business men began to realize the fact that the Government was at once ready and able to maintain the public credit, at first affected the iron trade slowly, and was manifested rather in the appreciation of prices and the diminution of stocks than in any immediate increase in production. February had shown an actual decrease in the rate of production of raw iron and steel, as the makers hesitated as to the future; while from March to June the production continued at a nearly even level, notwithstanding continued inquiries for material and other manifestations of increasing demand. The first half of the year had almost closed before the active list of blast furnaces much surpassed the point attained six months before.

In June, however, the improvement in general business had so far advanced, the demand for finished products had so increased, and the disposition to undertake new construction had become so general that there was no longer any hesitation. It became evident that there would be a demand which would tax the resources of the producers of raw material and would speedily exhaust the existing stocks. The manufacturers of finished material in its various forms came into the market to secure supplies and began to be urgent in their demands. As July opened a genuine "boom" was well under way; prices were going up rapidly and production was gaining at an unprecedented rate. As usual at such periods, the conditions of the market increased the anxiety of buyers and their disposition to supply themselves before a further rise should come; at the same time the element of speculation entered in, and operators for a rise are understood to have bought very considerable quantities of iron for future delivery. Under these circumstances the plants which had been able to keep at work during the depression enlarged their operations and put all their available capacity at work; others which had suspended started up, and as the demand was still maintained still others were brought in, until the output reached nearly the producing limit of the available plants.

The rise in prices thus briefly sketched, while it affected more or less all branches of the trade, was most marked and most active in steel billets. Attention has frequently been called to the extent to which steel has replaced wrought and cast iron, and the result has been that steel billets have become almost the foundation of the trade in finished material and to a great degree the barometer which indicates its condition. Accordingly we find that the first marked rise and the subsequent speculative "boom" was shown chiefly in steel billets and Bessemer pig iron, and while there was a very considerable increase in prices of other products, it was much less abrupt and later was much better maintained.

Rapid as was the gain in production briefly sketched above, it did not seem to surpass that in demand, and throughout the third quarter of the year the prices were not only well maintained, but continued to rise, and the readiness with which the output was taken up showed no sign of decreasing. By September the production of pig iron had reached a rate equivalent to over 10,500,000 tons a year, which was the highest point on record up to that time, but there was no cessation in the growing activity and apparently none in the demand, since the output was absorbed as fast as it came on the market and stocks decreased somewhat rather than increased.

In September, when the highest point of the rise was reached, steel billets, which had started in January at $14.75 per ton at mill, had reached a quotation of $24.50, showing an appreciation of $9.75, or about 66%; while Bessemer pig iron had shown a still greater proportional gain, from $9.88 to $17.25, an advance of $7.37, or nearly 75%. The "boom" then showed signs of weakening, and a sharp break followed, prices for several weeks falling rapidly. At first it seemed as if this reaction had been caused by a cessation of the demand. This proved to be the case, however, only to a small extent; a number of large consumers were supplied for their immediate needs, but orders continued to come in, and both mills and furnaces continued steadily at work. In reality the break was chiefly due to the loss of the speculative element in the market, which had carried prices further than the situation warranted, but in part to the general conviction that the continued entrance of new producers into the market would certainly prevent any scarcity of supplies and would in time result in an over-supply, which must restore a lower level of prices. It is almost certain also that the reaction was to some extent due to the combined action of a number of large buyers, who aided in the attack upon the speculators, which met with a certain degree of success. The reaction once started continued, with some slight checks, and at the close of the year the price of steel billets ranged about $18.25 at mill and of Bessemer pig about $12.75 at furnace. In spite of the drop from the highest point, both of these products show a substantial gain—of 23.7 and 29.1% respectively—over the opening prices of the year.

The speculative element in the market during the latter half of the year was confined almost entirely to steel billets and Bessemer pig. Those products were carried to the highest point and suffered from the succeeding reaction almost alone. The prices of foundry irons showed a steady rise from the beginning of the business improvement, and when the fall in Bessemer pig came in September they retained the advance and held it substantially until the close of the year. The same thing may be said of almost all forms of finished productions. Bar iron, structural iron and steel, merchant steel, and the other forms in which the market is supplied advanced steadily in spite of a great increase in production, and in almost all cases the prices at the close were near the highest point reached during the year.

Another evidence of the largely speculative nature of the billet and Bessemer market is the fact that the production of pig iron continued to increase steadily, notwithstanding the much-talked-of "reaction," and that this increase was taken up without difficulty, the stocks reported on hand at the close of the year being rather smaller than usual. Although, also, December is not generally a very active month, the production of pig iron, which in November had reached the rate of 11,500,000 tons yearly, continued through that month at substantially the same rate.

In considering the general advance in prices it is to be remembered that a very large proportion of this went directly to the benefit of the iron makers. The greater part of the Bessemer pig produced during the second half of the year, for instance, was made from ore supplied at low rates under contracts made early in the year. Advances were made in prices of coke, but not until some time after iron prices began to go up ; in many plants advances were made in wages also, but these formed only a small part of the total cost. The probability is that much of the raw iron sold cost the operators but little more than when prices were ruling at their lowest point.

During the closing six weeks of the year the general iron market was in what can only be described as a waiting condition. The concerted raid on prices which began in September and which succeeded, as has been said above, in shaking out the purely speculative element in the market and in bringing quotations down from the high point to which that element had carried them, succeeded, with the aid of some of the self-constituted "organs" of the trade, in arousing in buyers of the raw material expectations of a decided fall in prices, and led them to believe that by holding off until the latest moment they could secure their supplies for next year at the fall. On the other hand, nearly all the producers were so fully employed that they were in a condition to hold out and not under the necessity of soliciting business, except in a very few cases. The result was that the closing of large contracts was unusually slow, and the year ended with much less business concluded for 1896 than had been expected.

One considerable element of demand was largely absent from the market during 1895. Not many years ago the railroad purchases were almost the ruling element in the iron trade. The rapid extension of the use of iron and steel in building construction and for other purposes has reduced the railroad trade in relative rank and importance, although it remains large in absolute amount. The railroads felt the effects of the business depression very severely and postponed both new work and renewals as a rule, so that they have made very small purchases. In November and December a large number of orders for cars were placed, and some contracts for locomotives also; the rail orders, however, continued on a limited scale, largely because of the mistaken policy of the steel-rail combination. At the opening of the year the price for standard sections steel rails was $22 per ton at mill, and this quotation was continued up to June, orders still remaining very light, as the railroads had not yet recovered sufficiently from the depression to undertake renewals on any considerable scale, and the construction of new lines was very small. On June 30 a meeting of the rail makers was held, and as the growing business improvement was then manifest, an increase to $24 per ton at mill was ordered. To this, perhaps, no serious objection would have been offered, as prices of other descriptions of iron and steel had begun to rise, though the cost of fuel and raw materials to most of the rail makers was practically unchanged. The combination was not yet satisfied, however, and three months later, in September, another meeting was held, at which the price was raised to $28 per ton at mill. This action was taken in face of the fact that orders for rails continued to be much lighter than had been expected, and its direct effect has been to discourage purchases. The combination, in its eagerness for profit, probably overlooked two important facts: first, that the recovery in earnings had not yet passed the point which required strict economy in expenses; and, second, that the railroad tracks are now very largely laid with steel and that renewals can be postponed for a certain length of time without seriously compromising the safety of operation. The result has been that the rail business has not shown the same growth as other branches of the trade. A few of the great companies—like the Pennsylvania—have placed their orders, though on a restricted scale, while many companies have held out altogether. With regard to the rate, it must be remembered that rails are almost the simplest and least costly form in which finished steel can be put upon the market, and that the profit upon their manufacture at the present price is out of all proportion to that obtained on other products under normal conditions.

The rail combination continues to control the trade absolutely. It was reported that it had made arrangements by which the large new plant of the Ohio Steel Company at Youngstown, if it does not join the combination, will at least keep out of the market. The report was credible and was supported by the fact that the concern in question has so far made no rails.

As affecting the rail market, it is to be noted that the construction of new railroad lines fell during 1895 to a lower point than in any year since 1870. The total new mileage built during the year, as collected and estimated by the *Railroad Gazette*, was 1400 miles, or considerably less than that constructed in 1894, when 1760 miles were reported. It must be remembered that it takes some time to carry out a railroad project to completion, and that in the first year of depression there are generally a number of lines partially built, for the construction of which arrangements have been made and which must be carried out. The low mileage of 1895, therefore, reflects the extreme depression of the previous year.

To some extent the loss in rail demand from the steam railroads was made up by the increased construction of electric railroads. The additions to electric lines in 1895 were about 1900 miles, against 1500 miles in 1894. Not all of the mileage reckoned was new; probably one-half of it was of roads which had previously used animal motive power, so that the demand for new rails was less than would appear at first sight. There was, however, an actual increase in new electric construction of about 450 miles.

The growth of electric railroads promises to furnish a continually growing demand upon the rail mills. Not only is the building of new lines going on rapidly, but it is found that renewals are required more frequently than on steam roads. The present construction, in which the heavy motors are carried on the axle and all the shocks of rotation are communicated directly to the track without the interposition of springs, is particularly trying, and the life of the heaviest steel rails yet used is found to be much shorter than on the steam lines running the heaviest locomotives at high speeds.

It may be noted that in the English market steel rails were selling a year ago at $17.50 per ton at mill, and remained at that price for the greater part of the year, while billets were selling at $14.50 per ton, or a difference of only $3 per ton. A rapid rise began in August and rails in December were quoted at $23.50. This rise was due chiefly to a large demand from India and other countries and to unusual orders for renewals from home lines. The increase in price and the difficulty of meeting orders promptly was the means of sending some Indian and colonial orders to Belgian and German makers.

The iron trade throughout the year suffered little from labor troubles. The increase in business and the general rise in prices permitted a very general rise in wages also, and almost everywhere at least a part of the reductions made in 1893 and 1894 was restored. There was but little of the agitation and disturbance which affected the bituminous coal trade to so great an extent.

The Local Iron Markets.

The reviews given below of the leading local markets supplement the general review given above and show more in detail the course of prices and production during the year.

CLEVELAND.

Iron Ore.—The year 1895 was full of surprises to the iron-ore trade. The year opened with the trade terribly depressed. Furnace-men for a year or two had been buying ore from hand to mouth, and as the price kept dropping in 1893 and 1894 they found the practice advantageous. At the close of 1894 two large mines had gone out of business and others were on the verge of suspension. There were few signs of hope in the future. The mining companies held conferences for mutual protection and some of the newspapers talked of a pool among them. The conferences were attended by representatives of all the old Bessemer producing companies, and the Mesabi producers were the only factors in the high-grade ore market who did not participate. For nearly three months these meetings kept up at intervals, and late in March the producers announced to their customers a schedule of prices for the year 1895. It was stated that these prices would prevail throughout the year, so that buyers from time to time would get no advantage. The scale adopted was an advance of from 10 to 25c. per ton over the prices of 1894. Norrie was quoted at $2.90, Aurora at $3, Chandler at $3.05, Chapin at $2.55.

It was estimated by the ore-men that the total output for 1895 would probably not greatly exceed the 7,750,000 tons production of 1894. There were on the

Lake Erie docks May 1, 1895, about 2,640,000 tons of unsold ore, a slight increase over the previous year. Most of this consisted of non-Bessemers, which had had a very slow sale in 1894. The ore-men considered that a maximum of 7,000,000 tons of Bessemers might be produced during 1895. Of this it was computed 2,500,000 tons might be conceded to the Mesabi Range, the total production of the latter in 1894 having been nearly 1,800,000 tons. Therefore 4,500,000 tons was thought to be a fair maximum output of the old Bessemer companies for 1895, and the coming year's work was gauged to that basis.

Soon after this announcement of prices the furnace-men began to make contracts for their ore material, and by May 1 it was estimated that 5,000,000 tons of Bessemers had been sold, of which 1,200,000 tons were Mesabi ores, some 200,000 tons non-Bessemers, and the balance old Bessemers.

The season of navigation opened and the ore began coming down in fair volume. Quite a block had been contracted for by vessel-men on a basis of 80c. from Lake Superior ports, but there was a general feeling among shippers that lake carrying rates would average lower than that figure rather than higher, and a large proportion of the ore was left uncovered by lake contracts.

Although the bulk of the ore was sold early in the season, there was a constant nibbling by furnace-men, and before July 1 the curious spectacle was witnessed of buyers asking the Bessemer producers to sell more ore than the output agreed upon. Three months before the arranged output was considered the maximum amount which under any circumstances would be desired. The Bessemer owners declined to flood the market with a fresh output and buyers turned to the Mesabi ores. They bought and kept on buying right along. Early in July ore prices began to jump. There was an advance of 25 to 30c. during that month, and the demand for lake tonnage to cover the extra shipments started freights upward.

Fortunately for the ore shippers the miners' strike in the Marquette district broke out at this juncture. Shipments from that port dwindled to almost nothing. This released a large amount of lake tonnage, but the entire fleet was quickly absorbed in the ore-carrying trade from the head of the lakes, and still there were not enough boats.

The grain interests about this time also began bidding actively for the boats, and the freights advanced steadily at a pace that astonished the vessel-men and produced consternation among the ore-men, who had sold their product in the spring, who had left much of the ore uncovered and were now obliged to pay unexpectedly high rates. With one or two unimportant declines the freights continued upward throughout the season up to the very close.

The average ore freights from Duluth and from Escanaba to Ohio ports were by months as follows during the season:

AVERAGE FREIGHT RATES PER TON ON ORE TO LAKE ERIE PORTS, 1895.

Port of Shipment.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.
From Escanaba	42½	52½	55	57½	75	100	110	100
From Duluth	77½	85	85	92½	120	152½	200	....

The season charter rates for Duluth were 80c. and for Escanaba 40 to 45c.

Ore prices kept pace with these freights, that is, on the limited amount of ore that was for sale. The top figure for the year that was reported was $5.25, or more than $2.25 in excess of the prices established in the spring.

The Marquette strike did not end until about the close of September. Some of the Marquette range producers gave notice to their customers that they could not, in consequence of the strike, fill contracts, and the furnace-men looked again quite largely to the Mesabi mines for relief, thus still further stimulating the production from that district.

The result has been that the iron-ore output for 1895 on the upper lakes exceeds by more than 1,000,000 tons its largest previous productions. Of the total shipments of 10,233,910 tons by lake, 8,112,228 tons were shipped to Lake Erie ports, 1,863,781 tons to South Chicago and Bay View, and 257,901 tons to the charcoal furnaces of the upper lakes.

The entire output of 1895 was more than sold, and it was estimated that there would remain on Lake Erie docks in the spring only a small quantity—very small in comparison with the 2,640,000 tons unsold in the spring of 1895.

The accompanying table shows the average prices paid by buyers for lots on the docks at Lake Erie ports in the last week of each month, beginning with July. During the first half of the year there is little or no buying of ore from the docks, furnaces generally being supplied. The prices give the highest range for lots of moderate size. The first column gives the average price for the different grades of ore on season contracts, the figures being, of course, only approximate, as it is impossible to ascertain all the contract rates with any approach to exactness:

IRON ORE PRICES AT CLEVELAND.

Kind of Ores.	Season Contracts.	July.	August.	September.	October.	November.	December.
Bessemer specular........	$3.25	$4.00	$4.50	$5.25	$5.00	$4.75	$4.50
Bessemer hematites	3.05	3.25	3.75	4.50	4.50	4.25	4.00
Non-Bessemer specular...	2.90	3.00	3.50	4.00	4.00	3.75	3.50
Non-Bessemer hematites.	2.55	2.50	2.75	3.50	3.50	3.25	3.00

The range of prices shown represents the degree of demand as the activity of the furnaces increased and the makers of pig iron began to fear a shortage of ore supplies. Price and demand reached their highest point in September, and from that time both declined; partly because the urgency of the demand for iron was decreasing, and partly because the furnaces had secured sufficient supplies to carry them through the season.

Since the close of 1895 an effort has been made to combine the producers, at any rate so far as to prevent excessive competition. This was feared from the great extension of prospecting and development work on the Mesabi range and the opening up of a number of new deposits from which a large supply of ores may be expected. The leading producers of the Mesabi have taken part in the conferences referred to, and it is probable that an arrangement will be completed and carried out; that is, unless there should be a revulsion in the iron trade now wholly unexpected and the pressure to sell ore should become great. These conditions are not probable, however, and the prices obtained for ore will almost certainly average higher in 1896 than in 1895.

The experience of the past season will also lead to some changes in the carrying trade. The larger producers of ore seem to have made up their minds that they will not depend on the fluctuations of lake business and pay as high rates for charters as was the case in 1895. The Minnesota Iron Company has for some time owned vessels which carried a large part of the output of its mines, and is now increasing this fleet. Late in 1895 the Lake Superior Consolidated Mines—the Rockefeller interest—placed contracts for a number of large steel steamers to be used in the ore trade. These vessels cannot be ready by the opening of the season, but will be prepared to take part in the heavy work of September and October, if not of August.

The transportation and handling of iron ore seems now to have been reduced to almost the cheapest and quickest system possible, and we do not know of any ports in the world where the loading and unloading of vessels can be accomplished in less time or with less expense than at the ore ports on the lakes. Of course the nature of the freight very much facilitates the work; but the mechanical appliances found on the lake docks are worth careful study.

The agreement among Lake iron-ore producers above referred to is said to provide for an output exceeding that of 1895, which was the largest ever made.

Pig Iron.—At the opening of the year 1895 sales of Bessemer pig iron in Ohio were reported to have been made below cost of production in order to check the growth of stock piles. There were some labor troubles, but the men usually accepted with good grace the depressed condition of trade and made no prolonged strikes. The low-water mark for the year was about the first sales made, on a basis of from $9.90 to $10.15 for Bessemer pig in Cleveland.

RANGE OF PRICES OF BESSEMER PIG IRON IN CLEVELAND, 1895.

Month.	Lowest.	Highest.	Average.	Month.	Lowest.	Highest.	Average.
January	$10.00	$10.00	$10.00	July	$13.40	$14.40	$14.09
February	10.25	10.25	10.25	August	14.40	16.25	14.96
March	10.25	10.40	10.33	September	16.75	17.75	17.25
April	10.65	10 90	10.74	October	14.25	16.25	15.30
May	10.90	11.65	11.24	November	13.25	14.25	13.75
June	12.00	12.90	12.55	December	11.75	12.75	12.25

Transactions continued small until spring. If there had been buyers they would have had the advantage, but the market was lifeless. Perhaps the first feeling of strength was imparted by the persistent talk of an advance in coke, and it was not long before the ore-men also gave currency to reports that they too must receive higher rates for their product. Stocks in the hands of iron consumers had run low, but when the tide turned and prices began to strengthen the demand for pig iron grew, and the course of the market for eight months was steadily upward. Stocks were thoroughly cleaned up and the bare state of the market gave rise to some peculiar conditions of trade. Pig iron in considerable quantities was shipped in early summer from Chicago to Cleveland and here worked into finished products to be transported back to the West. Legitimate demand for finished iron and steel during this rising market came not as largely from the railroads as usual, but from various other sources. Structural material was unusually active, and the mills for months were unable to keep up with their orders. Shipbuilders were seriously cramped and delayed in getting the big steel freighters off the ways through inability to procure plates, angles, and channels. Everybody wanted iron and its products at one time. The tide reached its culmination in September, when a valuation of $17.50 for Bessemer was touched in this market. From that point the trend was steadily downward to the close of the year.

CHICAGO.

The year started in with very low values, only a small business in hand and not a very much larger amount in prospect, and with not an especially hopeful feeling among dealers and manufacturers. The preceding year had been dull and in it losses by fire, strikes, failures, and receding values had been large, causing iron and steel manufacturers generally to entertain very conservative views as to the future. For several months in the first part of 1895 business was not large, but iron and steel men generally gained faith in the future, and with a more hopeful feeling among sellers came more confidence among buyers; sales gradually increasing in number and in volume. About March 1 prices commenced to rally, and from then until almost the end of the year they continued to rise, with only occasionally a slight reaction which in nearly every case was very soon made up. About March also orders began to be more plentiful and buyers commenced to realize that if they were not on the verge of a "boom," at least there was every prospect for continued good business for their products and probabilities for higher values of material were great. In May wages and fuel commenced to advance and these advances added to the belief, becoming more and more prevalent every day, that iron and steel products would maintain their values easily and also advance in cost.

In May came labor troubles at the South Works and the Joliet Works of the Illinois Steel Company, dissatisfied laborers asking for an advance in wages. These strikes lasted at the South Works only a few days, but at the Joliet Works two weeks, causing a delay in shipments of pig iron and billets and quite a little embarrassment to users of the latter, notably tin-plate manufacturers, a number of whom expected to have to shut down. This was avoided by the starting up of the works on the settlement of the labor troubles.

In the latter part of June the market began to take on the features of a boom, largely increasing sales and advancing values being reported every week. Apparently, however, the increase in demand was caused almost entirely by increased needs on the part of consumers, and not by the entering into the market of any speculative element. While later developments showed that there had been some buying of billets and Bessemer pig by speculators, at the same time a very much larger part of the purchases throughout the year came from consumers for legitimate needs, and not for speculative purposes. Commencing in June prices advanced very rapidly, a rise being chronicled in some classes of material each week for several months. During July and August crude material was quiet and sales were smaller than in the months immediately preceding. This change was a welcome one to the furnaces, however, as they were very heavily over-sold. and the falling off in new purchases gave them a chance to catch up on their contracts.

In July and August buying of billets, rods, and sheet bars was very heavy, and prices advanced from $22.50 on July 1 to $25 in September on billets and proportionately on rods and bars, with considerable fluctuations between those dates. Some large contracts for structurals were also placed in the summer months and prices advanced from $4 to $5 a ton. On September 15 the Calumet Furnace was put in blast and ran until December 1 on foundry iron, turning then to Bessemer to fill a contract of 15,000 tons for the Illinois Steel Company. About September 1 the purchases of material commenced to fall off, and from then on to the end of the year the market generally was a declining one. In some branches trade continued good—notably in bars and structural material—until considerably later in the year. The prices of bar iron were held up throughout the decline and until almost the close of the year by the Merchants' Bar Iron Association. About the middle of December, however, the association found it was necessary to reduce the price of these products to meet the lower values of other material, and quotations were cut from 1.50 to 1.35c. Chicago. In September and from then until December 1 orders for cars from the railroads and transportation companies were very large, and the car works received sufficient business to keep them busy through the year and well into 1896. This created a large demand for bar iron and other classes of material.

Early in December orders for 14 large vessels were given to lake shipbuilders by the ore interests, causing a very large demand for plates, angles, and other material required for their construction.

The course of the Chicago market was ruled mainly by actual demand; there was little or no speculation in iron during the year.

The range of values in the Chicago market during the year is shown by the following table of prices:

MONTHLY RANGE OF IRON PRICES IN CHICAGO, 1895.

Date.	Pig Iron.			Steel Billets.	Rails.	Bars.	Beams.	Plates.	Sheets.
	Lake Superior Charcoal.	Northern No. 2 Foundry.	Southern No. 2 Foundry.						
January 1	$13.00	$9.75	$10.25	$17.00	$23.00	1.05c.	1.45c.	1.40c.	2.35c.
February 1	13.00	9.75	10.00	16.50	23.00	1.00	1.45	1.40	2.30
March 1	13.00	9.75	10.00	16.50	23.00	1.00	1.45	1.35	2.30
April 1	13.00	9.75	10.00	16.50	23.00	1.00	1.45	1.30	2.25
May 1	13.00	10.25	10.50	17.50	23.00	1.10	1.45	1.30	2.25
June 1	13.00	10.25	10.25	20.00	23.00	1.15	1.50	1.45	2.40
July 1	13.25	11.50	12.50	22.50	25.00	1.30	1.70	1.70	2.60
August 1	13.50	13.00	12.25	23.50	25.00	1.30	1.80	1.90	2.80
September 1	14.50	13.50	13.25	25.00	25.00	1.50	1.90	2.10	2.85
October 1	15.50	14.50	13.85	26.00	29.00	1.50	1.90	2.00	2.95
November 1	15.50	14.50	13.85	24.00	29.00	1.50	1.90	1.90	2.75
December 1	15.00	14.50	13.85	22.00	29.00	1.50	1.90	1.75	2.55

Bessemer pig is not a prominent article in the Chicago market and is not quoted.

NEW YORK.

The local iron market in New York may be said to have followed very nearly the course of the general market during 1895. Its condition can, perhaps, best be understood by the table of prices given below. New York is not the center of a great producing district like Pittsburg, nor is it a distributing point of great importance. A considerable quantity of iron is sold during the year for the supply of local establishments and contracts are made for the supplies of a manufacturing district of some extent and importance. Nevertheless it can hardly be ranked among the more important iron markets of the country.

Up to June there was very little activity in the local market, and the foundries and machine shops generally reported business quiet and were buying supplies and material lightly. About the close of June business began to improve and orders came in more freely; this state of affairs continued through July and August, and in September unusual activity was the rule. The foundries and mills were full of orders, large and small, demand and prices were good. There was a rapid expansion in the demand for structural iron as new buildings were planned and started, and this branch of the business continued active up to the end of the year. A temporary interruption was caused by a strike in the building trades in November and December, but it was not of very long duration.

The feature of the market from September to well into December was the steady buying on small orders, showing the extent to which the smaller concerns were employed. In many cases the foundries running on general work found some difficulty in securing supplies of lower grade irons or scrap for mixing, and the latter commanded for a time much above its usual price.

The speculative rise in Bessemer pig iron did not affect this market, where that grade of iron is not sold. The foundry irons as a rule held till the close most of the advance which they made when business became active.

The following table shows the range of prices in the New York market during the year 1895:

Month.	Pig Iron, per Ton.				Common Bar, per Lb	Refined Bar, per Lb
	Northern No. 1.	Southern No. 1.	Southern No. 2 Soft.	Gray Forge.		
January	$12.00@12.50	$11.25@11.50	$10.25@10.75	$10.00@11.00	1.15@1.30c.	1.25@1.80c.
February	12.00@12.50	11.25@11.50	10.95@10.75	19.00@11.00	1.15@1.30	1.25@1.90
March	12.00@12.50	11.25@11.50	10.75@10.75	10.00@11.00	1.15@1.30	1.25@1.90
April	12.00@12.50	11.36@11.56	10.25@10.75	10.00@11.00	1.15@1.30	1.25@1.90
May	12.25@12.75	11.50@11.75	10.56@10.81	10.30@11.00	1.15@1.30	1.25@1.90
June	12.75@13.25	12.35@12.81	11.30@11 60	10.50@11.00	1.15@1.30	1.24@1.80
July	13.25@13.75	13.06@13.56	12.06@12.44	10.75@11.50	1.30@1.45	1.45@1.60
August	13.70@14.20	13.50@14.00	12.50@13.00	12.05@12.55	1.35@1.45	1.45@1.60
September	13.88@14.38	13.75@14.00	12.94@13.44	12.38@12.88	1.40@1.50	1.50@1.65
October	14.00@14.50	13.75@14.00	13.25@13.75	12.50@13.00	1.40@1.50	1.50@1.65
November	13.88@14.38	13.70@13.95	13.20@13.70	12.50@13.00	1.35@1.45	1.45@1.60
December	13.75@14.25	13.63@14.00	12.83@13.41	12.00@12.50	1.28@1.41	1.39@1.54

Month.	Steel Billets, per Ton.	Steel Wire Rods, per Ton.	Structural Material.			
			Beams, per Lb.	Angles, per Lb.	Channels, per Lb.	Plates, per Lb.
January	$17.50@18.00	$24.00@24.50	1.30@1.50c.	1.20@1.30c.	1.40@1.50c.	1.25@1.40c.
February	17.50@17.88	23.63@24.13	1.30@1.60	1.20@1.35	1.40@1.50	1.25@1.40
March	17.35@17.75	23.50@24.00	1.30@1.50	1.20@1.35	1.40@1.50	1.25@1.40
April	17.25@17.75	23.50@24.00	1.30@1.50	1.20@1.35	1.40@1.50	1.25@1.40
May	17.44@17.94	23.56@24.06	1.30@1.50	1.20@1.35	1.40@1.50	1.25@1.40
June	18.25@18.75	23.90@24.50	1.41@1.52	1.31@1.38	1.43@1.52	1.27@1.42
July	21.00@23.00	26.00@29.00	1.63@1.73	1.50@1.60	1.65@1.75	1.45@1.60
August	23.20@23.90	30.10@30.80	1.65@1.75	1.54@1.64	1.65@1.79	1.81@1.88
September	26.00@26.50	31.50@32.25	1.80@1.88	1.73@1.85	1.88@2.00	1.90@1.95
October	24.58@25.25	30.50@31.33	1.80@1.90	1.73@1.87	1.90@2.00	1.90@1.95
November	22.63@23.25	30.81@31.38	1.78@1.89	1.68@1.81	1.84@1.95	1.85@1.93
December	19.25@19.90	28.44@29.25	1.90@1.80	1.58@1.68	1.70@1.80	1.64@1.74

The closing month of this year was less active. In New York, as elsewhere, buyers were holding off in expectation of lower prices, and for several weeks a waiting market was reported. The stock-market excitement had an unfavorable effect, but the year closed with fair prospects for the future.

PHILADELPHIA.

The course of the iron market in Eastern Pennsylvania can be most readily seen by an examination of the following table, which gives the prices of leading products at the opening of each quarter and also for the month of December:

PRICES OF IRON IN PHILADELPHIA, 1895.

Product.	January.	April.	July.	October.	December.
Pig iron:					
No. 1 foundry	$12.50	$12.50	$13.00	$14.50	$13.25
No. 2 foundry	11.50	11.50	12.00	13.50	12.25
Gray forge	10.50	10.50	11.50	12.00	11.50
Bessemer	12.00	12.25	13.50	15.50	11.00
Steel billets	17.00	17.30	21.50	26.50	17.00
Manufactured:					
Angles	1.25c.	1.25c.	1.45c.	1.75c.	1.60c.
Beams and channels	1.30	1.30	1.50	1.80	1.60
Tank steel	1.25	1.25	1.90	2.00	1.60
Heavy plates	1.25	1.25	1.50	2.00	1.60
Shell plates	1.50	1.50	1.50	2.10	1.65
Flange plates	1.60	1.60	1.80	2.25	1.75
Bars	1.15	1.15	1.25	1.60	1.40
Skelp iron	1.20	1.20	1.45	1.45	1.30
Old material:					
Choice railroad scrap	$12.00	$12.00	$12.50	$14.50	$14.50
Heavy shell scrap	11.00	12.00	11.50	12.50	13.25
No. 1 wrought	11.00	10.00	11.50	14.00	13.50
Light scrap	6.50	6.00	7.50	9.00	8.50
Old iron rails	11.75	12.00	14.50	16.50	15.00
Old axles	15.50	15.50	16.00	18.00	16.50
Old car wheels	9.75	10.50	11.50	12.00	11.50

The year opened with promise of better trade and better prices than in 1894. Manufacturers felt as though the turn had at last come. In fact, many large buyers of billets had already covered their requirements for the first quarter of the new year as a matter of wholesome precaution. The ore question gave Eastern furnace people a good deal of concern, but there was no thought or even suspicion of what was ahead. The demand for ore had just advanced 25c. a ton, and buyers were figuring on possibilities of a further advance. There were also in January evidences of a growing demand for foundry and forge iron, and large producers made prices on large blocks of material. But stocks had been increasing and consumers were not rash. The tin-plate industry had suffered a 15% reduction in wages. A great deal of business was talked of; there was an evident impatience to push ahead, but withal the experience of the previous 12 months admonished manufacturers to measure their steps cautiously. One of the stimulating influences which had its effect early in the year was the placing of a 35,000-ton order for a bridge near New York City, and another of 18,000 tons for a bridge across the Delaware River at Philadelphia. A sale in one lot of 30,000 tons of billets aroused a good many steel buyers to the possibilities of a heavier demand. Small orders were coming in for plates and shapes. Big orders had been received for improvements at Buffalo. A good many people began to wonder if the iron trade was not really improving. Each succeeding week developed greater demand, greater strength, and firmer tone in the market. New requirements appeared, furnaces and mills began to book orders of some magnitude, and pig-iron stocks were drawn upon for certain desirable makes.

By the opening of April the market had acquired a strong undertone, even though prices had not quotably advanced. There were disquieting rumors then of a coming demand that would push all prices up to a higher level, but pig-iron makers and mill-men were too anxious for business to pay much attention to them. Finished material was weak; cost of production, however, was pointing upward because of ore advances. Furnace-men began to buy ore greedily; large season contracts were made, and also big Bessemer pig contracts. Manufacturers who scented the coming squall kept their secret and bought and contracted ahead in a way that surprised many. On the surface a good many were holding aloof from buying. The storm was on its way, but they did not know it. When May arrived, more manufacturers got their eyes open. Big concerns were found to be enormous buyers. The smaller buyers said it was a speculative movement and would soon blow over. Every week and in fact every day brought new surprises.

By July pig had begun to climb. Foundry had advanced 50@75c., forge was up $1, Bessemer $1.50, billets had bounced $4.50, and a first-class flurry was aboard. There was a continuously good demand; mills had all the business they could handle. Furnace-men began to show signs of increasing prosperity. The situation had not been better for years. The market was clearly working to higher conditions. Manufacturers began to be downright scared. Those who needed forge had to scamper after it and telegraph to know why shipments were delayed. There were signs of a shortage in billets. Wrought-pipe mills found themselves unexpectedly sold ahead. The bar mills were somewhat suddenly loaded up. The plate and structural mills began to quote higher prices. All raw material was advancing.

All through the summer months orders piled in, business expanded, wages were advanced, and manufacturers saw three to four months' business ahead. The supply of raw material was a great source of anxiety. Enormous purchases of ore were made during the summer. By the opening of October everything was at full speed. Billets were up to $26@$26.50, Bessemer imagined itself worth $15.50, beams and channels had 1.80c. marked opposite them in market quotations, and old iron rails were ticketed $16.50.

People were convinced this sort of business could not last, that the momentum of the movement would soon exhaust itself. Railroad managers and other large consumers when asked to place orders declined for good reasons. The manufacturers had filled up with large orders and were content for the time. Every mill in Eastern Pennsylvania was at work. And at this speed October and part of November were put in. Late in the latter month the tide turned, but the effects were not for a while visible in the mills.

The month of December brought declining demand, almost no demand in some lines, and lowering prices. The furnaces, however, were generally busy with orders for at least a month ahead, though contracts for 1896 had been closed rather slowly.

PITTSBURG.

The iron and steel operations for 1895 will long be remembered as showing wonderful increase in volume and exceeding all previous records by amounts so astonishing that it went to prove that Pittsburg is the greatest iron mart in the world. In the year 1894 sales of Bessemer pig reached 944,825 tons; in 1895 Bessemer sales amounted to 1,856,095 tons, exceeding the previous year by 911,-270 tons. The total sales of raw material, of all descriptions, for 1895 reached the enormous amount of 3,546,555 tons; the amount for 1894 was 2,277,979 tons, being 1,268,576 tons below that of the later year. These figures show the wonderful growth of the trade of Pittsburg; no person can form any conception of what the trade will be in a few years.

The year showed a wide range in values. Bessemer pig iron was dull at the beginning, selling at $9.90@$10; prices showed very little change until May, but during that month they advanced to $12.50; again they moved up in June to $13.65; July closed with quotations at $14.50; August was a good month, for it closed with sales at $17@$17.50; September showed good prices for the entire month, closing at $17.50; in October quotations showed signs of weakening and closed at $15.70@$16.50; in November they started on the down grade, closing at $13.75@$14 for next year's delivery; December opened weak, with sales for 1896 delivery at $12.60@$12.75.

Steel billets opened in January at $14.60@$15.15; in April prices began to advance and touched $16; in May the highest reached were $17@$17.50; in June prices again advanced to $19.75@$20.25; in July they reached $21.50@$22; August showed sales at $23.75@$24; September was a very good month for makers, as billets opened at $25 and closed at $24.65; in October, however, prices steadily declined, closing at $20.85@$21.75; November quotations showed continued weakness, and billets sold down to $18.25; in December the decline continued with sales at $16.80.

Gray forge opened in January at $9@$9.25; advanced in June to $11@$11.50; in August touched $12.75@$13; declined in November to $12.25@$12.50; and closed in December at $11.75@$12.

The following table shows the total amount of sales of raw material in Pittsburg for the year:

TOTAL SALES OF RAW MATERIAL IN PITTSBURG IN 1895.

Period.	Bessemer Pig.	Billets.	Gray Forge.	Raw Material, all kinds.
	Tons.	Tons.	Tons.	Tons.
First quarter	312,750	150,860	53,565	681,235
Second quarter	636,420	159,790	73,225	1,123,325
Third quarter	667,925	239,200	113,350	1,252,810
Fourth quarter	255,830	83,800	27,025	517,990
Totals	1,872,925	638,650	267,165	3,575,360

The greatest volume of business in Bessemer pig shown in one week was in that ending June 21, when 104,000 tons were sold. In billets the transactions reached their maximum in the week ending August 2, with sales of 32,750 tons. The highest total sales were for the week ending June 21, when 156,450 tons were reported; the week ending September 6 coming second with 146,505 tons.

The tables show the astonishing fact that one-third of the raw iron made in the United States is bought and sold in the Pittsburg market.

The following table shows the average monthly prices of leading varieties of iron and steel in Pittsburg during 1895:

PRICES OF IRON AND STEEL IN PITTSBURG IN 1895.

Month.	Pig Iron.			Ferro-manganese.	Steel Billets.	Wire Rods.	Sheet Bars.	Muck Bar.
	Bessemer.	No. 1 Foundry.	Gray Forge.					
January.......	$9.90@10.04	$10.18@10.87	$9.09@ 9.22	$47.73	$14.81@15 23	$21.03	$20.59	$18.33
February......	10.02@10.22	10.80@11.07	9.08@ 9.20	47.46	15.10@15.23	21.33	21.03	18.31
March.........	10.11@10.33	10.75@10.93	9.00@ 9.17	47.55	14.95@15.22	21.34	18.82	18.21
April....... ..	10.60@10.79	10.63@10 89	9.25@ 9.38	47.31	15.59@15.86	21.28	20.75	18.40
May...........	11.21@11.43	11.18@11.43	9.56@ 9.89	47.80	16.20@16.82	21.85	22.21	18.73
June...........	12.41@12.83	11.83@12.41	10.54@10.83	50.38	18.79@19.50	25.16	22.54	20.09
July...........	13.88@14.35	13.60@13.85	11.25@11.51	51.44	20.88@21.56	27.93	23.56	21.56
August........	14.68@15.24	14.10@14.32	11.99@12.23	53.55	22.23@22.55	29.72	24.20	22.77
September.....	17.24@17.85	14.77@14.95	13.35@13.61	56.56	24.25@24.89	32.40	26.69	23.69
October........	15.90@16.48	14.69@14.90	13.12@13.31	56.38	22.50@23.31	30.88	25.25	22.81
November......	14.42@14.88	14.47@14.70	12.57@12.86	55.35	24.59@25.63	28.40	23.50	21.60
December......	12.15@12.75	14.17@14 37	11.92@12.67	55.00	17.00@17.53	25.25	19.50	20.67
Year.......	$12.93@13.10	$12.61@12.86	$10.20@11.10	$51.28	$18.51@19.02	$26.08	$22.43	$20.42

As the fluctuations in Bessemer pig iron and steel billets constituted the leading feature of the market for the year, and in fact its chief speculative feature, we give below the range of prices weekly of those articles:

WEEKLY PRICES OF BESSEMER PIG IRON AND STEEL BILLETS IN PITTSBURG FOR 1895.

Week.	Price per Ton.		Week.	Price per Ton.		Week.	Price per Ton.	
	Bessemer Pig.	Steel Billets.		Bessemer Pig.	Steel Billets.		Bessemer Pig.	Steel Billets.
January 4...	$10.00	$15.15	May 3....	$10.90	$15.80	September 6	$19.00	$25.15
" 11...	9.90	15.15	" 10....	11.35	16.65	" 13	17.65	25.00
" 18...	10.00	15.25	" 17....	11.40	16.75	" 20	17.50	24 75
" 25...	10.25	15.35	" 24....	11.75	17.40	" 27	17.25	24.65
February 1..	10.35	15.35	" 31....	11.75	17.50	October 4...	16.90	23.50
" 8..	10.25	15.30	June 7....	12.50	18.25	" 11...	16.00	23.75
" 15..	10.15	15.10	" 14....	12.65	19.25	" 18...	16.50	23.60
" 22..	10.15	15.15	" 21....	12.90	20.25	" 25...	16.50	22.40
March 1......	10.25	15.10	" 28....	13.25	20.25	November 1	16.40	21.75
" 8......	10.25	15.15	July 5....	13.75	20.75	" 8	15.75	21.75
" 15......	10.20	15.10	" 12....	14.50	21.50	" 15	14.50	20.00
" 22......	10.30	15.10	" 19....	14.65	22.00	" 22	13.75	20.00
" 29......	10.65	15.65	" 26....	14.50	22.00	" 29	14.00	19.00
April 5.......	10.75	15.75	August 2.	14.50	22.00	December 6.	13.25	18.00
" 12.......	10.85	15.90	" 9.	14.20	22.00	" 13.	12.75	17.60
" 19.......	10.80	15.80	" 16.	14.75	22.25	" 20.	12.25	17.00
" 26.......	10.75	16-00	" 23.	15.25	22.50	" 27.	11.25	16.50
			" 30.	17.50	24.00			

It will be seen that prices reached their highest point in the first week in September, when sales also were very large. Quotations began to drop from that time, but the decline was not heavy until October.

The following table gives the cash prices the last week in December for six years. In 1895, compared with 1894, Bessemer showed $2.50 advance; No. 1 foundry, $2.85; gray forge, $2.50. At the closing prices, ferro-manganese showed $4.50 advance; muck bar, value $2.60 above 1894; charcoal iron showed a slight advance; steel billets, $2.45 advance; old iron rails, $2.10; new steel rails, $6 advance. Coke at furnace advanced 60c. in price. Notwithstanding the heavy decline in most leading products in the closing two weeks of the year, the closing prices show a material advance compared with those ruling one year previously.

CASH PRICES OF IRON AND STEEL IN PITTSBURG LAST WEEK OF DECEMBER.

Year.	Pig Iron.													
	Bessemer.	Coke Foundry.							Charcoal Iron.				Ferro-manganese, 80%.	Spiegel, 20%.
		No. 1.	No. 2.	No. 3.	Gray Forge	Mottled	White.	Silvery.	No. 1.	No. 2.	Cold Blast.	Warm Blast.		
1890......	$16.50	$17.25	$16.25	$14.75	$14.25	$14.25	$14.25	$16.50	$24.00	$22.50	$26.00	$24.50	$65.50	$30.00
1891......	15.75	16.00	15.25	13.65	13.25	13.25	13.25	17.00	22.50	20.50	26.50	19.50	63.00	27.00
1892......	13.75	14.25	13.25	12.60	12.50	12.00	12.00	16.00	20.00	19.00	25.00	19.00	61.00	28.50
1893......	11.00	12.25	11.25	10.00	10.00	10.25	10.60	15.50	18.50	18.00	25.00	18.00	52.50	23.75
1894......	10.25	11.40	10.40	9.50	9.25	9.00	9.00	13.60	17.50	16.25	23.50	16.50	49.50	18.50
1895......	12.75	14.25	13.50	12.00	11.75	9.00	9.00	14.80	17.80	17.25	24.00	16.00	54.00	18.00

Year.	Steel.							Wrought Iron.						Coke at Furnace.
	Billets.	Rail Ends.	Bloom Ends.	New Rails.	Old Rails.	Steel Nails.	Wire Nails.	Muck Bars.	Old Rails.	No. 1 Scrap	No. 2 Scrap	Bar Iron.	Iron Nails.	
1890...........	$26.00	$17.75	$17.50	$29.00	$18.50	$1.90	$2.10	$29.50	$26.00	$22.00	$18.00	$1.85	$1.90	$2.15
1891...........	24.50	17.25	17.25	30.00	17.50	1.60	1.70	26.00	23.25	24.00	17.50	1.65	1.60	1.90
1892...........	22.50	15.50	16.00	30.00	14.50	1.55	1.55	24.50	20.50	20.50	15.00	1.60	1.55	1.90
1893...........	16.75	11.50	11.50	24.00	10.50	1.10	1.20	21.00	14.50	16.25	15.00	1.45	1.10	1.15
1894...........	15.15	10.50	10.45	22.00	10.00	1.00	1.00	18.40	12.50	10.00	9.50	1.15	1.00	1.00
1895...........	17.60	14.50	14.60	28.00	14.00	1.25	1,30	21.00	14.60	14.00	12.50	1,25	1.25	1.60

Iron-Ore Sales.—The following table shows the sales of Lake Superior iron ore in Pittsburg for three years. All sales are made deliverable on the docks at Cleveland, Erie, or some other Lake Erie port. The ore sales for the year are generally made during February, March, and April. In 1895 the first sale occurred March 27.

SALES OF LAKE SUPERIOR IRON ORE AT PITTSBURG.

Date of Sale.	Quality.	Tons Sold.	Prices.
March 27......................	Bessemer.	300,000	$2.90@3.25
April 5........................	"	3,000,000	2.90@3.25
Total sales, 1895...............	"	3,300,000	2.90@3.25
" " 1894...............	"	2,950,000	2.25@3.25
" " 1893...............	"	4,010,000	2.75@3.00

At the close of the year the prices demanded for 1896 deliveries were materially above those which governed the market in 1895.

A good deal of discussion has been going on in Pittsburg over the prospects of the proposed ship canal to connect Lake Erie and the Ohio River, and Pittsburg iron makers have indulged in anticipations of lower rates on iron ore to come when transshipment at a Lake Erie port will no longer be necessary, and the ore boat loaded at Duluth or Escanaba will be able to discharge her cargo at a Pittsburg wharf. This time, however, is too far distant to have any effect on present rates of freight.

As shown by the table above, the sales of iron ore for the season were late, owing to the uncertainties of the iron business early in the year. The amount showed some increase over 1894; it did not represent all the sales, since some contracts were increased and new purchases were made later in the year to meet requirements which had grown beyond all anticipation.

Some Recent Proposals for Improving the Efficiency of the Blast Furnace in the United States.

By Sir Lowthian Bell.

While personal considerations have prevented the writer from preparing an extended paper for the present volume of The Mineral Industry, he has nevertheless ventured upon a brief exposition of his views on certain questions embodied in the title given above. One of these is a suggestion to inject superheated steam about half way down the furnace, where the horizontal area is contracted. The other is on the advantages to be derived from raising furnaces to from 80 to 100 ft. in height, and blowing them with blast at a pressure of 25 lbs. on the square inch.

As a preliminary to such an inquiry, it may in some cases be useful to explain shortly the different functions of the blast furnace, and with this object we will first consider a comparatively modern furnace, say one having a height of 45 ft. and blown with air of atmospheric temperatures.

The practical, indeed it may be said the only, value of using compressed air is to insure its penetration and that of the resulting products of combustion through the column of materials filling the interior of the furnace. This pressure unquestionably may be increased to a certain point if it be desired to increase in quantity the daily production of pig iron. All that is contended for at present is that the heat obtained by burning one unit of carbon is not affected by the pressure of the oxygen employed for its combustion. In any estimate of the quantity of heat evolved in the hearth, the carbon may be regarded as being exclusively burned to the state of carbon monoxide, because any dioxide generated in this region is instantly reduced to the lower oxide by the intensely heated carbon through which it must pass.

The great volume of air poured into a furnace, expanded probably to eight times its original bulk by elevation of temperature, renders its passage upward one of very high velocity. The descent of solid matter rapidly cools the upward flow of heated gases. For this operation time is required, and it is this which limits the quantity of air driven in at the tuyères; because, having regard to the cubic capacity of the furnace itself, any excess of duty imposed upon it would simply mean an escape of heat at the top unutilized. It may be here observed that almost as soon as the ore is introduced at the top reduction begins and is completed before it has passed the first 10 perpendicular ft. of the furnace we are considering. The function, therefore, of the remaining 35 ft. of its height is, after fusion is effected, the interception of heat which would otherwise be wasted. Valuable as is the furnace space for preventing this loss, in those in use 70 years ago the waste of heat in the escaping gas was then nearly 25% of that generated by the combustion of the fuel employed.

As bearing immediately upon this question of waste occasioned by the velocity of the current of gas through the blast furnace, the application of the hot blast affords some useful information. At its first introduction it was claimed that the heat of 5 cwt. of coal burned in the hot-air apparatus was equal in its effect to above a ton consumed in the furnace itself. In explanation of this we will apply the figures as afforded by a 48-ft. furnace blown with air at 485° C. = 905° F.

Let it be assumed that in the case of the cold-blast furnace referred to 122,000 centigrade calories were evolved, out of which about 28,000 calories were carried off in the escaping gases. We will now suppose that 15,000 calories are brought in by the heat communicated to the blast. This contribution of heat has required no consumption of fuel at the tuyères, and therefore no air for burning it in the furnace. By this change the weight of the gases and therefore their volume becomes reduced to the extent of about 25%, or from 170 cwt. per ton of iron to 128 cwt. By this simple alteration the loss of heat by the gaseous current is reduced from 28,000 to 16,000 calories, which added to that contained in the air accounts for nearly all the economy effected by Neilson's invention of the hot blast. Still the waste, even when so reduced, has been shown to be equal to 16,000 calories, or fully 57% of that lost in the gases from a similar furnace driven with cold air.

For 40 years or thereabout the manufacturers of pig iron contented themselves with furnaces 40 to 50 ft. in height blown with air at something like 600° F., or the melting point of lead. Up to this period—say 1868—very little, if indeed any, attention had been given to the actual heat requirements of a blast furnace with a view to comparing them with that afforded by the fuel consumed. Had they been made aware that nearly one-quarter of the heat evolved escaped unutilized at the top of their furnaces, they probably would have considered the possibility of arresting at any rate a portion of such a loss. It is true that a few furnaces of 60 ft. had been erected, but it was not until 1864 that a Middlesborough ironmaster, Mr. John Vaughan, ventured on one of 75 ft. in height. This bold step was made, not in the hope of economizing fuel, but of increasing the output of the furnace. Its success, however, in both directions was so manifest that others of 80 ft. and twice the cubic capacity were speedily constructed, by which fully 12½ cwt. of coke were saved as compared with the older furnaces of 45 to 50 ft.

The loss at the 80-ft. furnaces in the outgoing gases was ascertained during my own experiments to be about 9000 calories, representing about 3 cwt. of coke, and therefore well worth the saving were it possible to effect this by a further addition to its height. I had, however, previously determined, as mentioned above, that all reduction of the iron oxide was accomplished in the uppermost zone, and having proved that there was a balance of heat left over by the generation of carbon dioxide after satisfying the requirements of that zone, I arrived at the conclusion that the only effect of any increase of height would be that the zone of reduction would be also raised and that the loss of heat would therefore remain unaltered. On hearing from a neighbor that he proposed building two furnaces 100 ft. in height, I warned him of probable disappointment. It was a satisfaction that my advice was not followed, inasmuch as it afforded an opportunity of verifying the correctness of my conclusions on the subject.

A further and the last improvement requiring notice is the heating of the blast to a temperature far exceeding that capable of being attained in pipes of cast iron. This is done, as is well known, by heating a large surface of brickwork contained in an air-tight iron case and then conducting the blast through it. By this contrivance an average temperature of 1400° F. can be maintained, and the loss at the furnace outlet may be taken at 8000 calories per ton of metal.

In further illustration of the subject before us a case of a fairly good specimen of furnace work is submitted, in which the coke consumed was a trifle below 20½ cwt. per ton of metal. The statement may be regarded as an average of several investigations:

	Cwt.	
Coke consumed per ton of iron	20.40	
Deduct ash and moisture	1.90	
		18.50
Deduct 1.3 carbon as carbon dioxide in limestone, carrying off in upper zone the same weight by its reduction to state of monoxide		1.30
Leaves to be burned at tuyères of carbon		17.20

STATEMENT OF HEAT EVOLUTION.

	Centig. Calories.
17.20 cwt. of carbon burned at tuyères to carbon monoxide gives	41,280
Of this 6.0 carbon burned to carbon dioxide gives	33,600
Total	74,880
Heat contributed by blast	12,600
Total heat evolved	87,480

DISPOSED OF AS FOLLOWS.

	Calories.
Evaporation of water in the coke	300
Reduction of iron oxide in the ore	33,100
Carbon in pig iron (dissociated in carbon monoxide)	1,440
Expulsion of carbon dioxide from limestone	4,480
Decomposition of carbon dioxide of limestone	4,600
Decomposition of water in blast	2,500
Reduction of silicon, phosphoric and sulphuric acids	4,100
Carried off by tuyère water	1,800
Transmission through walls of furnace	3,600
Fusion of slag	15,500
Fusion of pig iron	6,600
Total used	78,020
Carried off in escaping gases	9,460
Total	87,480

I would now examine the first of the suggestions alluded to in my introductory remarks—the injection of superheated steam at a point intermediate between the charging plates and tuyères. Although the principle has, it is said, been favorably entertained by several successful furnace managers in the United States, I am not aware of any experimental proof having been given of its efficiency. I may say at once that I very greatly doubt whether any such confirmation of its success will ever be realized. This opinion is grounded on the following considerations.

It cannot be doubted that a considerable amount of heat can be imparted to the contents of a blast furnace by the injection of a sufficient quantity of steam largely charged with heat. It is needless to inquire how much less effective heat so obtained would be than that generated by the direct combustion of carbon within the furnace. The fatal objections to such a procedure are twofold. Its use is recommended on the ground of promoting the reduction of the ore. The reply to this expectation is that the ore *is* reduced long before it arrives at the points prepared for the reception of the steam. But let us suppose the impossible alternative, that there was still unreduced oxide to be operated on: how, it may be asked, is steam, previously highly heated or not, to effect this? since we know that the vapor of water passed over red-hot iron oxidizes the metal with the liberation of hydrogen—in short, the very reverse of the action now recommended.

It may be assumed that those who pronounced favorably on this scheme attach some importance to the presence of the element hydrogen, but I would ask them to recollect that this hydrogen is separated from its associated oxygen as it exists in steam by the absorption of as much heat as it affords when it is reconverted into water. Now after the hydrogen had acted on the iron oxide as a reducing agent, water, in the form of steam, is the product. In other words, the evolution of heat is absolutely nothing.

The line of argument, in the minds of those who recommend the employment of steam, presupposes that were unreduced oxide of iron present at the point of its introduction it would be deoxidized by hydrogen. This is extremely doubtful, for it is known that carbon monoxide is a far more powerful agent for this purpose than hydrogen, and the result is that hydrogen once in the furnace is given off unchanged in the gases.

In my opinion, if steam is ever injected into a blast furnace it will be for the opposite reason to that claimed by its proposer, viz., to cool instead of raising the temperature of its interior. Since the adoption of the firebrick stoves there has been a largely increased tendency, at any rate when smelting Cleveland ore, to *hang*, as it is called. This is probably due to an extension of the zone of fusion upward, which leads to a partial fusion of an earthy ore like that obtained in the Cleveland mines. The viscous matter, at any rate, adhering to the slopes of the bosh interferes with the uniform descent of the materials. Channels of greater or lesser dimensions are probably established which form a too ready mode of exit of the gases, which then fail in performing their proper duty. In some cases this kind of interruption may last for some hours. Ultimately the mass gives way, but the evil effects of the stoppage continue for several days or indeed weeks. It is pretended that a temporary reduction of the temperature of the blast palliates this difficulty (and such cooling would be the result of admitting steam). The interruption cannot, however, so far as the Cleveland ore is concerned, be otherwise regarded than as a very serious drawback to the use of the firebrick stoves; so much so that many cases can be given where the average consumption of coke is no less, often greater, indeed, than that obtained when metal stoves were employed for heating the air to about 1000° F.

The objections which have been urged against the introduction of steam into a blast furnace involve, as I have endeavored to prove, a direct interference with the known principles upon which its action depends. No such imputation, however, can be brought against the proposal to construct a furnace 100 ft. high and to blow it with air at a pressure of 25 lbs. on the square inch, nor perhaps against driving it at a rate equal to a production of 600 tons per day.

It is true that some difficulty may attend the dealing, in a very limited space, with nearly a ton of raw materials for each minute of the 24 hours, and in the preparations for receiving a torrent of pig iron of half this quantity pouring into the hearth in the same time. But there is nothing physically impossible in providing the necessary mechanical means of mere movement of even these large masses of matter. The volume of air for such a production of pig iron as that mentioned—600 tons per 24 hours—will be about 3,250,000 cu. ft. per hour. I am not prepared to say what pressure may be necessary for forcing this volume of blast through a furnace 100 ft. in height when smelting the rich ores from Lake Superior. It will be remembered that it has been already shown in this paper how a furnace of these dimensions failed in economizing fuel in smelting the clay ironstone of Cleveland, and an explanation given of the cause. It is not improbable that the upward passage of so vast a volume of gas as that accompanying so large a production of metal may involve a very high velocity in the current. This may be so rapid as not to afford time enough for the performance of those functions already described, and to effect which an increased capacity of furnace may be necessary, in which case the additional height may be an advantage. Admitting, however, from whatever cause, such a pressure to be a necessity, we must not lose sight of the additional quantity of fuel which will be needed to increase the pressure of the air from 5 to 25 lbs. on the square inch. If this pressure has to be of continuous application, the fuel so consumed for its generation may far exceed the power of the escaping gases, and must swell the cost of the metal far beyond the possible gain. Guided by the weight of coal required for compressing the air for a Bessemer converter at something like the pressure proposed, about 12½ cwt. will be needed for each ton of pig iron. It is unnecessary to say that this is three or four times the consumption in driving an ordinary non-condensing blast engine when the pressure does not exceed 5 or 6 lbs.

It remains to be seen whether the use of superheated air in such a furnace as that proposed will be attended with the hanging tendency which has been found so inconvenient and so wasteful in the Middlesborough district of England. I apprehend that in smelting the rich hematite ores of the United States this difficulty may not occur, owing to the small quantity of earthy constituents.

When the furnaces under consideration are set to work, no doubt especial attention will be paid to keeping down the temperature of the escaping gases. Instances have been already given of the heavy losses which may happen from this cause; but there is another which must be kept in view when driving a furnace at a speed beyond its power to deal with. The temperature of the reducing zone may be so raised that the carbon dioxide generated by the act of reduction may pass back into the condition of monoxide, which will involve a loss of 5600 calories for each unit of carbon passing through these transformations.

I may here mention a summary of the experience at the Clarence Works, where 12 furnaces are engaged exclusively in smelting the ironstone of Cleveland. The furnaces have a uniform height of 80 ft., but owing to differences of diameters they vary in capacity from 11,500 to 25,000 cu. ft. When the whole establishment was supplied with air heated in metal pipes the smallest furnaces produced a ton of iron with as low a consumption of coke as the largest, the only difference being that for every 1000 cu. ft. of capacity 30 tons per week were made, against about 24 tons in all those of larger dimensions. At that period all the furnaces were blown with air at a pressure of about 3½ lbs. per square inch. Since that period the pressure has been raised to 5½ lbs., and the temperature of the blast, heated now in brick stoves, varies from 1300 to 1450° F. The weekly produce of the small furnaces is now 45 tons per 1000 ft. per week, while the best of the larger furnaces does not exceed 25 tons for the same cubic space.

Steel Production in the United States and Great Britain.

The following table presents an interesting comparison between the two leading steel-making nations, showing the total production of Bessemer and open-hearth steel in each for ten years ending with 1895, in long tons. The production of crucible and other special steels, which is comparatively small, is not included:

Year.	United States.					Great Britain.				
	Bessemer.		Open Hearth.		Total Tons.	Bessemer.		Open Hearth.		Total Tons.
	Tons.	Per Cent	Tons.	Per Cent		Tons.	Per Cent	Tons.	Per Cent	
1886........	2,269,190	91.2	218,973	8.8	2,488,163	1,570,520	69.3	694,150	30.7	2,264,670
1887........	2,936,033	90.1	322,069	9.9	3,258,102	2,089.403	68.0	981,104	32.0	3,070,507
1888........	2,511,161	88.9	314,318	11.1	2,825,479	2,032,794	61.1	1,292,742	38.9	3,325,536
1889........	2,930,204	88.7	374,543	11.3	3,304,747	2,140,791	59.9	1,429,169	40.1	3,569,960
1890........	3,688,871	87.8	513,232	12.2	4,202,103	2,014,843	56.3	1,564,200	43.7	3,579,043
1891........	3,247.417	84.9	579,753	15.1	3,827,170	1,642,005	52.0	1,514,538	48.0	3,156,543
1892........	4,168.435	86.2	669,889	13.8	4,838,324	1,500,810	51.4	1,418,830	48.6	2,919,640
1893........	3,215,686	81.3	737,890	18.7	3,953,576	1,493,354	50.6	1,456,309	49.4	2,949,663
1894........	3,571,313	82.0	784,936	18.0	4,356,249	1,535,384	49.4	1,575,318	50.6	3,110,702
1895........	4,909,128	81.2	1,137,182	18.8	6,046,310	1,535.225	47.1	1,724,737	52.9	3,259,962

This table shows that while the fluctuations in our own production have been much greater and more abrupt than in the British output, the tendency has been generally to an increase. The quantity of steel made in the United States in 1895 shows an increase over that for 1886 of 3,558,147 tons, or 143%; while the gain in Great Britain during the ten years was 995,292 tons, or 44.4%. In 1886 the total steel production of the United States was to that of Great Britain as 100 : 91; while in 1895 the proportion was as 100 : 54. Our proportion of open-hearth ingots to the total increased in ten years only from 8.8 to 18.8%, while the British figures show an advance from 30.7 to 52.9%.

Our own statistics do not distinguish between the steel made by the acid and basic processes. There is no basic Bessemer steel made here, however, and until very recent years the basic open-hearth process made very little headway, its use being confined to a single plant. As its advantages become more apparent the process is growing in favor, and we find that out of the new open-hearth plants built or begun in 1895, which included 62 furnaces with a total capacity of 690,450 tons yearly, 34 furnaces were intended to make basic steel. The transformation is going on with increasing rapidity, and its progress will be hastened by present trade conditions, the tendency of which is to induce the mills turning out finished steel in its various forms to make their own ingots instead of depending upon billets bought from others.

The slow progress made by the basic process has been due partly to some doubt which has existed as to the quality and reliability of the product, which has been gradually removed as it was tested and came into use; but in greater degree to the fact that we possessed in the Lake Superior region an apparently inexhaustible supply of ores adapted to the Bessemer process. More recently some of the Southern furnaces have shown that they can furnish basic pig in abundance and at a low price, and this fact will have a great effect in the future, especially in furthering the manufacture of steel in the South.

Alloys of Iron.

By R. A. Hadfield.

The great and growing importance of The Mineral Industry, Its Statistics, Technology and Trade makes it a special honor to be asked to contribute to the fourth annual volume. As one of many Englishmen who not only marvel, but rejoice, at the extraordinary and successful progress in American mineral and metallurgical industry, the writer considers that the editor of this report lays very many, whether American, English, or European, under a debt of gratitude for the excellent reference work he has prepared at so much expenditure of time, labor, and money. No metallurgical library can be considered complete without this book, and the writer can only conclude these opening remarks by wishing the editor a constantly increasing circle of those who when they become readers will be also admirers of his labors on behalf of the cause.

In the use of iron the possibly latest and not least important phase of development is found in its alloys or compounds with other elements. This study is perhaps one of the most fascinating of all its branches of research and manufacture, and we metallurgists devoted to this special branch are continually endeavoring to improve and strengthen our beloved "Ferrum" by giving it higher tenacity and elasticity, more ductility and greater hardness, without sacrificing the metal's valuable and inherent toughness.

There is no doubt that the metal iron in itself would be of little service to the world at the present day with our enormously higher stresses and strains. Prof. T. Turner has shown that the pure metal iron is not considerably harder than copper, and we can readily imagine how in itself such a material would render impossible that combination of high speed with greater wear and tear for uses which are the result of modern mechanical developments of all classes. Without doubt further developments in modern mechanical progress will largely depend upon the material which the experimentalists in question can offer for utilization by the mining, mechanical, or electrical engineer.

It need also hardly be said that such progress renders necessary a development which becomes each year more complex and requires more specialization of research. The problem to be solved presents a field in which results at all approaching to finality are very far away, and can only be attacked little by little. The investigator, besides having general technical knowledge, must be able to devote in the first place much energy to the examination of the properties of the various elements to be used in such an alloy, a matter not so easy as it may at first sight seem, for our knowledge of many of the elements themselves in their pure form is still very meager. In producing his alloys he must also be prepared for many contradictory results most difficult of explanation and for a large percentage of apparently useless work. And, finally, while studying this problem, which continually presents new perplexities, he must also recognize how all his efforts are largely dependent upon the investigator or worker at the opposite end of the scale—he who produces the raw material for the alloys. In other words, we must go back again and look for much help from those who are attacking mother earth herself in our mineral industries. One cannot help feeling in these matters as Peter Ibbetson did when studying the forces of past ages which had produced the present ego of flesh and blood. So the investigator of the complex question of iron alloyed with elements some of which have only recently become at all available for practical investigation finds himself indirectly dependent upon the smelter, the latter upon the humble mine laborer, and he in turn upon the early explorer who faced dangers and difficulties of which we perhaps at the present day have little conception when prospecting and opening out the world's mineral wealth.

The properties of the principal iron alloy, carbon-steel, are too well known to need more than a general reference here. Purity of material still holds the field for the production of the highest and best quality of carbon-steel, a point which no one has done more to impress upon those interested than your able metallurgist, Mr. Metcalfe. The writer can only speak as regards this subject from his English knowledge, but he can safely say that the success of Sheffield steel, notwithstanding modern improvements in all branches of metallurgy, is still owing to the attention paid to this consideration. Speaking of crucible steel, there are probably used in Sheffield at the present time no less than 30,000 crucibles each week, a large proportion of which are being used for the production of carbon-steel of the highest purity and uniformity. That city is, in its turn, dependent upon raw iron of special high purity, chiefly produced in Sweden, a fact which offers much food for consideration, seeing our often boasted ideas as to modern advances in metallurgical practice for enabling cheap material to be purified. The practice in Sheffield as regards the production of crucible steel is still that brought to practical issue over a century ago by Benjamin Huntsman, whose descendants even at this date continue to manufacture crucible cast steel. Much as other carbon-steels have prospered and served their useful ends, we cannot but be struck by the vitality of the high-class product.

Another branch of metallurgical industry, the manufacture of steel castings, is in itself an alloy industry, for while carbon is the element which confers upon the material the most important characteristics, satisfactory results would not be possible without the use of other elements—silicon, aluminum to some extent, and manganese. The advance of this manufacture is due largely to manufacturers of the special ferro-alloys, such as ferro-manganese, ferro-silicon, silicon-spiegel, ferro-chromium, and other products. Take ferro-manganese for example. It is but little more than a decade ago that the ferro-alloy containing 80% of manganese was a metallurgical curiosity, and even when its manufacture was made at all practicable, it readily fetched $6 per ton per unit; yet in the past year the price has been as low as $48 per long ton, or little more than 60c. per unit. Ferro-silicon can now be readily obtained with as high as 17 to 18% of silicon, ferro-chromium with 65 to 70% of chromium, and so on with other ferro-alloys. Thus the user has a choice of alloys at his command which would have made much easier the work of such early experimentalists in this field as David and Robert Mushet, Robert Heath, Henderson, and many others. The magnificent steel castings now used in all branches of engineering practice have, after all, only been made possible by the work of these men, the producers of ferro-alloys, whose names are seldom heard of. It is not a pleasant fact that we can only obtain complete success through many failures. A remarkable example of this has been the well-known Terre-Noire Company, whose magnificent exhibit of ferro-alloys at the Paris Exposition of 1878 was the wonder of all metallurgists. The time, thought, and money expended over the production of these exhibits deserved that a better fate than "liquidation" should so soon after have been the fate in store for this enterprising company. Yet it was principally through its efforts that the manufacture of ferro-alloys used for the production of steel and steel castings was first made a commercial success.

One of the iron alloys that has been much before the world of late is nickel-steel. Without doubt this metal has given high results, and for special purposes its use is of great service, but the writer, from experiments with many hundreds of samples and up to very high percentages of nickel, believes that the cry of "nickel-steel for everything" has been much overdone. There is no doubt a large field of application for it, but it is expensive to produce, besides possessing qualities which are difficult to deal with in manufacture. We must not overlook the fact that Harveyed carbon-steel plates containing no nickel after very severe treatment have held their own excellently, smashing up the best class of steel armor-piercing projectiles, and this without showing serious cracks.

Nickel in the presence of carbon does no doubt considerably raise the elastic limit of iron, but its combination with carbon more than its direct influence upon the iron present has been much overlooked, or perhaps it would be more correct to say that the carbide of iron is rendered much more powerful by the presence of nickel. In other words, its action is not at all dissimilar to that of chromium. It is very questionable whether carbonless nickel-steel would be found upon careful examination and by means of proper tests to possess qualities that would render its use, at any rate for most purposes where carbon-steel holds the field, of any considerable value in comparison with some of the cheaper alloy steels; that is, the use of nickel *per se* does not cause the improvement noticed in carbon-nickel steels. Some important experiments by Mr. H. H. Campbell, recently published, prove that the expected great gain by using nickel for certain classes of work has not been realized. The writer does not wish to depreciate the benefits that may be gained in certain special work, but those engaged in steel-alloy production must consider the various products from many standpoints, cost not being one of the least of these. The writer has discovered several curious facts respecting high nickel-steel alloys. As would be naturally expected, the two magnetic metals, iron and nickel, alloyed together and in the absence of carbon are magnetic, but singular to say 25% nickel-steel containing 1¼% of carbon is only feebly magnetic. This powerful influence of carbon is very extraordinary; but, as will be seen when dealing with other alloys, such as manganese-steel, its influence is no doubt shown in effecting some remarkable change not yet understood in molecular structure. Probably the reason for the curious behavior of the various non-magnetic alloys of iron will be found largely in this cause, that is, carbide changes, but it is impossible to offer any very definite explanation of the fact until our chemists have made it possible to more accurately determine the various forms in which carbon exists in steel. Professor Arnold's recent valuable paper to the Institute of Civil Engineers in London is perhaps one of the first articles to thoroughly attack this important research from the correlative point of view. Those who have not studied this paper will find it to contain most valuable information. Professor Arnold has devoted special attention to microscopy, and the very minute examinations he has made in his series of some eight or ten specimens of carbon-steel, commencing with the softest and going up to the hardest tempers now manufactured, furnish information which should be of the greatest service in this branch of metallurgy. Without treading upon the dangerous ground of allotropy, the writer cannot help stating here that it seems to him that Professor Arnold has shown the true direction in which we must now attack this important problem.

Cobalt-steel has been produced in various percentages for experimental purposes by the writer, and in many respects its properties resemble that of nickel-steel.

One of the special developments of alloy-steel has been the result of the writer's experiments in the production of manganese-steel, a material which has been further investigated in America by the well-known metallurgist, Mr. H. M. Howe, of Boston, and in practical application by the Taylor Iron and Steel Company of High Bridge, N. J.

Until a short time ago it was very difficult to state what were the properties of the main element in manganese-steel, that is, of the metal manganese, but that metal has been rendered available by the experiments of Drs. Greene and Wahl for practical examination. His results prove that in itself it is very hard and brittle, capable of scratching glass, not readily oxidized, as hitherto stated, and possessing in several respects different qualities from those before imagined. The question of oxidization, for example, is an important one settled by his research, for hitherto, owing to the easy and rapid oxidization and disintegration of the ferro-alloy containing 86 to 87% manganese, it had been usually supposed that the metal itself could not be kept exposed to the air or other oxidizing influences for any length of time. As a matter of fact, the metal produced by Mr. Wahl, when pure and free from carbon, can be readily retained without oxidization even when exposed for a long time to atmospheric influence. There is no doubt, therefore, that the properties previously noted were due to the high percentage of carbon present, which of course exists in the ferro-manganese alloy and which no doubt also existed in previously examined samples of the product supposed to have represented the pure element.

Knowing the properties of manganese, we can readily understand that whether manganese-steel is merely an alloy or a definite chemical combination, the influence of the metal when present in comparatively large proportions would be to add considerably to the hardness of the softer metal iron.

But alloys of manganese-steel present most perplexing anomalies, for while those containing 3 to 6% in the presence of not more than 0.6% of carbon give an exceedingly brittle and hard product, yet upon doubling the proportion of manganese, that is, to 12 or 14%, alloys possessing entirely different properties are obtained. Castings of this latter material when suitably treated possess a most extraordinary combination of hardness and toughness, which enables them to offer the highest resistance to abrasion than any alloy yet produced. The same material in the forged condition, also after suitable treatment, possesses tenacities of 60 to 70 tons per sq. in. with high elongations, 35 to 45%. Yet these materials, whether in the cast or forged conditions, cannot be machined except with the greatest difficulty; in fact, their hardness approaches that of chilled iron. Here again these properties cannot be judged from the same standpoint as that of other metals possessing hardness, for such manganese-steel, while so hard to the machine tool, can be indented with an ordinary hand hammer; in other words, it is not "glass-hard," but combines in a specially peculiar manner hardness and toughness.

Here, we may note, is another reason why metallurgists and engineers generally should come to some understanding upon the meaning of the word hardness, which is often used to indicate brittleness and *vice versâ*. An established definition of this property of metals, so that comparisons could be accurately drawn, would be of the highest service.

Owing to the rapid progress of electrical science, which demands quite a special class of materials, new alloys are now at once subjected to electrical tests. Here again manganese-steel entirely differs from all carbon-steel. It is practically non-magnetic even under the highest magnetizing forces, and at one time it seemed as if no treatment would change that condition; but recent tests of the writer have proved that by heating manganese-steel for about 100 hours at a comparatively low temperature the material can be considerably modified in this respect. Yet the same material heated to a higher temperature of about 1000° C. can be again made to assume the non-magnetic condition, and it is only by a further lengthy heating at a low temperature that the magnetic state again occurs. Thus it has been possible to produce a bar of manganese-steel, one end of which is non-magnetic, while the opposite portion is considerably susceptible to magnetic influence, the latter being a non-stable condition readily removable by subsequent heating. So far no satisfactory explanation of this curious behavior has been obtained, but the writer thinks that there is reason to believe that a double carbide of iron and manganese exists in this material, one which is more or less stable according to the heat treatment used. Other recent experiments prove, too, the very important part played by carbon in manganese-steel. The brittle 3 to 6% manganese alloy has its properties entirely modified by reducing to a low point the percentage of carbon. It is very astonishing to find that by removing about 0.4% of carbon—that is, reducing it from 0.50 to about 0.10%—the physical properties of the material are entirely changed. Instead of having an extraordinarily brittle compound, hard enough to scratch glass and readily powdered under a hand hammer, a comparatively soft product is obtained which possesses quite a respectable degree of toughness. When it is considered what an enormous revolution of structure is thus obtained by the comparatively small reduction of the carbon—and this is a cast material which has not been forged or which has had no heat treatment or water quenching—it can be safely said that no other branch of scientific research offers more field for meeting with the unexpected. It is, too, only another proof of the extraordinary power of carbon.

The manganese-steel containing 7 to 20% manganese—principally that with about 14%—has a considerable and growing application, particularly for purposes in which readers of this work are concerned. Thus its use for mine-car wheels has been found invaluable. Its toughness and extraordinary resistance enable such wheels to be made having 25 to 30% less weight than those hitherto used, and yet at the same time so hard that they outlast several wheels of cast iron. They will withstand the most severe usage; spragging does not produce flat spots; and the cars, owing to the lightness of the wheels, are much more readily handled. About 40,000 of these wheels are already at work in the anthracite and bituminous coal mines of America, Great Britain, and the colonies, and after several years of service not a single wheel has yet been worn out.

Other applications for purposes specially interesting to readers of this work are manganese-steel castings for milling and crushing machinery. The qualities required in a material having high resistance to abrasion are peculiar and different from those which at first sight might seem necessary. Mere hardness is not the only quality, for in that case chilled iron would be the best material, whereas manganese-steel, which is not so hard as chilled iron, but possesses the toughness of mild steel, will wear in crushing and other machinery as much as four to seven times as long. When the heavy expense of replacing worn parts, such as stoppage of machinery, loss of time, and other points are considered, then the advantages of manganese-steel are very considerable, and its higher first cost is no bar to its employment.

Both in England and in America and in South Africa also manganese-steel has been found to be of the highest service in crushing machinery of all types. Of it are made shoes and dies, crushing rings, rollers and paddles, cones for gyratory crushers of the Gates, Comet, McCully, and other types, stone-breaker jaws, faces, toggle bearings, balls, etc. Users in all parts of the world testify to the important place this material is now occupying by the assistance it renders in reducing cost of production.

As showing its remarkable qualities to resist abrasive action one special instance may be quoted. A curved rail of this material on the Philadelphia Traction system wore 14 months, whereas those formerly used had to be replaced every 6 or 8 weeks. When the cost of replacement is considered, the saving by the use of manganese-steel in connection with the work must have been large. Another instance was of a manganese-steel crossing piece which was not worn out until over 750,000 trolley cars had passed over it. Similar results have been obtained with the pins used in the buckets of dredger ladders. Those of manganese-steel outlast from three to seven sets of ordinary steel pins. Manganese-steel, being uniformly hard throughout its whole thickness, possesses in this respect decided advantages over chilled iron or other material where the hardness is of no great depth. This, combined with its toughness, renders it one of the most valuable steel alloys so far produced. In a short article like the present it is not practicable to give with any degree of definiteness all the advantages as well as the peculiarities of this material, nor to show how in certain cases designs must be modified or shaped to meet its characteristics.

Another important alloy is chromium-steel. With its principal application to armor-piercing projectiles the readers of this article are probably familiar. This material in itself has no great hardening influence upon iron, but in the presence of carbon, even if there be only a low percentage of the latter element, its influence seems to be very energetic. In other words, a carbon-steel without chromium will not harden so readily as when the metal in question is present. The latter seems to have the property of causing the formation of intensely hard carbides of iron or double carbides of chromium and iron.

Tool steel has been found to be improved by the addition of chromium, but its general use does not appear to be on a very large scale. Probably until we more fully understand the action of third elements in iron-carbon alloys we shall not make very rapid advance. There is too much haphazard employment of this metal as well as tungsten; that is, no good grounds can be given as to the reasons why these elements improve iron.

Silicon alloys of iron seem in some respects to resemble other alloys, such as those with chromium and tungsten. One would have hardly expected this, owing to the entirely different properties of the metalloid. Thus steel containing 2% of silicon and 1% of carbon hardens in the same way as chromium and tungsten steel, though probably not so intensely. It is also tougher. When it is remembered that 2% of silicon in cast iron prevents any chilling, it is somewhat remarkable to find that the same percentage in steel in the presence of much less carbon—probably one-third less—not only does not prevent the hardening of the steel upon quenching, but rather assists it. This is a striking anomaly difficult to understand or explain with our present knowledge.

Aluminum alloys of iron do not at present seem to present any special commercial use, though the addition of small percentages of this metal for certain classes of work does considerably help the production of sound castings. The writer believes as a matter of fact that silicon metal—say 98 to 99% of purity—unfortunately not at present available, would be found quite as beneficial as aluminum. At the present time it is difficult to add silicon without at the same time adding carbon. When the latter is present there is of course always more or less liability to the disengagement of carbonic oxide.

Copper-steels have been produced. They also seem to possess no special commercial application. The elastic limit is raised, but providing the copper is under about 1%, this is apparently done without much loss of ductility.

In concluding these remarks, necessarily imperfect from their brevity, on such an important and wide subject it is well to remind readers that these results chiefly concern what may be termed a primary alloy, either iron or carbon steel, to which has been added one other element. It will be seen how wide a field is open to speculation when we try to think what results might be obtained by a triple or quadruple alloy; but such experiments, besides being very costly, are almost endless. We must be content to attack the problem little by little. Perhaps some day we may be able to control the atomic grouping of our iron alloys in such a manner as will render possible the production of alloys having properties now little dreamed of.

Professor Dewar, before the Royal Institution of London, has obtained most remarkable results with metals and alloys at low temperatures—results which in the near future may prove of the highest importance. Monsieur Osmond has done great service by his invaluable research work, both as regards chemical and physical observation of iron alloys. Professor Roberts-Austen has followed up these lines still further and greatly improved our knowledge in regard to pyrometrical research. Professor Arnold has recently contributed most important research work on the micro-structure as well as the chemical composition of iron and its alloys. His recent paper before the Institution of Civil Engineers must prove of the greatest importance. Mr. T. Andrews has written a series of treatises upon the properties and structure of iron almost in its pure form, and from an entirely different standpoint from most other investigators. Mr. J. Stead continues his important research work from the chemical standpoint and has already added largely to this field.

On the Continent a number of earnest workers, such as Osmond, Charpy, H. and A. Le Chatelier, Ledebur, Müller, Wedding, and Martens, as well as on this side such men as Howe, Metcalfe, Langley, Sauveur, Webster, Keep, Campbell, Dudley, and others, are all actively engaged in pushing on the good work. Never, probably, were the properties of any metal so much probed and examined as those of our friend "Ferrum." That the numerous physicians engaged in its diagnosis, guarding its welfare, curing its defects, and improving its physique will obtain results which will render it of still greater use than ever before in the world's service can be safely answered in the affirmative.

When it is considered how much has been done in less than a generation, we must all feel that the world at large is greatly indebted to that indefatigable body of men, the metallurgists, who through good and evil report, through times of boom, depression, and difficulties of all kinds, are ever faithful to the cause of the improvement of iron and its alloys or combinations for the general benefit of mankind.

The Relative Corrosion of Wrought Iron and Steel.

By Henry M. Howe.

We have two kinds of evidence bearing on this question, that of actual service on a large scale in commercial and other industrial applications, and that of direct comparative tests on a small scale, in which all conditions are made closely alike, so that comparison may be precise; in short, of the industrial and of the laboratory tests. Of these the former, when sufficiently extended, may be held to be the more valuable of the two, because for all that we know they may necessarily imply conditions which work powerfully in favor of one or the other of these two classes of iron, conditions which, if they do not escape analysis, may at least easily escape our foresight in planning our laboratory tests.

But this industrial evidence must be very extended to be trustworthy, because the conditions of industrial use are liable to vary so very greatly. In view of these variations we must be very cautious in comparing the corrosion of wrought iron at one place or time with that of steel at another place or time, and even when these two classes of iron are simultaneously exposed side by side in industrial use, there may often be unnoticed differences in condition which work in favor of one or the other class so as to vitiate our comparison. The mere fact that the wrought iron and steel are in actual contact or even that they are electrically connected might hasten the corrosion of one and retard that of the other to such a degree as to make a great difference in their rate of corrosion—a difference which might disappear wholly were each of the two completely isolated from the other. So, too, slight differences in the position of the two metals, differences in the temperature or in the velocity of the water to which they are exposed, in their contact with copper or other metals, and a dozen other causes may in industrial use vitiate the comparison.

Besides these rather general considerations, we have one which applies especially to this case, viz., that under identical conditions of exposure not only different classes, but even apparently like pieces of wrought iron corrode at very unlike rates, and so do apparently like pieces of steel. This is shown us not only by common observation, but by direct experiment. We all know how rust will form at certain spots on a razor, knife, or iron roof, avoiding the rest, though this is apparently of the same metal identically exposed. So of twelve knives in a drawer: some will rust more than others. The careful direct laboratory tests of Parker show a like result. Thus in one set of tests Lowmoor best wrought iron corroded 67% faster than Bowling best, and in another the latter corroded 64% faster than Skerne common wrought iron.* And though in these particular cases the differences are unusually great, yet in general very considerable variations are found between the rates of corrosion of different pieces in our small scale tests. It is generally believed that impure wrought irons as a class corrode much less than pure ones. This, if true, complicates the comparison: in each case we should know how impure the particular wrought iron is with which the steel is compared and what its impurities are.

So, too, there are conditions and conditions and there is steel and steel. It is probable that the relative corrosion of a given steel and a given wrought iron

* *Journ. Iron and Steel Inst.*, 1881, I., p. 46.

varies greatly with the conditions of exposure, and that the absolute corrodibleness of steel, like that of wrought iron, varies greatly with its treatment, its solidity—*i.e.*, freedom from blowholes—its homogeneousness, and its composition.

This has been strangely lost sight of in many discussions of the subject. Experimenters proceed as if steel and wrought iron were two substances which differ from each other as iron differs from zinc and as if all steel were alike. In reality, however, the differences between different steels, even between different low-carbon steels such as usually compete with wrought iron, are very great, probably far greater in their influence on corrosion than the difference between normal low-carbon steel and normal wrought iron. Apart from variations in the carbon content, the manganese even of low-carbon steel may vary from 1.25% to next to nothing, and the silicon, phosphorus, and sulphur may vary much. The structure varies not only with these variations in composition, but also with those in treatment, both thermal and mechanical. Some steels are full of blowholes, others completely solid. Some are uniform throughout, others heterogeneous. Each of these variations may affect the corrosion markedly; and taken cumulatively their combined influences may be very great.

Those who determine the corrosion of one piece of steel or of half a dozen pieces, and at the same time of a few pieces of wrought iron, and forthwith formulate the relative corrosion of these two classes, may well ask themselves whether it would be wise to measure the first six Frenchmen and the first six Germans they met in the street and thence deduce a formula for the relative height of these two races.

A striking example of the influence of differences in treatment, which in industrial tests might easily be overlooked, on the corrodibleness of iron is at hand in the case of punching, shearing, and other forms of permanent distortion. They create a difference of potential between the distorted parts and the rest of the metal and thereby lead to a marked increase in corrosion. Hence if corrosion is to be especially guarded against, it may be well to consider carefully whether this difference of potential should not be avoided, either by drilling instead of punching, by reaming, or by heating slightly the sides of the punched hole, so as to draw the effects of the punching.

Thus industrial results, unless they are fairly harmonious and based on very extended use of steel of normal composition and normally free from blowholes, must be received with great caution. Even then they can be applied only with caution to conditions other than their own. And though when sufficiently harmonious and extended they may be more valuable as a guide to the relative industrial value of these two classes of iron than the laboratory tests are, yet even then the latter should be carefully studied, for they may reveal some condition which in industrial use has led one of these classes of iron to corrode excessively fast, and may thus enable us to avoid that condition and so to retard the corrosion.

In studying this question some years ago* I was led to doubt whether there was in general any considerable difference between the rate of corrosion of wrought iron and that of steel. Since then the results of several series of laboratory tests have been published, increasing greatly our available data. This and

* *The Metallurgy of Steel*, 1890, p. 98.

the fact that steel has begun to be used for enormous sheet-metal conduits for conveying water to great cities, a use in which resistance to corrosion is a matter of the most vital importance, have led me to study the question anew, with the results which form the remainder of this paper. In doing this I have not been able to widen the basis of industrial evidence nearly as much as that of laboratory evidence.

That wrought-iron conduits will resist corrosion for a great length of time, strongly as the conditions seem to favor corrosion, opposed as they seem to be to the longevity of the metal, is shown by abundant evidence. This important fact has, however, escaped the notice of so many that it seems well to give some of this evidence here briefly.

Examples of the Resistance of Wrought Iron to Corrosion.—Eminent and most trustworthy hydraulic engineers vouch for the endurance of wrought-iron mill penstocks in New England for 30, 40,* 47, and even 49† years, and at least in some cases with so little corrosion that a life of a hundred years seems probable. Indeed, we are told that the first failure of a wrought-iron penstock from corrosion has yet to be reported.‡ Mr. Clemens Herschel, after examining some 200 running feet of the great Rochester 36 and 24 in. riveted wrought-iron water conduit when it had been buried for 18 years, reported that it was entirely free from rust, both inside and out.§

California Experience.—For over 42 years thin wrought-iron pipes have been used in California for carrying water under pressure,‖ and as much as 39 years ago a pipe 40 in. in diameter was there used for this purpose.¶ This use has increased, and the very extensive pressure and like pipe lines on the Pacific coast, whether for the many hydraulic mines or for supplying cities, were and I believe still are made almost exclusively out of sheet and thin plate iron. Out of many striking cases I select the following.

Two 20-in. pipes of No. 16 iron ($\frac{1}{16}$ in. thick) of the North Bloomfield Company, after 16 years' use, during which they had carried water for 10 months in each year on an average, seemed to be in nearly as good order as when first laid.**

The thin sheet-iron pipes through which San Francisco is supplied are credibly reported as showing no sign of weakness after more than 20 years' use.††

The 30-in. sheet-iron pipe of the Spring Valley & Cherokee Hydraulic

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* Clemens Herschel, *Journ. New England Water Works Assn.*, 1893, VIII., p. 24.

† John R. Freeman, then a commissioner of the Metropolitan Water Board of the State of Massachusetts, private communication, Oct. 15, 1895. Mr. Freeman says: "A few Sundays ago, in company with Mr. Hiram F. Mills, the well-known eminent hydraulic engineer, I examined some of the earliest water-wheel penstocks at Lowell, and at the Merrimac Manufacturing Company found one that had been in use for 49 years and 3 months. It showed no signs of having received any special protection, and on scraping the tubercles from the interior surface at several points I found no spot where the corrosion had eaten into the metal for more than $\frac{1}{16}$ in., and this was only in a spot of very limited area, less than 1 circular in. In general I believe that the interior of the sheet had lost not exceeding $\frac{1}{64}$ in. in average thickness. The corners of the sheets were almost as sharp as new work, and so were the tool marks on the rivets. This penstock was $\frac{3}{8}$ in. in thickness, 9 ft. in diameter. Both Mr. Mills and myself concluded that the penstock bade fair to do just as good service for the next 50 years as it had for the past 49. I am also very familiar with certain other old water-wheel penstocks in Lawrence which have been doing daily duty for 47 years and are still in excellent condition and practically unimpaired." If it were to continue losing only $\frac{1}{64}$ in. in 49 years over 1000 years would be required to dissolve the penstock completely. Even if it rusted at the greatest rate noticed by Mr. Freeman except at a single small spot—viz., $\frac{1}{16}$ in. in 49 years—nearly 300 years would be required to dissolve it completely.

‡ Clemens Herschel, *Journ. New England Water Works Assn.*, 1893, VIII., p. 24.

§ *Ibid.*

‖ A. J. Bowie, Jr., *A Practical Treatise on Hydraulic Mining*, 1885, p. 49.

¶ *Ibid.*

** Hamilton Smith, *Trans. Am. Soc. Civ. Eng.*, 1884, XIII., p. 32.

†† E. B. Dorsey, *Idem*, p. 35.

Mining Company, about 2½ miles long and in part of No. 14 iron ($\frac{1}{12}$ in. thick) under a stress of 13,374 lbs. per sq. in., is reported to be "as good as new" after 26 years of constant service.*

The 11.5-in. sheet-iron pipe of the Virginia & Gold Hill Water Works, 7 miles long, is reported as in good condition after 11 years'† and even after about 24 years'‡ use. It is in part of No. 16 iron ($\frac{1}{16}$ in. thick).§

A 20-in. wrought-iron sewer pipe at Santa Barbara, Cal., which extends about 600 ft. into the ocean, shows no sign of corrosion after 3½ years' immersion.‖

Wrought-iron pipe as thin as No. 14 B. W. G. ($\frac{1}{12}$ in. thick) has been found in perfect condition when taken up after lying in the ground for 30 years, and there is a great deal of 18, 22, and 30 in. pipe which has been in service for from 20 to 25 years.¶

Besides the direct assertion of Mr. Hamilton Smith, a most distinguished engineer with unsurpassed opportunities for studying the use of these thin sheet-iron water pipes, that a proper coating of asphalt seems to be a "perfect" protection, we have indirect evidence that corrosion can be practically completely prevented in the fact that in California practice, after their very extended experience in cases in which a given pipe has to sustain very different pressures in different parts of its length, its walls are made of a thickness directly proportional to the hydrostatic pressure which it has to withstand, so that thin sheet iron is exposed to as great stress per inch of thickness as thick, without allowance for corrosion. Now, were corrosion to occur, it would be only the thickness of metal left after corrosion which could effectively resist the hydrostatic pressure. But the absolute loss of thickness due to corrosion would be the same whether the pipe were initially thick or thin. Hence after corrosion a smaller proportion of the initial metal of the thin than of the thick pipe would be available for resisting the hydrostatic pressure. Consequently the hydrostatic stress permissible per inch of initial thickness would be smaller in thin than in thick pipes. The fact that this consideration is wholly neglected, thin pipes being exposed to as great hydrostatic pressure per inch of initial thickness as thick ones, indicates that corrosion is there thought so slight as to be safely neglected, or at least that it has not been so serious there as to thrust on engineers the need of making such an extra allowance in case of thinner pipes.

I am informed that the iron bottom plates of the United States lake steamer "Michigan," when removed after some 40 years' use, had not been appreciably reduced in thickness by corrosion.

Industrial Evidence as to the Relative Corrodibleness of Wrought Iron and

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* E. B. Dorsey, *Trans. Am. Soc. Civ. Eng.*, 1884, XIII., p. 35; A. J. Bowie, Jr., *Hydraulic Mining*, pp. 172–175; J. B. Whitcomb, receiver of the company, private communication March 10, 1896.

† A. J. Bowie, Jr., *Hydraulic Mining*, pp. 172–175.

‡ A. J. Bowie, Jr., private communication, March 25, 1896.

§ A. J. Bowie, Jr., *Hydraulic Mining*, pp. 172–175.

‖ Private communication from J. K. Harrington, Esq., City Engineer of Santa Barbara, Cal., Jan. 1, 1896.

¶ A. J. Bowie, private communication, March 25, 1896. From information already obtained it was evident that the life of these pipes was often great. The further important question arose whether such long life could safely be expected or whether there were cases in which, in spite of all reasonable precautions, these pipes had not lasted well. In reply to my question to this effect Mr. Bowie, an eminent authority in these matters, says: "The inverted siphons on the ditch lines are, or were all when last I looked into the matter, in first-class condition. Wrought-iron pipe, *well riveted* and *well coated*, will, so far as our present experience goes, last over 30 years."

Steel.—In 1887 a careful examination of published opinions and of the answers to inquiries which I made indicated that opinions were about balanced as to whether wrought iron or steel was the more corrodible. Of those whom I consulted a majority, even among the marine users, saw no difference; several, especially among the fresh-water users, thought steel the less corrodible; nearly as many thought it the more corrodible. Opinions were on the whole more favorable to steel among the fresh-water than among the sea-water users.

It is to be noticed that at that time the direct laboratory tests of Mallet, Parker, Andrews, and Farquharson were prominently before engineers, and that these tests taken collectively indicated that these two classes of iron corroded at substantially like rates, save, indeed, that the results of a single observer—Parker—indicated that in boiling sea water steel corroded considerably faster than wrought iron.

Shortly after this a paper by Mr. David Phillips gave evidence tending to show that steel corroded not only faster, but very greatly, indeed astonishingly, faster than wrought iron. The untrustworthy character of this paper I shall consider later. An earlier paper of Mr. Phillips, which also tended to show that steel corroded much faster than wrought iron, was justly discredited because of faults which completely vitiated his comparisons. That this later paper was intended as a vindication is probable from its author's partisan tone, especially in the discussion.

How far experience had been changing the opinion of engineers on this subject and how far Mr. Phillips' paper caused a change in opinion I do not know. Certainly those who discussed his paper arrayed themselves in striking harmony against steel, although shortly before that time I had been unable to find any preponderance of opinion in either direction. Earlier experiments which had been thought to show no considerable difference between wrought iron and steel were now held to show that this difference was very great. Of the 13 who discussed the paper Mr. Farquharson alone seemed to insist on being convinced instead of led—I am tempted to say "stampeded." It is but fair to add that there are only two among them whom I know to be entitled to speak with authority, and only one whom I know to have disputed the inferiority of steel. Since then I find the inferiority of steel asserted by most of those who express an opinion, though (except as to welded pipes) so far as I have noticed it is chiefly the marine users of steel who speak as of their own knowledge.

Welded steel pipe has lately been very severely attacked as being much more corrodible than wrought-iron pipe. In particular it is reported that the steel tubes of the boilers of the United States cruiser "Chicago" some three years ago rusted through in many spots, in fact, became riddled with holes, within 40 days of service. It is reported further that the Standard Oil Company has abandoned the use of steel pipes,* and I am informed that many careful boiler makers and users believe that wrought-iron boiler tubes are far less corrodible than those of steel. Indeed, there was a sensational report that the National Tube Works Company of McKeesport, near Pittsburg, had abandoned the manufacture of steel pipes, but this was promptly denied by its general manager, who added that its manufacture of steel pipes has been completely successful; that

* *The American Manufacturer and Iron World*, LVIII., p. 44, 1896.

though it had made between 400,000 and 500,000 tons of steel pipe in the last three years, not enough had been sent back to it "to make a first-class puddle ball;" and that 95 tons of steel pipe are called for to 5 of wrought iron.*

This, however, is rather a peculiar case. The first requirement of steel for welded tubes is that it shall weld readily; this implies that it must be nearly free from carbon, and this in turn creates a strong tendency to the formation of blowholes,† and especially of blowholes reaching nearly to the surface. Owing to this proximity to the surface, the interior of these blowholes is likely to become oxidized when the ingot is heated; and though they may be completely closed by the subsequent forging, the oxide thus formed probably persists. In a higher carbon steel it might possibly be reduced by the carbon of the metal, but this is not likely to occcur in steel so nearly free from carbon as that which is suited for ready welding. It is but reasonable to suppose that these little streaks of oxide will, by difference of potential, give rise to rapid corrosion, and it has been observed that blowhole-containing steel is especially corrodible.‡ Indeed, the particular form of corrosion which these boiler tubes undergo, viz., "pitting," is just that which blowholes should cause.

Even with this soft and easily welding steel these external blowholes can with care be prevented. It would, however, be strange if some makers of such steel, aiming chiefly to make at the minimum cost a readily welding steel and without considering the influence of blowholes on corrosion, had not sent out a great deal of unsound blowhole-containing steel which had been welded up into tubes and had corroded rapidly.

We have here one explanation of the fact that many use wrought iron for boiler tubes who use steel for boiler shells, and indeed for almost everything else. Surely the fact that steel tubes through this defect may be especially corrodible does not indicate that steel plates and other products, which can most readily be freed from blowholes, are more corrodible than wrought iron. We have here a warning to watch carefully the manufacture of the steel, and especially to reject all rising ingots if corrosion is especially to be guarded against.

The present opinion adverse to steel is certainly not to be ignored, but neither are the probable influence of the occasional use of blowhole-bearing steel tubes and the possible influence of Mr. Phillips' paper, hitherto unchallenged, I believe, to be lost sight of; for we all know how we unconsciously tend to make our own observations agree with our preconceptions as to the laws of nature, and how readily the results of the latest observations, if vigorously bruited about with claims of accuracy, will pass current as law if nobody takes the trouble to challenge them, the silence of competent critics being taken for their acquiescence.

To weigh against this now often expressod opinion that steel is decidedly more

* *The American Manufacturer and Iron World*, LVIII., p. 52, 1896; also *The Iron Age*, LVII., p. 135, 1896.

† See an article by W. H. Gibbons, *American Engineer and Railroad Journal*, LXIX., p. 158, April, 1895.

‡ Mr. W. E. Koch, of the Spang Steel and Iron Company, a most experienced and intelligent maker of soft steel suited for pipe making, who has paid especial attention to the question of corrosion, informs me that his extensive observations and experiments show that steel containing blowholes corrodes, but that steel free from blowholes, if it contains a fair quantity of manganese and is not unusually free from phosphorus, resists corrosion as well or better than wrought iron. He cites 3 and 4 in. steel boiler tubes in his own works which have been in constant use for nearly 10 years, and steel water-tube boilers which have been in use for about 5 years, both of which "seem to be just as good as the day they were put in." (Private communication, April 27, 1896). I record here, as a basis for further observation, Mr. Koch's belief that the presence of a fair quantity of manganese, apparently from 0.50 to 0.80%, opposes corrosion by preventing blowholes.

corrodible than wrought iron, we have the very extended and fast extending use of steel, under conditions which make resistance to corrosion a matter of great moment—for instance, in the hulls of sea-going vessels,* parts of which are difficult of access for repainting, in the shells of marine boilers, and in conduits for the water supply of great cities. Thus, after studying the relative corrosion of wrought iron and steel, Mr. I. M. De Varona, engineer of the water supply of the city of Brooklyn, N. Y., recommended the use of sheet steel for the proposed 60-in. conduit for the water supply of that city.† A 54-in. sheet-steel conduit 6400 ft. long has lately been laid for carrying water to Syracuse, N. Y.‡ So eminent an engineer as Mr. Clemens Herschel used soft steel for the great 48-in. conduit, 21 miles long, and the 36-in. conduit, 5 miles long, of the East Jersey Water Company, for supplying the city of Newark, N. J.§ Our present experience of about 10 years with steel steamers on the great lakes indicates that the corrosion of steel under their conditions is very slight.‖ Practice, in that it represents merely the opinions of the practitioners and tells us nothing directly of the trustworthiness of the evidence on which those opinions are founded, is of less value for our present purpose than that evidence itself would be. Nevertheless it may be fairly offered here to aid us in interpreting the opinions unfavorable to steel which have just been referred to.

Looking now at this evidence in a general way, and having in view the enormous extent to which both materials have long been in use competitively for important purposes for which resistance to corrosion is of the first importance—an importance clearly and attentively recognized—I find it most difficult to reconcile the belief that there is a marked and constant difference between wrought iron and steel as regards corrosion, either with the known continuance and growth of the use of steel for these very purposes by eminent, well-informed, and cautious engineers, or with the great differences and fluctuations in opinion which we have noticed. Were this difference in corrodibleness great and constant it could not long escape such attentive observation, and hence it would prevent such differences and fluctuations of opinion and would tend greatly to restrict such use. Opinion neither fluctuates nor differs as to whether coatings

* In 1889, 90% of the 800,000 tons of shipping building under the superintendence of Lloyds register was of mild steel. B. Martell, *Journ. Iron and Steel Inst.*, 1889, I., p. 60.

† *Annual Report of the Commissioner of City Works for the Year 1894*, Brooklyn, N. Y., pp. 89 *et seq.*

‡ *Journ. New England Water Works Assn.*, VIII., p. 40.

§ *Idem*, pp. 18 *et seq.*

‖ "As far as I have ever observed or been able to learn from others there is no corrosion whatever on the immersed bottoms of steel lake vessels, nor does the simple rusting of that part of the hull seem to proceed to any appreciable extent, even when they have been a long time out of dock, say 2 or 3 years. We take no particular pains in painting the bottom of a new vessel before launching, commonly using only oxide-of-iron paints, and sometimes putting on only a coating of linseed oil. It does not seem to make much difference what is put on for paint with a new ship, either on the bottom or anywhere else, as we of course do not follow the naval practice of pickling the plates to remove the mill scale, and any paint will come off with the scale in the first year. After that the hull above water and the interior parts of the ship which are exposed to the air will rust the same as any other metal structure if not carefully painted, but the bottom does not do so. I have repeatedly seen the ships docked and showing no rust at all on the bottom when the water left them; in fact, it may be said that that is universal. Of course, in a few hours' exposure to the air they will get a thin coat of rust all over, but as for corrosion in the sense that the word is used on the coast—that is, pitting and wasting caused by galvanic action in the salt water—that does not exist here. With the great variation in draught between the light and loaded condition in our lake vessels there is an extensive area of plating at the water line which is alternately in and out of water, and I have sometimes observed considerable surface roughness there in the older ships, but never anything serious. and that caused entirely by neglect in painting." Private communication, W. I. Babcock, manager of the Chicago Ship Building Company, Nov. 7, 1895.

of zinc, paint, and asphalt protect iron, as to whether iron or copper best resists corrosion, as to differences in general which are marked and constant.

Between the corrosion of wrought iron and steel there may be a slight constant difference, of constant sign, or there may, under certain conditions of composition, manufacture, or exposure, or both, be a very considerable difference, the sign of which may vary with these conditions; or there may be both such slight constant and such marked occasional difference; or there may possibly even be equality; but a great and constant difference certainly seems irreconcilable with our industrial evidence. The differences and fluctuations in opinion are readily accounted for by the known great variations in the corrodibleness of each class and by the varying effects of different conditions of exposure. Some iron, especially corrodible, fails in a place where it is especially exposed to corrosion and where its failure causes serious consequences which attract attention. Down goes the credit of iron. Later the same thing happens to steel and their relative credits are reversed.

The facts that the opinion of the majority is slightly unfavorable to steel, that we do not find any minority with opinion entitled to weight which asserts with comparable positiveness the superiority of steel in this respect, and that, so far as I have noticed, those of judicial mind and ample knowledge either think that there is no considerable difference or express themselves very guardedly adversely to steel, argue, like the fluctuations, that there is no great and constant difference; but they argue further, though less forcibly, that under the conditions of some important uses steel probably does on the whole corrode materially faster than wrought iron, at least in certain cases. The distribution of the evidence indicates that if steel is at a disadvantage anywhere, it is in sea-water uses.

Laboratory Evidence as to the Relative Corrodibleness of Wrought Iron and Steel.—Turning now from this industrial evidence, which certainly leaves much undecided, to that afforded by direct comparative tests in which pieces of wrought iron and of steel have been simultaneously exposed to corrosion under identical conditions, I must first point out that in these tests one possibly important element is lacking. Though we have instances of remarkable endurance on the part of naked wrought iron,* yet it is probable that in the majority of cases we have to depend chiefly on the protection afforded by the paint or other coating. A good coating of asphalt, so long as it remains intact, will probably preserve iron completely and indefinitely, and if proper precautions (such as having the iron hot during its application) be observed it should long remain intact. Thus while the laboratory tests which we are about to study represent naked metal, it is coated metal that usually concerns us in practice. Now the relative corrosion of wrought iron and steel may be influenced not alone by their behavior after the corroding agent reaches them, but also by the tenacity with which they retain their protective coating and thus shield themselves from corrosion; and in this respect the presence of the cinder in wrought iron and its absence from steel

* When Bowie wrote in 1885, the 40-in. San Juan wrought-iron pipe, 2200 ft. long, of No. 7 and No. 11 B. W. G. (0.187 and 0.125 in. thick), though bare inside, had stood for 5 years; the 11 and 12 in. pipe at the same place, of No. 18 B. W. G. (0.049 in. thick), under a hydrostatic stress of 9755 lbs. per sq. in. of metallic section, had lasted 8 years, though naked inside and out; the 16-in. Smartsville pipe, of No. 18 B. W. G. (0.049 in. thick), under a hydrostatic pressure of 12,725 lbs. per sq. in., though naked inside, had lasted 5 years, and the Smartsville 18-in. pipe, of No. 14 B. W. G. (0.083 in. thick), was laid with no coating. Bowie, *A Practical Treatise on Hydraulic Mining*, Table XV.

may possibly create an important difference by affecting the texture of the surface. This point, on which we have as yet no definite information, seems one on which direct experiments are desirable.

Generic and Specific Differences.—Wrought iron differs from steel always and necessarily in containing more or less cinder mechanically intermixed, from which steel is free, and habitually in containing more phosphorus but less manganese than steel. There may also be a necessary difference in structure, owing to this presence and absence of cinder, and to the fact that wrought iron is worked from a pasty mass, while steel is made from a molten one. These differences we may call generic, because taken broadly they distinguish these two classes of iron from each other. In addition, even different low-carbon steels differ materially in composition, in uniformity, in solidity—*i.e.*, freedom from blowholes—and in the treatment, both thermal and mechanical, which they have undergone; and like differences exist among wrought irons. We may call these latter differences specific to distinguish them from those which we have just named generic. They distinguish different steels and different wrought irons from each other. That these specific differences, and apparently even the individual peculiarities of single pieces, play an important part in corrosion, I have endeavored to make clear in beginning this paper.

The influence of specific differences, and more especially of the composition and solidity of steel, on corrosion seems to me of such importance as to justify, and indeed to demand, early and thorough investigation, since by studying it we may be able by suitable selection to restrain corrosion very greatly. Nevertheless I am forced in the present paper to slight this study and to confine our investigation chiefly to the influence of the generic differences. Grouping together, according to the conditions of exposure, the different experiments which I find recorded, those referring to cold sea-water in one group, those referring to fresh water in a second, etc., I seek answers to two questions:

(1) Under given conditions of exposure, how does the corrosion of low-carbon steel compare on an average with that of wrought iron?

(2) Still under given conditions of exposure, how does the fastest corrosion of low-carbon steel compare with the fastest corrosion of wrought iron?

The first relates rather to the generic, the second both to the generic and to specific differences. The answer to each has its use. For some purposes—for instance, when the structure is accessible for inspection and repair—the average corrosion may be the more important matter. For others—for instance, where, as in buried structures, the excessive corrosion of a single member or even of a single sheet could not readily be detected till it had gone so far as to cause great damage, perhaps even as to endanger the whole—the maximum corrosion is the more important. It might profit us little to know that a buried, inaccessible conduit of steel would, on an average of its whole length, lose no more by corrosion than a like one of wrought iron. It might be far more important to know whether there was a likelihood that, though many sheets might resist corrosion altogether, some others might corrode very rapidly, and without warning throw the conduit out of commission and paralyze an industry or even a great city.

In seeking answers to these questions I am obliged to ask, not whether there are steels which compare favorably with wrought iron both as to their average and as to their maximum corrosion, but how such low-carbon steels as have actually been experimented with compare with the wrought irons tested along with them.

Taking up the first of these questions, it is readily conceivable not only that these generic differences might readily cause steel as a whole to differ greatly in its corrosion from wrought iron, but that they might cause the relative corrosion of these two classes of iron to vary greatly with the conditions of exposure, so that steel should be the less corrodible of the two under some conditions, but the more corrodible under others. For while the mechanical protection of the cinder, acting as a barrier to obstruct the attack of the corroding fluid, should be independent of the nature of that fluid, the influence of the habitual differences in manganese content and phosphorus content may, with varying conditions of exposure, vary greatly, both as to the direct resistance of the compounds of these elements to corrosion and as to their electro-chemical effect by difference of potential. In this latter respect the cinder itself may have an importantly varying effect. The electrical effect of the cinder being in general destructive and the opposite of its protective mechanical effect and supposably varying in intensity (if not in sign) with the inclosing medium, it may well be that the resultant of its electrical and mechanical influences will vary in sign, so that the cinder itself might under certain conditions cause wrought iron to corrode faster, under others more slowly, than steel.

If, as is very important for us to know, the sum of these generic differences between wrought iron and low-carbon steel has, under important classes of conditions, a strong resultant effect, causing a serious difference in corrosion, this certainly ought to appear when a large number of low-carbon steels are compared intelligently with a large number of wrought irons under these conditions group by group.

Where but few pieces of iron and steel are represented, the influence of the specific variations may mask that of the generic differences. But where we have many results obtained by different observers, certainly without collusion and very probably without similar kinds of selection, the effect of these generic differences ought to appear; for the influence of the specific variations in the individual cases should in large part efface each other.

Such a grouping as I have above referred to is presented in Table I.,* in which are collected the results which form the basis of this study. For simplicity, the loss of weight of the steel by corrosion is given in percentages of the corresponding loss of weight of the wrought iron similarly and simultaneously exposed.

* In preparing this table I have not had access to the results obtained by the boiler committees of the British Admiralty. Of the results obtained by Mr. D. Phillips in 1881 and 1890 I give only a few, believing that the rest are vitiated by neglect of most obvious precautions. (*Proc. Inst. Civ. Eng.*, 1881, LXV., p. 73, and *Trans. Inst. Marine Eng.*, 1890.) Of the results in the former paper, which I have rejected, some were certainly and the rest apparently obtained with pieces of dissimilar metal in galvanic contact, in some cases even with brass. These are rejected because the conditions were indeterminate and because the present paper does not attempt to ascertain the influence of the contact of wrought iron with steel on the corrosion of these two classes. His results, which I have taken from this paper, are those included in his Table IX. which are not also given in his later paper. I have given all the results in his second paper except those clearly vitiated by contact with dissimilar metals or by contact with scale and those apparently vitiated by reckoning mechanical losses as corrosion. I have excluded also a series of results reported by J. Collins (*Iron*, 1879, XIV., p. 461), in which steel corroded much less than wrought iron, because the medium to which they were exposed is not given. With these exceptions I have included all the recorded results which I have found.

In only three, or at most four, of these sets of conditions is our evidence sufficiently abundant and harmonious to allow valuable inferences as to the net effect of the generic differences. These are immersion—(1) in pure cold fresh water; (2) in pure cold sea water; (3) in boiling sea water; and (4) in acidulated water. Taking a weighted mean of each of these groups, as is done in Table II., we find that in fresh water low-carbon steel and wrought iron corrode at the same rate; in cold sea water steel is slightly the more corrodible; in boiling sea water it is much the more corrodible; while in acidulated fresh water its advantage over wrought iron is very great, far greater than its disadvantage in boiling sea water.

TABLE II.—WEIGHTED MEAN RATIO OF CORROSION OF LOW-CARBON STEEL TO CORROSION OF WROUGHT IRON.

Number.	Immersed in—	Number of Pieces.		Number of Sets of Observations.	Number of Observers.	Ratio A. Corrosion of Steel ÷ Corrosion of Wrought Iron.
		Wrought Iron.	Soft Steel.			
1	Fresh water........	11	13	6	3	0.96
2	Cold sea water.....	22	17	8	6	1.13
3	Boiling sea water...	21	12	3	1	1.51
4	Acidulated water...	13	9	7	5	0.36

The ratio A given in the last column of this table is the weighted mean ratio of the corrosion of steel to that of wrought iron, arrived at as follows: Let NI_1, NI_2, NI_3, etc., be the number of pieces of wrought iron experimented on in the first, the second, the third, etc., set of observations; NS_1, NS_2, NS_3, etc., represent the number of pieces of steel simultaneously experimented on; A_1, A_2, A_3, etc., represent the ratio of the loss of weight by corrosion, in pounds per square foot of surface per annum, of steel to that of wrought iron in the several sets of observations; and let A represent the weighted mean ratio of the loss by corrosion of steel to that of wrought iron. In attaching weight to the several individual ratios (A_1, A_2, etc.) I ignore all differences except those between the number of pieces (*i.e.*, of kinds) experimented on. Clearly an experiment based on many kinds of metal is of more value as a guide to a general comparison of wrought iron with steel than one based on a single specimen of wrought iron and a single piece of steel. If we assume for the moment that the number of pieces of wrought iron is the same in all the different sets of observations and that the number of pieces of steel varies, then the accuracy of the ratios A_1, A_2, etc., would be proportional to $\sqrt{NS}$. If, on the other hand, we assume that the number of pieces of steel experimented on is constant and that the number of pieces of wrought iron varies, then the accuracy of the ratios A_1, A_2, etc., would be proportional to $\sqrt{NI}$. Hence, taking both these elements into consideration, the accuracy will be proportional to $\sqrt{NS \times NI}$. Applying this to the general formula for weighted mean, the weight to be attached to each ratio is proportional to the square of the accuracy, $\sqrt{NS \times NI}^2 = NS \times NI$, and the formula becomes

$$A = \frac{NS_1 \times NI_1 \times A_1 + NS_2 \times NI_2 \times A_2 + \ldots\ldots NS_n \times NI_n \times A_n}{NS \times NI + NS_2 \times NI_2 + \ldots\ldots NS_n \times NI_n}$$

It might at first be thought that the weight should be proportional to the sum of NS + NI rather than to their product, NS × NI; but a single example suffices to show that this would be wrong. Thus if in Series 1 of tests we compared 10 pieces of steel with 1 of wrought iron and in Series 2 we had still 10 pieces of steel but 2 pieces of wrought iron, the sums of the pieces experimented with are as 11 to 12, so that if we weighted them according to the sum of NS + NI, Series 2 would receive only about 9% more weight than Series 1. But this is manifestly unjust. The teachings of Series 2 are clearly much more valuable than those of Series 1, because in the former each piece of steel is tested against twice as many pieces of wrought iron—*i.e.*, the basis of observation is twice as broad as in Series 1. For a late and good account of this subject, see *Discussion of the Precision of Measurements*, S. W. Holman, 1892, p. 31. I have made no correction for differences in the sizes of the pieces experimented on, doubting whether it would affect the results to a degree commensurate with the labor involved and fearing that it might give an unjustified air of accuracy.

Let us now see whether a closer examination of the data leads to like results.

Fresh Water.—In the six series of experiments in pure fresh water the loss by corrosion of the steel is 112, 113, 83, 100, 83, and 127% respectively of the corresponding loss of wrought iron, the average corrosion of the steel being slightly less than that of the wrought iron. The only case in which steel loses decidedly more

TABLE I.—CORROSION OF STEEL, MEASURED IN PERCENTAGES OF THAT OF WROUGHT IRON.

Observer.	Number of Pieces.		Exposed to or Immersed in—															
	Wrought Iron.	Steel.	The Weather.	Sea Water. Cold. Pure. Free.	Sea Water. Cold. Pure. Confined.	Sea Water. Cold. Foul.	Sea Water. Boiling.			Salt Water. Cold.	Salt Water. Boiling.	Air, Alternately Wet and Dry.	Alkaline Water.	Steam	Fresh Water.	Acidulated Water.	Beer, etc.
HALF-HARD AND HARD STEELS.																	
1. Mallett	18	7	86.7%	90%		102%									103%, Pure; 82 Foul		
2. Andrews	2	4			127%												
3. Andrews	1	2			125												
4. Adamson	3	1														24%	
5. Adamson	3	1														29	
6. Ledebur	(?)	(?)														75	
SOFT STEELS.																	
7. Andrews	2	2			102%												
8. Parker	7	4	141%	111%		101%	134%	198%	122%								
9. Farquharson	3	3		107													
10. Phillips	2	2		106											83%		
11. Phillips			147 (1–1)	227 (2–1)								228% (1–1			112 (2–2)		
12. Phillips				147 (2–1)								368 (1–1			113 (1–1)		
13. Adamson	3	1														9%	
14. Adamson	3	1														14	
15. Boies	1	1														120	
16. Bonifacius																98	
17. Wheeling	1	1														34	
18. Wheeling	1	1														29	
19. Gautier	(?)	(?)		42.9													
20. Carnegie	3	3			110					103%	111%			109%	100	37	Beer..33%
21. Carnegie	2	4											176%		83	Mine. 75	Wort..40; Hopj'k 61
22. Williams	1	1															(a) 87
23. Varona	1	1													127		
LOSS BY CORROSION OF NICKEL-STEEL, IN PERCENTAGES OF THAT OF CARBON-STEEL.	Nickel-Steel.	Carb.-Steel															
24. Carnegie	1	3			98%					93%	54%			66%	102%	39%	Beer..48%
25. Carnegie	1	4											50%		135	90	Wort..31; Hopj'k 59

The numbers in parentheses in the Phillips results give the number of pieces of wrought iron and of steel experimented on—*e.g.*, (2–3) means that there were two pieces of wrought iron and three of steel. (*a*) In this case the pieces were imbedded in loam sand, with which were mixed sodium carbonate and nitrate and ammonium and magnesium chlorides. (1) Mallett, *Report Brit. Assn.*, 1840 and 1843. (2–3) Andrews, *Proc. Inst. Civ. Eng.*, 1885, LXXXII., p. 281. (4–5) Adamson, *Journ. Iron and Steel Inst.*, 1878, II., p. 398. (6) Ledebur, *Berg- und Hütten- Zeitung*, 1877, p. 280. (7) Andrews, *Proc. Inst. Civ. Eng.*, 1885, LXXXII., p. 281. (8) Parker, *Journ. Iron and Steel Inst.*, 1881, I., p. 39. (9) Farquharson, *Ibid.*, 1882, I., p. 204. (10–11–12) Phillips, *Proc. Inst. Civ. Eng.*, 1881, LXV., p. 73, and *Trans. Inst. Marine Eng.*, May 13, 1890. (13–14) Adamson, *Journ. Iron and Steel Inst.*, 1878, II., p. 398. (15) Private communication. (16) *Iron Age*, Aug. 18, 1887, p. 22. (17–18) *Ibid.*, XLI., p. 518. (19) Gautier, Jeans' *Steel*, 1880, p. 744. (20–21) Carnegie, *Report Dept. City Works for 1894*, Brooklyn, N. Y., 1895, pp. 101–104. (22) Williams, *Iron Age*, XLVII., p. 1109. (23–24–25) *Report Dept. City Works for 1894*, Brooklyn, N. Y., 1895, pp. 101–104.

than wrought iron is of little importance, because it represents only a single very small piece of wrought iron compared with a single piece of steel.

Besides these six sets there are two others in which higher-carbon steel was exposed together with wrought iron in pure and in sewage-bearing fresh water. In these the loss of the steel was 103 and 82.2% respectively of that of the wrought iron. While we should attach relatively little weight to these cases, they are certainly suggestive, as tending to confirm the general teaching of the other cases, that in fresh water the generic differences between steel and wrought iron do not tend appreciably to make the former the more corrodible.

Cold Sea Water.—In five out of the eight sets of experiments, made by five different observers and representing 31 specimens, steel corroded either at substantially the same rate as wrought iron or slightly faster, the difference being so slight as not to indicate any important generic difference between them. In two sets of experiments by Phillips, representing six specimens, steel corroded much faster than wrought iron. In the last set, by Gautier (the number of pieces represented by which I have been unable to discover), the advantage of steel over wrought iron was more marked than its disadvantage is in Phillips' results.

The ratio of the corrosion of the steel to that of the wrought iron, 1.13 : 1, given in Table II., seems to me too high. If we reject a single result, the corrosion of a single plate of Mr. Phillips, for which the ratio of corrosion was much more than twice as great as that found by any other observer and nearly twice as great as in his own parallel experiments, a plate, moreover, which by his own assertion was extremely heterogeneous, and hence we may infer unfit for comparison, the ratio becomes 1.09. If, further, we include the harder steels the ratio becomes 0.98. It may on one hand be objected justly that these harder steels are not strictly comparable with the softer ones; but, on the other, they agree so much more closely with the remaining soft steels than this single one of Mr. Phillips' does as to make this ratio 0.98 at least very suggestive.

Further, in Mr. Phillips' earlier experiments important and obvious precautions were omitted. In some of the present series there are indications of grave sources of error, so grave that I have rejected some of his results outright.* Now, as steel is the newer substance and hence on probation, so that an important aspect of our problem is whether we can safely apply to steel our experience con-

* In many of his tests plates of wrought iron and of steel were coupled together. No objection on the ground of inaccuracy can be made to thus coupling together, because this was done for a special and sufficient reason; but for the purposes of our present inquiry these tests are rejected, because of probable galvanic influence due to contact of unlike metals. In several other sets, however, the plates were initially covered in large part with a thick coating of mill scale. During immersion much of this mill scale fell off. Now, I can see no way in which one could distinguish the loss of weight due to the corrosion of the metal itself by the sea water from the loss of weight due to the large flakes of this mill scale dropping off. Nevertheless, the total loss of weight from both these sources seems to have been reckoned in as loss by corrosion. In one of his series of tests, in which both wrought iron and steel were partly covered with scale, that on the iron was "exceedingly thin," while that on the steel "was of more than ordinary thickness," "in two distinct layers," and "very compact" (p. 12 of his paper). Indeed, if we may judge by the photographs the scale on the steel was extraordinarily thick. Yet he apparently reckons the loss of this thick scale from the steel as part of the true corrosion of the metal, an injustice which manifestly could be offset in but small part by the corresponding loss of the "exceedingly thin" scale from the wrought iron. A letter addressed to Mr. Phillips to obtain light on this matter brings the unwelcome intelligence that he died some years ago; but the honorary secretary of the Institute of Marine Engineers, to which his paper was presented, Mr. James Adamson, informs me that though he had been for many years exchanging views and experiences with Mr. Phillips on the relative corrosion of iron and steel, this point did not occur to him (private communication, March 10, 1896). It appears to me, therefore, doubtful whether it occurred to Mr. Phillips. Hence I reject outright all these results in which the plates were partly covered with mill scale as open to grave suspicion of neglect of an obvious precaution against a most mislead-

cerning the power of wrought iron to resist corrosion, it has seemed to me most prudent in preparing Table II. to give steel the benefit of no doubt. Hence those of Mr. Phillips' results which are retained received full weight in this calculation. But I think that we should be nearer the truth were we on this account to assign to his results one-fourth the weight which we should otherwise attach to them. Doing this, and still excluding the harder steels as not strictly comparable, the ratio becomes 1.10. If, finally, we include Parker's bilge-water experiment, the ratio becomes 1.07, which means that steel corrodes on an average 7% faster than wrought iron in cold sea water.

There is room for a difference of opinion as to whether the slight differences which we here find really represent a generic difference in corrodibleness between wrought iron and steel. If they do it is probably a small one.

In boiling sea water the corrosion of steel exceeds that of wrought iron by 22, 34, and 98% respectively in the three sets of experiments. Moreover, in two of these sets the slowest corroding steel corroded at 8 and 34% faster than the fastest corroding wrought iron. The difference is so marked and so constant as to create a suspicion that under these particular conditions steel does corrode materially faster than wrought iron, especially in view of the fact that these same wrought irons corroded at about the same rate as these same steels when they were exposed together to cold sea water.

In acidulated water steel corrodes so generally and so very much less than wrought iron as to indicate that here the generic differences between them do favor steel greatly. Thus in five out of the eight sets of tests, representing 18 specimens, steel corroded not only less, but surprisingly less than wrought iron. In a sixth steel and wrought iron behaved alike, while in a seventh, representing but two small pieces, steel corroded somewhat the faster. In an eighth set of experiments steel in coal-mine water (which from internal evidence was probably acidulated) corroded 75% as fast as wrought iron.

In harmony with this is the fact that in three sets of experiments the loss by corrosion of higher-carbon steels in acidulated water was only 24, 75, and 29.2% respectively of that of wrought iron, and that in a single set of experiments the loss of nickel-steel was only 14% of that of wrought iron, though in mine water nickel-steel lost 67% as much as the wrought iron. This inference that steel

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ing source of error, and because the contact with scale introduces a condition beyond the scope of this study. It appears from his paper that he had but little understanding of the nature, conditions, and importance of galvanic action. Further evidence of unfairness is that though he reaffirms the general belief that impure wrought irons resist corrosion better than pure ones, yet (presumably without foreseeing it) he selected extremely impure irons for comparison with steel. Thus in describing one series of tests he admits that one of the two wrought irons used was "exceedingly dirty," and not only that the other was worse, with severe laminations, but that "a worse piece of plate for the purpose of testing with other metals could not have been selected." As the badness of this iron apparently consisted, at least in part, in the very defects which are thought to give it the greatest power to resist corrosion, and as the steel compared with it was extraordinarily heterogeneous, a defect which clearly must hasten corrosion, this test to establish the relative corrosion of these two classes of metal was made by comparing an apparently abnormally slowly corroding iron with an abnormally fast-corroding steel. The many physical tests of his wrought irons show that all which were tested were bad. Only one had more than 15.5% elongation, measured in 4 in. The transverse elongation of one was only 4.45%. It further appears that in some of his tests, in which parts of the plates were painted, the steel plates received a different paint from that used on the iron ones (p. 15 of his paper). With such methods of inquiry no wonder that his results differ widely from those of all other observers. It is far from pleasant to criticise the work of one who is no longer here to defend it, but if we seek truth we must present matters in their true light, not flinching even out of courtesy to the departed. I see no evidence that he understood the unfairness of his work, and I do not believe that any unfairness was intended.

resists acidulated water better than wrought iron receives slight further support from the fact that in one of the experiments with boiling sea water this water was thought to be acidulated, and that in it the corrosion of the steel exceeded that of the wrought iron much less than in the other boiling sea-water experiments. This is as if the acid in this boiling sea water had been more unfavorable to the wrought iron than to the steel, and so had gone far to offset the disposition of the sea water to attack the steel more than the wrought iron. In this connection it is striking that in beer, wort, and hopjack strongly charged with carbonic acid steel corroded very much less than wrought iron, and that, on the other hand, in alkaline water it corroded very much faster than wrought iron.

Further in harmony with this is the relative behavior of the different wrought irons of the Carnegie tests. For just as while the difference between wrought iron and steel as regards corrosion is apparently insignificant in fresh water and slight in cold sea water, yet of the two wrought iron corrodes much the faster in acidulated water and in liquor impregnated with carbonic acid, but much the more slowly in alkaline water; so the impure wrought iron, which differs from the pure in the very way in which the latter differs from the steel (viz., in having more cinder and phosphorus), while corroding at the same rate as the pure in cold fresh and in cold sea water, yet corroded faster than the pure in acidulated water, but more slowly than it in alkaline water. In brief, the impure wrought iron differs from the pure in just the way in which the latter differs from steel, which is what we should expect. Table III. gives these results.*

TABLE III.—RELATIVE CORROSION OF PURE AND IMPURE WROUGHT IRONS IN NEUTRAL, ACID, AND ALKALINE LIQUORS (CARNEGIE).

Kind of Wrought Iron.	Fresh Water.	Acidulated Group.					Alkaline Water.	Sea Water.
		Sulphuric-Acid Water	Mine Water	Beer.	Wort.	Hopjack.		
Best	100	100	.....	.....	.....	.....	.....	100
Ordinary good	112	213	.....	.....	.....	.....	.....	100
Common pipe	104	278	.....	.....	.....	.....	.....	98
Good	100	.....	100	100	100	100	100	.....
Common	110	.....	112	185	366	238	75	.....

Miscellaneous Conditions of Exposure.—In our laboratory tests steel corrodes much faster than wrought iron when exposed to the weather, when alternately wet and dry, and when immersed in alkaline water; slightly faster than wrought

* This observation that in acid liquids steel so nearly invariably corrodes much less than wrought iron, that in certain neutral liquors (cold fresh and sea water) they corrode at nearly equal rates, that in alkaline water steel corrodes more than wrought iron, and that the relative corrosion of pure and impure wrought irons seems to follow a like law—generalizations now put forward tentatively for the first time, so far as I know—suggested to me the explanation already hinted at, viz., that while the mechanical protective effect of the cinder is relatively constant, its electro-chemical effect may vary greatly in intensity, if not in sign, with the inclosing medium, so that in some liquids the net effect of the cinder may be protective, in others destructive. In some preliminary experiments I found that tap or puddling-furnace cinder, the chief source of that in wrought iron, while decidedly electro-negative to nearly pure iron in acidulated water, was faintly electro-positive to it in alkaline water, so that the electro-chemical effect of the cinder would be to hasten the corrosion of the wrought iron which contains it in acid liquids, but to retard it in alkaline ones. This observation, agreeing with the observed inferiority of wrought iron in acid liquids and its apparent superiority in alkaline ones, lends support to my explanation. I do not of course lose sight of the influence which the differences in manganese and phosphorus content also may have, both directly and electro-chemically, in varying the relative corrosion of these two classes of iron.

iron in boiling brine and in steam; at the same rate as wrought iron in bilge water and in cold brine. But as to no one of these conditions have we sufficient evidence to yield us any strong inference.

Maximum Corrosion of Wrought Iron and Steel.—The results condensed in Table IV. indicate that steel compares with wrought iron in regard to the maximum rate of corrosion very much as it does with regard to the average rate. If we except two of Mr. Phillips' results with sea water, we find no indication of more trouble from the exceptionally rapid corrosion of individual pieces in case of steel than in case of wrought iron, either in cold fresh or in cold sea water. While I cannot attach much weight to Mr. Phillips' results, it is well that they should make us more watchful than we otherwise need be. In boiling sea water the results are less favorable to steel, while in acidulated water steel stands very much better than wrought iron.

TABLE IV.—FASTEST CORROSION OF LOW-CARBON STEEL, MEASURED IN PERCENTAGES OF THE FASTEST CORROSION OF WROUGHT IRON IN THE SAME TEST.

Observer, etc.	Number of Pieces.		Immersed in—			
	Wrought Iron.	Steel.	Cold Fresh Water.	Cold Sea Water.	Boiling Sea Water.	Acidulated Water.
Andrews	2	2		96%		
Parker	7	4		95	169%, 111, 143	
Farquharson	3	3		105		
Phillips			76%	112		
Phillips			112	213		
Phillips			113	139		
Adamson	3	1				6%
Adamson	3	1				10
Boies	1	1				120
Bonifacius						98
Wheeling	1	1				34
Wheeling	1	1				29
Carnegie	3	3	99	125		55
Carnegie	2	4	109			
Varona	1	1	127			

These results are reassuring as far as they go, especially because they agree with the teachings of the weighted means; but a much larger basis of observation is needed for safe inferences as to liability to exceptional corrosion than for inferences as to average corrosion.

Nickel-Steel.—The results of the Carnegie experiments with nickel-steel are given in Table I. as a nucleus for further observation rather than for anything which their scanty number can teach. It is noticeable that greatly as the carbon steels excel wrought iron in acidulated water and carbonated liquids, they are here greatly excelled by the nickel-steels. These contained 3.03 and 3.62% of nickel respectively.

Looking at these laboratory results in a general way, the behavior of soft steel and wrought iron is so nearly alike in fresh water as to indicate very strongly that the generic differences between these two classes here have no important resultant effect on corrosion. Such differences as we find, inclining first in one direction, then in the other, are far more probably due to specific variations between the different members of each class. The same is true of their behavior in cold sea water, if we except the results of a single observer with an apparent strong personal prejudice, selecting his specimens unfairly, comparatively ignorant of the conditions affecting corrosion, omitting obvious precautions, and reaching results which differ extraordinarily, not only among themselves, but also from the rather harmonious results of nearly all other observers. There are, however, strong suggestions of a generic difference unfavorable to steel in boiling sea water, and very strong evidence of such a difference in favor of steel in acidulated water.

If we compare the general teaching of the laboratory tests with that of the industrial tests, we may fancy that we find a certain harmony. The long, enormous, and still extending use of steel for important purposes for which corrosion is of the first moment agrees with our inference that there is no important constant difference between wrought iron and steel as to corrosion in cold sea and cold fresh water, no such difference as would exist were the generic differences between them decidedly unfavorable to steel. On the other hand, the belief that steel corrodes more than wrought iron is of such a vague nature and of such distribution that it may well be due jointly (1) to the occasional use of heterogeneous (segregated or imperfectly mixed) steel or of steel of improper composition or containing blowholes—*i.e.*, to the preventable disqualifications, (2) perhaps to the influence of Mr. Phillips' paper, and (3) to actual moderate inferiority of steel in boiling sea water. Its very probably great superiority in acidulated water might well cause the occasional belief in its general superiority as regards corrosion, and finally if it really be generically better than wrought iron in acidulated water, but worse in boiling sea water, it is not strange that opinions should both differ and fluctuate among those to whom this distinction is unknown.

If I am right in the foregoing, it is misleading to say either that normal low-carbon steel corrodes more or that it corrodes less than wrought iron, since their relative corrosion varies with the inclosing medium. I think that we have very strong reason, reason amply strong for most purposes, to believe that such steel when carefully made, free from blowholes, not worked cold nor injured by punching, shearing, etc., nor prejudiced by galvanic contact with other metals, resists corrosion in fresh water as well as wrought iron, in cold sea water at least nearly as well as wrought iron, and in acidulated water better than wrought iron.

The German Iron Industry in 1895.

By E. Schrodter.

The results of the iron and steel trade in Germany in 1895 can be designated as generally satisfactory. The amount of business increased, and the selling prices, which in the beginning of the year were close to the cost of production, reached higher points later in the year. The production of pig iron in Germany, including Luxemburg, reached during the year 5,788,798 metric tons, showing an increase of 4.5% over the production of 1894. The Rhenish Westphalia district, which has heretofore been the principal producer of iron in Germany, has now to make an increasingly active fight against the growing competition resulting from the occurrence of minette ore in Lorraine, Luxemburg, and on the Saar;

so the production of basic pig used in making Thomas steel in the last-named district showed an increase exceeding that in the Lower Rhine and Westphalia more than 25%. A substantial advantage to the iron industry resulting from the use of minette ore has been the improvement in processes resulting in the diminished consumption of coal. The direct conversion of molten pig iron into steel —that is, direct transmission of iron from the blast furnace to the converter without a second melting—was carried on everywhere with the best results. New plants have been erected which produce from the ores billets and slabs, using no fuel in steel making but the gases generated in the blast furnaces.

The Rhenish Westphalian district is trying hard to get a share of the profits derived from the use of minette ores, though these ores have to be transported a distance of about 300 kilometers to the furnaces in that district, but with the Prussian state administration of the railroads the attempt has not been a success. A scheme to open up water transportation by means of the canalization of the Moselle also failed. This district is therefore compelled, for the purpose of keeping up its production, to have increasing recourse to the importation of foreign ores. The first imports were of Spanish ores, but lately the importation of Swedish ores from Gellivara and elsewhere has increased until it reaches at present 500,000 or 600,000 tons a year.

In consequence of the rise in production new plants were erected. Hans Holsch's steel works at Dortmund added two blast furnaces; the Deutscher-Kaiser works also added two blast furnaces and a steel plant; the Dillinger iron works, at Dillinger-on-the-Saar, a Thomas steel plant. New blast furnaces are also in construction at Esch and at Burbach.

A deposit of iron ore containing phosphorus was found in Middle Germany, and a new Thomas steel plant and blast furnace were built to use those ores.

A strong market was caused by the extension for 10 years of the Rhenish Westphalian Coal Syndicate, which includes almost all the coal mines. The production of coal in Westphalia during the first three-quarters of 1895 amounted to 30,129,963 metric tons, or about 0.28% above 1894.

The prices of the principal materials used in the iron industry during 1895 stood as follows: Gas coal ranged throughout the year 10 to 11 marks per metric ton; lean Foerder coal 7 to 8 marks. Furnace coke was 11 marks per ton up to December, when the price was raised to 11.50 marks. Spathic iron ore cost through the year from 9.50 to 10.50 marks per ton. (The mark equals 23.8c.) White iron brought 43@44 marks per ton for three-quarters of the year; in October it rose to 46@47 marks and in December to 48@49 marks. Foundry iron for nine months stood at 63 marks; in October it rose to 65 marks and remained at that price until the close of the year. Best grade bar iron was quoted 102@105 marks per ton in January and remained at that point until October, when it went up to 108 marks and remained there the rest of the year.

During 1895 nothing was heard of labor troubles or strikes; this is probably due in great part to the system of insurance of workmen against sickness, accidents, old age, and disability. The assessments which fall on the iron industry from this system are considerable, but its results in operation have been upon the whole satisfactory, though many iron makers consider the burden a heavy one.

The Past and Future of the Iron Trade in the United States.

By John Fritz.

Recently I was handed three letters which I had written 42 years ago to Mr. George Walters, then chief engineer of the Phœnix Iron Company, and they bring back to my mind the condition of the iron industries in 1854 and state some of the difficulties we then had to contend with. It may interest many readers, especially the younger ones, to know how work was done in the earlier days of the industry, and may enable them the better to appreciate what gigantic improvements have been made in the manufacture of iron and steel since 1838. As many things which I remember have not been in print, I shall give but few statistics, and those only such as are necessary to show how marvelous is the development which has taken place, with nearly all of which I have been in touch. To give exact data would involve too much time and labor, and would, besides, add little to the interest of the story; but those which I shall cite are accurate enough to accomplish the object in view.

In 1838 all the pig iron was made with charcoal as fuel, and practically all the furnaces were driven by water power and usually made from 15 to 30 tons of pig iron a week. Wrought iron was made from pig, in some cases by being run through the refinery or "run-out" fire and then to the finery, converted into wrought iron, and hammered into a bloom; or the pig was taken direct to the finery, thus saving the expense of the run-out fire. The blooms were heated in the chafery fire, and at many works were drawn into bars under the hammer or were worked up into various manufactured forms, plows being at that time an important article of commerce. The hammers were usually tilt hammers, worked by water power.

Prior to 1838 puddling had made little progress, and there was used in that process only plate metal, at times mixed with pig made in the run-out fire or pig iron of low grade, principally mottled and white. The ball was shaped by the old-fashioned helve or Welsh hammer, and woe unto the puddler if the hammer-man did not like him, for he would flatten the ball so thin that when edged it would go to pieces, and then the puddler would have to take it back to the furnace and ball it up again. In those days, if the hammer-man, or "shingler" as he was called, was "boss," and if he and the puddler were on good terms with each other the puddler was his assistant, and they could make it lively for the proprietor when they chose.

After several years of slow puddling the "crocodile" squeezer was introduced and was found more manageable than the hammer, as less skill was required to work it. The owners and managers of the works were so happy that they thought the millennium had come, but they were mistaken; the crocodile did not fill the bill, and breakers were ahead once more.

Between 1845 and 1849 the rail business began to loom up. Several large rolling mills were built, and from this time puddling became the leading feature in the iron business, a place which it held for many years. It was soon discovered, however, that there must be some quicker, cheaper, and better way of getting the balls into shape than either the crocodile squeezer or the hammer. About 1839 the Burden squeezer came forward and was looked upon by the iron-men as their deliverer, which in fact it proved to be. Even to-day it is the best machine ever devised for the purpose for which it was intended. It does its work well, rapidly, and cheaply, and compels the puddler to do his work fairly well; but at first the puddlers looked askant at it, and when it was installed and ready to work they made known their objections in the usual way by striking. Then commenced a series of long and disastrous strikes at almost every place where it was put in. The puddlers' objection was that they could not make the iron "stand," and they struck without trying what they could do. At length after many long and bitter fights they accepted the situation and went to work, and to their surprise, and at the same time probably their secret delight, they found they had no trouble in making the iron stand, and that it was to their interest as well as to that of the manufacturer to have this invention brought into general use. About the same time that the Burden squeezer was introduced the Winslow squeezer was brought out, but it was not as good a machine as the other and failed to come into general use.

About 1840 mineral coal as a fuel was first successfully used in the blast furnace in place of charcoal, and within a few years both anthracite and coke iron took a prominent position in the market. As they were produced at a lower cost than charcoal iron the rail mills were able to use them, and this, of course, greatly stimulated puddling, which by this time had become a very important factor in the trade; indeed, the puddlers had become paramount and they knew it. From 1846 to 1857 business was dull and the manufacturers, especially the rail mills, had a most uncomfortable time of it, as the price of rails, which ruled low for the greater part of this period, was less than they could be made for. Strikes were continually taking place, and many large concerns were compelled to suspend.

In 1857 the three-high mill for rolling rails was introduced. It was a success from the start and soon placed the rail trade in a much better position than it had held at any previous time. This style of mill is in general use to-day, and the only change that could well be suggested would be to make it a three-high reverse mill without reversing; an arrangement which would give all the advantages of a reverse mill without the objection of reversing. The reverse mill has two advantages over the ordinary three-high flywheel mill, the first being that the mill can be slowed down until the bar is entered in the groove and can then be run just as fast as any reverse mill; secondly, should a collar happen the mill can be reversed as quickly as the ordinary reverse mill; and lastly, a small and light flywheel might be used with advantage, which could not be well done on an ordinary reverse mill.

In 1856 or 1857 some trials were made at Johnstown, Pa., by William Kelly—who had long previously experimented in the same direction—to test the possibility of converting pig metal into wrought iron by blowing air into the molten metal; but the results were not altogether satisfactory. In 1864 or 1865 the Bessemer process was introduced, which was destined to revolutionize the iron business. While all our available mechanical and metallurgical skill was brought to bear on this process, yet in the early days there was much trouble in its practical working. This was largely due to lack of knowledge of the process and to difficulty in procuring the proper kind of metal and the best refractory material.

Only experience, the great teacher, joined with energy and perseverance, enabled us to overcome finally the many difficulties. I do not believe that there was a man in the steel business during its infancy who did not at some time wish that he had never gone into it. Had any person in its early days prophesied that the time would come when there would be made 1000 tons of steel in 24 hours out of two 8-ton converters, he would have been considered a lunatic. But it has been done, and more, one plant having turned out in one month over 53,000 tons with three 10-ton vessels and made over 44,000 tons of rails on one mill, and that with fewer men than it used to take on an old-fashioned bar mill.

While all this enormous increase in production was taking place the mills had to be put in shape to take care of it, which was no small job. New blooming trains had to be built and all the other parts to be rearranged to suit the new conditions. But at this time how few know the troubles and cares of that early period, while fewer still think of them. While all this great change and the vast increase in production in Bessemer steel were going on the blast furnaces had not been standing still. We left them in 1846 in their infancy, as it were, making from 100 to 150 tons per week; now some of them are making from 2000 to 3000 tons per week, and there are new ones in course of construction that are expected to make 4000 or 5000 tons a week.

About 1868 or 1870 the Siemens open-hearth furnace for making steel was introduced, but like most new processes it took some time before it came into general use. To-day it occupies a very prominent position, and in the future, in connection with the Thomas basic furnace, may rank in importance with the Bessemer process in this country. I shall give my reasons for so thinking further on.

The Siemens furnace is constructed on scientific principles without neglecting practical ones. It is easily managed and can be kept under perfect control. While high-class steel can be and is being made by the Bessemer process, yet, practically speaking, all the better grades are now being made in the Siemens furnace. When its efficiency and simplicity of construction are taken into consideration, it will be no easy task to displace it. The open-hearth process is here to stay; and the regenerative principle is the only one by which we have so far been able to get the heat necessary for it. What electricity may do in the future for the science of metallurgy I do not know and do not think it wise to make a prediction.

The next improvement that I wish to mention and have already alluded to is the Thomas basic process, which is now largely in use. It is the invention of Sidney Gilchrist Thomas, whose untimely death we all sincerely deplore. But his name will be indissolubly connected with that of Bessemer and Siemens as one of the great metallurgical scientists of the age. To give the reasons for my belief in the future of the Thomas basic open-hearth process, it is necessary to say here something of the iron ores of this country.

East of the Mississippi and outside the Lake Superior region only one large deposit of ore is known which is suitable for making acid Bessemer steel; that means practically that the ores used in making Bessemer pig must come from the Lake region. But if the demand for and production of Bessemer steel should continue to increase in the ratio we can expect from the past growth, the Lake mines, unless new discoveries are made, cannot for any length of time supply the demand. The ores in the great Mesabi range are not all Bessemer, and most of them being fine in grain are not as desirable to work in the furnace as are the coarser ores of the older mines.

With regard to the Thomas-Bessemer basic process, there is but one large mine in the East whose ores are known to be suitable. This is the Witherbee-Sherman, at Port Henry, N. Y., although it is said that there are some ores in Wisconsin that can be used. As a matter of fact, outside of the Cornwall mines all the acid Bessemer ores are practically confined to the Lake Superior region. For the benefit of those not well posted in iron metallurgy I will give the essential differences in the metals for the two processes. For the acid Bessemer process it should be low in phosphorus—the lower the better; but should not at most contain over 0.08 to 0.10%, and should be as low as possible in sulphur; silicon, from 1 to 2%; metal, open gray. For the basic process it should contain not less than 2% of phosphorus; 1¼% of manganese; silicon, the lower the better, but should not exceed from 0.5 to 1%; sulphur should always be low, but it can be much better eliminated in the basic than in the acid process. In the acid process the silicon gives the heat and no phosphorus is expelled; in the basic the phosphorus gives the heat and goes out with the slag. The only practical difference in the two processes is in the lining of the vessels, the acid being lined with silica and the basic with lime or dolomite.

With regard to acid Bessemer pig iron, it is difficult to get it low enough in phosphorus, and for the Thomas basic it is equally difficult to get the phosphorus high enough. It is between these two extremes that the Thomas basic open-hearth comes in. In this lies the great advantage it has in this country over any other known process, as there is scarcely a State in the Union that has not some suitable ore. In fact, it is a kind of scavenger. I do not use the word in a derogatory sense, but on the contrary, and in order to show what a wide range of material it can utilize. Nor do I mean by this that you can get the highest grade of steel out of the lowest grade of material, but that there can be made a fairly good steel from very ordinary metal; and in this respect it will be the sharpest competitor puddling has ever had. By the introduction of the modern Siemens furnace, which is much less costly and more economical in fuel than the old furnace, a small plant can be built at a cost merely nominal as compared with Bessemer works and can be located in almost any part of the country. It has many advantages; it will give employment to labor in the locality in which the plant may happen to be located; and will have a tendency to check, in a measure, the too great centralization of both capital and labor.

On more than one occasion I have thought the end of puddling was in sight, but while iron has been largely superseded by steel, puddling is still continued, and for many purposes iron will be used at least for some time yet. The puddling process has changed but little since boiling was generally introduced about 1848, though there have been many attempts made to improve it—experiments with the rotary furnace and mechanical working of the metal; with the blowing of air and steam; with the introduction of chemicals of various kinds, all intended to facilitate the process and improve the quality of the iron—but all with little or no result; and to-day it is practically in the same condition that it was 48 years ago, a hard and laborious occupation. My opinion is that a great advance over present practice would be found in the proper introduction of the modern Siemens furnace, which would effect improvement in four directions: 1. In economy in fuel. 2. In lessening the waste by oxidation. 3. In improved quality and increased quantity of output. 4. In relieving the men from much laborious and disagreeable work. Some years ago a distinguished metallurgist and ironmaster said that we were then in the last stage of the iron age. I see to-day nothing to prove his prophecy incorrect; on the contrary, everything is tending toward its fulfillment. There is one thing we are quite sure of—we are in a state of rapid transition from iron to steel, and before any large expenditure of money is made in the direction of puddling the field should be very carefully looked over.

In 1840 there was produced in this country 286,903 tons of pig iron; in 1895 the output was 9,446,308 tons. In 1840 puddling was in its infancy and but little was made. About 1844 or 1845, as I have already stated, it commenced to assume some importance, but we have no rolling-mill statistics prior to 1856, in which year the total product of all kinds of rolled iron was 498,080 tons; and in this all the charcoal blooms, which at that period were a considerable amount, were included. In 1895 the production was about 1,500,000 tons.

About 1863 the Bessemer process was introduced, and about 1867 it began to assume some importance. I shall not bother with yearly statistics, but in 1895 there was made 4,909,128 tons of ingots. Adding the puddled iron and the Bessemer ingots together we have 6,409,128 tons, all of which was to be practically rolled twice. When we look back to 1856 we see that the total quantity of rolled iron of all kinds was only 498,080 tons, while going forward to 1875 there was made in that year only 2,036,091 tons. The increase shown was much more rapid during the 20 years from 1875 to 1895. The Bessemer steel industry has all grown up in the 25 years since 1870. During this time practically all the plants were built; the few existing previous to that time had all to be rebuilt. Blooming mills had to be erected, new rail and billet mills were found necessary or old ones altered—everything had to be changed to suit the new conditions. The change was so great and made in so short a time that it sounds almost like a fairy tale.

We have now reached a point that requires the most thoughtful consideration. In what is all this going to result? How is it going to affect labor? For, after all, this is the great problem that this country has got to meet, and one that requires the most thoughtful consideration. If the whole of the finished production in 1895 had been puddled iron it would have required 60,000 skilled men one year to have taken the pig iron and converted it into puddled bars. On the other hand, had it all been Bessemer and the molten metal had been taken direct from the blast furnace to the converter—which is now becoming the general practice—it would only take about 3000 men one year, and those with few exceptions men less skilled than the puddlers. This showing relates only to the conversion from pig iron into malleable, the balance of the labor into the finished material not differing very materially one from the other. We see that by the introduction of the Bessemer process a great body of hard-working and industrious men heretofore not only useful, but essential, have been or will be compelled to change their vocation. This change in many cases is attended with distress, since it is no easy matter for a man, especially when well along in years, to change from a calling that he has followed all his life to one of which he knows nothing. In this case, fortunately, the new process supersedes one of the hardest and most laborious branches of the iron industry; and where the puddler can find something that he can do he will have reason to rejoice. The changes caused by the introduction of quick processes and labor-saving machinery form no new problem to solve. Let us go back to the great Lancashire riots in England in 1825, when the mob went from one factory to another destroying the pioneer loom that was the object of their vengeance. And again, as late as 1842 many operatives were advocating violence and destruction. But to-day the workingman is in a much better condition in England than he was at that time, notwithstanding the introduction of labor-saving machinery which has taken place. Much the same condition of affairs existed in this country, yet we find the condition of our workmen generally much better than it was some 60 or more years ago. They are receiving much higher wages, are better housed and have more comforts.

We frequently hear the assertion that manufacturing is overdone, especially in the iron trade, and I must confess that many times during my connection with the business it looked so; yet on each return of prosperity my fears have happily proved groundless. The only way we can rightfully judge the future is by the past. In 1740 the consumption of iron did not amount to 1 lb. per head. In 1870 it was 102 lbs. per capita; in 1890 it was 370 lbs. It has been predicted that in 1910 the population of this country will be over 100,000,000; and supposing the per capita consumption remains stationary, the wants of the country would be 15,000,000 tons per annum. It would not be safe for any man to say that this would not be realized. If we take the same ratio of increase as took place between 1856 and 1895, we find that the quantity required will be much greater than the figures named. During the last 20 years the use of steel for structural purposes has been largely increased, and its use is being rapidly extended for many other purposes; and it is not unreasonable to suppose that this expansion will continue. Then, again, we have the vast territory west of the Mississippi, embracing over one-fourth of the population, half of the railroad mileage, and two-thirds of the entire area of the country, and it is increasing in population much more rapidly than the older States. Surely we can calculate with a great degree of certainty on a large increase in consumption from that source.

THE LABOR QUESTION.

We are now brought face to face with one of the most important problems that we have ever had to deal with, one that every one is interested in and that requires our most serious consideration. This is the question of the rights and duties of labor and capital in relation to each other. Much has been said and written on the subject by calm, able, thoughtful, and philanthropic men who have given the matter their serious and earnest consideration in order to bring about a better understanding between the two parties and to devise some plan by which the rights and interest of both will be respected and they may be enabled to work in harmony. In many instances this has been partially successful. On the other hand, there has been much said by men of good intentions, but lacking in discretion, who in some instances have excited the passions of men to such a degree that loss of life, destruction of property, and disaster to the men themselves have resulted. How is this continuous strife and how are the disastrous strikes which are of such frequent occurrence to be stopped? Legislation will not accomplish it and the unions so far have failed. Unfortunately the general tendency of those bodies is to level downward. The only immediate remedy, and it can only be partial, is the practice of forbearance, practical common sense, and brotherly love, with a strong admixture of the milk of human kindness. Strikes can then to a very great extent be avoided.

Here let me say that I have been nearly 50 years managing iron and steel works and for 40 years the largest plants in the country. I know of no business that suffered so much from frequent changes, and wages had all the time to be altered to suit the changing conditions. Yet during all this time we had but two strikes. Both should have been avoided, and there was not a drop of blood lost or one dollar's worth of property destroyed. This should certainly prove that to a great extent serious labor troubles might be avoided.

Can the present conditions be changed? If so, how is it to be done? My answer is that if it is done at all it will be by a better and more systematic education of the people. Many say that to educate a man unfits him for labor. To this I take exception, as it is at variance with all my long experience in the management of men. And in addition I will say that I ought to know the character and disposition of iron workers well, as I was one of them in early life, worked with them, lived with them, was their companion, their confidant, and in many instances their adviser; and I have all my life been associated with them in their hardships, their troubles, trials, and misfortunes, and have ever found them when properly treated straightforward, manly, sympathetic, loyal, and grateful, in this respect comparing favorably with men moving in much higher circles. What is wanted, I believe, is higher education, which will make men more happy and useful and will add to the luster of the nation.

What is labor without intelligence? The savage labors, but with what result? Intelligent production and creative skill are the only absolute wealth of the nation. And this means a thorough education of the whole people, elementary, scientific, and technical, and must begin at the top, as we cannot begin at the bottom and go up. "Where," as J. Scott Russell says to the English people, "each workman shall thoroughly know his work, where each foreman shall thoroughly understand the right principles and best methods of executing that work, and where each master of a manufactory and each member of a profession shall have received the highest education in the philosophical principles and modern methods of his art, science, and profession." This is true to the letter. The time has gone by for the rule-of-thumb, sink-or-swim policy. And we must adopt the most modern and enlightened means if we expect to gain and hold the control of even our own market, to say nothing of the desirability of exporting to other nations. This can only be brought about by a better and more thorough education of the whole people. It is essential that the capitalist who invests his money in any manufacturing enterprise should fully understand it to enable him to manage it prudently and talk intelligently to his customers, so that he can inspire them with confidence in his ability and integrity. Justus Liebig said that the nation promoting the intellectual development of its industrial population must advance as surely as the country neglecting it must inevitably retrograde. This a fact that cannot be gainsaid.

The question now arises, How is the proper education of the industrial people to be brought about? This is one of the most difficult problems of the day, and wiser heads than mine have failed to solve it. So I shall be content only to suggest what in my opinion is the kind and extent of education workmen should have and leave it to others to work out the details. Whoever may suggest a plan that can be successfully carried out will richly deserve the gratitude of the nation. Humboldt years ago foresaw that the time was not far distant when science and manipulative skill must be wedded together; that national wealth and the increasing prosperity of nations must be based on an enlightened employment of national products and forces. The time is here and the work should be commenced in earnest. What is wanted is an education that will enable men to think intelligently and endow them with power to investigate nature and ingenuity to create and to fit them well for whatever vocation or calling they may elect. This is an all-important matter, as the happiness and prosperity of life largely depends on this selection; it should be well considered, and mental and physical ability, as well as adaptability, should be taken into account. Men differ in their tastes and capacities, and it is only when they choose a calling for which they are by nature well adapted that they can expect to be either happy or successful. In the one case the performance of their duty would be a source of pleasure, and their work would be done with alacrity, which is the great highway to promotion. On the other hand, it would prove both laborious and distasteful and would probably be done in a slovenly and unskillful manner, which would prove disastrous to any industry.

The first course of education is elementary or primary. It is with the general, technical, and practical courses that I propose to deal, as they are the most difficult for the industrial and laboring classes to obtain, from the fact that many of the workmen receive small wages and are not able to let their children attend school long enough to secure a proper education. Many of them scarcely get beyond the rudimentary stage, and to make their attendance at school compulsory would result very often in great hardship, as many families are almost entirely dependent on their children for support. How is a good general and technical education to be obtained? For the present I will leave the practical part out. Here the statesman should come to our relief and formulate some plan by which it should be accomplished. I know of no expenditure that the Government could make, if properly done, that would so richly repay it. The education which is desirable in order to mature the man is called general, and he should know something of many things which go to make us able, good, and useful citizens. The special education makes a person useful in the arts, and he should know something of many of them, but should know thoroughly those pertaining to the branch or calling which he intends to follow. This renders his talents useful in the line of his business, enables him to do his work more systematically, more rapidly, and with less waste, and to be always on the alert for better methods. He will take pleasure in his work, as a person always takes pride in doing that which he feels conscious he can do well. Such men would work under prudent, energetic foremen, similarly trained, but necessarily more thoroughly, standing as it were on watch looking into the future for some new discovery or improvement that will facilitate, cheapen, and better their work. And here I cannot help quoting an extract from a treatise on the *Coeducation of Mind and Hand*, by Charles H. Hand, of the New York College for the Training of Teachers, an admirable paper which should be read by every person in the land. Mr. Hand says: "It follows that the ultimate object of education is the attainment of skill in the arts. To this end the speculations of philosophy and the experiments of chemistry lead. At the door of the study of the philosopher and of the laboratory of the chemist stands the artisan, listening for the newest hint philosophy can impart, waiting for the result of the latest chemical analysis. In his hands these suggestions take form. Through his skillful manipulations the faint tracings of science become real things, suited to the needs of human life, for it is through the arts alone that all branches of learning find expression." These words will be thoroughly appreciated by all persons who have considered the subject of the better education of the industrial classes in the arts.

One of the most important and at the same time most difficult problems is the selection of a manager or superintendent. He should have a thorough general education, a good knowledge of the commercial part of the business, and a good general scientific knowledge; he should be thoroughly practical and many-sided; a man of keen foresight to enable him to anticipate the changes that are constantly taking place in the manufacturing arts; he should be broad, liberal-minded, and sympathetic. His position in a measure is a dual one, as he should stand between his employer and the workmen and see that justice is done to both parties; he should be energetic, a good judge of human nature, to enable him to act wisely in the selection of his foremen, as they are in importance next to himself and should be as far as possible the same class of men and as free from any form of jealousy as the air they breathe.

Much has been said on general and technical education and their importance, especially that of the latter when we come to apply it to the manufacturing arts. Knowledge is power and is the first condition of success in art, but cannot be applied without skill, which calls for a practical education. How is this education to be secured? It means special training in both cases to properly fit the man for the occupation he may choose. It is no easy matter for a person without means to secure either of them, to say nothing of securing both. And yet this is what is wanted and should by some means be secured if we ever expect to share in the markets of the world. The practical skill is the more easily obtained of the two, from the fact that children are apt to follow the calling of their father. If not, as they cannot live without work, they must do something to earn a living, and in many cases have to assist the father to support the family. The problem is how to secure a proper technical education in order to thoroughly equip a man for his calling. On the other hand, how is the man who is so fortunate as to secure a technical education going to get the practical training so essential to render his technical knowledge valuable? In many instances he has spent the greater part of his life in school or college, knows little or nothing of manual labor, and unfortunately, in many instances, has arrived at a time of life when he does not feel like beginning at the bottom, which is so essential to secure a thorough success. While I fully comprehend the difficulty of combining technical and practical education, I believe it could be done if its importance and the vast amount of good, both commercial and financial, that is sure to flow from it, were generally understood.

When we take into consideration the low wages that the larger number of the laboring class ordinarily receive—and in times of business depression they are still further reduced—it is evident that they cannot bring up their children in such a manner as to make them good and useful citizens. It is unnatural for poverty and intelligence to dwell together. And to their condition I would call the attention not only of the philanthropist, but also of all good citizens. Every industrious workman should receive wages sufficient, if prudently used, to take proper care of his family and to give him an opportunity to better his condition. It is unreasonable to expect men to rise in the scale of morality and civilization while they are struggling for their very existence. The conditions must be changed, and this can only be brought about by the united efforts of the whole people. Employers must give the subject the most thoughtful consideration and urge all to treat their employees in an unselfish and liberal manner. Let employers become better acquainted with their workpeople, listen to their grievances, their troubles, their trials, and manifest sympathy for them in the difficulties they have to encounter; cheer them, do all they can to give them courage to enable them to fight the great battle of life; and above all, let them know that the employer really respects them and will do all he can to better their condition. Out of such treatment there will surely spring a closer and more sympathetic bond between the employer and employee, which will be the first great step toward improvement in the condition of the working people.

LEAD.

The production of lead in the United States in 1895 from native ores was somewhat less than in 1894, the total being 156,854 short tons and the decrease being 4013 tons, or 2.5%, while the decrease as compared with 1892 was 25,823 tons, or 14.2%. The total amount smelted or refined and prepared for market in this country, partly from foreign material, was, however, the largest ever reported, reaching a total of 233,913 tons, an increase of 12,953 tons, or 5.9%, as compared with the preceding year.

The following table shows the production, imports, exports, and approximate consumption of lead in the United States for the five years ending with 1895:

PRODUCTION AND CONSUMPTION OF LEAD IN THE UNITED STATES. (IN SHORT TONS.)

Year.	Stock of Refined, Jan. 1.	Produced from United States Ores.				Imported.		Total Supply.	Consumed.	Exported in all Forms.	Stock of Refined, Dec. 31.
		Desilverized.	Soft.	Antimonial.	Totals.	In Ores and Base Bullion.	As Refined Lead.				
1891....	10,000	138,749	32,897	5,105	176,651	b25,777	....	212,428	200,728	2,700	9,000
1892....	9,000	145,217	31,655	5,805	182,677	b40,883	....	232,560	214,186	12,874	5,500
1893....	5,500	130,026	31,369	5,283	166,678	64,270	....	236,443	195,457	35,000	5,991
1894....	5,991	119,486	37,044	4,337	160,867	60,093	9,648	236,599	191,146	40,000	5,453
1895....	a12,634	119,057	32,797	5,000	156,854	77,059	23,412	269,959	232,854	18,130	a18,975

(a) Includes lead in bond. (b) Includes refined and other forms imported.

The output of desilverized lead from native ores in 1895 was very nearly the same as in 1894; as compared with 1892 there was a decrease of no less than 26,260 tons. This decrease is largely due to the closing down of mines which depended chiefly upon the silver values in their ores for profit. Thus the reductions were most marked in the silver-lead mines of the Cœur d'Alênes in Idaho, in the Montana mines, and in some of those in Colorado. This industry seems to have reached about its lowest point in 1894 and to remain about stationary for the present. In the production of soft or non-argentiferous lead the year showed a decrease of 4247 tons, or 11.5%, as compared with its immediate predecessor, though the output was quite equal to that of the three years prior to 1894. This lead comes chiefly from the mines of Missouri, Illinois, Wisconsin, and Iowa, the lead region of Southeast Missouri being the chief producer.

The production of hard or antimonial lead showed a slight increase over that of 1894, and was about at the average of the five years given in the table.

The extraordinary increase in the production of lead from foreign material was chiefly due to the shipment to this country of ores and base bullion from British Columbia and from Mexico. The bullion is usually refined here in bond and part of the desilverized lead is exported, though most of it pays the duty and remains in this country. It is very probable that this production will continue to increase, as the Mexican mines will doubtless continue to ship their bullion here as long as the present commercial conditions last; while the production of silver-lead ores and bullion in British Columbia will probably also increase, and most of them will continue to come to our works.

As noted above, the Southeastern Missouri district is the chief producer of soft lead. A number of companies are at work in this district, which extends over St. Francois, Madison, Washington, and Jefferson counties, the most important mines being in St. Francois County. The ores occur chiefly disseminated in limestone and the lead is nearly pure. The treatment of the ores, which consists chiefly in freeing them from rock and smelting, is very simple.

In the old district of Northwest Illinois and Southwest Wisconsin, where the first lead mines in the West were worked, mining is still carried on, but generally on a small scale. The aggregate production of this district is still considerable, though it has been much exceeded by that of Missouri and other States.

In Iowa, where a continuation of the Illinois-Wisconsin district is found, lead was first mined near Dubuque as early as 1788, but regular operations were not carried on until about 1833. From 1835 to 1849 the Iowa mines were prosperous and productive, but have since declined, and the region is now worked chiefly for zinc ores. The production of the Iowa mines in 1895, according to the State Geological Survey, was 750,000 lbs., or 375 short tons. The greater part of this product came from the Dubuque Mine. The lead ores are found chiefly in what is known locally as the galena limestone.

Lead has been mined in the East in several places, but nowhere in quantities large enough to be of much importance, and none of the mines are now able to compete with the Western producers.

In Tennessee during the summer of 1895 the Hardwick Lead and Mining Company had its furnace at Blue Springs Station, 4 miles southeast of Cleveland, at work on a galena ore obtained from a good vein in the Knox dolomite. Some other lead mines exist in Tennessee, though they have not been actively worked. Outside of that State and Virginia no lead is mined in the South, though some veins carrying galena have been found in Georgia. In Southwest Virginia some lead is found in connection with zinc ores.

In Arkansas some lead is found in connection with zinc in the northwestern section of the State. Mines have been worked at Lion Hill and elsewhere, but the output so far has not been large. The Arkansas mines are on the continuation of the belt of zinc-lead ores which passes through Southwest Missouri and Southeast Kansas.

White Lead.—The production of white lead, which consumes an important part of the lead output, has been as follows for three years ending with 1895:

PRODUCTION OF WHITE LEAD IN THE UNITED STATES.

Year.	Quantity.		Value.	
	Short Tons.	Metric Tons.	Totals.	Per Short Ton
1893	88,500	80,286	$9,469,500	$107.00
1894	87,242	78,155	8,445,174	108.00
1895	95,389	86,537	9,061,965	104.00

The production in 1895 shows a very considerable increase over the previous year. The old process of making white lead by corroding pig lead is the one still chiefly in use, though other processes for making the carbonate of lead have been introduced to some extent.

Lead Production and Consumption.—The following table shows the production and consumption of lead in the leading countries of the world for the five years ending with 1894. It will be seen that the United States is the largest consumer as well as the largest producer of the metal. Great Britain comes next, supplementing its own small production by imports, taking the greater part of the Spanish production, as well as a considerable quantity from other countries:

PRODUCTION, IMPORTS, EXPORTS, AND CONSUMPTION OF LEAD IN THE CHIEF COUNTRIES OF THE WORLD. (*a*) (IN METRIC TONS.)

Year		Aust'a-Hungary.	Belgium.	France.	Germany.	Great Britain. (*b*)	Italy.	Russia.	Spain.	Switzerland	United States
1890	Production	11,251	9,617	4,578	104,958	49,795	17,768	836	177,953	....	146,966
	Imports	3,824	35,985	70,747	14,939	161,187	2,781	21,238	....	3,753	9,049
	Totals	15,075	45,602	75,325	119,897	210,982	20,549	22,074	177,953	3,753	156,015
	Exports	1,613	27,370	15,327	54,777	72,394	2,125	....	140,660	100	....
	Consumption	13,462	18,232	59,998	65,120	138,588	18,424	22,074	37,293	3,653	156,015
1891	Production	11,851	12,698	6,680	98,114	49,414	18.500	558	165,978	....	180,800
	Imports	5,027	34,093	78,147	19,598	172,439	4,803	18,770	....	2,800	1,737
	Totals	16,878	46,791	84,827	117,712	221,853	23,303	19,228	165,978	2,800	182,537
	Exports	1,547	24,073	16,312	46,970	65,302	2,572	....	140,000	129	....
	Consumption	15,331	22,718	68,515	70,742	156,551	20,731	19,228	25,978	2,671	182,537
1892	Production	12,209	10,146	6.655	100,719	44,935	22,000	600	160.000	....	186,548
	Imports	8,131	31,054	76,289	19,590	185,707	2,396	21,046	....	3,020	....
	Totals	20,340	41,190	82,944	120.309	230,642	24,396	21,646	160,000	3,020	186,548
	Exports	1,874	24,700	15,119	49,780	74,956	3,017	....	153,859	114	....
	Consumption	18,466	16,490	67,825	70,529	155,686	21,379	21,646	6,141	2,906	186,548
1893	Production	12,364	12,006	8,119	97,855	38,186	19,898	....	152,620	....	177,764
	Imports	7,027	37,459	80,220	26,163	191,435	1,870	28,697	....	3,159	31,752
	Totals	19,391	49,465	88,339	124,018	229,621	21,768	28,697	152,620	3,159	209,516
	Exports	1,796	35,023	14,938	49,622	49,653	3,752	....	141,000	89	....
	Consumption	17,595	14,442	73,401	74,396	179.968	18,016	28,697	11,620	3,070	209,516
1894	Production	9,683	13,500	8,758	100,753	30,162	19,605	300	175,000	....	227,599
	Imports	9,042	....	84,674	28,449	163,970	1,499	22,000	....	1,412	34,907
	Totals	18,725	....	93,432	129,202	194,132	21,104	22,300	175,000	1,412	262,506
	Exports	242	....	8,133	27,855	47,813	2,157	....	151,368	....	29,625
	Consumption	18,483	....	85,299	101,347	146,319	18,947	22,300	23,632	1,412	232,881

(*a*) The statistics of production in the above table are derived from official sources, as are also the imports and exports of the United States, Spain, and Belgium. The imports and exports of other countries are taken as reported by the *Metallgesellschaft*, Frankfurt-am-Main. In the statistics of production litharge is calculated as containing 80% lead.

(*b*) In the imports and exports for Great Britain the chemical products are not taken into consideration.

The following table shows the lead production of the world for the five years ending with 1894. The figures given differ slightly from those in the former table, which are arranged chiefly to show the actual consumption or the statistics of the trade, while the table below gives the actual production—that is, the quantity of metal produced in each country from its own ores:

LEAD PRODUCTION OF THE WORLD. (IN METRIC TONS.)

Year.	Austria.	Belgium.	Canada.	France.	Germany	Greece.	Hungary	Italy.	Japan.
1890	9,827	9,617	51	4,544	101,781	13,787	1,266	17,768	776
1991	9,397	12,698	267	6,680	95,615	14,528	2,173	18,500	803
1892	9,268	10,146	547	8,776	97,742	15,958	2,335	22,000	889
1893	7,212	12,006	968	8,119	74,659	14,534	2,514	19,898	1,115
1894	7,570	13,500	2,628	8,758	100,753	13,955	2,113	19,605	950

Year.	Mexico.	New South Wales.	Russia.	Spain.	Sweden.	United Kingdom.		United States.	Totals.
						Foreign Ores.	Native Ores.		
1890	22,339	42,113	838	161,875	310	15,655	34,410	128,880	565,837
1891	30,186	56,482	558	160,418	299	16,681	32,733	160,347	618,365
1892	47,532	46,660	930	215,906	799	14,921	30,014	186,548	710,971
1893	60,525	59,780	885	169,707	461	8,012	30,656	152,080	622,648
1894	57,000	50,000	910	152,620	330	10,034	30,162	145,906	616,824

Spain is the largest producer of lead in the world, though in recent years the United States has approached that country closely, and in 1895 passed it, if the lead obtained from foreign ores is taken into account. The production of Spain by districts for the years 1894 and 1895 is given in the following table, the figures for 1894 being official and those for 1895 furnished by Señor Roman Oriol in advance of the regular returns:

LEAD PRODUCTION OF SPAIN. (IN METRIC TONS.)

Year.	Murcia.	Jaen (Linares).	Cordoba.	Almeria.	Guipuzcoa.	Totals.
1894	85,465	31,529	17,795	13,295	4,536	152,620
1895	92,000	42,500	20,500	15,000	5,000	175,000

Most of the Spanish product goes to Great Britain, either as pig lead or in ores; some lead is sent to France also, and some to Belgium. The pig lead carries some silver, but little or none of it is refined in Spain.

Germany stands third as a producer, having an output which reached 100,753 tons in 1894 and is estimated at 103,000 tons in 1895.

Mexico produces a considerable quantity of lead, most of which comes to the United States. Formerly it came in ores, but now chiefly in the form of base bullion carrying silver, which is refined here.

New South Wales is a large producer, the metal coming chiefly from the silver mines of the Broken Hill district.

No other country is a large producer of this metal, which has a very considerable commercial and industrial importance.

The New York Lead Market in 1895.

At the close of 1895 a period of 18 months had elapsed since the duty on lead was reduced from 2c. to 1c. It had been greatly feared by many that production in this country would seriously decrease. Events have proven the fallacy of this idea, and in spite of the lower level of prices ruling—which amount in round figures to about 25% of the value which the metal formerly had—production has not only held its own, but showed a tendency to increase. To a very great extent this may be due to the fact that lead is largely produced as a by-product when mining gold and silver, while the pure lead ores found in South Missouri can be profitably mined even at present prices.

During 1894 the large smelting works in Colorado formed a sort of combination to pay not above certain figures for ores, yet giving the miners fair market values, but in consequence of some differences arising among the interested parties, this combination went to pieces early in the year 1895, and the competition for all lead ores in Colorado and adjacent States has been very sharp.

Idaho continued to suffer from the vexatious demands on the owners of lead mines by the labor unions.

Consumption for all purposes was good throughout the year, and especially the white-lead industry has shown satisfactory results.

In the beginning of the year stocks were moderate throughout the country, and prices were at the low figure of 3.05@3.10c. These low figures induced consumers to lay in stocks somewhat earlier than usual in anticipation of the spring business, and prices gradually hardened and advanced slowly, reaching by the end of February 3⅛@3.15c., this being the price at which foreign lead could be imported. The fear of this and the very cold weather experienced in February and March had a depressing influence, and by the middle of March 3.05c. was again reached, at which price a very large business was done. After a slight flurry at the end of March the market again became very weak during the month of April, and for some time prices experienced but slight fluctuations, being 3.07½@3.10c. Toward the end of May values in Europe hardened considerably, and for several months thereafter prices ruling on this side were more or less governed by those established abroad. In any case, prices here were favorably affected and quickly jumped to 3.25@3.30c., remaining steady until the end of July. A continuous good demand was experienced, but refiners proved to be reluctant sellers, in spite of the fact that for some time past the lead which is refined in bond at the east coast was not exported. All other metals then showed considerable advances in price, and it was surmised that lead could not remain behind. In consequence of producers being so firm, prices actually advanced to 3.50@3.55c. by the beginning of August, and this figure was kept up until the beginning of September, when signs of weakness appeared. It was learned that very large purchases of refined lead had been made in Europe before the rise set in there, and in all about 7000 to 8000 tons of foreign lead were imported and brought into our market to the detriment of the home product. These importations had a good effect in forcing the lead refined in bond out of the country.

Exports during the summer months stopped almost entirely, but from the beginning of September to the end of the year exports were very heavy, and everything available was shipped abroad. In consequence of this, stocks of bonded lead at the close of the year were at the lowest possible ebb, comprising practically only what was in the course of being refined.

From the moment that refiners were somewhat willing to meet the market, prices declined in spite of the advancing market in Europe, and by the end of September 3.30@3.32½c. had been reached, and with unimportant changes these figures were maintained until the middle of November, when all at once a heavy pressure from the West was felt. Lead had been piled up there for some time in anticipation of a good fall trade, but when business in general was found to be unsatisfactory and the looked-for larger demand did not set in, the quantities so accumulated were all at once thrown on the market, and very large contracts were made at from 3.25 down to 3⅛c. After these forced sales were effected, it was found that all the metal had gone into strong hands and would be firmly held until wanted for consumption. For this they had not long to wait, as consumers were anxious buyers, and prices quickly advanced to 3.25@3.30c. by the beginning of December. Later in the month prices showed a considerable decline, partly owing to the dullness of trade and partly to the threatening aspect of financial and political affairs. They closed on December 31 at 2.90c. per lb. St. Louis and 3.15c. per lb. New York.

The following table shows the average price of lead in New York for each month of the last six years, compiled from the weekly reports given in the *Engineering and Mining Journal*, p. 410. For the years prior to 1890 statistics will be found in THE MINERAL INDUSTRY, Vols. I. and II. The quotations are for spot lead in carload lots or over:

AVERAGE MONTHLY PRICES OF LEAD IN NEW YORK, IN CENTS PER POUND.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1890	3.86	3.85	3.95	4.05	4.20	4.42	4.62	4.60	5.11	5.87	5.02	4.24	4.48
1891	4.38	4.31	4.35	4.25	4.28	4.48	4.42	4.42	4.52	4.39	4.12	4.25	4.35
1892	4.20	4.12	4.21	4.15	4.22	4.16	4.13	4.11	4.11	4.02	3.84	3.80	4.09
1893	3.87	4.22	3.96	4.08	3.89	3.77	3.58	3.41	3.80	3.51	3.41	3.27	3.73
1894	3.19	3.31	3.37	3.43	3.39	3.31	3.50	3.41	3.17	3.12	3.14	3.10	3.29
1895	3.10	3.12	3.12	3.08	3.16	3.25	3.25	3.50	3.35	3.33	3.25	3.22	3.23

ST. LOUIS LEAD MARKET.

THE general features of the St. Louis market in 1895 did not differ widely from those found in New York. St. Louis is the primary market for the lead region of Southeast Missouri, as well as for that of the Southwestern Missouri and Southeastern Kansas region. The following table gives the receipts and shipments for four years. They are reported in pigs, averaging 80 lbs. each, but in the table the amounts are reduced to tons of 2240 lbs.:

RECEIPTS AND SHIPMENTS OF PIG LEAD AT ST. LOUIS.

Source of Supply.	1892.	1893.	1894.	1895.
	Long Tons.	Long Tons.	Long Tons.	Long Tons.
By railroad	54,401	42,106	38,889	41,673
By boat	116	6,056	13,369	11,931
Total receipts	54,517	48,162	52,258	53,604
Shipments	38,235	34,586	38,724	34,162

An important part of the receipts comes to St. Louis by the Mississippi River steamers, 22% of the arrivals in 1895 reaching the city in this way. This lead is from the Southeastern Missouri district, and the amount will probably decrease in future as new railroad connections now in progress are completed.

The following table shows the fluctuations of prices in St. Louis during the year:

RANGE OF PRICES OF LEAD PER POUND IN ST. LOUIS.

Month.	Highest	Lowest	Month.	Highest	Lowest	Month.	Highest	Lowest	Month.	Highest	Lowest
	Cts.	Cts.		Cts.	Cts.		Cts.	Cts.		Cts.	Cts.
January..	2.95	2.75	April...	2.95	2.85	July........	3.40	3.05	October ..	3.25	3.00
February	2.95	2.90	May....	3.13	2.85	August.....	3.35	3.25	November	3.05	2.95
March....	2.95	2.80	June...	3.15	3.05	September.	3.30	3.05	December	3.10	2.90

The highest quotation was 3.40c., in July, and the lowest 2.75c., in January.

The following table, compiled from the weekly reports of the *Engineering and Mining Journal*, shows the sales of lead ore from the Southwestern Missouri and Kansas districts in the ore market at Joplin, Mo.:

SALES OF LEAD ORE AT JOPLIN, MO.

Month.	Sales.	Month.	Sales.	Month.	Sales.
	Lbs.		Lbs.		Lbs.
January............	5,237,160	May..............	4,699,320	September.......	4,887,110
February..........	3,512,812	June.............	6,208,770	October..........	4,120,110
March..............	3,983,400	July..............	5,251,350	November........	4,787,930
April...............	4,504,230	August...........	5,621,060	December........	3,856,360

While the zinc is the predominant industry in that region, the figures given show that lead mining is also an important industry. The total sales at Joplin amounted to 56,674,720 lbs. of lead ore for the year.

The average yearly prices thus showed a steady decrease during the six years, and 1895 was somewhat below the level of 1894. The variations from month to month were less marked than in any previous year. The large lead production referred to above checked any tendency to an increase from larger demand.

The London Lead Market in 1895.

In 1894 we had to record a decline during the first six months from £9 8s. 9d. to £9 per ton for soft foreign lead, the lowest price on record, followed by a rise to £10 2s. 6d. and a relapse to £9 11s. 3d.

The year 1895 opened at £9 12s. 6d. with a better demand, but no permanent improvement was possible in the face of the comparative stagnation characteristic of this period of the year, and the almost entire cessation of work in the building trades, which resulted from the very severe and protracted frost which reigned in February and March, checked all consumptive demand and depressed the value from £9 13s. 9d. to £9 11s. 3d. Sellers abstaining from pressing offers, the market was enabled to maintain a certain steadiness of tone despite the adverse factors, and when the break-up of the frost permitted of the resumption of open-air work the tendency of the lead market quickly improved, and producers, biding their time, were rewarded by witnessing a gradual advance in values, culminating at the beginning of April in the price of £10 1s. 3d. per ton.

From then till the early part of May there was a slight easing off, demand having subsided, but there was no pressure to sell, and consumers soon beginning to display a more active interest, the values quickly advanced and a good business was done, up to £10 7s. 6d. being paid for soft foreign lead before the close of the month. Sellers became decidedly reserved, and June opened with a continuation of the firmness, stocks being inconsiderable and many shipments delayed, while the higher prices cabled almost daily from America furnished an additional element of strength. After £10 10s. had been realized for warehouse lead the tension was relieved by the placing upon the market of several parcels by parties desirous of realizing, and a relapse to £10 5s. ex ship ensued; but July brought a fresh development of the upward movement, America still tending toward higher values and absorbing its overproduction, while the notable falling off in supplies from Australia assisted the London market materially. Toward the close of the month a fire in the Broken Hill Mine begot anticipations of a further reduction in Australian shipments, and demand, especially in the provinces, remaining brisk, £11 to £11 1s. 3d. was reached by the commencement of August. The tone quieted down a little during the month and the value eased off to £10 17s. 6d., but firmed up to £11 again before the close. There was a lull in the demand during September, but a strongish undercurrent was perceptible, and anything obtainable at a trifle under the regular quotation was readily taken up. During October and November there was a marked scarcity of spot and early delivery lead and a renewal of active consumptive demand, resulting in very large business and an almost uninterrupted advance of values, viz., from £11 to £11 12s. 6d. per ton. December opened at the latter value, but the subsidence of demand, due to the various interruptions to active business common to the time of the year (holidays, stock-taking, etc.) and to the fact that buyers had already filled their wants to a large extent by their previous extensive purchases, brought about a gradual slackening of prices, which closed at £11 5s. for soft foreign and £11 7s. 6d. for English, the tendency being quiet but steady.

The Board of Trade returns give the total imports and exports of lead in the United Kingdom as below, in tons of 2240 lbs.:

Year.	Imports.	Exports.	Net Imports.	Year.	Imports.	Exports.	Net Imports.
1892	182,782	58,162	124,620	1894	161,372	47,146	114,226
1893	188,249	48,871	139,378	1895	162,924	41,666	121,258

The following table shows the average price of Spanish lead in the London market for five years ending with 1895. For the years previous to 1891 the prices can be found in THE MINERAL INDUSTRY, Vols. I. and II.:

AVERAGE MONTHLY PRICE OF SPANISH LEAD IN LONDON, PER TON OF 2000 LBS.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1891	12 14 4	12 9 8	12 9 6	12 10 0	12 8 9	12 13 11	12 7 6	12 2 9	12 4 3	12 0 7	11 12 2	11 6 9	12 5 0
1892	10 18 1	10 13 11	10 17 4	10 12 4	10 11 9	10 13 5	10 19 3	10 5 11	10 3 4	10 7 0	10 1 10	9 19 0	10 9 5
1893	9 15 11	9 10 9	9 16 3	9 14 0	9 11 3	9 7 3	10 0 9	9 19 6	9 15 7	9 12 0	9 14 8	9 10 0	9 14 0
1894	9 8 1½	9 5 7½	9 5 0	9 3 9	9 1 10½	9 2 6	9 9 6½	9 7 ½	9 17 6	9 17 6	9 14 2	9 11 3	9 8 7
1895	9 12 6	9 11 3	9 15 0	10 0 0	10 2 6	10 6 3	10 12 6	10 18 9	10 18 9	11 3 9	11 12 6	11 8 10	10 15 3

English lead ranges usually 2s. 6d. per ton higher than the Spanish metal.

Recent Improvements in the Treatment of Argentiferous Lead Ores.

By H. O. Hofman.

The following pages form a record of whatever of importance has appeared during the past year on the metallurgy of argentiferous lead; also of the principal patents as published in the *Engineering and Mining Journal.* The subject is continued from The Mineral Industry, Vol. III., pp. 419–443, the same arrangement of contents and abbreviations being used.

B. & H. Ztg., Berg- und Hüttenmännische Zeitung.
Bull. Geol. S'y Am., Bulletin of the Geological Society of America.
Ch. C., Chemisches Centralblatt.
Chem. News, Chemical News.
Ch. Ztg., Chemiker Zeitung.
E. & M. J., Engineering and Mining Journal.
Freib. J., Jahrbuch für das Berg- und Hüttenwesen im Königreiche Sachsen.
J. Am. Chem. S'y, Journal of the American Chemical Society.
J. Chem. S'y, Journal of the Chemical Society (London).
J. Fr. I., Journal of the Franklin Institute.
M. I., Mineral Industry.
M. & S. P., Mining and Scientific Press.
O. J., Berg- und Hüttenmännisches Jahrbuch der K. K. Bergakademieen, etc.
O. Z., Oesterreichische Zeitschrift für Berg- und Hüttenwesen.
Proc. Eng. S'y West. Pa., Proceedings of the Engineers' Society of Western Pennsylvania.
Pr. Z., Zeitschrift für Berg-, Hütten- und Salinenwesen in Preussen.
S. M. Q., Columbia School of Mines Quarterly.
Tr. A. I. M. E., Transactions of the American Institute of Mining Engineers.
Z. Angew. Ch., Zeitschrift für Angewandte Chemie.
Z. E. Ch., Zeitschrift für Elektrochemie.

INTRODUCTORY.

Properties of Lead and of Some of its Compounds.—Blondel* writes about a new way of welding lead. He places between two clean surfaces a thin layer of lead amalgam and joins them by passing an ordinary soldering iron along the line of junction.

Sabatier and Senderens† find that nitrous oxide slowly converts at about 300° C. finely divided lead (reduced from litharge by hydrogen) into yellow oxide.

Hannay‡ believes that there are two volatile compounds of lead of the formulæ $PbS.H_2O$ and $PbS.SO_2$. Roberts-Austen,§ Jenkins, and Rose did not succeed in producing or isolating the hypothetical $PbS.SO_2$. Lodin‖ says that although lead sulphide fuses only at 935° C., its vapor tension is considerable at a much lower temperature. This is the reason for the reaction of lead sulphide upon lead oxide and lead sulphate at a temperature below 935° C., and may also explain the volatilization attributed by Hannay to the hypothetical PbS_2O_2.

Lead Ores.—Spencer¶ publishes three analyses of Missouri galena concentrates:

Name of Mine.	Zn.	Pb.	Fe.	S.	As.	SiO_2.	Al_2O_3.	CaO.	CO_2.	Hygr. H_2O.
Stevenson and Wamper....	3.359	80.225	0.117	14.040	0.109	0.903	0.345	0.396	0.316	0.014
Magnet....................	1.045	77.255	1.066	14.351	0.099	1.257	0.411	0.228	0.184	3.728
Ashcroft..................	0.482	83.537	0.640	13.722	0.027	0.208	0.153	0.003	0.002	0.922

He also gives the following analyses and commercial values of galena concen-

* *E. & M. J.*, Aug. 10, 1895.
† *Ibid.*, April 27, 1895.
‡ *J. Chem. S'y*, 1894, p. 113; *Chem. News*, LXIX., p. 270; *Ch. C.*, 1894, II., p. 192.
§ *Chem. News*, LXX., p. 43; *Ch. C.*, 1894, II., p. 410.
‖ *Chem. News*, LXXI., p. 293.
¶ *Bull. Mo. Mg. Club*, I., No. 1, p. 30; No. 2, p. 51.

trates from Aurora, Mo. The samples represent averages from lots of smelting ore ready for shipment. The results are calculated on the basis of moist ore:

Name of Mine	Henrietta.	St. Louis & Aurora.	Coffman.
H_2O, hygr.	0.114	0.111	0.140
H_2O, comb.	0.407	0.706	0.183
Insol.	1.050	0.912	1.201
S	13.948	14.537	12.364
Zn	1.748	3.246	5.720
Pb	81.693	80.059	79.751
Fe	0.357	0.294	0.251
Al_2O_3	0.238	0.260	0.239
Totals	99.555	100.125	99.849
Value per ton	$18.50	$17.00	$15.40

The subjoined three analyses by Dietrich* represent the averages of galena concentrates smelted at Pribram during the years 1891–93:

	1891.	1892.	1893.
Pb	31.632	28.620	28.700
Ag	0.251	0.226	0.223
Cu	0.160	0.146	0.152
As	0.485	0.437	0.415
Sb	0.696	0.765	0.854
Sn	0.117	0.102	0.096
Fe	3.030	2.970	2.655
Fe (sol. in HCl)	8.020	7.910	7.690
Zn	5.940	6.076	6.300
Mn	0.965	1.168	1.206
CaO	1.215	1.512	1.505
MgO	0.424	0.523	0.496
Al_2O_3	2.096	2.470	2.347
SiO_2	22.320	24.363	25.475
S	11.590	11.284	10.876
CO_2	8.483	8.926	8.727
Bi, Cd, Ni, $BaSO_4$	Trace.	Trace.	Trace.

Sampling.—An illustrated description of a new sample grinder manufactured by the Engelbach Machine Company of Leadville, Colo., appeared in the *Engineering and Mining Journal* of May 18, 1895. In principle it resembles the well-known sample grinders of Hendrie & Bolthoff and of Fraser & Chalmers. The main advantages claimed for it are that the hopper and grinding ring may be swung open (thus permitting the lifting out and cleaning of the cone), and that the discharging spouts on either side are of cast iron and thus without seam, which is always liable to retain some pulp from a previous sample.

J. E. Surman & Co.† have constructed a laboratory crusher and pulverizer in which lump ore is crushed and ground to a fine powder in one operation. It is intended to replace the hand crusher and bucking board. The apparatus is recommended by Prof. P. L. Hobbs, of the Western Medical College, Cleveland, Ohio, who says that with it he pulverized in one hour 20 lbs. of limestone fine enough to pass a 60-mesh sieve. The same firm has put on the market the Clarkson sampler‡ in five different sizes. It is claimed that size No. 1, weighing 50 lbs., will sample in one hour 1 ton of ¼-inch material, and No. 5, weighing 2300 lbs., 12 tons of 1-inch material.

* *B. & H. Ztg.*, 1895, p. 132. † 187 Broadway, New York City, and 439 Unity Building, Chicago. ‡ *M. I.*, III., p. 420.

Krauss patented* a mechanical base-bullion sampler. It is a drill consisting of a slightly conical stem with collar at the upper end and cutting edge with V-shaped recesses at the lower end.

The year's record would be incomplete without calling attention to the illustrated paper by A. Raht, "The Distribution of Silver in Lead Bullion and the Different Methods of Sampling," which appeared in THE MINERAL INDUSTRY, Vol. III., pp. 414–418.

Assaying.—Seamon and Parker† carried on a series of experiments to determine the loss in silver and gold in cupelling. They used a Battersea coke muffle furnace and measured the temperatures with a pyrometer (made by Zaubnitz, of New York), which is a great improvement on the common way of judging by the eye. If the current of air passing through the muffle had also been accurately regulated, the results would have been still more valuable. In heating silver buttons varying in weight from 1 to 80 mgms. to a temperature of from 900 to 1000° C. for ½, 1, 1½, 2, 3, and 4 hours, it was found that there was a loss at 1000° C. which was probably due to oxidation and absorption. In keeping the time of heating constant at 1½ hours and varying the temperatures from 1000 to 1050° C., 1200 to 1250° C., and 1500 to 1600° C., the loss increased with the temperature, and was with from 1500 to 1600° C. on the whole the greater the smaller the button; with from 1000 to 1250° C. there was little regularity. In heating gold buttons from 1 to 20 mgms. in weight in the same manner as the silver buttons to temperatures varying from 1000 to 1650° C. no losses were observed. In the first series of cupelling experiments 10 gms. lead were taken as standard, and the weight of silver varied from 1.15 to 1063.8 mgms. and the temperatures from 760 to 820° C., from 960 to 1020° C., and from 1200 to 1250° C. The loss experienced increased directly as the temperature and indirectly as the size of the button, the lowest figure being 0.928%, the highest 7.838%. The tests showed that it is essential for good results to run a cupel so as to obtain feather litharge. In experimenting with gold lower results of the same general character were obtained. In varying the amount of lead it was found that the more lead the greater was the loss in silver. In experimenting with cupels (from the same lot of bone ash) of three different degrees of hardness (hard, medium, and soft), it was found that if the cupelling was carried on at a low temperature (760–960° C.) a hard cupel was better than a soft one; if at a high temperature (1100° C.) there was little choice. The reason for this is that at a low temperature the loss is mainly due to oxidation and absorption and at a high temperature to volatilization. In determining the loss in cupelling doré silver it was found that gold had a tendency to diminish the loss in silver. The paper contains 10 tables, in which the numerical results obtained are given in detail.

Torrey‡ records a set of experiments undertaken to ascertain whether it is necessary to allow a long interval between the time of making and using a cupel to prevent the metal from spurting while cupelling. One thousand cupels one week old and 1000 one year old were compared, and about 1% of each kind was found to have spurted. Courtis§ says that if before charging a cupel this is

* U. S. Patent No. 537,044, April 9, 1895.
† *Bull. Mo. Mg. Club*, I., No. 2, p. 13.
‡ *E. & M. J.*, March 9, 1895.
§ *Ibid.*, March 16, 1895.

heated in the muffle, first with a closed door, then with an open one (to oxidize any organic matter that is present), no spurting will occur in cupelling.

The difficulty of getting reliable results in the assay of silver sulphides, especially if mixed sulphides of silver and copper as produced by the Russell process and frequently bought by silver-lead smelters, induced Furman* to compare three standard methods. They are a combination of wet and scorification assay, the scorification assay proper, and the crucible assay. He worked on a sulphide containing 19,693 ozs. silver per ton, and added to it such impurities as arsenical and antimonial oxides, metallic copper and zinc, and barium sulphate and iron sulphide. The combined method is as follows: Dissolve 0.05 A. T. in nitric acid (27° B.), boil off red fumes, dilute to 300 c.c., add 110 c.c. salt solution (1 c.c. = 10 mgms. Ag), and stir. When settled, add 10 c.c. strong solution of lead acetate, 1 c.c. concentrated sulphuric acid drop by drop, stir, and allow to settle over night. Filter, dry, place in 2½-inch scorifier, and burn filter; mix with 8 gms. litharge, 10 gms. test lead, and ½ gm. borax glass, scorify and cupel lead buttons weighing about 10 gms. The scorification (30–40 gms. test lead, 0.5–1 gm. borax glass) and crucible assays (ordinary fluxes—litharge, sodium bicarbonate, borax glass, lead flux, and nails; time of fusion 30 minutes) were made in the muffle as usual. The results were as follows:

Method.	Ounces Silver per Ton.	Percentage Silver Recovered.
....	19,693	100.00
Combination................ ...	19,608	99.56
Scorification..................	19,583	99.44
Crucible........................	19,344	98.22

Oehmichen† investigated the losses occurring in cupelling silver-gold alloys containing zinc and tin. He finds that in cupelling zinc-bearing alloy without preliminary scorification, the loss in precious metal becomes greater the higher the percentage of zinc and the lower the contents of silver. With about 15% zinc and 30% silver the results of direct cupellation are about the same as those of scorification followed by cupellation, direct cupellation giving sometimes a higher result. In scorifying alloy with 20 times its weight of lead 3 minutes are sufficient to slag all the zinc and tin; if the operation is carried on for a longer time principally lead will be scorified and very little copper. The result of this may be that the lead button retains too much copper to permit its being cupelled without additional scorification.

F. and C. Heberlein‡ found that if a doré-silver button contains tellurium, this will show a tendency to remain with the gold in parting and can be removed only by boiling repeatedly in nitric acid with a small addition of tartaric acid.

Priwoznik§ has an interesting paper on the effect of platinum and the platinum metals on the results obtained in parting doré-silver buttons, to which the reader is referred.

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* *Tr. A. I. M. E.*, XXV.

† *Z. Angew. Ch.*, 1895, p. 133; *B. & H. Ztg.*, 1895, p. 173.

‡ *B. & H. Ztg.*, 1895, p. 43.

§ *O. Z.*, 1895, p. 272; *B. & H. Ztg.*, 1895, p. 325.

Eakins* treats in detail the quantitative determination of bismuth† in base bullion and refined lead. The subject is one of growing importance, as the occurrence of bismuth in argentiferous lead ores seems to be becoming more and more frequent. The determination cannot well be made in a smelter laboratory with the ore, but by the method given the refiner can do it with base bullion before making up his softening-furnace charges, and with the refined lead to see whether it comes within the necessary limit, 0.04% bismuth, which forms the commercial dividing line between corroding and non-corroding lead.

Method for refined lead: Flatten out sample, cut into pieces of from 5 to 3 gms. each, weigh out 75 gms., dissolve in beaker in 90 c.c. nitric acid (sp. gr. 1.42) diluted to 400 c.c.; transfer to flask containing 30 c.c. strong sulphuric acid somewhat diluted, fill to mark, cork and shake. When precipitate has somewhat settled, pour liquid through large filter and reserve aliquot part of filtrate for analysis. The actual amount of metal contained in it will be found by calculation, remembering that 100 gms. lead give 22.5 c.c. lead sulphate. Concentrate reserved solution in beaker, evaporate to sulphuric-acid fumes in porcelain dish, cool, dilute to 125 c.c., boil for several minutes to insure solution of all bismuth salt, cool, settle for 2 or 3 minutes and filter, washing with dilute sulphuric acid (10 c.c. to 1 liter). On standing any length of time, difficultly soluble bismuth sulphate is liable to fall out. Heat filtrate, introduce hydrogen sulphide for 10 or 15 minutes, allow to stand warm, filter, wash, return precipitate to beaker, using little water from wash bottle, add from 15 to 20 c.c. potassium sulphide, heat to boiling, pour through filter, retaining still some sulphide, and wash with dilute potassium sulphide. Place filter and precipitate in same beaker in which hydrogen sulphide precipitation was made, add 5 c.c. strong nitric acid diluted to 25 c.c., warm, filter into porcelain dish, burn filter and add ashes to the dish, give 3 c.c. sulphuric acid and evaporate to sulphuric-acid fumes. Cool, dilute, heat, settle, filter, and wash with dilute sulphuric acid. Make filtrate just alkaline with solution of sodium carbonate (an excess will make precipitation incomplete), using methyl-orange as indicator, add a few drops of potassium cyanide, boil for a few minutes to remove all carbonic acid, and allow to settle warm (this assists clear filtration), filter through dense filter paper, wash with warm water, dissolve precipitate in warm dilute nitric acid, make alkaline with ammonia, and add from 3 to 5 c.c. ammonium carbonate, heat to boiling, let stand warm until clear, filter and wash. Dry precipitate, remove from filter, burn filter at a low heat, ignite precipitate and filter at a low heat, and weigh as Bi_2O_3; at bright redness bismuth oxide fuses and is difficult to remove from crucible.

Method for lead bullion: Start as above, using, however, for 75 gms. bullion from 20 to 22 c.c. sulphuric acid instead of 30 c.c. Do not evaporate measured solution until sulphuric-acid fumes pass off, but make ammoniacal, adding 50 c.c. in excess, introduce hydrogen sulphide to saturation, give additional 20 c.c. ammonia, and allow to stand warm. Filter clear solution and wash slightly, transfer filter and precipitate to beaker, add 15 c.c. nitric acid (sp. gr. 1.42), dilute to 60 c.c., warm, filter into 4-in. porcelain dish, burn filter, add ashes to dish, give

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* *Proc. Colo. Sc. S'y*, Feb. 14, 1895.

† See Heintorf, "The Dry Assay of Bismuth," *M. I.*, III., p. 425.

10 c.c. strong sulphuric acid, and evaporate to sulphuric-acid fumes. Proceed as before. More potassium sulphate is required for the larger amount of arsenic and antimony than with refined lead and double the sulphuric acid at the second evaporation.

Nissenson and Neumann* give a detailed description of the methods in use at the large silver-lead works of Stolberg, Prussia, for determining (1) in refined lead Ag, Cu, Bi, Cd, Zn, Fe, Ni, Co, Sn, and Sb, and occasionally As and Mn; (2) in hard lead Sb alone or Sb and Cu; (3) in base bullion Bi, Cd, Cu, Ag, Fe, Ni, Co, and Zn, or Ag, Cu, and Sb alone; (4) in galena Pb, Ag, As, and Zn; and (5) in matte S, Fe, Pb, Cu, and Ag.

The De Haen iodide assay for copper has been modified by Low.† His method of procedure is as follows: Treat 1 gm. ore in a 250-c.c. flask with 10 c.c. strong nitric acid, boil nearly to dryness, add 10 c.c. hydrochloric acid, boil for 2 or 3 minutes, add 10 c.c. strong sulphuric acid, and heat until sulphuric-acid fumes pass off freely. Cool, add 40 c.c. water, boil, filter through 3-in. filter into 3-in. beaker, and wash, the filtrate not to exceed 75 c.c. Precipitate copper with strip (3x1½ in. bent up at ends ⅝ in.) of sheet aluminum from boiling solution in 6 or 7 minutes, pour liquor and bulk of copper into original flask (leaving aluminum foil with adhering copper behind), allow copper to settle, decant supernatant liquor, pouring it through a filter, and wash two or three times with a little hot water. Dissolve copper from filter into beaker containing aluminum foil with 3 or 4 c.c. concentrated nitric acid, wash with water, and rinse into original flask containing the bulk of the copper, keeping the volume of solution low. Heat until copper is dissolved, add 0.5 gm. potassium chlorate, boil down to 1 or 2 c.c. (avoiding formation of basic salt or oxide), add 5 c.c. water, then 5 c.c. strong ammonia water, boil for 1 minute, cool slightly, add 6 c.c. glacial acetic acid, 40 c.c. cold water, cool, add potassium iodide (3 gms. for ores with under 50% copper, 5 gms. with over 50%) to precipitate cupreous iodide (Cu_2J_2), titrate with sodium hyposulphite (38 gms. $Na_2S_2O_3 + 5Aq$ to the liter), first without starch liquor until the solution, colored brown from free iodine, has become light, then add cold starch liquor (0.5 gm. starch boiled in a little water and diluted to 250 c.c.), and continue till the disappearance of the blue color. One c.c. of the hyposulphite solution, to be standardized with pure copper foil, corresponds closely to 0.01 gm. copper. The results are as accurate as those obtained by electrolysis.

According to Dulin‡ the iodide assay gives results that are from 0.1 to 0.3% too high.

SMELTING OF LEAD ORES.

In General.—Kroupa,§ who visited this country during the Columbian Exposition, gives a well-illustrated sketch of the condition on non-ferrous metallurgy in the United States. Of the 179 pages, 30 are devoted to the metallurgy of argentiferous lead. The author, who is well known to readers of the leading Austrian mining paper, has comprised much that is of value into a very small space.

* *Ch. Ztg.*, 1895, No. 49, p. 1141; *B. & H. Ztg.*, 1895, p. 27.
† *E. & M. J.*, Feb. 9, 23, 1895.
‡ *J. Am. Chem. S'y*, XVII., p. 346.
§ *O. J.*, 1894, XLII., pp. 275–454.

In the Ore Hearth.—Sexton* describes the method of treating lead ores in the ore hearth in the neighborhood of Leadhills and Warlock, Scotland. The ore is a galena concentrate assaying 77% lead. The furnace used is represented in Figs. 1, 2, and 3. In these *S* is a sump of cast iron 22 in. long, 30 in. wide, 6 in. deep; *T W*, single tuyère resting on a 2-in. iron bar; *L B S*, lower back stone, on iron bar 8 in. square; *U B S*, upper back stone of same size; *L S S*, lower side stone, on iron bar 6 in. square, overlapping the sump on either side 3 in.; *U S S*, upper side stone, 6 in. wide, 10 in. deep; *W P*, working plate, 1 ft. 6 in. wide, with turned-up edge and groove for overflowing lead; *L P*, lead pot, 2 ft. 6 in. long and 12 in. wide, with vertical partition reaching nearly to the bottom; *B*, cross bar carrying front of flue.

The mode of working differs from the common Scotch method by not being intermittent, the smelting being carried on from Monday morning until Saturday noon.

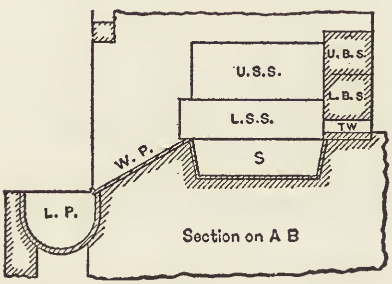

Fig. 1.

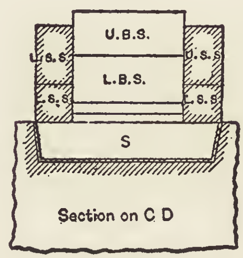

Fig. 3.

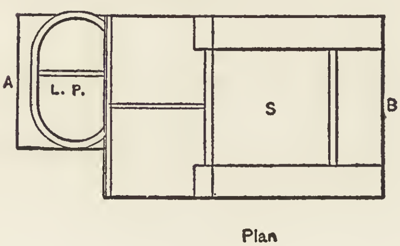

Fig. 2.

SCOTCH ORE HEARTH.

Two men work as partners in 6-hour shifts; 8960 lbs. of lead are produced in 24 hours with a consumption of 2240 lbs. of coal. An analysis of the gray slag shows: PbS, 5.63; $PbSO_4$, 10.36; PbO, 34.88; CaO, 4.10; ZnO, 0.95; $Al_2O_3 + Fe_2O_3$, 18.20; SiO_2, 26.

In the Blast Furnace—Lead Slags.—Harpf† examined a crystallized slag from the acid open-hearth furnace of Donawitz, near Leoben. The analysis—SiO_2, 30.75; FeO, 60.23; Al_2O_3, 2.07; MnO, 5.10; CaO, 1.30; MgO, 1.10; Fe, 0.07; total, 100.62—shows the slag to be a singulo-silicate. The crystals are orthorhombic; they are tabular rather than prismatic; the forms most prevalent are the prism, the base, the prism pinakoids, and two makrodomas. The sp. gr. is 4.280; the hardness a little over 6; the slag is non-magnetic.

Lane‡ describes some crystallized copper slags obtained in smelting reverbera-

* *E. & M. J.*, Feb. 23, 1895. † *O. Z.*, 1895, p. 75. ‡ *Bull. Geol. S'y Am.*, VI., p. 469.

tory slags in the blast furnace. Their composition is SiO_2, 34.84; Fe_2O_3, 16.78; Al_2O_3, 13.26; CaO, MgO, etc., by difference, 35.12. They have the form of tetragonal tablets.

Struthers* melted down in graphite crucibles a large number of lead blast-furnace slags with the object of allowing them to cool slowly and thus separate out as crystalline compounds. In nearly all fusions some iron was reduced by the graphite forming a small button in the bottom of the crucible, thus changing the composition of the original slag. A very full index to the literature on slags is given in the paper.

Influence of Foreign Matter.—Lorenz† carried on extended laboratory experiments to solve the question whether it was possible to separate by electrolysis zinc, lead, silver, cadmium, and copper from their fused chlorides, treating the chlorides separately and in different mixtures. He found that zinc was readily separated from its chloride when this had been completely dehydrated; with lead chloride the process worked from the start; with silver chloride some difficulty was encountered in collecting the silver in the form of a melted globule under the cover of fused silver chloride, but it was easily collected if the electrolyte consisted of a mixture of zinc chloride or lead chloride and silver chloride; cadmium chloride was also readily decomposed, but as the melting point of the salt is near the volatilization point of the metal, the separation was imperfect, brown fumes of volatilized cadmium permeating the otherwise clear and colorless fused salt at the cathode; cupric chloride alone could not be used, as its point of volatilization lies below the melting point of copper, and cuprous chloride was out of the question, as the chlorine set free at the anode would at once convert it into cupric chloride; from the mixed chlorides of copper and zinc brass was readily separated. The mixed chlorides of the above metals gave a colorless electrolyte of good conductivity. Fractional electrolysis of mixed chlorides gave on the whole satisfactory results—*e.g.*, from mixed silver and zinc chlorides and from silver and lead chlorides silver was first precipitated; from mixed zinc and lead chlorides lead fell out before the zinc; and from a mixture of the three chlorides first silver separated out, then lead, and lastly zinc. As it was difficult to find just the points at which each of the metals is completely separated, the silver would contain some lead and zinc, the lead some silver and zinc, and the zinc some lead, until finally pure zinc was obtained. The sequence in which the metals separated out was not much influenced by the strength of the current, provided of course that the metals were far enough apart in their electro-chemical order; the intensity of the current required was small, as the resistance of the fused chlorides was low. The outline of a process for treating mixed sulphides based upon the above experiments is as follows: The mixture of blende and galena, with blende prevailing, is roasted, treated with hydrochloric acid, the solution evaporated to dryness, and the chlorides melted and electrolyzed; the chlorine set free at the anode is converted into hydrochloric acid by being passed with water vapor over incandescent coke: $Cl_2 + H_2O + C = 2HCl + CO$. Thus the solvent is regenerated. If galena prevails, the ore is roasted and treated with acetic acid and lead and silver precipitated as chlorides with hydrochloric acid; the solution,

* *S. M. Q.*, XVI., p. 356. † *Z. E. Ch.*, II., p. 318.

containing now free acetic acid and zinc acetate, is passed again over roasted ore, the smaller quantity of lead and silver dissolved is again separated as chloride, and solution and precipitation continued until all the acetic acid is present in combination with zinc. Now hydrochloric acid is added and the solution distilled, giving zinc chloride as a dry residue and acetic acid as distillate, to be used again as solvent.

Two sets of experiments are under way for treating the argentiferous zinc-lead sulphide ores of the Broken Hill Proprietary Company, Australia, the first by J. Howell, the second by Siemens Brothers & Co.* In both the ore is roasted to form zinc sulphate and oxide and leached with water and dilute sulphuric acid. From the solution Howell proposes to precipitate zinc oxide by magnesia prepared by calcining magnesite and to reduce this to spelter, while Siemens Brothers & Co. want to deposit metallic zinc electrolytically.

Lungwitz† proposes to smelt zinc-lead ores in a blast furnace in which there is sufficient pressure to prevent the volatilization of zinc.

Bartlett patented‡ a furnace with bottom grate for working zincky ores which has coal pockets along the sides feeding the coal on to the grate. The side walls rest on a perforated blast pipe, the air of which burns the volatile hydrocarbons set free when the coal becomes heated, while under-grate blast furnishes the air necessary for the combustion of the resulting coke.

Petraeus proposes§ to roast mixed blende and galena to sulphate, to leach with dilute sulphuric acid, filter, and add calcium chloride to the filtrate, when zinc chloride and calcium sulphate will be formed. After separating the gypsum the zinc can be precipitated as hydroxide with milk of lime, forming a rich oxide ore.

Another process for working zinc-lead ores is the one patented‖ by Roux.

Roasting Ores.—The Ropp straight-line furnace¶ is a one-hearth mechanical reverberatory roasting furnace with three or more exterior fireplaces. Along the center of the hearth runs a straight narrow channel, through which extend at equal distances vertical arms attached to four-wheel trucks and carrying each a rake of the width of the hearth. The rakes, on entering near the flue where the ore is fed automatically, carry it slowly toward the discharge, and leaving the furnace return again on an outside rail and reënter at the same place as before. It takes a car 3.52 minutes to make the circuit. Below the inside rails that convey the carriages is an underground passage deep enough for a man to stand in and attend to any necessary repairs. A steel rope connecting the carriages passes, on entering and leaving the furnace, over a horizontal sheave, the latter being connected with the power. The rope does not become hotter than the hand can bear and the rakes are thoroughly cooled on their return trip. A furnace of standard size is 105 ft. long by 11 ft. wide in the clear, and requires 66,000 lbs. ironwork, 54,000 red brick, and 23,000 firebrick. It treats in 24 hours 36 tons of mixed sulphide ore (20% S, 8% Pb, 17.5% Zn, the rest being Fe and SiO_2), reducing the sulphur to 5%. The fuel consumption in 24 hours is 4

* *E. & M. J.*, Aug. 17, 1895.
† U. S. Patent No. 538,785, May 7, 1895.
‡ U. S. Patent No. 539,021, May 14, 1895.
§ U. S. Patent No. 547,587, Oct. 8, 1895.
‖ U. S. Patent No. 543,753, July 30, 1895.
¶ U. S. Patent No. 532,013, Jan. 1, 1895; *E. & M. J.*, July 13, 1895; *M. & S. P.*, July 6, 1895.

tons bituminous coal. The capacity of the furnace is reduced to 20 and 22 tons if the ore is to be dead-roasted—*i.e.*, the sulphur reduced to below 1%. The amount of flue dust formed is small. One man attends to a furnace in a 12-hour shift; 4 horse-power is required to propel the rakes.

Keller, Cole, and Gaylord have erected their well-known roasting furnace* at the Germania Lead Works, Salt Lake City, Utah. A later patent† relates to a circular mechanical roasting furnace having two or more hearths, approximately semicircular, one above the other. The ore is raked by horizontal arms attached to a central vertical pipe. The arms have a reciprocal movement and the plows attached to them are turned 90° with every passage.

Rhodes and Kloz patented‡ a device by means of which air can be admitted at will to a reverberatory roasting furnace, having the general form of a Brückner cylinder.

Roger patented§ a system of swinging doors for a furnace similar to the Pearce turret furnace,‖ which are to divide off a portion of the hearth for cooling purposes.

Other patents are those of Edwards,¶ Pilon,** Holland,†† and Pierce.‡‡

The Blast Furnace.—In selecting the site for a large modern smelting plant with water-jacket furnaces, the question of water, quantity, quality, etc., is of paramount importance. In many cases the furnace-man is forced to use the same water over and over again, which of course necessitates quick cooling of the water-jacket overflow before it can be used again as feed water. Henrich§§ has recently constructed a water-cooling apparatus entirely of wood for the Herreshoff elliptical water-jacket furnace (120x42 in. at the tuyères) of the Pittsburg & Tennessee Copper Company at Ducktown, Tenn. The cooler consists of an oblong wooden framework in which are placed level thin strips of wood in such a way that the water fed from a central trough at the top shall spread over these strips and drop from one set on to the other, thus exposing a large surface to the cooling action of the air as the water passes slowly downward to be collected at the bottom. The frame is about 18 ft. high, 8 ft. wide, and 48 ft. long, and will cool about 200 gals. of nearly boiling water per minute. Full details are given in the paper. In the discussion of it Brown‖‖ refers to two disadvantages—that wood cannot last long and that it absorbs organic matter which gives the water a very disagreeable odor. He recommends an iron water cooler built by the Henry R. Worthington Company in Brooklyn, N. Y. It consists of an iron cylinder 15 ft. in diameter and 30 ft. high, with tiling. The water fed at the top is met during its descent by an air current forced in at the bottom by a fan 6 ft. in diameter.

Penberthy patented¶¶ a contrivance by means of which he cools the hot water coming from a water-jacket blast furnace. It consists of a horizontal tubular boiler placed above the level of the jackets and connected with the water inlets

* U. S. Patent No. 506,511, Oct. 10, 1893. See Peters, *Modern Copper Smelting*, 7th ed., p. 214.
† U. S. Patent No. 534,160, Feb. 12, 1895. See *M. I.*, II., p. 432.
‡ U. S. Patent No. 532,704, Jan. 15, 1895.
§ U. S. Patent No. 542,715, July 16, 1895.
‖ *M. I.*, II., p. 432.
¶ U. S. Patent No. 537,024, April 9, 1895.
** U. S. Patent No. 548,088, Oct. 15, 1895.
†† U. S. Patents No. 546,450, Sept. 17, 1895, and No. 544,761, Aug. 20, 1895.
‡‡ U. S. Patent No. 532,903, Jan. 22, 1895.
§§ *Tr. A. I. M. E.*, XXV.
‖‖ *Ibid.*
¶¶ U. S. Patent No. 545,718, Sept. 3, 1895.

and outlets. The hot water of the jackets in passing through the water chamber of the boiler is cooled by air which is forced through the tubes and there enters the bustle pipe of the blast furnace.

L. S. Austin* calls attention to the increasing amount of sulphide ore treated by lead smelters and the consequent larger production of argentiferous matte. As in disposing of concentrated matte only 95% of the silver is paid for and none of the lead, the aim of the metallurgist must be to produce a matte low in silver and lead. But here comes in the adverse fact that the silver of the matte increases with the lead, and this as a rule with copper, and in all cases it is difficult to accurately regulate the percentage of lead. Further, in removing melted masses from the blast furnace there is danger of base bullion becoming entangled in matte and matte in slag; hence many different ways are being tried to attain a more perfect separation of matte and slag, both inside and outside of the furnace. Two for inside the furnace are that of using the Matthewson slag tap† and the tapping of matte and slag at different levels from a closed breast. For outside the furnace are the following settling devices: An iron brick-lined settling box with slag overflow and matte tap; the Herreshoff automatic tap; a combination of internal and external crucible with settling box having a slag overflow and matte tap; several cast-iron overflow pots, to be exchanged when filled with matte, or only one pair, the matte being tapped at intervals from the upper one, the lower one serving as a safeguard; the ordinary two-wheel cast-iron slag pot, in which matte and slag separate according to specific gravity and solidify in two sharply defined layers; the Devereux slag pot, having a tap hole for clean slag above the level of the settled-out matte; the Omaha & Grant receiver (see below), similar in principle to the Devereux patent, but holding 4 tons of slag; lastly, the Iles-Rhodes separating furnace, a deep reverberatory furnace, where matte and slag remain long enough at a sufficiently high temperature to get a perfect separation.

Iles‡ determined by calorimetric methods the temperatures of lead slags while flowing from the blast furnace. A small bar of $1\frac{1}{4}$-in round steel, 3 in. long, weighing 1.875 lbs., and another of octagonal steel, weighing 1.07 lbs., were placed alternately in a depression of the slag runway. Slag tapped from the furnace passed over the steel. When it ceased to flow the bar with adhering slag was quenched in a weighed quantity of water, the rise of temperature measured, and the temperature of the flowing slag calculated. The lighter steel gave in nearly every case higher results than the heavier one, the average difference being 276° C. The general average gave 1034° C. as the temperature of the melted slag, 13.9% fuel being used in the blast furnace.

Iles§ also measured the temperatures of the gases passing off from two furnaces run under exactly the same conditions. The average temperature for 28 days was 101° C.; the temperature rose with the increase of wall accretions; it averaged for 9 days 143° C. Generally speaking, the temperature of lead blast-furnace gases may be said to range from 90 to 150° C.

Matte.—L. S. Austin‖ describes in an illustrated paper the method of C. D.

* *E. & M. J.*, Aug. 10, Nov. 30, 1895.
† *M. I.*, III., p. 435.
‡ *S. M. Q.*, XVII., p. 20.
§ *Ibid.*, p. 19.
‖ *E. & M. J.*, Nov. 23, 1895.

Livingstone in use at the Omaha & Grant Smelting and Refining Works at Denver, Colo., to separate matte from slag and dispose of the latter. Matte and slag are tapped from the blast furnace into ordinary slag pots and their contents emptied into large conical settling pots let into the ground, the shells of slag going back to the blast furnace. A settling pot holding 4 tons of slag and matte has in the side two slag taps, one close above the other, and a matte tap at the apex of the cone. When the pot is filled and the matte has separated out, which takes from 10 to 15 minutes, the pot is carried up and on by a traveling differential pulley to a point where it hangs suspended over the tracks on which run the waste-slag cars having a capacity of 3 tons of slag. The slag is tapped, as with the Devereux pot, into a slag car, to be carried to the dump, and the matte into another similar pot holding 1000 lbs. Matte and small amounts of slag (to be resmelted) are separated when cold. The shell of slag remaining in the settling pot is slid out upon the dump by raising and tilting the pot.

Slag.—The increased size of blast furnaces has made the removal of the slag by the use of the ordinary two-wheel slag pots to the edge of the dump impossible. Several slag cars* have been constructed which collect the clean slag from settling pots and convey it to the discharge. Henrich† has described his new tilting slag car, holding from 5000 to 5500 lbs. of slag. It resembles the modern slag car used with the iron blast furnace.

Flue Dust.—The Brown-De Camp fume collector in use for nearly a year at the Omaha & Grant Smelting and Refining Works at Omaha, Neb., is described and illustrated in the *Engineering and Mining Journal* of October 19, 1895. The flue dust is collected by filtering the fume through cloth stretched up and down zigzag across a condensing chamber, the cloth offering a very large filtering surface to the dust-laden gases which are blown against its lower sides by a fan. In order to keep the pores open, the dust collecting on the lower sides is constantly shaken off by beaters. The gases from 10 blast furnaces, 42x120 in. at the tuyères, are sucked by a 12-ft. Murphy fan making 200 revolutions per minute through a flue 800 ft. long and of 64 sq. ft. in area, where they cool down to 65° C. and then pass into the collector. With a filter-cloth area of 80,000 sq. ft. there are recovered per month from 7 blast furnaces, 42x120 in., 100 tons lead assaying 10 ozs. silver per ton, amounting to about 6% of the lead of the charge. The finely divided dust, containing considerable carbon, is transferred from the condenser into a closed chamber and piled up and ignited, where the carbon burning off slowly will create sufficient heat to agglomerate the dust and thus make it suited for charging back into the blast furnace.

Bauer‡ describes in a well-illustrated paper the extended plant for collecting flue dust at the silver-lead smelting and refining works of Freiberg, Saxony. It embraces brick flues and chambers above and below ground, with and without Freudenberg plates, iron flues, lead flues, and Monier flues. It represents a condensing surface of 675,116 sq. ft. and an inner space of 1,079,800 cu. ft. If all the flues and chambers were formed into a single straight flue of 40.9 sq. ft. in section it would have a length of 26,361 ft. In this condensing apparatus was

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* Hofman, *Lead*, p. 202; *M. I.*, II., p. 436. † *Tr. A. I. M. E.*, XXV.
‡ *Freib. J.*, 1894, p. 39; *E. & M. J.*, April 13, 1895.

collected in 1893 2.84 lbs. flue dust for every 100 cu. ft. of space, or 4.47 lbs. for every 100 sq. ft. of condensing surface, or 9.71 tons for every 100 tons of ore worked. But this represents only 80% of the flue dust formed, although the cooling and retarding of the air current had been carried so far that fans are required to furnish artificial draught. The flue dust saved in 1893 yielded 36,484 ozs. of silver, 3642 tons of lead, and 2017 tons of arsenic.

In condensing flue dust the main stress was formerly laid on having large

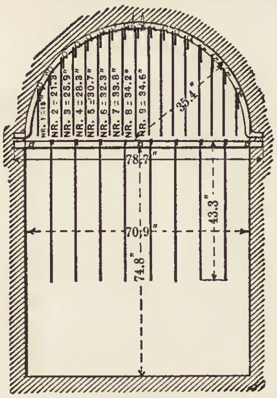

Fig. 4.

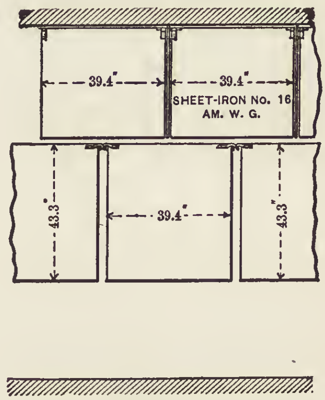

Fig. 6.

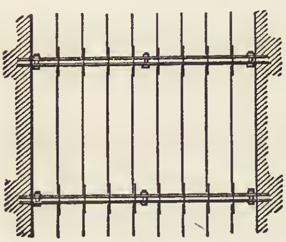

Fig. 5.

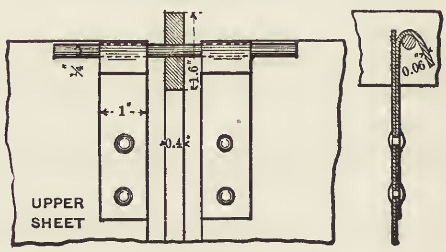

Fig. 7.

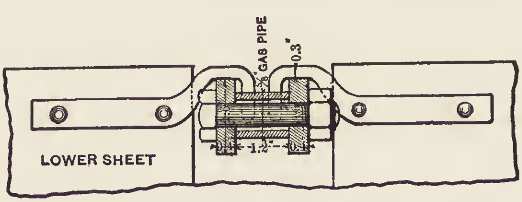

Fig. 8.

chamber space to retard the air current. By the researches of Freudenberg* this has been changed. To-day the aim is to make the dust-laden air pass over large surfaces which by retarding the current through friction causes the settling out of the dust. At the Ems (Prussia) smelting works the Freudenberg plates, of $\frac{1}{32}$-in. iron, are from $4\frac{3}{4}$ to $5\frac{7}{8}$ in. apart and are self-cleaning—*i.e.*, when the flue dust has collected on them to a thickness of from $1\frac{1}{8}$ to $1\frac{1}{4}$ in. it glides off and collects on the bottom of the flue. The manner of suspending the plates at

* *Tr. A. I. M. E.*, XI., p. 379; Hofman, *Lead*, p. 286.

Freiberg (see Figs. 4 to 8) differs from that adopted by Freudenberg at Ems. All plates are 3 ft. 3⅝ in. wide and $\frac{1}{32}$ in. thick. The plates in the arched portion of the flue (from 8 to 16 in number) are from 1 ft. 3 in. to 2 ft. 10¼ in. long. They are suspended at intervals of 4¾ in. by hooks from pins passing through band iron which, following the sweep of the arch, is let in at the sides and fastened to the roof. There are half as many plates in the lower part of the flue; they are 3 ft. 7¼ in. long and about 8 in. apart. They rest with lugs riveted to the upper ends on cross bars let into the sides. Thus when enough dust has collected on the bottom of the flue to make a clean-up, the lower plates are pushed to one side and then do not interfere with the work.

A comparison of three years' work both with and without Freudenberg plates shows that the amount of flue dust collected both in the flues leading to the chamber containing the plates and in the chamber itself is twice as much with the plates as without them, and the dust in the flue leading from the chamber to the stack much less. A comparison of the assay values shows that the dust settled out in the flue leading to the chamber is richer in lead and arsenic than when no plates were used, and that in the chamber proper and the flue leading from it to the chimney more arsenic was collected and less lead. These results speak very well for the plates. The disadvantages are that they are not suited for high temperatures and are quickly corroded at temperatures below 50° C. by the acid moisture which condenses on them; that they very much retard the natural draught, so that forced draught becomes necessary; and that they are expensive both as regards first cost and royalty. When in 1895 the condensation plant was enlarged, the consideration of these drawbacks led to the construction of Monier flues,* which used for similar purposes had proved so effective at Harzgerode, Harz Mountains,† and at Tarnowitz,‡ Silesia.

It will be remembered that the building material employed in the Monier system is a coarse lattice (Fig. 9) of iron wire incorporated in cement concrete. The objections at first made to it, that the cement would not adhere to the iron, the different expansion and contraction of the two materials, and the rusting of iron in contact with the wet concrete, have been disproved in the event and the experimental results of Waysz and Bauschinger verified. Fig. 10 represents a cross section of a Monier flue. The sides rest on and partly extend into a foundation, 1 ft. 11⅝ in. deep and 1 ft. 7¾ in. wide, of cement concrete consisting of 6 parts siliceous slag, 3 parts sand, and 1 part cement. The foundation of the floor is only 3⅛ in. thick. In building the foundation a V-shaped trough is kept open in the concrete to receive the lower part of the side wall by inserting a board 7⅛ in. wide and 4 in. thick at the top. The flue is put up in lengths of 78 ft. 9 in. The wire lattice (2¾-in. meshes, $\frac{3}{16}$-in. horizontal and ¼-in. vertical wires, with ⅜-in. vertical wires at short intervals) is stretched over the center and kept 1 in. away from it by small supports. The concrete, consisting of 1 part cement with either equal parts of coarse (0.4 to 0.6 in.) sand and a mixture of coarse sand and fine (30-mesh and smaller) or 1 part of the former and 2 of the latter, is pressed through the wire lattice, and when the space under it has been filled it is tamped on 1 in. thick, making the entire thickness of the wall 2 in. In a few

* Hofman, *Lead*, p. 291. † *M. I.*, II., p. 439. ‡ *Ibid.*, III., p. 440.

days it is hard enough to permit the removal of the center. In order to give stability to the flue, buttresses of Monier material are placed at intervals of 6 ft. $3\frac{3}{4}$ in. After finishing the walls the bottom is tamped down with concrete to a thickness of $3\frac{1}{8}$ in. The outer and inner sides of the flue are then coated with a thin cement mortar, the bottom receiving a coating $\frac{25}{32}$ in. in thickness. Finally

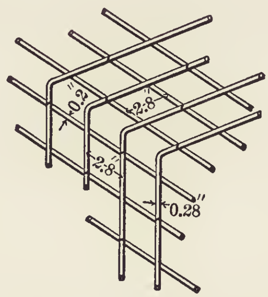

Fig. 9.

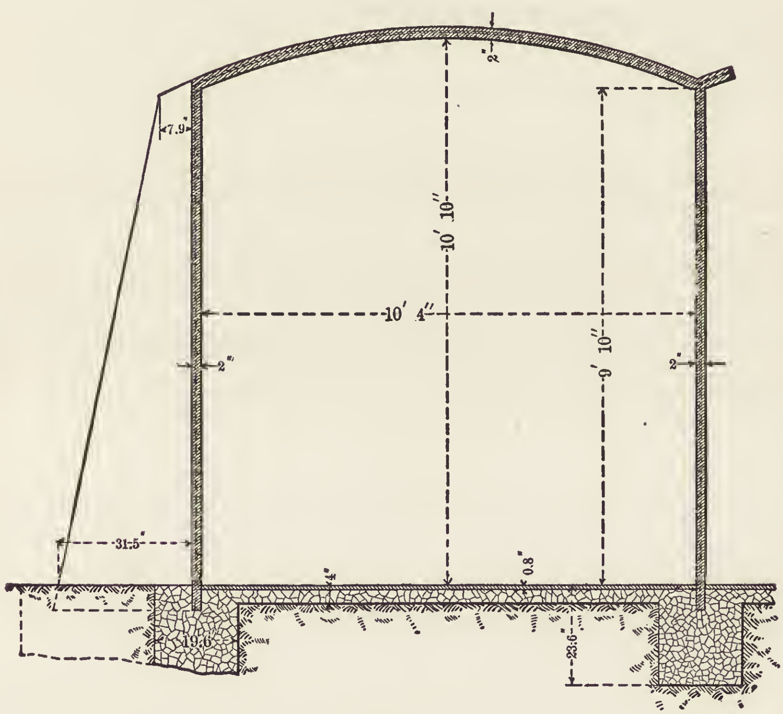

Fig. 10.

the whole interior is painted with an acid-proof paint, the composition of which is not made public, and the exterior with tar. One sq. meter (10.7641 sq. ft.) of this Monier wall with supports 1 meter (3.28 ft.) apart can bear a load of 720 kgs. (1587 lbs.) if evenly distributed and half the amount if applied in the center. Up to the present time (after $7\frac{1}{2}$ months) the flues have stood well the corroding influences of the gases. The temperature of the gases after passing through the zigzag flue, which has a total length of 682 ft. 3 in., is reduced 21° C.

The following data show the cooling effect of the different materials used in building flues. The temperature of gases is reduced 1° C. by 9 ft. 10 in. of lead flue, by 14 ft. 9⅛ in. of Monier flue with two sides exposed to the air, by 19 ft. 8¼ in. of brick flue with two sides exposed, by 27 ft. 2¾ in. of Monier flue with one side, and by 39 ft. 4⅝ in. of brick flue with one side exposed.

For each 100 cu. ft. of condensing chamber 0.524 lb. of flue dust settled out and assayed 33% lead and 32% arsenic. In the flue leading to the Monier chamber the assays of flue dust showed 38% lead and 24% arsenic.

Iles* shortly reviews the experiments made in electrical condensation of fog, mist, smoke, and fume by Lodge, Clark, Walker, Hutchins, Rösing, and Dieudonné, and believes that with a cheap source of static electricity a large amount of volatile metal can be commercially saved.

DESILVERIZATION OF BASE BULLION.

Parkes' Process.—A correspondent† records the failure of Honold in working his apparatus for mechanical desilverization of base bullion by means of zinc,‡ and criticises two patents taken out by Swan and Mays in England for a similar purpose.

F. and C. Heberlein§ found that the zinc obtained in retorting zinc crust at the Pertulosa (Italy) silver-lead works‖ was often coated with or had suspended in it a carmine-colored compound which upon examination proved to be zinc telluride (ZnTe). This led to their investigating the behavior of tellurium in desilverizing by the Parkes process. Tellurium is present in the Pertulosa ores in very small quantities; the base bullion contains only 0.0025%, and an addition of 0.25% zinc to such a bullion suffices to carry 95% of the tellurium into the first —the gold or copper—crust. Softening, desilverizing, and refining the base bullion obtained by smelting in the blast furnace such a crust, which was especially rich in copper, gave the products shown in Table I.

TABLE I.

Products.	Cu.	As.	Sb.	Te.	Ag.	Au.
Softening dross	34.29	....	....	0.0525	....	....
Softening skimmings	0.76	1.36	8.42	0.0185	....	....
Softened base bullion	0.23	0.051	0.12	0.0159	0.522	0.0012
Softened bullion after first zincking	....	....	....	0.0019	....	....
Softened bullion after second zincking	....	....	....	0.0008	....	....
Market lead (after third zincking refining)	....	....	....	0.00065	....	....
Refining skimmings	....	....	....	0.0010	....	....

The dross is richer in tellurium than any of the other products. This is probably due to the copper. Tellurium does not follow arsenic and antimony into the skimmings, as one might be led to expect from the similarity between it and these metals. It combines readily with zinc and enters the zinc crust. The products resulting from retorting this are given in Table II.

* *S. M. Q.*, XVI., p. 354.
† *E. & M. J.*, April 20, 1895.
‡ *M. I.*, II., p. 440.
§ *B. & H. Ztg.*, 1895, p. 41.
‖ *Ibid.*, 1886, p. 372.

TABLE II.

Products.	Te. (*a*)	Se.	As.	Sb.	Sn.	Bi.	Cu.	Cd.	Fe.	Zn.
First zinc tap	0.0030	......	......	......	......	......	......	......	......	......
Second zinc tap	0.0051	......	......	......	......	......	......	......	......	......
Third zinc tap	0.0150	......	......	......	......	......	......	......	......	......
Skin of zinc lining condenser.	0.037	......	Trace.	Trace.	......	......	......	......	0.327	......
Zinc telluride	30.0	......	0.018	0.022	......	......	......	......	0.409	(*a*) 67.024
Blue powder	3.46	......	......	......	......	......	......	......	......	......
Retort bullion	0.5156	Trace	1.4095	0.3019	None.	0.0237	2.2477	0.0052	0.2205	0.8537
Gas from condenser	......	......	......	......	......	......	......	......	......	......

Products.	Ni,CO.	S.	Ag.	Au.	Pb.	CO_2. (*b*)	CO. (*b*)	N. (*b*)	C.
First zinc tap	......	......	......	......	......	......	......	......	......
Second zinc tap	......	......	......	......	......	......	......	......	......
Third zinc tap	......	......	......	......	......	......	......	......	......
Skin of zinc lining condenser	......	Trace.	0.006	......	1.470	......	......	......	Trace.
Zinc telluride	Trace.	......	0.004	......	2.523	......	......	......	Trace.
Blue powder	......	......	......	......	......	......	......	......	......
Retort bullion	0.0068	Trace.	5.4616	0.0564	(*a*) 88.8974	......	......	......	......
Gas from condenser	......	......	......	......	......	1.4	55.2	43.4	......

(*a*) By difference. (*b*) Volumes.

The three successive zinc taps, with their increasing percentage of tellurium, show that this is not as easily distilled off as the zinc. The fact that the zinc adhering to the iron condenser and also the retort bullion retain considerable tellurium substantiates this. Samples of the carmine-colored telluride of zinc adhering to the iron condenser and to some of the zinc gave as much as 30% of tellurium, the rest being made up by zinc and the impurities shown in the table. Telluride of zinc changes its color to a grayish-black in a few days if exposed to daylight. If it comes in contact with air while hot it is quickly oxidized; the reducing atmosphere in the condenser (see Table II.) permits the condensing of the alloy. Some alloy, however, is oxidized, as seen from a selected sample of blue powder which is very rich in tellurium. A comparison of the analyses of softened base bullion and retort bullion (Tables I. and II.) also shows that arsenic follows more readily the zinc than the antimony does, viz.:

In softened bullion, As : Sb = 1 : 2.5.
In retorted bullion, As : Sb = 1 : 0.25.

In cupelling bullion with 0.31% tellurium in an English cupelling furnace the products in Table III. were obtained.

TABLE III.

Products.	Te.	Se.	As.	Sb.	Pb.	Ag.	Au.
First litharge	0.217	......	......	......	......	......	......
Crude silver while brightening	0.0487	Trace.	Trace.	0.0197	0.1785	(*a*) 96.2711	0.6190
Second litharge	3.3437	Trace.	Trace.	0.0972	74.3440	1.1292	0.0008
Refined silver	0.0130	Trace.	Trace.	Trace.	0.0038	98.4937	0.6340

Products.	Cu.	Bi.	Fe.	Zn.	Ni,CO.	Cupel Bottom.	O and Loss.
First litharge	......	......	......	......	......	......	......
Crude silver while brightening	1.9332	0.0140	0.0113	0.0032	0.0013	......	......
Second litharge	5.9709	0.0538	0.0608	0.0211	0.0041	2.4580	12.5174
Refined silver	0.8454	0.0028	0.0073	Trace.	Trace.	......	......

(*a*) By difference.

The sample of silver taken during brightening had a bluish-gray color, was brittle, and showed a fine-grained fracture. The analyses again show that tellurium has the same tendency as copper to remain with the silver. To the crude silver in the furnace some lead was added to remove the impurities, with the results shown in the table. Of the tellurium contained in the crude silver, 61% entered the litharge, 1.4% remained in the refined silver, and the difference, 37.6%, was volatilized or absorbed by the hearth material. The volatile character of tellurium was clearly shown by the assays made of the flue dust from the cupelling furnace; samples taken from 70 to 90 ft. away from the furnace were richer in tellurium than those closer to it. The tellurium present in the base bullion was found to be distributed in the products of the refinery as follows: Dross, 7.4%; skimmings, 2.2%; retort products, 10.9%; first litharge, 50.5%; second litharge, 7.3%; flue dust and cupel bottom, 18.1%; refined silver, 0.2%; refined lead, 0.4%.

The most satisfactory test for tellurium proved to be to boil the sample, finely comminuted by pulverizing, filing, etc., with concentrated caustic alkali and the addition of powdered zinc. The solution then assumes the characteristic amethystine color if tellurium is present.

The consumption of coal in the desilverization of base bullion by means of zinc and the manner of softening are discussed in the *Engineering and Mining Journal* of 1895 by Hutchings (February 23 and March 23), Hofman (March 2), and Huntington (March 30). Hutchings gives from 10 to 12% of coal on the market lead as representing the best European practice, and says that he has obtained figures as low as 6.9 and 5.95% for all operations excluding softening. The figure given by Hofman is 8.7% on the bullion or, assuming 80% market lead, 10.9% on the market lead. Huntington gives 6.6% on the market lead with a 40-ton furnace and 5% with a 43-ton furnace, using Newcastle coal, as averages at the works of Pertulosa, Italy—extremely low figures. Hutchings calls attention to the importance of thoroughly softening base bullion before adding the zinc for desilverization. He works with a furnace holding 140 tons and softens the lead at as low a temperature as possible. In order to reduce the copper contents to a minimum he taps the softened lead not into the desilverizing kettle, but into suitable receivers, where it solidifies, and then melts it down again in the desilverizing kettle. He finds that the smaller amount of zinc consumed and the decrease of wear and tear pay him for his slow and careful mode of working. The bullion treated must run very low in arsenic and antimony to permit such a procedure. In order to apply this method to American practice it would be necessary to have, in addition to the large low-temperature furnace of Hutchings, several smaller high-temperature furnaces to remove the arsenic and antimony. Huntington advocates tapping the lead from the softening furnace into a storage kettle, where it may cool and give up any copper that it had taken up from having been liquated at too high a temperature. That his liquation is too rapid can be seen by his figures, when, his blast furnace base bullion containing 0.455% copper and softening dross containing 7.520% copper, the dross from the kettle storing the softened base bullion gave as much as 2.390% copper. The bullion before discharging into the desilverizing kettle retained only 0.080% copper. The writer maintains that American practice lays the necessary stress on removing the copper at a low temperature, which it raises quickly, in order to oxidize arsenic and antimony, as soon as the coppery dross has been drawn off. Tapping directly into the desilverizing kettle is then no disadvantage; on the contrary, it saves considerable time in the first zincking.

Hasse* carried on at Friedrichshütte, Silesia, a successful series of laboratory experiments in desilverizing base bullion by means of an alloy of magnesium and zinc, and followed them up by treating charges of 880 lbs. in cast-iron kettles, the results of which are given below. Magnesium plays the same part as does aluminum in the Roessler-Edelmann process, that of preventing the oxidation of the zinc and thus permitting the production of an alloy of zinc and silver instead of a mixture of zinc-silver-lead alloy and zinc oxide and lead oxide. The magnesium-zinc alloy is prepared by heating zinc to just above its melting point and stirring in the required magnesium, holding it in a pair of iron tongs. It is important not to overheat the zinc, as the burning of magnesium to magnesia takes place at a temperature very little above its melting point, and if the temperature of the zinc bath is too high particles will separate from the magnesium that is being stirred in, rise to the surface, and burn there with the characteristic white flame. When once alloyed with zinc there is no danger of the magnesium's oxidizing; on the contrary, it prevents the zinc from combining with oxygen when melted. An alloy of zinc with only ⅓% magnesium was sufficient to desilverize base bullion by one zincking, and no more zinc was required than usual, viz., 1% of the bullion charged. It was found that the temperature at which the alloy should be stirred in was about 500° C. The zinc crust had to be removed by two separate skimmings if the lead was to be thoroughly desilverized. The first crust was taken off in the usual way as dry as possible, the lead in the kettle then allowed to cool until it just hardened, then liquefied again, and the crust on the surface taken off to be used with the first zinc of the next charge. The following table gives some of the results obtainable in the process:

Experiment.	Charge.			Stirring-in Temperature. Degs. C.	Products.			Assay, Silver. Ounces per Ton.	
	Softened Base Bullion. Kgs.	Magnesium-Zinc Alloy. Kgs.	Totals. Kgs.		Zinc Crust.		Desilverized Lead Before Refining. Kgs.	Softened Base Bullion.	Desilverized Lead Before Refining.
					Kgs.	Charge. Per Cent.			
No. 1	303.0	3.1	306.1	500	55.3	18.1	250.5	10.50	0.29
No. 2	367.0	3.7	370.7	450	52.7	14.2	317.5	10.79	0.34
No. 3	409.5	4.5	414.0	500	{ 68.9 2.7	16.6 0.7 }	342.0	12.02	0.93
No. 4	400.0	4.0	404.0	460	60.8	15.1	342.5	....	0.87
No. 5	374.8	3.7	378.5	334	67.0	17.7	311.0	10.50	1.00
No. 6	386.3	3.9	390.2	334	69.7	17.9	320.0	12.83	0.29
No. 7	378.0	3.8	381.8	334	58.5	15.4	322.7	11.66	0.29
No. 8	409.4	4.1	413.5	334	73.3	17.7	339.1	11.43	0.17

The most satisfactory test was No. 8, where the silver contents was reduced to 0.17 oz. In experiments Nos. 3 and 4 stirring out the remnant of the crust after the bulk of it had been removed was tried, but without success. In experiment No. 3 an attempt was made to skim the crust in the usual way without permitting the kettle to solidify, but this also was a failure.

* *B. & H. Ztg.*, 1895, p. 320.

Suppan* publishes the following analyses of American spelter:

	Glendale, Mo.	Cherokee, Kan.	Nevada, Mo.	Pittsburg, Kan.	Peru, Ill.	Peru, Ill.	Peru, Ill.	Peru, Ill.	La Salle, Ill.
Pb	0.6531	0.6295	0.6725	0.4105	0.8723	0.3063	0.5875	0.3765	0.2513
Cd	0.0056	Trace.	0.0011	Trace.	Trace.	Trace.	Trace.	Trace.	0.0188
As	0.0353	Trace.	....	Trace.	....	....	....	....	Trace.
Fe	0.0095	0.0315	0.0546	0.0523	0.0233	0.0283	0.0357	0.0390	0.0475
Ni	Trace.	....	....	....	....	....	....	....	....
S	Trace.	Trace.	Trace.	Trace.	0.0601	Trace.	Trace.	Trace.	....
Bi	....	....	....	....	....	....	Trace.	....	....
Sb	....	Trace.	....	Trace.	....	....	Trace.	Trace.	....

They are of interest as showing what pure material is used in desilverizing base bullion by the Parkes process.

PARTING DORÉ SILVER.

Electrolysis.—Faunce† in a paper, "Electrometallurgy as Applied to Silver Refining and Incidentally to Other Metals," gives in addition to general matter a full description of the Moebius process of parting doré silver by electricity as carried out at the works of the Pennsylvania Lead Company, at Allegheny City, Pa. This is the first detailed description of the process ever published.

* *Bull. Mo. Mg. Club*, I., No. 2, p. 51

† *J. Fr. I.*, CXL., p. 287.

MAGNESITE.

MAGNESITE, or magnesium carbonate, is usually found in association with some of the magnesian rocks, such as serpentine. It generally occurs in nearly pure form, the most common impurities being ferrous oxide and silica. Magnesite was for a long time mined in small quantities, being used in the manufacture of the various magnesium salts, and more recently as a bleaching agent for wood pulp in the manufacture of paper. Within a few years it has been found that it was an excellent refractory material and specially adapted for the hearths of furnaces used in the basic-steel process. This discovery has very much increased the demand, especially in Germany, where the basic process has been so successful.

Magnesite has been found in many places in the United States, but has been mined actually at very few. In New York it is found in small veins and seams near Rye, Westchester County, at Stony Point, Rockland County, in the southern part of Orange County adjoining the New Jersey line, and on Staten Island. It has also been found in Sussex County, N. J., and in Hudson County in the neighborhood of Hoboken. In Pennsylvania masses of magnesite have been located in Chester, Delaware, and Lancaster counties, and a small quantity was at one time taken from a deposit at Goat Hill, Chester County, but work at that point was abandoned after a short time. It has been found in considerable quantity in Western North Carolina, chiefly in Yancy and Cabarrus counties, but none is mined there at present. It occurs also in Western Texas, and probably the largest known deposits in this country are those in Arizona, where large masses of magnesite of great purity were discovered some years ago. Owing to their location and the difficulties of transportation none of them has been worked.

The entire supply of magnesite obtained in this country at present is obtained in California. In that State the outcrops of magnesite have been found at many points, chiefly associated with the magnesian rocks in the foothills of the Sierra Nevada. The more important are at Cedar Mountain and Livermore, Alameda County, at Gold Run and Iowa Hill, Placer County, and at several points in Monterey, Mariposa, Santa Clara, Tuolumne, and Napa counties. The first deposit worked in California was that at Cedar Mountain, Alameda County, but this was abandoned after a short time. The supply is at present derived from the workings at Childs' Valley, Napa County.

The following table shows the production of magnesite in California for the five years ending with 1895. It will be seen that this output has steadily increased and was larger in 1895 than in any previous year:

PRODUCTION OF MAGNESITE IN CALIFORNIA.

Year.	Crude.		Calcined.		Crude Equivalent of Calcined. Short Tons.	Total Crude.	
	Amount. Short Tons.	Value at Mine.	Amount. Short Tons.	Value at Works.		Amount. Short Tons.	Value.
1891	117	$819	322	$6,440	644	761	$5,397
1892	608	4,256	397	7,940	794	1,402	9,814
1893	263	1,841	440	8,800	880	1,143	8,000
1894	450	1,600	460	6,500	920	1,370	7,864
1895	520	2,520	840	12,180	1,680	2,200	14,700

The calcined ore reported is nearly all sent to Oregon to be used in the manufacture of paper, the Willamette Paper Company being the chief customer; the crude ore has been sold to the Pacific Rolling Mills at San Francisco and to other mills for use as furnace linings.

Little or none of the California magnesite finds its way to the East, the cost of railroad transportation preventing it from competing with that imported from Europe. The demand is at this time quite small and the imports are trifling in amount, usually consisting of magnesite bricks for special uses. It is probable that with proper management a considerable market could be made for the magnesite as a refractory material.

In Europe the deposits at present worked are those of Styria, in Austria, Silesia, in Germany, and of Greece. The Austrian deposits have been longest worked and at one time were the most extensive known, but the German magnesite is now the best known in the market. In Silesia two quarries are worked, both near the town of Frankenstein and both owned by the Deutsche Magnesit Werke, which has near the mines large works where the mineral is calcined and is made into bricks. The yearly production now amounts to about 6000 tons of the crude mineral, and besides furnace linings the company makes tiles for roofing, flooring, and other purposes in connection with so-called fireproof construction. At the Austrian works the manufacture of brick and tiles is also carried on.

In Greece the magnesite deposits are in the island of Euboea, where the mineral is found in large veins in the serpentine and is usually very pure. For a number of years the deposits were worked only in a small way; a few years ago they were acquired by a French company, which has brought the output up to from 13,000 to 14,000 tons yearly.

Deposits of magnesite are also known to exist in Russia on the eastern slope of the Ural Mountains, but these have been worked only occasionally and to a very small extent.

Several deposits of magnesite have been found in the serpentine rocks of the eastern portion of the Province of Quebec, Canada. So far as examination has been carried here it seems that these contain too high a proportion of iron oxide to be available; at any rate, they have never been worked.

MANGANESE.

The production of manganese ore in the United States in 1895 showed a considerable increase over the small output in 1893 and 1894, although it was below that of 1891, when the maximum so far attained in this country had been reached. The output reported for 1895 was 14,883 tons, but this was only a small part of the total consumption, imported ores having continued, as in previous years, to form the principal supply which reached the consumer. The approximate consumption of manganese ore for the year was 100,994 long tons, which was the largest quantity ever disposed of in the United States, and exceeded by no less than 44,604 tons the consumption reported for 1894.

The following table shows the details of the production and imports for the five years ending with 1895:

MANGANESE-ORE INDUSTRY IN THE UNITED STATES.

(In tons of 2240 lbs.)

Year.	Production.									Imports.		Consumption.	
	Arkansas.	California.	Colorado.	Georgia	Tennessee.	Virginia.	West Virginia.	Total	Value.	Tons.	Value.	Tons.	Value.
1891..	1,650	....	964	3,575	....	16,248	....	22,437	$191,613	28,624	$371,594	51,061	$563,207
1892..	6,708	150	4,000	2,000	... ...	6,079	....	18,937	154,582	58,364	830,046	77,301	984,628
1893..	2,000	450	4,700	500	....	1,500	....	9,150	60,000	67,717	860,832	76,867	920,832
1894..	3,060	250	5,000	1,000	921	1,438	66	11,735	74,890	44,655	432,561	56,390	507,280
1895..	2,500	245	7,968	2,614	....	1,556	....	14,883	92,044	86,111	747,910	100,994	599,324

There was, as is shown by the table, considerable variation in the production of the different States. The largest and most important increase was shown in Colorado, and this production was from the Leadville mines, the producers there having made contracts under which their ore was disposed of at advantageous rates, chiefly to the Illinois Steel Company. In Arkansas there was a slight decrease, owing to the partial exhaustion of some of the ore pockets which have been worked in that State. The Georgia production showed an increase which was relatively large, though small in actual amount. In Virginia and California very little change was shown, while no ore was produced by the mines in Tennessee and West Virginia during the year. The fact that most of the mines of manganese ore worked are in localities where the transportation charge forms an important part of the cost has prevented those mines from competing with the imported ores at any point on or near the seacoast. Under present conditions manganese ore can be put down in New York much more cheaply from the Cuban, the Spanish, or even the Russian mines, than from those of Arkansas or Colorado. The increase in the Colorado production noted above was due to the facts that the owners of the Leadville mines are in a position to sell the ore cheaply and that the consumer is located a long distance from a seaport.

The main use for manganese ore in this country is in the manufacture of steel, and by far the larger part of the ore produced or imported here is made into ferro-manganese for this purpose. With the exception of some ferro-manganese made by a few steel companies for their own use and a small quantity made from the manganiferous ores from the zinc mines of Sussex County, N. J., most of the supply of this alloy is furnished by the Carnegie Steel Company in Pittsburg, which has at times a surplus for export as well as for sale to other steel makers. A small quantity of manganese is also used in the chemical industry.

Discoveries of manganese ore continue to be reported occasionally from different parts of the country, but none of sufficient importance to justify the commencement of actual mining can be noted during 1895.

The following table shows the production of manganese ore in the different countries in the world for the five years ending with 1894:

WORLD'S PRODUCTION OF MANGANESE ORE.

Year.	Austria-Hungary.	Belgium. (a)	Bosnia.	Canada.	Chile.	Cuba.	France.	Germany.	Greece.
1890	9,452	14,255	5,500	1,205	48,759	22,161	15,984	41,841	13,547
1891	5,409	18,498	8,847	231	35,017	22,341	15,343	40,335	13,453
1892	5,868	16,775	7,944	104	50,000	18,000	32,406	32,861	11,716
1893	5,411	....	7,403	193	50,000	13,922	38,080	40,798	5,250
1894	5,055	....	6,588	67	....	....	32,751	43,702	9,319

Year.	Italy.	Japan.	New Zealand.	Russia.	South Australia	Spain.	Sweden.	United Kingdom.	United States.
1890	2,147	2,612	490	182,468	2,808	9,872	10,698	12,643	19,094
1891	2,429	3,249	1,172	113,090	861	6,993	9,079	9,628	22,757
1892	1,243	5,027	529	199,195	715	16,910	7,832	6,175	19,247
1893	810	14,169	324	(b)225,000	2,467	14,600	7,061	1,357	9,297
1894	760	....	....	(b)275,000	....	29,997	3,359	1,837	11,927

(a) Ferro-manganese. (b) Partly estimated.

Commercially, the most important production is that of Russia, which supplies at present a large part of the European demand as well as that of this country. The chief producing district is that of Sharopansk, in the Caucasus, which has been worked for several years and which has largely increased its production in recent years, owing to the completion of the Trans-Caucasian Railroad, with which most of the mines have direct connection. The Cuban ores approach the Russian in grade more nearly than any others, but the mining of those ores during 1895 was to some extent interfered with by the troubles in the island.

Some shipments were made to the United States in 1894 from Central America, and development is proceeding in the mines there with encouraging results. The supply from this source will probably increase hereafter.

MICA.

THE subject of mica, its geologic occurrence and usages, has been very fully treated in the previous volumes of THE MINERAL INDUSTRY, and it is not necessary to repeat that information. The principal varieties are three: muscovite, or white mica; phlogopite, or amber mica; and biotite, or black mica. The last-named variety is of the least importance. In composition the different varieties of mica are complex silicates of alumina and other minor bases, usually potash, magnesia, soda, and iron. Mica is found chiefly in the older rocks like those of Northern Quebec in Canada and the Appalachian range in the United States.

The occurrence of mica is quite frequent. It is found in many places in small quantities, but very few of these occurrences are of importance sufficient to warrant mining. The commercial value of the mineral depends entirely upon the size of the blocks in which it is found and the fineness of the grain permitting it to be split into even sheets of considerable size. The color also has some influence upon its value, though less than the size and the grain. Formerly almost the entire production of sheet mica was used in the stove trade, but in recent years a large demand has grown up for electrical purposes, and the latter has somewhat changed the requirements. In the stove business the demand was chiefly for the light-colored or white mica. In the electric manufacture the color makes no difference; the requirements are that the sheets must be flexible, free from cracks, and able to stand a high temperature. After all, the most important requirement for commercial mica remains the size of the sheets, and it is for this reason that its occurrence in small blocks only, whatever may be the other quality of the mineral, renders such deposits almost valueless. There has been in recent years an increasing demand for ground mica, but this is met chiefly by grinding the waste and broken sheets from the existing mica mines.

Mica beds were discovered in Idaho several years ago, and although they have not been explored to any considerable depths, the indications are that a supply of good quality could be obtained from these mines. Two companies have been organized to work these deposits, but very little has so far been done, principally because of the difficulty of transportation. When this is overcome the Idaho mica will probably make its appearance in the market.

In the United States the supply comes almost entirely from two States, New Hampshire and North Carolina. The New Hampshire production is not increasing, and North Carolina furnishes the greater part of the output. The following table shows the mica production of the United States for 1894 and 1895:

MICA PRODUCTION OF THE UNITED STATES.

States.	1894.				1895.			
	Ground.		Sheet.		Ground.		Sheet.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
New Hampshire	252,500	$10,957	8,000	$8,728	195,000	$23,435	3,200	$3,250
North Carolina	577,000	25,000	1,900	2,375	545,000	8,521	3,000	3,150
Totals	829,500	$35,957	9,900	$11,103	750,000	$31,956	6,200	$6,400

For the past two or three years the industry has not been in a very flourishing condition and the total production has been gradually declining. Some extension of the works in North Carolina and the exercise of greater care in mining and preparing the product there promise better for the future. Very much depends upon the proper management in mining and the handling and splitting of the blocks, and carelessness or neglect will very much depreciate the value of the product.

The imports of mica in 1895 exceeded the domestic production. The total of all kinds imported was 1,120,221 lbs., valued at $174,886. A portion of this comes from Canada, but some is also brought to this country from India. The Indian mica is generally of very good quality and is furnished at a price low enough to enable it to compete with the domestic product.

In Canada mica is mined in considerable quantities in Quebec and Eastern Ontario and in the neighborhood of Ottawa. The mines generally were reported in operation during the past year, and the total output of the mineral in the Dominion was valued at $65,000 for 1895.

No other country outside of the United States, Canada, and India is a large producer of mica. It is possible, however, that the increasing demand for electric uses may be the means of inducing a larger production and new discoveries.

MINERAL PAINTS.

THE production of mineral paints in the United States in 1895 is shown in the following table. It will be seen that there was a slight decrease in the iron pigments and ochers, that the production of zinc oxide was very nearly the same in both years, and that white lead showed a very considerable increase:

PRODUCTION OF MINERAL PAINTS IN THE UNITED STATES.

(In tons of 2000 lbs.)

Products.	1894.			1895.		
	Tons.	Value.		Tons.	Value.	
		Totals.	Per Ton.		Totals.	Per Ton.
Iron oxides	21,844	$233,850	$10.70	20,903	$235,727	$11.28
Ochers	17,565	173,532	9.88	15,851	147,440	9.30
Ultramarine	2,600	520,000	20.00	2,500	500,000	20.00
Umber, sienna, and slate	3,400	34,100	10.03	4,850	45,900	9.43
Venetian red	2,184	49,700	22.76	2,980	67,700	22.72
Vermilion	91	111,209	1,112.19	118	118,190	10.02
White lead	87,242	8,445,174	96.60	95,389	9,061,965	95.00
Zinc oxide	22,814	1,711,275	75.00	22,690	1,588,300	70.00
Totals	....	$11,278,840	....	....	$11,765,222	....

It will be seen that the total value of these mineral paints reached the very considerable amount of $11,765,222 in 1895, showing an increase over 1894 of $486,382. Of this total in 1895 white lead constituted 77%. Zinc oxide came next in value, but far below the lead.

Ochers.—This class of mineral pigments, in which the siennas and umbers are included, are very widely employed because of their frequent occurrence in nature and their many excellent qualities. Speaking generally, the different varieties of ochers are clays tinted with the oxides of iron and manganese, but there are many minor variations in composition, and in some cases additions are made to the natural material to vary its color and other qualities. The ochers have been used as paints from a very early date, the oldest applications positively recognized having been made in Italy by the Romans, though it is believed that some varieties were used still earlier by the Egyptians and the Greeks.

Besides their abundance and cheapness, the advantages presented by the ochers are that they are free from all the poisonous ingredients which are found in many mineral paints; they resist to a great degree the effects of light, air, and moisture, thus making pigments particularly adapted for outside or exposed work; they can be mixed with a variety of substances to make a wide variety of colors.

In modern time the ochers were first mined and prepared in Italy, and the siennas and umbers derive their names from the Italian towns where they were manufactured into pigments. The Italian product, however, has been generally superseded in the European markets by the English, French, and German colors, and those from Spain and the island of Cyprus. In this country the native product is chiefly used.

According to a recent paper by Arthur Morris,* as far as the quality of the product is concerned, England stands foremost. Oxford ochers are the brightest and best in the world, and fetch in the market a much higher price than the French ochers, which come next on the list. As to quantity produced, Germany exports 20,000 tons annually; France produces about 40,000 tons and exports something less than half of it. The most important German mines are in Bavaria. The Cassel and Cologne browns are often called ochers, but they are actually ligneous earths. The German product is usually irregular and often filled with useless matters. In France the deposits are numerous and widespread. Burgundy especially has long been noted for her product. The ocher works in this province have combined and sell their product through a single agency. The ocher washeries of France are well equipped, and an excellent article is turned out. Austria, Belgium, and Sweden also have ochers of their own, and "paint beds" have been found in several places in the United States, notably in Pennsylvania. Ocher is also mined near Cartersville, Ga.

Ochers are classified to an infinite extent, according to place of origin, composition, and shade. Practically they may be divided into yellow, red, and brown. Yellow ocher is clay which owes its tint to hydrated sesquioxide of iron. Red ocher is clay colored with anhydrous sesquioxide of iron. It occurs naturally, and, as is evident from its composition, it may be prepared by calcining yellow ocher. Brown ocher is red ocher modified in shade by the presence of black oxide of manganese. The varying proportions of this give a long range of browns, among which are the pigments known as Vandyke brown, sienna brown, and umber.

The variation of ochers in shade and in quality depends chiefly, but not altogether, upon the amount of iron oxide present. A red ocher very rich in this is sometimes improperly spoken of as iron minium. It is merely a calcined and finely pulverized limonite very free from clay.

Several ocher deposits have been opened up in mining for iron. The well-known "paint bed" in Pennsylvania at Lehigh Gap was intended for an iron mine, but the ore was not rich enough. A vein of paint varying from 6 in. to 6 ft. in thickness was struck and has been worked very successfully.

Few pigments are freer from adulteration than the ochers, for the simple reason that any filter that could be used with advantage would be dearer than the ocher itself. A little chrome yellow is sometimes added to lift up the tone of a poor-colored ocher. This, however, is very easily detected.

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* *Oils, Colours, and Drysalteries.*

PETROLEUM.

THE petroleum industry as it is conducted in the two chief producing countries—the United States and Russia—has been so fully described in previous volumes of THE MINERAL INDUSTRY that little is to be added except the production and progress made during the year.

In the United States the production of the older fields in Pennsylvania, New York, and West Virginia showed a slight decline; that of the Indiana fields showed a falling off of about 10%, the number of new wells opened being insufficient in number to replace the older ones which were exhausted. In Colorado there was a small increase from the Florence field, which is the chief producer in that State, and in California there was an increase of more than 50%, due to the active exploitation of the field in and around Los Angeles.

Near the close of 1895 there was some excitement over new discoveries of oil in Eastern Kentucky, and large tracts of land were leased or taken up for the purpose of exploring for oil. The results so far attained have not been sufficient to indicate the probable extent or value of the new field.

The following table shows the production of crude petroleum in the United States for the five years ending with 1895. The statistics for the years previous to 1891 will be found in Vols. I., II., and III. of THE MINERAL INDUSTRY:

PRODUCT OF CRUDE PETROLEUM IN THE UNITED STATES.

(Barrels of 42 gallons.)

Year.	Pennsylvania and New York.	West Virginia.	Ohio.	Indiana.	Colorado.	California.	Kentucky and Tennessee.	Wyoming and Other States. (a)	Total United States.
1891........	33,009,236	2,406,218	17,740,301	136,634	665,482	323,600	9,000	1.504	54,291,980
1892........	28,422,377	3,810,086	16,362,921	698,068	824,000	385,049	6,500	135	50,509,136
1893........	b30,541,740		16,134,485	2,232,303	730,000	600,000	9,000	1,700	50.349,228
1894........	b30,622,336		13,891,795	2,606,505	803,000	600,000	1,000	2,700	48,527,336
1895........	b30,408,375		c 16,109,101	2,306,530	845,000	975,000	1,000	7,019	50,652,025

(a) Illinois, Kansas, Texas, Missouri, Indian Territory, and Wyoming. (b) The crude from West Virginia and southwestern Pennsylvania being run into mutual pipe lines, its production cannot be given separately for each State. (c) Buckeye pipe lines run+Macksburg production.

It will be seen that the production, while showing a slight increase over that of 1894, due chiefly to the increased output of Ohio, was very nearly the same as in 1892 and 1893 and was less than the maximum reached in 1891 by 3,639,955 bbls. No additions are noted to the producing oil fields, which remain as in 1894: 1, the Appalachian field, including Western Pennsylvania, Western New York, Eastern

Ohio, and West Virginia; 2, the Limestone field, which includes Northern Indiana and the Lima district in Western Ohio; 3, the Kentucky field, which is apparently an extension of the West Virginia deposits; 4, the Florence field in Colorado; 5, the Wyoming field; 6, the Southern California field.

Of the Western fields, the most promising one is the Wyoming oil field, but its development continues slow, owing to the entire lack of transportation from the wells. When railroads or pipe lines reach the oil districts of that State, there is no doubt that they are capable of furnishing a considerable supply.

The Oil Markets.—The United States and Russia continue to be the chief exporting nations of the world. The exports from the United States for the five years ending with 1895 are given in the following table:

EXPORTS OF MINERAL OILS FROM THE UNITED STATES. (IN GALLONS.)

(1 = 1000 in quantities and values.)

Year.	Crude Petroleum.		Naphthas.		Illuminating.		Lubricating and Paraffine.		Residuum.		Totals.	
1891	96,723	$5,366	11,424	$868	531,445	$34,880	41,247	$7,979	1,003	$61	681,842	$49,754
1892	104,013	4,660	16,351	1,033	586,406	31,488	33,805	5,071	329	31	740,905	42,313
1893	114,609	3,926	16,249	933	705,675	31,283	34,763	4,888	461	28	871,757	41,058
1894	114,269	4,617	14,832	904	726,727	29,799	38,975	5,137	119	10	894,922	44,463
1895	116,108	6,286	12,922	1,000	686,006	43,540	47,876	6,289	170	15	863,082	57,131

It will be seen that the reduction in the exports in 1895 as compared with those of 1894 was 31,840,000 gals., in spite of the increase in production. Part of this falling off in exports was due to the competition of Russia in Southern and Eastern Europe; part to the great increase in the output of the Austrian oil wells, which now furnish a supply for export to the countries of Central and Western Europe; and partly to the development of the oil fields of the far East.

The exports of oil from Russia have been a rapidly increasing factor in the market. In five years the shipments of refined oil have increased by fully one-third, notwithstanding some difficulties in the way of shipment. The exports of illuminating oil from Batoum, which is a shipping port for the Baku district, in 1895 rose to very nearly 300,000,000 gals.—that is, to more than 40% of the quantity of oil of the same grade exported from the United States. The proportion of crude oil, residuum, naphtha, etc., exported from the Russian wells is much smaller than in the United States, a larger proportion of the by-products from the refineries being consumed at home for fuel and other purposes, while very little crude oil from the Baku district finds its way abroad. We may therefore conclude that the total shipments of oil of all kinds from Russia were about 45% of the total from the United States.

SHIPMENTS OF REFINED OIL FROM BATOUM IN 1895.

Country.	Gallons.	Country.	Gallons.	Country.	Gallons.
Austria-Hungary	29,616,000	Italy	6,147,000	India	45,822,000
Germany	4,836,000	United Kingdom	30,865,000	The far East	74,525,000
Belgium	10,827,000	Bulgaria and Servia	3,830,000	Other countries	9,316,235
Holland	4,601,000	Turkey	19,671,000	Russian ports	28,000,000
France	15,896,000	Egypt	8,472,000	Total	292,424,235

It will be seen that this table includes 28,000,000 gals. which was shipped to Russian ports by way of Batoum—that is, to the older Black Sea ports. Besides this there is a very considerable shipment of Baku oil which is not included in the above table. It is sent from Baku direct by way of the Caspian Sea and the Volga River to various interior points in Eastern Russia.

In the markets of the far East the influence of new competitors is beginning to be felt both by the American and Russian exporters. The Japanese product hardly exceeds as yet the home demand, and the explorations undertaken by the India government have not succeeded in developing a supply sufficient for even the home trade. Petroleum from the Dutch East Indies, especially from the Langkat district, has, however, made its appearance on the Eastern market in considerable quantities, and its quality is so good as to give it a quotation in the Chinese ports very nearly equal to the best grades of American oil.

Prices of Petroleum in the United States.—The rise in prices which began in the closing months of 1894 continued through the early part of 1895, and the price of crude oil continued to advance until April, when it reached a maximum of $1.79 per bbl. From that point a decline set in, very gradual at first, but as the year advanced it became more rapid. This continued until October, when there was an upward reaction. At the end of the year there remained an increase of more than 50% over the closing prices of 1894. The following table shows the average price of pipe-line certificates, which represent the general market for crude oil, for the five years ending with 1895:

MONTHLY AND YEARLY AVERAGE PRICE OF PIPE-LINE CERTIFICATES PER BARREL OF CRUDE PETROLEUM AT THE WELLS.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Average
1891.....	$0.74¼	$0.78⅜	$0.74¼	$0.71½	$0.69¾	$0.68⅛	$0.66½	$0.64	$0.58½	$0.60¼	$0.58¾	$0.59⅛	$0.67
1892.....	.62⅜	.60¼	.57⅛	.57⅞	.57⅜	.54⅛	.52½	.55	.54⅜	.51⅜	.52	.53¼	.55⅝
1893.....	.53½	.57⅜	.65¼	.68¾	.58¾	.60¼	.57⅝	.58⅞	.64⅝	.70¾	.73⅞	.78¼	.64
1894.....	.79¾	.80⅝	.82	.84¼	.86	.89⅜	.83⅛	.81	.83	.83	.83	.91½	.83⅞
1895.....	.99	1.04¾	1.09¾	1.79	1.74¼	1.53⅝	1.46⅝	1.26⅛	1.22⅜	1.24¼	1.48⅝	1.42	1.35⅞

The following table shows the course of prices of illuminating oil in New York for the six years ending with 1895, the standard being the price per gallon of 70° Abel test refined oil in New York:

Year.	Cents per Gallon.	Year.	Cents per Gallon.
1890..................	7.33	1893..................	5.25
1891..................	6.85	1894..................	5.17
1892..................	6.06	1895..................	7.82

It will be seen that the increase in the price of illuminating oil has very nearly corresponded with that in the crude product of the wells.

Petroleum Production of the World.—The following table shows the world's production of petroleum for the five years ending with 1894:

THE WORLD'S PRODUCTION OF PETROLEUM. (a) (IN METRIC TONS.)

Year.	Austria.	Hungary.	Canada.	Germany	India.	Italy.	Japan.	Russia.	United States.
1890........	122,500	990	107,020	15,226	6,437	417	6,720	3,984,247	6,418,765
1891........	123,006	....	105,660	15,315	20,455	1,131	7,400	4,756,417	7,978,923
1892........	120,000	20	109,080	14.527	29,084	2,548	9,825	4,207,562	7,000,982
1893........	122,000	14	111,700	13,974	31,079	2,652	13,276	4,754,304	6,388,318
1894........	131,930	....	116,000	17,232	....	2,853	....	4,873,000	6,158,119

(a) From official reports.

We give below in geographical order some notes on the production of petroleum in the different countries of the world during 1895.

Canada.—The only producer in North America outside of the United States is Canada. The output of that country for 1895 is reported at 802,573 bbls. of 42 gals., showing as compared with 1894 a decrease of 26,531 bbls. No new developments of special importance are reported this year in the older fields of Ontario, nor has anything been done toward developing or exploring the oil which is known to exist in the Northwest Territory.

South America.—Petroleum is known to exist in considerable quantities in several South American countries. On the Pacific slope of the Republic of Colombia oil has been found, and an effort is now being made to explore the district thoroughly. In Peru petroleum has been found at several different points, the most important district so far being that of Mancora, on the Tumbec River. This district now reports a considerable production, refineries have been established, and the output in 1894 rose as high as 30,000 metric tons. Oil wells are also in operation at several other points. At Telara at one time the wells were producing as high as 100 tons of crude oil per day. Peru now produces enough to supply its own demand, with some surplus for export, and experiments have been made in the use of crude oil and residuum as fuel at the smelters and elsewhere—a matter of considerable importance to a country where fuel of all kinds is very scarce. Recently a shipment of oil was made to the Huanchaca mines in Bolivia, where operations have been very much retarded by the high cost of fuel. Petroleum has been found in Chile in considerable quantities, the oil belt being apparently an extension of that in Peru. Oil is also said to exist in Bolivia, but is not worked at present. Oil has also been discovered in the Argentine Republic in the provinces of Mendoza, of Salta, and of Jujuy, but no large amount has been yet produced in any of them.

Europe.—The chief producer in Europe and the only one at all approaching the United States in quantity of importance of its output is Russia. The principal field in that country, the district of Baku, or the Apsheron Peninsula, continues to furnish the chief supply. The methods of working there and the nature of the field have been fully described in previous numbers of THE MINERAL INDUSTRY. But little was done in 1895 in the oil fields of Northern Russia and of the Caucasus, owing to difficulties of transportation.

The most important field outside of Russia is found in the province of Galicia, in Austria. The extension of modern methods to this field and the use of deep drilling in place of the former shallow pits, together with the discovery of an extension of the field, were the causes of a remarkable increase of its production during the year. This increase has attracted new capital and operations are now going on in the province on a largely extended scale. New refineries are being built and other preparations made for handling the increased production. A special account of the Galician fields will be found in the following pages.

The remaining oil fields of Europe can be very briefly described. The production of petroleum in Roumania has increased somewhat slowly, owing to local circumstances. The Roumanian oil belt seems to be a continuation of that of Galicia. Oil has been found through a district about 60 kilometers long, but of no great width. The principal centers of production are at Prahova, Dimbovitza, Bacau, and Buzeu. According to a recent official report there were in existence in Roumania 751 oil wells, belonging to 123 different firms or companies, and in addition 47 new wells were in progress. The depth of the existing wells varies from 60 to 240 meters, while some of those which are in progress are expected to reach a depth of from 300 to 350 meters. The production for the year is estimated at 74,600 metric tons. Of the wells in existence 152 were owned by the State, which has recently placed these wells and also the general supervision of the private boring in charge of Emile Baum as chief engineer.

Petroleum has been found in Moldavia and Wallachia, but the oil-bearing territory there does not seem to be extensive and the production has not increased in recent years. A few wells are found in Transylvania also, but the production there is small. Some oil has been found in Servia, but little is produced.

In France a small quantity of petroleum is produced, and the oil wells of Pechelbronn have been known for a considerable time. Apparently the oil basin there is not extensive and the production does not increase. It varies from 8000 to 10,000 metric tons of crude oil yearly.

In Italy oil has been found in the Emilia and at Chieti. The former is a light oil of an excellent quality, making a high proportion of illuminating oil, but the quantity produced is not large. The latest report shows the existence of 19 wells, producing about 1000 metric tons of crude oil per year.

The discovery of petroleum in England was reported two years ago, when it was announced that oil had been struck near Ashwick Court, in Somerset, but nothing has been heard since then of this discovery.

Asia.—In this continent oil deposits are known to exist in Eastern Siberia over a considerable extent of country, and such explorations as have been made would indicate that they will be of much importance when the completion of the Siberian Railroad furnishes transportation for machinery to sink wells and for the oil produced. The most promising field in Russian Asia, however, is on the island of Sakhalin, on the Pacific coast, where enough has been done to show the existence of petroleum apparently in large quantities, although the actual production has so far been small. Toward the end of 1895 a discovery was reported in the northern part of the island, where a well sunk for testing purposes is said to have developed into a producer as large as some of the great wells of Baku.

Outside of Siberia oil is said to be found in Persia in the Valley of the Euphrates, but has never been worked to any extent. In British India oil has been found in the northeastern provinces and in Beloochistan. Some capital has been put into the exploration of the petroleum basins of Burmah, but so far without any brilliant success; although oil of a fair quality has been found, the quantity produced has not been great. Petroleum has been found in China, but nothing new has been made known about it.

In Japan in recent years the production has been increasing, and exploration is being carried on carefully and scientifically. In 1893 the total production was 13,276 metric tons and in 1894 about 15,000 tons.

The most important of the Asiatic deposits are believed to be in the island of Formosa. Under Chinese rule very little was done there, but now that the island has passed under Japanese rule scientific explorations are to be undertaken.

The latest discoveries in Asia are on the line of the Russian Trans-Caspian Railroad not far from Bokhara. They are on Russian territory, and the district is being studied by the government engineers chiefly with the object of securing a supply of fuel for the locomotives of the Trans-Caspian line.

Africa.—No oil is now known to be produced in Africa, although for very many years a small quantity has been obtained from shallow pits in certain portions of the Nile Valley. This oil has been, like that first discovered in America, chiefly used for medicinal purposes. Some years ago two small wells were sunk at Gemseh and Gebel, in the Gulf of Suez, and oil was discovered, but the quantity was small and the quality very poor.

Other Countries.—In Australasia oil has been found in New South Wales in the districts of Maitland and Illawara, but though a number of wells have been put down, the production has never exceeded 15,000 metric tons a year. The New Zealand oil basins seem to be more promising.

In the Malay Archipelago oil has been found in the Dutch colonies of Java and Sumatra and in different parts of Borneo, and work has been done in some of these to a considerable amount. The most important production so far has been that of the district of Langkat, on the east coast of Sumatra. The oil obtained here is of an excellent quality and has made its appearance on the Eastern markets in such considerable quantities that it has already become a factor in the trade, and it is stated that the output is increasing. These oil wells have been put down and are operated by a Dutch company which was organized at Amsterdam in June, 1890, under the auspices of the Royal Netherlands Company for the Exploitation of Petroleum Wells in the Netherlands Indies. The company started with a capital stock of $520,000, fully paid up, and acquired a concession of 500 bouws (3,500,000 sq. meters) in Lower Langkat, which had been granted by the native government to private parties. For this concession, which was fully sanctioned by the Netherlands government in August, 1893, the sum of $150,000 was paid. The operations to the present time appear to have been conducted under intelligent direction and with much success.

In Java an increase in production is also reported. A number of new wells were bored during 1895 in the district of Sourabaya and a good deal of oil obtained. The Netherlands Company has had under construction a pipe line for the conveyance of oil to its headquarters at Samarang, and several tramways have been laid to different wells in the district.

Petroleum in Galicia.

By R. Helmhacker.

On the northern foothills of the Carpathian Mountains are deposited strata consisting chiefly of sandstones, clayey sandstones, and shales, sloping partly to the north, partly to the south, on account of their anticlinal and synclinal position and because they have been displaced by disturbances. These strata have been known under the name of the Carpathian sandstones, or Carpathian formation, and attributed to the Lower Tertiary or Eocene. This section of country, remarkable for its oil-bearing deposits, has a width of 15 to 20 kilometers in the general trend from near Gdow, in Western Galicia, through Limanow, Gribow, Dukla, Sanok, Brohobych, and Kolomea, in Eastern Galicia, to Suchawa, in the Buckowina, and further east and southward through Moldavia, where the strata are covered by younger deposits. The total length may be estimated to be about 400 to 450 kilometers. But in the general direction of the strike of this oil-bearing formation the strata crop out again on the promontory of the Taman Peninsula (on the Crimea), on the east side of the isthmus between the Azov and the Black Sea. They become further eastward from this point very prominently developed, forming the soil of the oil fields on the east side of the Caucasian Mountains, on the Apsheron Peninsula (Baku), and reappear again on the eastern coast of the Caspian Sea, in the Trans-Caspian territory.

The sedimentary rocks of the Carpathian formation are deposited on both sides of the Carpathian Mountains in Galicia on the northern slope, as well as in Hungary and Transylvania in the southern range. The oil-bearing strata in Galicia do not always supply petroleum in sufficient quantity to work, but it has been stated that petroleum occurs sparingly everywhere.

The geology of the so-called Carpathian formation was found to be more complex than the reconnoisances of previous years had indicated, because it was at first thought that the strata were almost devoid of distinct petrifications. But many interesting facts have been discovered to serve as a basis for more detailed investigations. Few fossils only, among them many poorly preserved, were collected, and from the recognized species it may be said that the fauna indicate the Cretaceous and Eocene periods connected together, and that the Carpathians embrace deposits covering the whole Cretaceous period and ending with the Upper Eocene group of the Tertiary. All the formation has been quite undisturbed, so that the end of the Cretaceous and the beginning of the Tertiary cannot be traced. The Upper Eocene group is overlaid with similar but softer strate of the Neogen (Miocene) group with more abundant fossils, carrying salt in some places. The porous sandstones and fissured shales are impregnated on some horizons to a remarkable degree with petroleum, and there are known three series of oil deposits within them.

The first oil-bearing horizon is indicated by the Upper Neocomian strata of the Lower Cretaceous formation, known locally under the name of Ropianka beds. It is the lowest horizon, in which the deeper oil wells are sunk near Ropianka itself, also near Kimpolung, in Bukowina. The oil-bearing strata in the southern range of the Carpathian Mountains in Hungary, in the districts of Sharosh and Zemplin, are also members of that group.

The other beds yielding petroleum above the first mentioned present the group of Middle Eocene with its fish remains; the lower oil-bearing strata of Baryslaw belong to this second group.

The third and highest horizon supplying oil is indicated by the Lower Miocene group with its clayey sandstones, marls, salt clay, and shales (the latter bearing salt in other places, as the famous salt mines in Galicia), as well as salt springs in the hanging wall of the oil beds. But this third or youngest horizon is also a very remarkable one, from the fact that besides liquid hydrocarbons the strata contain also solid hydrocarbons of the paraffine group, such as ozokerite (mineral wax), the latter sometimes associated with crystals of salt. The ozokerite-bearing strata afford masses of that valuable product, particularly in their eastern extension in Galicia and also in Moldavia, at Slanik.

In the petroleum-bearing series in or near the northern foothills of the Carpathian Mountains numerous naphtha and tar and naphtha springs, issuing from the outcrops of the oil sandstones, were long ago known. Springs percolating through superficial rocks in that country also emitted petroleum or viscid naphtha (a partly oxidized liquid hydrocarbon), and it exuded readily into pits or excavations made to collect it. The film of oil was skimmed off from time to time for veterinary purposes and as a substitute for oil. But some work was done between 1850 and 1870, when some officers of the Mining Division of the Department of Agriculture in Vienna considered it best that the mineral oil should not belong to the reserved minerals, as the other ores or useful minerals do. By the exemption of petroleum from the mine regulations in Austria mining claims could not be granted, and the oil belonged to the owner of the soil. This settlement was much opposed among mining engineers, and it proved both impracticable and destructive to proper development. The new mineral wealth attracted the attention of leasers and particularly of some elements including persons with peculiar morals and ignorant of practical mining, who leased the soil at low figures, in many cases paying with brandy. Finally it was found necessary to bring the oil wells under the mining law. Notwithstanding all drawbacks, the petroleum industry has already assumed large proportions. In the outset of operations wells were sunk in the vicinity of the petroleum springs and along the outcrop of the oil-bearing series, but they were very shallow. The water in the wells yielded petroleum, and when this source failed the well was left idle and then abandoned. There were 783 such wells in 1893; this number diminished to 670 in 1894, but only 82 of them yielded petroleum and were worked.

The oil-bearing deposits dipping with a varying angle require to be reached wells of greater depth, and therefore the owners of larger claims have sunk wells by boring. There are already 1614 holes partly or successfully worked. From 200 of these the oil is pumped by manual labor, while the pumping out of 744 others in operation is performed with steam pumps; there are 317 hand pumps and steam pumps of 1032 horse-power in use. There are 203 drilling plants operated by steam motors of 2313 horse-power.

The wells are cased with cast or sheet iron tubes. They are scattered in the districts of Taslo, Drohobych, and Stanislavow, where by recent statistics 3270 men, 31 women, and 3 boys, or 3304 hands in all, are employed, and the production amounted in 1894 to 111,930 metric tons. This compares with 96,331 tons in

1893 and 89,871 tons in 1892. The oil has sold from 255 florins to 306 florins per 100 kgms., or at the average price of 291 florins. In 1893 and 1892 the average prices were higher, 312 florins and 305 florins respectively.

But in another respect the development of the industry has improved, as the licensed proprietors of oil wells have built pipe lines of the total length of 110,-730 meters to convey the petroleum; they have also built 66 iron tanks and numerous wood tanks amounting to 676.

In a short period of time the boring in the granted claims has shown good technical progress, due to the employment of skilled managers and the abandonment of former wasteful systems of exploitation, with shallow wells on the edges of the oil-bearing series near the surface. In the future, as the oil supply in the outcrop is exhausted it is doubtful whether oil will be found in paying quantities in the older workings, and they will be abandoned, while the better plants based on licensed claims will continue prosperous. The technical improvement is shown by the fact that nearly all the new wells are drilled by the Canadian method as practiced in the Ontario oil field, and that the deepest well is down 635 meters. This Canadian method is carried out only by foreigners, of whom there were recently 44 (chiefly from Canada) at this work. The wages of the men engaged in the oil fields vary from 50 kreutzers to 3.50 florins (24c. to $1.69) daily; those of the miners, drill-plant foremen, and helpers are 30 kreutzers to 2.50 florins (14.5c. to $1.21); the women get 25 kreutzers (12c.) per day. The total average yearly wages of a laborer employed at the petroleum fields amount in the three above-mentioned districts to 206, 256, and 259 florins ($99.37, $123.50, and $125) respectively.

Ozokerite.—Besides the petroleum impregnations, the Lower Neogen or first Mediterranean group of Tertiary in the oil-bearing sandstones, shales, and sandy clays incloses deposits of an allied solid hydrocarbon mineral, ozokerite. The series of rocks containing this mineral wax has been traced down only in the two easterly districts, Drohobych and Stanislavow. The fractured clayey sandstones and shales bear the ozokerite in vein-like stringers in bunches lying along the stratification or in irregular fissures. This occurrence gives the impression that the matter came up from below and has oozed or distilled into these crevices in the rock. Extensive deposits of ozokerite occur in the neighborhood of Boryslav, southwest from Drohobych, and also at Truskawice. The irregular fissured gray clayey sandstones and sandstone shales, with stringers filled with ozokerite the stratification of which is very indistinct, include sometimes also impregnations of petroleum, because the two hydrocarbons bear some relation to each other, and in quite a number of places in the districts named both are sometimes found together.

In ozokerite mining when it began some few decades ago shallow wells were sunk until they struck the fissured rock with irregular stringers of the soft brownish-yellow or yellowish mineral. When this result was obtained the untimbered or slightly timbered wells were abandoned for a short time, sometimes only for a day. On the expiration of that time the native paraffine squeezed out from the stringers seeped up through the fissured rock and was gathered from the well. When the exudations or seepages became less frequent the shaft was sunk deeper, and new collections were made until the bottom of the shaft yielded less and less and at last failed to seep. Then another shaft was sunk in the vicinity. Nearly all the existing wells are worked successfully just now, but with increasing depth of the wells they are timbered throughout. Mining from the present shafts is carried on practically as described, except that instead of gathering the wax on the well bottom only, entries or drifts are started from the bottom of the shaft in two or more directions. This operation increases the surface from which the mineral exudes. This method of obtaining the mineral wax is a very simple one and can easily be carried on, either by wells alone or by shafts and drifts.

There exist now 137 mining properties with 680 shafts in the above-mentioned districts (10 less than in the year 1893), but only 262 shafts, belonging to 55 proprietors, were profitably worked in 1894, the remainder of the wells being idle or abandoned. Galicia now takes the first rank in the production of ozokerite, or native paraffine, and a review of this subject shows that ozokerite is assuming an increased importance among the mineral resources of the country. The production is large and slowly increasing, having been 6743 metric tons in 1894, as compared with 5625 tons in 1893 and 5638 tons in 1892. It adds appreciably to the wealth of the petroleum fields of Galicia.

The price per 100 kgms. of ozokerite varied in 1894 from 20.1 florins to 23.5 florins ($9.70 to $11.34); it is lower than in 1893 and 1892, when it averaged 22.55 and 26.72 florins ($10.88 to $12.89) respectively. A large part of the ozokerite shipped—2430 tons—in 1894 was exported to the refining establishments (mainly for ceresine) in Bohemia, Moravia, Vienna, Russian Poland, and Germany, while 39,900 cwts. were treated in Galician refineries. The depth of the shafts before they reach the ozokerite-bearing rock is, with the continual development of mining, constantly increasing, and it varies now from 40 to 185 meters. In ozokerite mining there were employed by the latest statistics 4855 men, 247 women, and 2 boys, a total of 5104 persons. The average yearly wages of a laborer in the ozokerite mines amounts to 139 florins ($67), but their employment is not constant, as it depends upon the season whether the operations are carried on extensively. To convey the rock or wax railways have been built of a total length of 4.67 kilometers, partly above ground and partly under ground, in the drifts. There are in use 15 steam engines of 278 horse-power, partly for hauling, but principally for pumping.

The ozokerite shafts yield also gaseous hydrocarbon (marsh gas or fire damp); at the depth to which they are now sunk the proportion of gas-yielding strata greatly increases. For ventilation there are established 227 hand and steam ventilators. In 1894 17 miners were killed and 27 other laborers injured. The average was 2 men killed and 3.3 injured to 1000 employed. Five of the accidents were caused by explosions of fire damp.

The Technical Utilizations of Petroleum and Its Products.

By Samuel P. Sadtler.

The great importance of petroleum to the world from an economic view is readily conceded even by those possessing the most superficial information. The picturesque accounts which have appeared from time to time in magazine articles and in the daily newspapers of the great oil fountains and flowing wells, of the pipe lines with their storage tanks and pumping stations, of the tank steamers for the ocean transportation of oil in bulk, and of the oil refineries, so mysterious and dangerous looking to the casual observer, have undoubtedly prepared the general public to believe in the existence of a great industry. That even the ordinarily well-informed man has any adequate conception, however, of the magnitude of the industry or of its ramifications and relations to other industries we doubt. A brief survey of the technical applications of petroleum and enumeration of its more important products may therefore be of some use.

I. DISTILLATION OF CRUDE PETROLEUM AND THE PRODUCTS THEREFROM.

General View of Results of Distillation.—The process to which the great bulk of the crude petroleum is submitted is that of fractional distillation, continued to the eventual coking of the residue. As the most valuable of the several distillates is that which is to be used as illuminating oil, the percentage of that obtainable is an important item for the refiner. A normally conducted distillation of Pennsylvania petroleum will give from 35 to 55% of naphtha and illuminating oil and from 20 to 30% of lubricating oils. It has long been known that if during the distillation the heavy vapors were made to drop back upon the hot oil in the still they became superheated and were decomposed. This process of destructive distillation, or "cracking," allowed of a notable increase of the illuminating oil fraction at the expense of the lubricating oil. So at present some 70 to 75% of burning oil is obtained, while the residuum left in the crude-oil still and used for the manufacture of lubricating oil is reduced to 6%.

The method of distillation followed in one of the large modern refineries using Pennsylvania or West Virginia oil is substantially as follows: The crude oil (Bradford, Middle District, Washington, Macdonald, or West Virginia) is run into horizontally placed cylindrical stills of steel holding from 600 to 750 bbls. The fractions collected from this distillation of crude oil are usually light naphthas, reaching a gravity of 0.705; heavy naphthas, from 0.705 to 0.744; extra heavy naphthas or light distillates, from 0.744 to 0.765; water-white distillate, from 0.765 to 0.795; heavy distillate, from 0.795 to 0.825; slops, from 0.825 to when the distillate becomes brown. The residue, called tar, is pumped while still hot to the tar stills, leaving in the crude-oil still a crust of separated carbon and solid decomposition products called coke.

The proportions of these fractions vary according to the nature of the crude oil and also with the usage of the particular refinery. Thus a refinery running on Washington, Pa., oil produced, according to Riche and Roume,* light naphtha 15%, heavy naphtha 5%, water-white 28%, distillate oil 42%, slops

Rapport sur la Production, l'Industrie et la Commerce des Huiles Minérales aux Etats-Unis, Paris, 1892.

3%, tar 3%, coke and loss 4%. The tar may be used without further distillation for the manufacture of vaseline or is separately distilled in smaller horizontal stills known as tar stills. The products of this distillation are paraffine oils, from which, after purification, the scale paraffine is separated by chilling and pressing, wax tailings, and coke.

Where the oil from Lima, Ohio, and the neighboring district is used a different procedure is necessary on account of the presence of sulphur in the oil. In this case the benzine distillate and the burning-oil distillate are both redistilled from stills containing oxide of copper, which is kept in constant agitation and as far as possible in suspension in the liquid. This takes out the sulphur, so that oils which blacken lead acetate before the distillation show no reaction after this treatment. The sulphide of copper formed in the reaction is afterward roasted and reconverted into oxide. The results with the Lima oil are not quite equal to those obtained with the Pennsylvania oil, the figures being, according to Jos. D. Weeks, naphtha of 0.700, 16%; burning oil, 68%; paraffine oils, 6%; solid residue, 10%.

As before mentioned, the percentage of burning oil is increased by the aid of "cracking." The distillation is, however, carried out normally until the more valuable fraction called the water-white distillate is all over, when this decomposition due to condensation and dropping back of condensed vapors is started by damping the fires under the still so that the distillation proceeds more slowly. The gravity of the distillate instead of continuing to fall begins to rise, showing that decomposition has begun. This is also accompanied by a formation of uncondensable gas. The chief drawback of this process of cracking is that it is both slow and comparatively ineffective, involving considerable waste of heat. Dewar and Redwood in England have patented a process for distilling under pressure that seems to obviate these difficulties and allow of the conversion of the intermediate and heavy oils into lighter oils suitable for use as ordinary illuminants, or even into naphthas suitable for use in carbureting coal gas.

The products obtained by the distillation of petroleum, whether light or heavy, require chemical treatment before they are in a marketable condition. They contain acid constituents as well as compounds which resinify on keeping and gradually impart a dark color and unpleasant odor to the distillate. The raw distillates also rapidly char the wick and lose their power of being drawn up by capillary action. The treatment universally adopted to free them from these defects is to agitate them first with sulphuric acid and then to wash with water, followed by agitation with caustic-soda solution.

This operation is conducted in tall cylindrical tanks of wrought iron lined with sheet lead which are called agitators. The bottom of this agitator is funnel shaped, terminating in a pipe furnished with a stopcock for drawing off the refuse acid and soda washings. The distillate to be treated must be cooled to at least 60° F., and before the main body of acid is added for the treatment any water present must be carefully withdrawn. This is done by starting the agitation of the oil by the air pump and introducing a small quantity of acid. This is allowed to settle and is then withdrawn. The oil is now agitated and about one-half of the charge of acid is introduced gradually from above. The agitation is continued as long as action is indicated by rise of temperature, when the dark sludge acid is allowed to settle and is withdrawn. The remaining portion of acid is added and a second thorough agitation takes place. The whole charge of acid needed for an average distillate is about 1½ to 2%, or about 6 lbs. of acid to the barrel of oil. The oil is now washed with water introduced through a perforated pipe running around the upper circumference of the tank. This water percolates through the body of the oil, removes the acid, and is allowed to escape in a constant stream from the bottom. When the wash water shows no appreciable acid taste or reaction, the washing is stopped and about 1% of a caustic-soda solution of 12° B. is introduced and the oil is again agitated. When this is drawn off the oil is ready for the settling tanks. A washing with water after the soda treatment is occasionally followed, but is not general.

Special Treatment of the Light Naphthas and Products Therefrom.—The light naphthas are either exported as crude naphtha to Europe or are rectified by a steam distillation and separated into a number of products. Where it is important that the various fractions should be kept separate and should be collected of the most constant composition possible, a condenser is sometimes used, the action of which depends upon the property possessed by volatile liquids of evaporating with increased rapidity when in contact with an extended surface, such as that of iron turnings. This condenser consists of a series of closed iron cylinders three parts filled with clean iron turnings and set in cooling tanks through which water constantly passes. The cylinders are usually six in number and are arranged in pairs at slightly different heights.

The vapors from the still pass from cylinder to cylinder, the lightest vapors being finally condensed by passage through a worm surrounded by ice. The various fractions condense in the different cylinders, the iron turnings merely preventing condensation of the lighter hydrocarbons, or, as it may be expressed, revaporizing them as fast as they condense. The lightest of these fractions has been called cymogene. It boils at 0° C., has a gravity of 110° B., and has been used in the manufacture of ice. The next is rhigolene, boiling at 18.3° C. (65° F.) and having a gravity of 100° B. (0.600). It is used somewhat for spraying as a local anesthetic in medicine.

Petroleum ether has a boiling point of 40–70° C. (104–158° F.) and a gravity 80 to 85° B. (0.650 to 0.666). It is used as a solvent for caoutchouc, fatty oils, and plant principles and for carbureting air in gas machines. The commercial product varies considerably, and it is said that certain oils obtained during the compression of oil gas and known technically as "hydrocarbon" are sometimes sold as petroleum ether.

Gasoline is the fraction that follows the petroleum ether, although the name is often applied to the whole mixture ranging from 0.635 to 0.690 sp. gr. Using the word in the narrower sense, it has a boiling point 70 to 90° C. (158–194° F.) and a gravity 75 to 80° B. (0.660 to 0.690). It is used in the extraction of oil from oil seeds, in carbureting coal gas, in gasoline lamps, gasoline cooking stoves, and in plumbers' lamps for soldering, etc.

Naphtha is a name applied broadly to all light fractions, but especially to the fraction boiling at 80 to 120° C. (176–248° F.) and having a gravity 76 to 67 or even 62° B. (0.680 to 0.710 or 0.729). It is used extensively as a solvent for resins in varnish making, in the manufacture of oil-cloth, and for burning in naphtha stoves.

Ligroine is a name given to a special grade of solvent naphtha.

Benzine is the name given to the commercial fraction boiling at 120 to 150° C. (248–302° F.) and having a gravity 57 to 62° B. (0.730 to 0.750). It is used as a substitute for and adulterant of turpentine for cleaning printers' type, and for dyers', scourers', and painters' use. The "benzine" of the United States Pharmacopœia is a different fraction. Its sp. gr. 0.670 to 0.675 and boiling point 50 to 60° C., together with the use of the words "petroleum ether" as a synonym, show that it is a higher distillate. The same is true of the "petroleum benzine" of the German Pharmacopœia, the gravity of which is 0.640 to 0.670.

The "air gas" above referred to is an inflammable mixture of air and the vapor of a volatile liquid hydrocarbon such as gasoline of high gravity. The proportion of such vapor which air can take up varies with the temperature and gravity of the gasoline. Thus 100 volumes of air will retain of the vapor of gasoline of 0.650 sp. gr. 5.7% by volume at 14° F., 10.7% at 32° F., 17.5% at 50° F., and 27.0% at 68° F. Air charged with 735 gr. of gasoline vapor per cu. ft. has been found to possess an illuminating power of 16.5 candles when burned at the rate of 3½ cu. ft. per hour in a 15-hole argand burner. Air gas, besides being employed as an illuminating agent, is used in gas machines as a source of power.

Classification of the Burning Oils.—Following the light naphthas in the list of products obtained from the crude oil, we mentioned the heavy naphtha and extra heavy naphtha. Both of these may be caught together or they may be separated. If they are caught apart the heavy naphtha is usually redistilled and separated into benzine and light distillate, which latter together with the extra heavy naphtha are then mixed with the heavy distillate in varying proportions to form a burning oil, which is marketed under the general name of standard white oil. As most of this is manufactured for the foreign trade it is also known as export oil. The water-white oil, which, as before stated, is the middle fraction of the crude-oil distillation, and as the best portion is caught separately, when purified constitutes what is known as domestic oil. The many grades of burning oil known by special designations and copyrighted names are not materially different in anything except "fire test." They range in this respect from the lowest legal standards (which differ in different States and countries) to the highest which can be used to advantage for burning purposes.

While it is not possible to give in this connection a detailed account of how burning oils are tested, we may note that the term fire test is made to include two distinct tests. We may determine the point to which an oil must be heated in contact with air in order to produce a momentary explosion of the mixture of inflammable vapor given off from the oil with air. This is called the "flash point." Or we may determine the point to which an oil must be heated in contact with air in order to ignite and burn on the surface. This is the "burning point" and is from 6 to 20° C. higher than the flash test.

Manufacture of Vaseline from the Residuum.—The residuum, or "tar," which remains after taking off all the fractions which are to be utilized for burning oil, instead of being distilled for paraffine oil in the tar stills may be utilized at once in the manufacture of vaseline. The residuum which is to be used for vaseline manufacture, however, should be, if possible, that obtained in vacuum distillation, where the burning-oil fractions are drawn off without any cracking taking place. In this way it is possible to get a residuum of 0.897 (26° B.) or lower without any pyrogenic products being formed. The semi-solid separated paraffine which collects in the crude-oil tanks in certain oil districts—as at Bradford, Pa.—is also used in the same way for the manufacture of vaseline. The residuum, from whatever source, is passed through boneblack placed in steam-jacketed filters, or the battery of filters may be arranged in a room kept at a temperature of 120° F. by steam coils. The first portion of the filtrate is colorless and then it becomes pale yellowish and eventually of the reddish-yellow color characteristic of some crude oils. The finer portion is used in pharmacy and medicine as a basis of pomades, salves, etc., and in hospital practice under the name of petrolatum, of which a softer grade melting at 40–45° C. (104–113° F.) and a harder grade melting at 45–50° C. (113–124° F.) are prescribed in the United States Pharmacopœia. The dark-colored filtrate is used as a lubricant for heavy bearings under the name of "filtered cylinder oil."

Manufacture of Paraffine and Paraffine Oils.—In case the residuum is to go to the tar still for further distillation, it is often brought down to 19° B. (0.940 sp. gr.) in the crude-oil still before being transferred. The tar stills are smaller than the crude-oil stills and hold usually 250 bbls. Superheated steam is used to carry over the heavy vapors and to prevent dissociation of the oil, which would lower the viscosity of the lubricating oil and decrease the yield of paraffine. The first portion of the distillate is a lighter fraction, which is often redistilled or used with the burning oils; following this are the fractions containing the paraffine.

These may be separated according to the demand into several portions and the oils which remain after the expression of the paraffine used as neutral oils, heavy machine oils, etc. The oils containing the paraffine are treated with sulphuric acid and alkali, but at a temperature which prevents the paraffine scale from separating out. Following this purification the oils are chilled by artificial means so that the paraffine separates out as completely as possible. The pasty mass so obtained is pressed in canvas bags (or in some of the larger refineries in filter presses) first at a temperature of 40° F. and again after melting and crystallizing at 70° F. The paraffine scale so obtained may then be purified by fractional treatment with solvent naphthas and filtration through boneblack or other filtering medium. The product is the white paraffine wax. The oils which are pressed out from the scale paraffine constitute the lubricating oils of commerce, as they possess the elements of body or viscosity and freedom from separated paraffine even at low temperatures, which give them what is called a low "cold test."

Production of Products of Minor Importance.—If the distillation of the residuum in the tar still be continued to ultimate coking of the contents of the still, there comes over at a cherry-red heat a yellow wax of a resinous luster, which is clearly a product of destructive distillation, as it is mainly composed of hydrocarbons of the aromatic series. It contains anthracene or an isomer of the same and higher hydrocarbons, of which the one called thallene, a greenish fluorescent solid, has been somewhat studied. The yellow wax is used in the manufacture of insulating compounds for electrical uses and in the manufacture of lubricants of low cold test.

It has recently been found that if the residuum be distilled very slowly with a current of air kept passing through it, products are obtained which greatly resemble the natural asphalts. These artificial asphalts, as obtained by the methods of Byerley just described, can be made of all degrees of hardness from "liquid asphalt," so called, to solid products resembling gilsonite. They are perfectly soluble in carbon bisulphide and are adapted for roofing, paving, or varnish manufacture.

II. SIDE PRODUCTS OF THE PETROLEUM INDUSTRY.

Sludge Acid and its Working.—The sulphuric acid used in the treating of the oil forms a black tarry layer which settles out in a distinct layer under the oil. It is run off from the agitator and allowed to settle in open cisterns, when it separates into an oily layer and a heavier acid one. After skimming off the oil the dark impure acid may be evaporated and concentrated like lead-chamber acid, the black tarry matters present being destroyed at the temperature demanded by the concentration. This procedure is followed at the Whiting Refinery. Or by diluting it with from 3 to 4 volumes of water much more of the dissolved impurity separates out when it is concentrated to from 60 to 66° B. Often, however, the sludge acid, after skimming the oil from it, is sold without further treatment to the manufacturers of artificial fertilizers.

Gas Produced in the Distillation.—The uncondensable gas which forms at the beginning of the distillation, and still more abundantly during the cracking of the oil, is now collected by the aid of pipes leading off from the condensers and is utilized. The buildings and offices of the refinery are often thus lighted and a large saving of fuel is effected, moreover, by its use under the stills.

Coke and Petroleum Pitch.—The coke which remains in the tar still at the end of the distillation is as a rule black, lustrous, and more or less spongy in texture. It was used at one time very largely as fuel under the still, but is now usually sold to the manufacturers of electric-light carbons, for which purpose it constitutes a very satisfactory material.

III. DIRECT UTILIZATIONS OF THE CRUDE OILS.

Use of Crude Oil as Fuel.—The application of crude oil for fuel purposes was tried many years ago in this country, and at Titusville, Pa., it was used for quite a time in the Eames process for melting and working scrap iron. With the discovery of natural gas, however, this latter was found to be more economical for fuel purposes than Pennsylvania oil.

The production of large quantities of Lima oil, at first considered useless for the manufacture of burning oil, again drew attention to the utilization of oil fuel. This Ohio oil was sent by pipe line to Chicago and other manufacturing points and shipped in bulk by the tank cars of the Manhattan Oil Company to many Eastern cities, where it was sold at a price which allowed it to replace coal for many industrial uses. Burned with the aid of an injector burner, it is capable of developing a high temperature and is under a more perfect control than is possible with solid fuel. Used in this way it has been found that 1 lb. of the crude oil will do the work of at least 2 lbs. of coke or charcoal. Another statement, based on the experience of the Chicago cable roads, is that 70 bbls. of the oil, weighing 288.54 lbs. to the barrel, or 10.1 tons, have proved the equivalent of 28 short tons of coal. The Lima oil has found successful application in rolling mills, potteries, cement and terra-cotta works, and a variety of other industries where a high heat is required which shall be kept for considerable periods without variation. The figures furnished by the Standard Oil Company for 1891 illustrate the development of this use of fuel oil:

	Barrels.
Sales of Lima oil for fuel purposes by the Standard	4,994,625
Sales of Lima oil residuums by the Standard	2,314,648
Consumed by the Standard Oil Company itself	1,252,655
Delivered by other parties	1,997,071
Total	10,558,999

Use of Crude Oil for Gas Making and for Carbureting Water Gas.—Oil gas is made to be used for illuminating purposes directly or for the purpose of admixture with coal gas and water gas. It is also employed as a source of power in gas engines. In the manufacture of oil gas the oil is slowly delivered into a retort heated to cherry redness and is thus converted into permanent gas. The illuminating power of the gas depends upon the temperature of the retort, more gas being obtained when the retort is highly heated, but the product being of lower lighting value. The two forms of retorts used for oil gas which have been most successful are the Pintsch, which is used for making gas for buoys, lighthouses, and railroad cars, and the Keith, which has been chiefly used for the production of gas for motors on the large scale.

In this country the manufacture of carbureted water gas has assumed large proportions. It is stated on the authority of the United Gas Improvement Company, which controls the more important water-gas processes, that of the 60,000,000,000 cu. ft. of illuminating gas made in the United States and Canada daily, two-thirds consist of carbureted water gas. The two forms of apparatus in general use at the present time are those of Lowe and Humphrey. In them the oil is introduced in a fine spray at the top of the water-gas generator and is immediately vaporized, so that the mixture of water gas and vaporized oil passes together into the superheater. Here the contact with the highly heated checkerwork of brick changes the vapors into permanent gases, which become thoroughly admixed with and constitute from this time on a part of the water gas.

In the best constructed and managed forms of apparatus from 3 to 4 gals. of crude oil suffice to carburet 1000 cu. ft. of gas. In many cases, however, 6 gals. or more are used with no better effect.

Use of the Natural Separated Paraffine of Crude Oil for Vaseline Manufacture.—In certain of the crude oils, such as those from Bradford, Pa., much paraffine of buttery consistency separates out in the storage tanks, in the pipe lines, and may even be scraped from the derricks and pumps. This natural paraffine is an excellent material for the manufacture of the vaselines of higher melting point. The method of filtration is that described under residuum.

The natural paraffine from Utah, known as ozokerite, is much harder and is adapted for other uses, such as the manufacture of insulating compositions, ozokerite candles, etc.

The Manufacture of Ceresine from Ozokerite.

By Norbert Fraenkel.

Galician ozokerite is repeatedly melted in open kettles over direct fire, each time with a little water, to allow its earthy contents to settle to the bottom, then drawn off or poured into conical molds, and after cooling turned out of these. In this form crude wax is sent to ceresine and paraffine factories, where it is carefully melted over direct fire in large open kettles with cast-iron bottoms and heated to 120° C. until the striking and foaming caused by the water, which is present to the amount of from 1½ to 4½% in the wax, have entirely ceased, when the wax is free from water and from the light oils which are collected in a receiver prepared with lime, by means of a ventilating arrangement connected with the chimney. These are afterward utilized in the distillation of ozokerite for paraffine. Strong or fuming sulphuric acid or a mixture of both is then gradually added to the crude wax through a leaden sieve in a very fine stream, and while stirring the melted wax continually by means of a paddle or a steam stirrer. The temperature of the wax must not fall below 80° C. After the whole of the acid necessary for refining has been added, the temperature is gradually raised to from 180 to 190° C. by increasing the fire under the kettle, stirring all the time. Sulphuric acid takes up the resinous contents of the crude wax, which forms black lumps, which are disintegrated by stirring at high temperature and copious quantities of sulphur dioxide gas are evolved and finely divided carbon remains. The heating process is continued from 7 to 10 hours until there is no more smell of SO_2. The temperature of the contents of the kettle is then lowered to 140° C., and in order to bleach the wax, carbonaceous residue of the manufacture of potassic ferrous cyanide is gradually added until a filtered sample yields clear ceresine of the desired quality. Bleaching lasts usually from 1½ to 2 hours. The contents of the kettle are finally left at rest for a few hours to settle the residue.

It is impossible to obtain white ceresine from crude wax by a single agitation with chemicals, because the large amount of acid necessary for refining destroys a part of the crude wax, turning it yellow. The white qualities are made from white-yellow or yellow ceresine, or preferably from wax gotten by extraction of residues left by the hydraulic press by means of benzine (petroleum naphtha). The amount of each chemical used depends on the quality of the ozokerite and on the color of the ceresine, which indicates its degree of purity. The value of crude wax is judged by its melting point and by the laboratory method of Dr. B. Lach, which method is a copy of the manufacture on a large scale. There are at least three kinds of discoloring powders, black, gray, and the so-called red ones. Gray and red bleach at 140° C. and neutralize the acidity of the wax, while the black powder is an excellent bleaching agent only at temperatures from 80 to 100° C. The value of different kinds of powder is judged by the discoloring effects obtained by them with yellow or white-yellow ceresine under equal conditions.

The following table shows the proportions of acid and powder required in preparing different grades of ceresine:

	Per Cent. Acid.			Per Cent. Powder.		
	Strong.		Fuming.	Gray.		Black.
Yellow IV. from crude wax requires..........	15	or	13	10	and	3
White-yellow III. from crude wax requires.........	28			15	and	3
White II. from yellow IV. requires....	26			9	and	3
White II. from white-yellow III. requires...........	20	or	10	10	and	5
White I. from white-yellow III. requires............	10	and	10	18	and	2
White-yellow III. from extracted wax IV. requires.	9	and	9	11	and	2
White II. from extracted wax IV. requires.........	10	and	10	15	and	3
White II. from extracted wax III. requires			8	11	and	4

This table shows that fuming acid has a much stronger refining effect than ordinary acid, because it contains more SO_3 and less H_2O, and in practical application 100 parts of it produce greater effect than 110 parts of strong acid, as it should theoretically. Fuming acid has for some kinds of ozokerite and colored ceresine a refining power, which is one and a half and two times that of ordinary acid.

After the powder has settled at the bottom (which is ascertained by means of a wooden rod dipped in carefully), the upper part, which is liquid ceresine, is drawn off or poured into heated steam-jacketed tanks, to keep it hot for filtration. From these it goes into filters of sheet iron covered with paper and also heated by steam. The filtrate is already pure ceresine.

The lower part of the contents of the kettle, a thick grayish-black mass, is also heated in jacketed tanks, and is run into bags and pressed between steam-heated iron plates in a hydraulic press to 150 to 300 atmospheres pressure. The material pressed out runs into a pit laid out with cement and heated by steam, and from there it is poured into the filters. The press residue remaining in the bags contains from 40 to 60% of ceresine. While warm it is rubbed through a sieve to prevent the formation of hard lumps, which are inconvenient in the next extraction. The sieved pressed residue and used-up filter paper now go into the extraction house, where they are mixed well with dry sawdust, a loosening material, and put in an extractor of Merz or Van Hecht and treated with warm benzine at the boiling point from 60 to 90° C. A complete extraction requires a press residue which is dry and finely powdered, dry sawdust, a thorough mixture of both, and sufficient benzine in the extractor to entirely cover this mixture. The fact has to be borne in mind that fresh residue III. absorbs on the average 83½% benzine, dry sawdust 219%, and their mixture in the proportion of 5 to 1 absorbs 118% benzine, 5 to 1½ absorbs 140% benzine, 5 to 2 absorbs 143% benzine, and 5 to 2½ absorbs 150½% benzine. The extracted wax and press residue is freed from benzine by means of live steam; and with a good condenser the loss of benzine is small. The whole operation for a charge of 1000 kgms. residue and for 5 to 6 barrows sawdust per apparatus lasts from 8 to 12 hours. To separate the extracted wax from water, it is drawn off into steam-heated tanks and it is then ready for refining.

The total yield of ceresine from crude wax averages about 85%, but it is possible to increase it to 90% or more by diluting the crude wax with a solvent like paraffine scales or German soft paraffine, which protects it from a too violent action of acid. Refining must be done at a lower temperature (80–90° C.) than usual. Paraffine-ceresine obtained in this way has naturally a lower melting point than ordinary ceresine, and the latter in general has a higher melting point than the crude wax from which it was made, caused by a loss of volatile oils.

To make ceresine non-transparent like beeswax, it is stirred with paddles while melted until it solidifies almost entirely and is immediately poured into molds. The non-transparency and lighter shade of the wax are caused by the finely divided inclosed air-bubbles. Ceresine turns darker in the air, especially when exposed to light, and to restore its original tint it must be melted and mixed with 2% of black powder.

Ceresine is mixed with paraffine or the so-called "mineral lard"—a by-product of distillation of ozokerite—to make candles, waxed paper, and cloth finish. It is dyed with vegetable or aniline colors and hardened with carnuba wax to make colored crayons, and mixed with resin or turpentine to make floor wax.

Some Costs of Manufacture of Ceresine.—Ozokerite at the mines in Galicia brings the following prices: 100 kgms. ozokerite of melting point 83 to 84° C., 33 florins; 71 to 72° C., 28½ florins; primissima, 68 to 69° C., 28¼ florins; medium, 22 florins; secunda, 22 florins; "Truskawiec" (at Boryslaw), 23 florins. Sulphuric acid 66° B., 100 kgms. cost at Vienna 8 to 10 florins; at Triest, 11 to 20 florins. Benzine for extraction, 100 kgms. cost at Bremen 32 marks (18 to 19 florins). Unskilled laborer is paid 60 to 80 kreutzers per day; foreman, 2 to 2½ florins per day.

The refined product sells in Galicia as follows: Ceresine, per 100 kgms. primissima, 62 florins; prima, 58 florins; secunda, 54 florins; tertia, 53 florins; yellow prima, 49 florins; yellow secunda, 48 florins; natural yellow, 50 florins. Residues for extraction sell at 43 to 44 florins per 100 kgms. Prices in Vienna are from 4 to 6 florins higher per 100 kgms. than those in Galicia.

PHOSPHATES.

The phosphate industry in the United States during 1895 suffered from low prices, which were the result of the increasing competition of the Algerian phosphate beds and of the remarkable increase in the use of slag from the basic process in Europe as a source of supply of phosphoric acid for the manufacturers of fertilizer. Thomas slag, as it is called commercially, has become an important article of trade and produces an increasing return to the steel manufacturers of Belgium and Germany. It has reduced the demand for phosphates to a considerable extent, or at least has prevented the normal growth of demand from influencing the trade.

The following table shows the shipments from the mines in the United States for the five years ending with 1895:

PHOSPHATE SHIPMENTS OF THE UNITED STATES.

Year.	South Carolina. Long Tons.	Florida. Long Tons.	North Carolina. Long Tons.	Tennessee. Long Tons.	Total Long Tons.	Value.	
						Total.	Per Ton.
1891	572,949	181,316	....	....	754,265	$4,608,559	$6.11
1892	548,396	354,327	6,000	....	908,723	3,354,098	3.68
1893	556,883	426,432	7,500	....	990,815	3,467,853	3.50
1894	493,800	558,990	9,000	17,384	1,079,174	3,291,481	3.05
1895	515,734	530,356	7,500	45,329	1,098,919	3,296,757	3.00

The South Carolina production shows a recovery from the depression of 1894, when the output was seriously interfered with by the destruction of several of the river mining plants by a storm. The Florida production showed a slight decline, and the industry was hardly a profitable one. A movement was begun toward the close of the year to shut down a number of the mines. So far, however, this has not succeeded, as it has been impossible to secure concerted action on the part of all the producers. In Tennessee the operations in the phosphate district have been considerably extended and the production increased. Although its amount is not yet very large, the prospect is for a still further growth. The work done in the Tennessee phosphate mines is fully described below. In North Carolina there was little change in the production, which is small.

Outside of Tennessee no new phosphate deposits were opened in this country. The Geological Survey of Alabama has made some examination of the phosphates of that State and reports the existence of several well-defined beds, the chief in importance being the Hamburg bed, in Perry County, which extends nearly all acros the State, although only at one or two points have the contents of phosphate of lime been ascertained to be sufficiently large to be of importance. The Coatopa bed, in Sumter County, has been traced for some distance, while the Snow Hill bed, which has been identified in Wilcox and Marengo counties, carries a higher percentage of phosphate of lime than either of the others and holds out more promise of commercial value than any other examined in the State. Deposits have also been distinguished at Sucarnochee, Wilcox County, where coprolites have been found in the prairie clay. At Manafalia concretions rich in phosphoric acid have been found imbedded in green sand, while a similar occurrence has been noted at Claiborne, Dale County. No mining has been carried on in any of these phosphate beds.

In Pennsylvania a discovery of phosphate rock was reported in the neighborhood of Reed's Gap, Juniata County. The belt in which the discovery was made is found at the foot and on the flank of a low ridge formed by the Oriskany sandstone resting on the lower Helderberg limestone. Specimens taken at several points have shown a high percentage of phosphate of lime. From preliminary investigations made it is believed that the phosphate rock can be cheaply mined and may prove to have a considerable commercial value. Further investigations are being carried on under charge of the Agricultural Experiment Station at the Pennsylvania State College.

The Canadian product in 1895 was small, the total amount reported being 1822 tons of apatite.

The Algerian production has increased very rapidly. The reported production from the Tebessa mines, which was only 6162 metric tons in 1893, rose to 53,224 tons in 1894 and to 136,591 tons in 1895. The distribution of the Algerian phosphates is shown in part by the following table, giving the shipments from the port of Bone during 1895. This statement of course does not include the quantity consumed in Algiers or the stock retained at the mines:

SHIPMENTS OF ALGERIAN PHOSPHATES FROM THE PORT OF BONE.

Shipped to—	Metric Tons.	Shipped to—	Metric Tons.	Shipped to—	Metric Tons.
France	34,835	Austria	8,645	Switzerland	1,550
Italy	16,395	Belgium	3,015	Other Algerian ports	420
Germany	7,710	Spain	555	Total	111,995
England	37,870	Holland	1,000	Value	$781,971

The development of the Tunis phosphates has been temporarily stopped by trouble in regard to the concessions which had been granted to two English companies; owing to some irregularities they were revoked by the French government, and pending a further investigation no further grants have been made.

The shipments of phosphate rock from French Guiana amounted in 1895 to 4210 metric tons, a decrease of 2166 tons from the preceding year. These deposits are found on the island of Grand Connétable, and it is reported that the shipments can be considerably increased if required.

Prices of Phosphates in Europe.—There are two grades of the Algerian phosphates recognized: the high-grade rock, carrying from 63 to 68% phosphate of lime, and the lower grade, from 55 to 63%. The average price in Europe for the first quality during the year 1895 was 6½d. (13c.) per unit of phosphate of lime per long ton of 2240 lbs. For the lower grade the average price was 6d. per unit of phosphate of lime, all prices being made f.o.b. shipping port. The closing prices of the year were lower than this average, and so far during the current year they have been still lower. Florida phosphates have sold in Europe at from 5¼ to 5¾d. per unit during the current year, these being high grade or 68% rock.

Tennessee Phosphates.—Mr. Lucius P. Brown, mining engineer, reports that the year just past has been characterized in Tennessee by continued development of the field in the face of powerful obstacles, among which the old question of transportation has been probably the most formidable. In this, however, very notable progress has been made. The Swan Creek Phosphate Company has built a narrow-gauge road about 4 miles long from a point on the Nashville, Chattanooga & St. Louis Railway to its mines on Haw Branch, a small stream running into Swan Creek from the west. It is the intention to extend this road across Swan Creek to the Blue Buck mines. A broad-gauge track has been built from Centerville 3 miles along the bank of Duck River to the mouth of Swan Creek. The Duck River Phosphate Company will in future run its barges only to this point and not, as heretofore, to Centerville. During the year the Tennessee Phosphate Company also constructed 4½ miles of narrow-gauge track from Ætna Furnace to its Nunn mines. From the miners' standpoint, probably the most notable development is the regular operation of underground workings. These have been carried on for almost the whole year, and the greater part of the rock mined has been won in this way.

An approximate cost estimate for an average mine and for stripping operations follows. Of course circumstances unfavorable or the reverse to the miner will influence these figures, but it is believed that they are not far from the truth under normal conditions. They include cost of breaking, and since a great deal of rock is shipped uncrushed, this charge may often be deducted.

APPROXIMATE COST PER LONG TON.

Output per Diem.	Labor, Including Dead Work, etc.	Supplies, Mine Timbers, etc.	Superintendence, Interest, Clerks, Repairs, etc.	Breaking to 2-in. Size.	Total Cost on Board Cars or Wagons at Mines.	Stripping.
Forty to 50 tons	$0.92	$0.07	$0.40	$0.15	$1.54	....
Eighty to 100 tons	.91	.06	.25	.15	1.37	....
Fifty to 60 tons	.72	.05	.40	.15	1.32	....

The total developments in the field besides the railroads mentioned above are as follows:

The Southwestern Phosphate Company has a mill building at the mouth of Falls Branch containing 60 horse-power engine, McCully crusher, and Sturtevant mill, besides houses for their workmen, commissary, etc. The company has done a considerable amount of stripping and a good deal of entry work.

The Duck River Phosphate Company has several hundred feet of entries, with a plant of ten Rand drills, air compressors, etc., and mine equipment of mine cars, tracks, etc. At Centerville is located the mill with Gates crusher, drying room, and incline hoist. To these must be added steam towboat and barges, for transporting rock on Duck River from mines to crusher.

The Swan Creek Phosphate Company has during the past year acquired a good property on Haw Branch, on the west side of Swan Creek. This property is now leased to Mr. H. I. Arnold. Developments consist of a large amount of stripping, some entry work, and mine equipment of cars, etc. The McCaleb mine of the same company is under lease to the Blue Buck Mining Company (office at Centerville), and developments are a crusher, entry work, mine equipment, and houses for men, etc.

The Tennessee Phosphate Company's developments consist of much stripping and entry work, mine equipment, and houses for men and officials. This company went into the hands of a receiver in September and its mine is still shut down.

The Hickman Phosphate Company and the Standard Phosphate Company, both of Centerville, and the Lewis County Phosphate Company of Ætna began work during the year. The mines of the first are on Persimmon Branch and Swan Creek and of the third on Upper Swan, near the Marshfield property of the Tennessee Company. The developments of all these consist only of stripping and a small amount of entry work.

The amount of rock stripped during 1895 was 45,329 long tons, valued at about $117,855. All this was for domestic consumption, except a trial order of 500 tons for Germany. No special effort has been made to sell abroad, both on account of the low prices prevailing on the other side and because there has been no difficulty in placing all the orders the miners cared to take in America. While, as may be seen from the cost figures given above, the margin of profit at present prices is not a very large one when the wagoning to rail is added, nevertheless the business is a sure one, and prices may be expected in the future to improve. The elimination of the wagon haul would do much to improve matters.

Marls.—Nothing new is to be reported with regard to the marls of New Jersey in 1895. The production is estimated at about 110,000 tons, or the same as in 1894. It is difficult to obtain the exact statistics of the output, as many of the marl beds are worked by the farmers for their own use and very few are shippers. The marls of New Jersey are taken from the belt running nearly across the State from Raritan Bay through Monmouth and Ocean counties and part of Burlington County to the Delaware River, the principal production being in Monmouth County.

The Agricultural Department of North Carolina has continued to draw the attention of the people of that State to the value of its marls, which very much resemble in composition and quality those of New Jersey. These representations are having some effect and an increasing use of this fertilizer is reported.

The Geological Survey of Alabama has investigated the marls of that State in connection with the phosphates, and reports that the green sand and calcareous marls exist in beds of considerable extent and thickness, and that their quality is fully equal, if not superior, to that of the New Jersey marls, as analyses show a somewhat higher percentage of phosphoric acid. Experiments are now being made on the use of the Alabama marls as fertilizers.

PYRITES.

The production of pyrites in the United States in 1895 showed a decrease of about 24% from that of the preceding year, although the total consumption increased. The output of the year was smaller than any which has been recorded for six years past. The following table shows the production, imports, and approximate consumption for the five years ending with 1895. The statistics for previous years will be found in Vols. I., II., and III. of The Mineral Industry:

IRON PYRITES INDUSTRY IN THE UNITED STATES.

(In tons of 2240 lbs.)

Year.	Production.		Imports.		Consumption.	
1891	109,319	$317,280	130,000	$400,000	239,319	$717,280
1892	106,250	357,000	210,000	630,000	316,250	987,000
1893	95,000	285,000	194,000	582,000	289,000	867,000
1894	107,462	466,466	146,023	590,905	253,485	1,057,371
1895	81,000	353,160	190,436	673,812	271,436	1,026,972

The chief producers of pyrites are the mines of Louisa County, Va., and those of the Davis Pyrites Company in Massachusetts. A small quantity is also furnished from mines in South Carolina. No new producers made their appearance during the year, although arrangements have been made to open one or two large deposits in Northern Georgia.

The chief use made of pyrites is in the manufacture of sulphuric acid. Several causes existed for the light production in 1895. One of these was the low prices of sulphur during the year, which made it in many cases more economical for the manufacturers to use brimstone in making their acid. A second cause was the comparative cheapness of the imported mineral. As most of the deposits in this country are situated some distance from a market, and as pyrites from Spain, Newfoundland, and elsewhere can be delivered by sea at different ports along the coast at very low rates of freight, in many cases they can be sold at lower prices than our own miners can make. Another minor cause was the comparative dullness of the fertilizer industry, which is a large consumer of acid.

Deposits of pyritic ores are very abundant in the Appalachian region extending through Southwestern Virginia, North Carolina, Georgia, and Alabama, and if the cost of transportation could be reduced the supply can be enlarged almost indefinitely. A good deal of exploration has been going on recently in Virginia, and some large deposits have been located; several of these will probably be worked whenever the market conditions permit.

There was no material change in prices during the year, nor is any possible under present conditions. The price of pyrites delivered was at the close of the year about 10c. per unit of sulphur for ores delivered at consuming points. The price at the mines of course varies according to their location and the cost of freight on the ore.

Pyrites in Alabama and Georgia.—According to W. M. Brewer, no progress was made in the development of properties in Georgia and Alabama on which large deposits of iron pyrites are known to occur. These deposits follow a line along the northwestern border of the crystalline schist, and in a formation which has been described as belonging to the semi-crystalline slates, but recent examinations have resulted in demonstrating that this rock is an altered eruptive. These examinations, though, are to be followed by others, because many of the best-known geologists are not fully convinced that the rock is not, in part at least, metamorphosed sediment.

The deposits of iron pyrites have been discovered as far south as Dollar, Coosa County, Ala., where the thickness of the body carrying finely granulated pyrites averages about 4 ft. Another deposit occurs near Hatchet Creek, Clay County, where the pyrites have a more massive structure and would probably be considered a desirable ore for use in sulphuric-acid plants constructed for burning lump pyrites. So far as the work on other deposits in this zone to the northeast has determined, the ore has the same granulated structure as that in Coosa County, and consequently is in little demand.

There are a series of deposits occurring in another zone to the southeast of that just mentioned; this is in the belt of country which several years ago produced some copper. So far as at present known there are only three occurrences in this belt. One of these is in Lumpkin County, Ga., and the other two in Randolph County, Ala. At the first named quite extensive exploration work was done in 1894, and some 200 tons of the ore were tested by the Scott Manufacturing Company in Atlanta. The results were satisfactory, but owing to the distance from railroad transportation work was suspended and the company commenced negotiations for the construction of a railroad from Lula Junction to Dahlonega. The other occurrences on this belt are also located about 20 miles from the nearest line of railroad, and no attempt has been made to utilize the ore since 1877.

QUICKSILVER.

THE production of quicksilver in the United States in 1895 showed a substantial increase over that of the preceding year. An increased demand and better prices gave a stimulus to the industry which was wanting in 1894. The total output was 35,122 flasks, of 76½ lbs. each, and the increase shown was 4682 flasks, or 15.1%.

California is the only State in which this metal is now produced. The discoveries of deposits of cinnabar in Texas and in Colorado which were reported some years ago have not resulted in any output from those States.

The following table, for the figures in which we are indebted to the Hon. James Butterworth Randol, of San Francisco, gives the production of the various mines for 1895, to which we have added, for purposes of comparison, the figures from the same mines in 1894 and 1893. The full statistics for earlier years will be found in previous volumes of THE MINERAL INDUSTRY:

QUICKSILVER PRODUCTION IN CALIFORNIA.

Month.	New Almaden.	Napa Cons.	Mirabel	Ætna.	Great Western.	Great Eastern.	Sulphur Bank.	New Idria.	Altoona	Abbott, Lake, and Redington.	Totals.
	Flasks.	Flasks.	Flasks.	Flasks.	Flasks.	Flasks.	Flasks.	Flasks.	Flasks.	Flasks.	Flasks.
January	725	540	299	265	500	130	....	65	145	120	2,789
February	640	410	405	270	377	132	....	65	26	120	2,445
March	620	450	440	310	460	153	....	60	48	120	2,661
April	660	400	335	335	387	187	....	60	108	120	2,592
May	410	490	400	295	386	160	....	150	154	120	2,565
June	480	590	385	215	425	185	17	80	475	120	2,972
July	500	450	345	240	435	205	183	85	728	120	3,291
August	800	450	295	360	354	130	220	85	352	120	3,166
September	600	400	300	360	379	122	306	90	289	120	2,966
October	660	425	220	270	344	167	549	100	426	120	3,281
November	560	315	225	160	283	106	449	100	591	120	2,909
December	500	610	280	300	255	136	530	110	584	180	3,485
Totals, 1895	7,155	5,530	3,929	3,380	4,585	1,813	2,254	1,050	3,926	1,500	35,122
Totals, 1894	7,235	4,930	4,229	3,575	5,341	1,368	348	1,005	....	2,409	30,440
Totals, 1893	6,614	6,120	5,211	3,795	3,187	1,445	1,200	869	....	1,723	30,164

None of the mines dropped out of the producing list during the year. On the contrary, the Lake, which reported nothing in 1894, was at work again in 1895, and the Sulphur Bank, which turned out very little in 1894, resumed work in June and gradually increased its output to over 500 flasks a month. In the other mines there were no changes of importance.

The Texas discoveries above referred to are in the mountain region of Western Texas, not far from the Rio Grande and about 90 miles from Marfa, on the Southern Pacific Railroad. The explorations so far made show outcrops of cinnabar at several points, but no attempt has yet been made to determine their extent, no shafts have been sunk, nor has any mining work been done.

The United States is almost the only country which has increased its mercury output during recent years. It is now the largest producer with the exception of Spain. In 1894 it furnished about one-fourth of the world's supply, while in 1895 the proportion had increased to nearly one-third.

The following table shows the quicksilver production of the world for the five years 1891–95, inclusive. For the years prior to 1891 the statistics can be found in THE MINERAL INDUSTRY, Vols. I., II., and III.:

QUICKSILVER PRODUCTION OF THE WORLD, IN METRIC TONS.

Year.	Austria.	Italy.	Mexico.	Russia.	Spain.	United States	Totals.
1891	570	330	....	324	1,665	794	3,683
1892	542	325	....	343	1,682	971	3,863
1893	511	273	....	367	1,672	1,047	3,870
1894	521	258	268	196	1,653	1,056	3,952
1895	....	....	160	....	1,484	1,219	....

American, Russian, and Italian flask, 76.5 lbs. (34.7 kgs.); Mexican flask, 75 lbs. (34.03 kgs.); Spanish flask, 76 lbs. (34.5 kgs.).

While there has been some variation in different countries, this table shows only very slight changes in the total production, which seems to remain about the same, the gains in one country being almost exactly offset by the losses in others. The same thing may be said of the demand, which seems to vary little from year to year.

The most important use of quicksilver is in the treatment of gold and silver ores by amalgamation. The increase in gold mining might be expected to extend the use of the metal were it not that gold and silver ores are now being smelted much more generally than formerly, and there has also been an important extension in the use of the chlorination and cyanide processes of treatment.

In the arts quicksilver is used in the manufacture of vermilion, a pigment which is in considerable demand, and this is the most important consumption outside of the mining industry. A small quantity is used in making mirrors, etc., and some also in medicines; but these items are almost insignificant in amount and vary little from year to year. The condition of the industry in the producing countries is given in the following notes:

Austria.—The quicksilver production, which comes from the Idria mines, has not varied much during the past five years. In 1894 it was slightly greater than in the preceding year, but less than in 1892. A small quantity comes from the Hungarian mines. Some addition to the Austrian production is expected from the cinnabar deposits of Gratwein-Eisbach, in Styria. These were discovered in 1830, and their exploration was undertaken by M. Mayr, of Leoben; under his direction shafts were sunk at several points and the mineral was found over a considerable area. The work was prosecuted very slowly and continued until 1848. Arrangements had then been made to put up reducing furnaces, when the sudden death of the proprietor stopped all work. The mines were closed until 1892, when a new company was organized and obtained a concession. Since then the old workings have been cleared out and extended, with satisfactory results. The erection of a reducing plant has been begun.

Italy.—The Italian production seems to be decreasing gradually. No new discoveries have been reported in recent years and the mines have been diminishing in productiveness slowly. The Italian product is chiefly exported to Great Britain, only a small part being consumed in the country. The mines of Castellazara and Ripa, in Tuscany, and of Vallalta, in Venetia, are among the important producers of this metal in Italy.

Mexico.—There are three producing mines in Mexico: the Huitzuco, owned by Señor Romero Rubio; the Guadalcazar, owned by the Guadalcazar Quicksilver Mining Company, an English concern; and the Nueva Potosi, owned by a company of the same name. In 1895 the Nueva Potosi reported a production of 941 flasks. The Guadalcazar reported 945 flasks, a large decrease from 1894, because the work in 1895 was on exploration and new development, which had been neglected for some time. The Huitzuco mines, which reported 4060 flasks in 1894, did not vary much from that amount in 1895. Quite recently a discovery has been reported in the State of Guerrero, not far from the Huitzuco Mine, which will be of importance if the deposits are as large as the preliminary explorations indicate. Arrangements are now being made for their development.

Russia.—The Russian production showed a decrease in 1894, but it is understood that there was a considerable improvement in 1895, though exact figures for the year cannot be obtained. The improvements made at the Auerbach works in the government of Ekaterinoslav enabled those works to increase their output. The deposits of cinnabar discovered in the Caucasus two years ago are not producers as yet, though a number of concessions to work them have been granted. These deposits are in the province of Daghestan, on the left bank of the Isamur River, near Hapza, and they are said to be of considerable extent. Some discoveries of cinnabar have also been reported recently in the Trans-Caspian territory.

Spain.—In the Almaden mines, which furnish over 90% of the total output and which are owned by the government and the output controlled by the Rothschilds, the most important event noted during the year was the vote by the Cortes of the necessary appropriation to buy a mechanical drill plant to hasten the work of exploration and development in gallery No. 12. The Almaden furnaces were closed down through the hot season, as usual. They were operated six months in all and the total production was 40,669 flasks of 34.5 kgs. (76 lbs.) each; a decrease of 3852 flasks as compared with 1894.

The total production of Spain in 1895 is given by Señor Roman Oriol in the *Revista Minera* at 43,000 flasks. This is a decrease of 4900 flasks as compared with 1894 and is the smallest output for five years past. Of the total in 1895 the Almaden mines furnished 40,669 flasks; the Porvenir mines 1260 flasks; the remaining 1071 flasks coming from La Soterrana and the mines of La Union Asturiana.

The Sociedad el Porvenir at Mieres, Asturias, reported for 1895 a total of 450 lineal meters of drifts completed. The total excavation was 2253 cu. meters of rock, from which there was obtained 7771 tons of ore. Of this ore 6876 tons were treated in the furnaces, leaving 895 tons on hand at the close of the year. From the ore treated the company obtained 1016 flasks, or 35,059 kgs., showing an average yield of 5.10%. In addition to this the company treated 266 tons of arsenical residues in its furnaces, from which it obtained 244 flasks, or 8419 kgs., bringing the total up to 1260 flasks, or 43,478 kgs., of quicksilver.

THE QUICKSILVER MARKETS IN 1895.

San Francisco.—The market during 1895 showed an acceptable recovery from the extreme low prices and depression of 1894 and the average quotation was over $5 per flask higher, though the supply was increased, the better demand for the metal being marked. The increased activity in gold-mining operations in California and the adjoining States explains these conditions.

The following table shows the range of prices in San Francisco for the years 1893–95, inclusive, and also for each month of 1895. The quotations are per flask of 76½ lbs., which is the customary market unit for this metal:

RANGE OF QUICKSILVER PRICES PER FLASK, SAN FRANCISCO.

Month.	Highest	Lowest	Month.	Highest	Lowest	Month.	Highest	Lowest	Year.	Highest	Lowest
January..	$37.00	$36.00	May	$41.00	$38.50	September.	$41.00	$37.00	1895...	$41.00	$35.90
February	37.00	35.90	June....	41.00	41.00	October....	41.00	40.00	1894...	37.00	27.50
March....	37.00	36.00	July	41.00	39.50	November..	41.00	40.00	1893...	43.50	30.00
April.....	38.50	36.50	August.	41.00	39.50	December..	41.00	40.00			

The range of prices for the year 1895 was more even than in 1894 or 1893. The general tendency for the year was upward, and the close in December showed the highest price of the year. The lowest price quoted is considerably above the lowest figure of either of the preceding years named. It must be understood that the prices quoted are for the home market, and that a discount varying in amount and occasionally as high as $2 or even $2.50 per flask is made on sales for export.

San Francisco handles by far the greater part of the California production. The receipts reported at San Francisco in 1895 were 31,024 flasks, or 88.3% of the total output. The receipts in 1894 were 25,717 flasks, and in 1893 they were 24,227 flasks. Shipments from San Francisco by water in 1895 were 18,377 flasks, but of this amount 14,000 flasks were to New York, leaving the actual exports for the year 4377 flasks. The chief foreign trade in Californian quicksilver is with Mexico, and that country in 1895 took 3987 flasks, or 91% of the total. In addition to the water shipments a considerable amount is sent to Mexico by rail. Some quicksilver is sent to British Columbia and a little to Australia and Central America; but these shipments are of small importance with the exception of the British Columbia business, which is increasing with the growth of the mining industry in that country.

The export of quicksilver to China, which was at one time a considerable trade, has apparently ceased altogether. The shipments to China and Japan were 3800 flasks in 1893 and 2000 flasks in 1894; in 1895 none was recorded.

The total exports of quicksilver from the United States in 1895, as reported by the Bureau of Statistics of the Treasury Department, were 15,542 flasks, against 14,407 flasks in 1894. No imports are reported for 1895.

New York.—The following table shows the range of prices of quicksilver in New York during 1895. The prices given are per flask of 76½ lbs.:

RANGE OF QUICKSILVER PRICES PER FLASK, NEW YORK.

Month.	Highest.	Lowest.	Month.	Highest.	Lowest.	Month.	Highest.	Lowest.
January	$36.00	$36.00	May	$40.00	$38.50	September	$39.25	$39.25
February	36.00	36.00	June	41.00	40.00	October	40.00	38.50
March	36.00	36.00	July	41.00	40.00	November	40.00	40.00
April	38.50	36.00	August	40.00	39.25	December	40.00	40.00

Highest for the year 1895, $41.00; lowest, $36.00.

The course of prices in New York is governed entirely by that in the London market, the price being based on the London quotation plus the duty. The market in New York is not an especially active one.

London.—The following table shows the range of quicksilver prices in London for the five years 1891–95, inclusive. For the years prior to 1891 the statistics will be found in THE MINERAL INDUSTRY, Vols. I., II., and III. The figures for imports, exports, and prices are in flasks of 76½ lbs. each:

QUICKSILVER MARKET IN LONDON.

Year.	Supply in United Kingdom.			Price of Spanish per Flask.	
	Imports.	Exports.	Consumption	Highest.	Lowest.
	Flasks.	Flasks.	Flasks.	£ s. d.	£ s. d.
1891	61,884	55,884	6,000	9 0 0	7 5 0
1892	56,203	49,939	6,264	7 15 0	6 1 0
1893	51,797	37.478	14,319	6 17 6	6 2 6
1894	51,250	43,598	7,652	6 15 0	5 10 0
1895	49,658	36,826	12,832	7 7 6	6 7 6

The difference between imports and exports of course represents the consumption in the United Kingdom approximately. The variations shown are equalized by the stocks carried over from year to year. The average for the five years given in the table is 7413 flasks; that is, the consumption may be put down at from 7000 to 7500 flasks yearly.

The lowest price of 1894—£5 10s. per flask—is the lowest quotation for quicksilver on record in the London market. The prices for 1895 showed a substantial recovery from the low range of the preceding year.

The London market is supplied chiefly from the Spanish and Italian mines, though some metal from the Idria mines in Austria also finds its way there. The Spanish product is almost all marketed in London, whatever its ultimate destination may be. Both imports and exports in Great Britain have been gradually declining, not on account of decreasing production, but because there has been an increase in the amount shipped directly from the mines to the place of consumption.

Treatment of Quicksilver Ores in the Asturias, Spain.

A recent paper by M. A. Dory* gives a very full account of the quicksilver mines of the Asturias, in Spain, from which the following particulars are taken. The quicksilver mines of the Asturias produced in 1893 about 2000 flasks of quicksilver of 3 arrobas (34.5 kgms.) each, representing a total value of 720,000 reals. In 1895 this production was 2331 flasks. The principal mines are those of El Porvenir and of the Mieres Company. The ore in both mines is cinnabar, which is usually found in masses of considerable size, varying somewhat in color, but frequently of a distinct red. Occasionally the cinnabar is accompanied by a small quantity of realgar and orpiment, but not in sufficient quantity to permit those minerals to be considered as a reliable source of arsenic. At Funon a variety of black cinnabar very rich in quicksilver has been found which is known as metacinnabarite and closely resembles a black cinnabar found in Lake County, Cal. The deposits of the Asturias are generally found in the sedimentary rocks in contact with the schists and upper calcareous strata. At the Peña mines of the Mieres Company the ore is found in a conglomerate of schist, quartzite, and limestone.

None of the wet or other processes for the treatment of cinnabar has been adopted in this district, the process of roasting and condensation of vapors having been used. The tendency for several years past has been to replace the furnaces formerly employed by new and improved types. The transformation has proceeded rather slowly and is not yet completed. Three systems were formerly in use, the oldest being the aludel furnace, which is also locally called the Bustamente furnace, because it was first introduced in Spain by Don Juan Bustamente from Peru in 1646. The construction of this furnace is so well known that it need hardly be described here, and while it was a great improvement at the time of its introduction, its defects have long been recognized. The principal objections to it are the loss of quicksilver and the tendency of the furnace to crack and permit the escape of mercurial vapors, with consequent injury to the health of the workmen. It is, moreover, not economical in the consumption of fuel. The other types formerly in use were the old Idria furnace and the Livermore furnace, which is also called locally the American furnace. The new types which have been in use are the improved Livermore furnace, designed by Eusebio Oyarzabal, director of the Almaden Company, the Rodriguez furnace, and the Gascue-Rodriguez furnace, which is also called sometimes the continuous furnace. These three types have each their advantages and are being introduced in different works.

The New Livermore Furnace.—This furnace is shown in section in Fig. 1. No full description has heretofore been published. In some respects it is analogous to the Hasenclever-Helbig furnace used for roasting blendes. In this furnace the mineral to be roasted is dumped upon an inclined plane 2.50 meters in width, divided by walls into twelve compartments or channels; the plane is inclined at an angle of 56° and is built of refractory brick. The mineral passes down the plane in a thin layer, offering a large surface to the action of the fire. In the various furnaces there are two different sizes of passages or channels, in one of

* *Revue Universelle des Mines*, December, 1895.

which are treated the more finely broken ores and in the other the larger lumps. It is necessary to pass the broken ore over a sieve in order to free it from fine grains and dust, which have a tendency to pack and obstruct the channels. This dust from the screens is afterward molded into bricks, or bolas, as they are locally called, which are treated in one of the old aludel furnaces. At the foot of the first series of channels there is a second series placed perpendicular to the first, the distance separating the two inclined planes being exactly equal to the depth of the charge of mineral in the distilling apparatus proper. The workman who operates the furnace stands near the intersection of the two planes; he draws out with a tool made for the purpose a quantity of the calcined mineral, which is replaced at once by an equal quantity of fresh mineral from a hopper at the top. The calcined mineral is pushed into the second series of channels. The firebox is below the second inclined plane and facing the first series; it has two grates placed at different levels. The air supplied to the furnace is heated before entering by its passage through the mass of masonry below the firebox. The treatment of a charge weighing 434 kgms. takes about 4 hours.

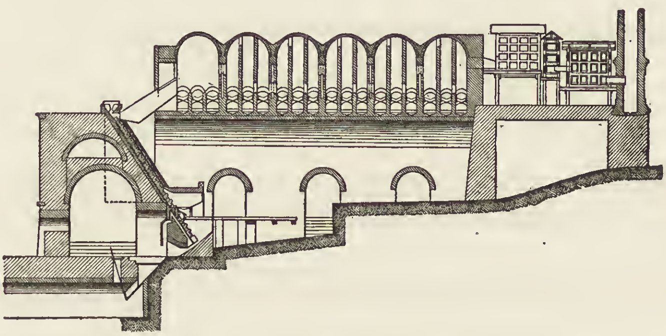


Fig. 1.—The Modified Livermore Furnace.

The condensation of the vapors takes place in a series of masonry chambers, each divided by walls into three compartments, openings left in these walls forcing the vapor to pursue a zigzag course through the chamber. The bottom of the chamber is corrugated in form, the corrugations being so arranged as to carry the condensed quicksilver into a single discharging channel. At the end of these condensing chambers there is another series of chambers constructed entirely of wood and glass; each of these is divided into four compartments, and they are generally placed at a level somewhat above the floor of the mill so that they can be easily examined. After passing through these chambers the gases are conveyed into the chimney.

The temperature obtained in these furnaces is not very high, and this is a favorable point. On the other hand, owing to the arrangement of the channels through which the ore passes, a great deal of heat is wasted and the consumption of fuel is high. The channels through which the minerals pass are frequently obstructed owing to the lumps sticking together and choking up the passage. The peculiar form of the distilling apparatus makes it impossible to protect it by iron plates, which can always be done easily with a cylindrical furnace. The absence of this protection results in frequent cracks in the refractory brick subjected to the action of the fire, permitting the escape of vapor and consequent loss of metal.

The Rodriguez Furnace.—This furnace, which is of the muffle type, is shown in Figs. 2, 3, and 4, which are respectively a cross section, an elevation, and a plan. The retort which receives the charge of mineral and in which the vaporization is carried on is furnished with three openings. The opening in front of the furnace can be partly or wholly closed by means of a sliding door, which serves to regulate the admission of air while the sulphur is being driven off. Above the retort and at the back end is found a cast-iron hopper furnished with two slides one above the other; these permit a charge of mineral to be introduced without allowing the escape of gases or injurious vapors. The back end of the retort is a cylindrical chamber of cast iron which serves as a connection with the condensation chamber, to which the vapors are conducted by a wrought-iron pipe. An inclined pipe of iron is also connected to the furnace near its front end to facilitate the extraction of the calcined mineral from the retort. The furnace is heated from below by a firebox in which coke is burned. It is not placed horizontally, but is inclined in such a way that the charge of fuel distributes itself naturally over the whole width of the apparatus. The quicksilver

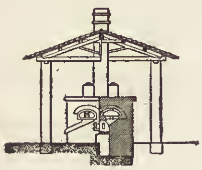


Fig. 2.

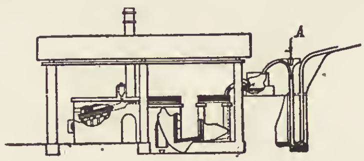


Fig. 3.

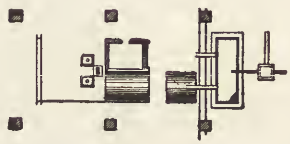


Fig. 4.

The Rodriguez Furnace.

vapors are condensed by passing them first through two chambers of masonry, then through two other chambers of somewhat smaller capacity, and finally into a wooden reservoir the bottom of which is cooled by a current of water. From this last condenser the gases and vapors are conducted by a tube into a sort of well divided into two compartments, where they are washed and cooled by a jet of water and then passed into the chimney. The scarcity of water during the summer season requires the use of a blower instead of the water current. In several cases the want of sufficient space in the narrow valleys where the works are situated has made it necessary to place the reduction works on the hillside. This has suggested the use of inclined passageways in carrying the gases to chimneys, which can be made high enough to provide sufficient natural draught. Each furnace is composed of two or three retorts, but those built in future will probably have a larger number of retorts in order to reduce somewhat the consumption of coke and the labor employed. A furnace containing two retorts consumes in 24 hours about 330 kgms. of coke.

The ore is treated by charges, a charge of 50 kgms. being made at intervals of about an hour and a half. When the ore carries over 15%, lime is added. In this way a double furnace will treat 1600 kgms. in 24 hours. Experience shows that the loss of quicksilver does not exceed 1%. Work in the furnace is very simple;

the furnace-man having drawn out the calcined ore introduces a new charge through the hopper, and then has simply to watch and see that the distribution of the mineral is uniform and regular. The oxidation by the air is so complete that the cinnabar is not only separated into metallic mercury and gaseous sulphureted products, but the quicksilver itself is oxidized and takes the form of a black powder. It is not a stable compound, however, and in its turn quickly decomposes, setting the metal at liberty. The larger part of the quicksilver is condensed in the first chamber, but a considerable part is collected on the inclined bottom of the second and third condensing chambers. From these condensers the quicksilver is drawn out through a spout into a stone basin. A part of the metal, in a very finely divided state, is carried over and settles in minute drops upon the walls of the condenser. One advantage which the Rodriguez furnace presents is that it permits the use of powdered as well as lump ore, and thus avoids the labor and cost of making the powder into briquettes.

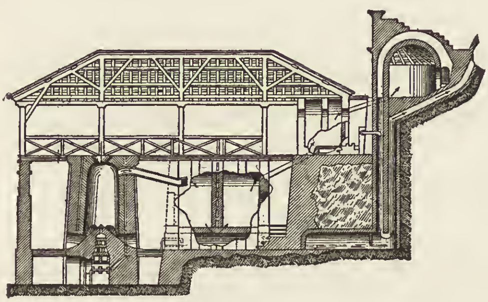


FIG. 5.

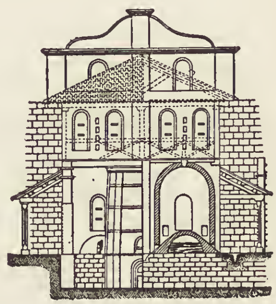


FIG. 6.

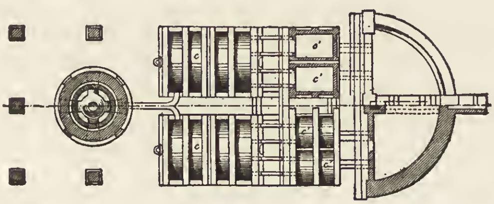


FIG. 7.

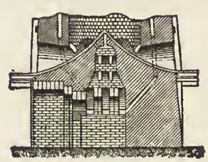


FIG. 8.

THE GASCUE-RODRIGUEZ FURNACE.

The Gascue-Rodriguez Furnace.—This furnace is shown in Figs. 5, 6, 7, and 8, Fig. 5 being a longitudinal section, Fig. 6 a cross section, Fig. 7 a plan, and Fig. 8 an enlarged view of the bottom of the furnace. This furnace, which is used for treating the mineral in a lump form, is in section a conical tower 2 meters in diameter just above the grate and 1.85 meters in diameter at the top where the gases are drawn off. The top of the furnace is conical in form with an opening, or hopper, through which the charge of ore can be introduced. This opening is provided with a bell which closes it when the furnace is charged. The total height is 6.55 meters, divided as follows: 2.85 meters from the ash pit to the masonry upon which the charge rests; 2.85 meters from the grate level to the opening through which the gases are drawn off; and 0.85 meter for the dome at the top. Openings are made in the wall of the furnace at different heights in order to permit the operation to be watched. The fire box has a section smaller than that of the reducing furnace proper. The grate is placed 0.85 meter from the bottom of the ash pit, and the interior diameter is 1.10 meters. Above the grate the walls are vertical for 0.80 meter, and above that point again they are conical in form, the diameter being reduced to 0.60 meter in a height of 0.50 meter. Above this cone is a cylinder 0.60 meter in height, closed at the top by a dome pierced with small openings which permit the products of combustion to pass through and into the charge of ore. Above this dome, as shown in Fig. 8, is a cone-shaped floor forming the bottom of the reducing furnace itself. The whole arrangement is made in such a form as to permit the gases from the furnace to pass freely, while at the same time the openings are so arranged as to prevent them from being clogged up by pieces of the ore. A cast-iron shoot permits the calcined mineral to be drawn off upon a stage, from which it is loaded in a wagon to be carried away.

The inner wall of the furnace is of refractory bricks and is 0.30 meter thick. Between this lining and the exterior wall, which is of ordinary masonry, four open spaces, 0.80 meter long and 0.10 meter wide, extend the whole height of the furnace. In these chambers any vapors of quicksilver or arsenic which may possibly filter through the lining of the furnace are condensed.

The products of the distillation are carried away from the furnace by an iron pipe which divides and leads these products into two series of chambers which serve as condensers. This arrangement allows operations to be carried on continuously, as one group of condensers can be shut off at any time to permit cleaning without interfering with the other group. The condensation of the quicksilver and arsenious acid is carried on in two ranges of chambers with inclined floors. On these floors the quicksilver collects and is drawn off by openings in the walls. Gases and vapors pass out of the upper part of the first chamber and into a second one by an opening near the bottom. Other openings made in the side walls permit the extraction of dust and arsenical products which collect upon the floors, under which a current of water is kept constantly in circulation to cool them. Entrance into the chambers in order to clean them can be had by doors which are carefully closed while work is going on.

These first condensing chambers, which have a total capacity of 40 cu. meters, are connected with four others which are of similar construction, but of smaller size and placed on a higher level. From these four small chambers four iron pipes conduct the gases and vapors into a large flue, from which they pass to a chimney which is situated about 100 meters from the furnace. Except the last condenser the whole apparatus is under roof.

This furnace treats 8500 kgms. of ore in 24 hours. The ore is charged in lumps of various size, the largest usually being about 600 c.cm. Fresh charges are introduced at intervals of 75 minutes, the usual quantity for each charge being 443 kgms. of ore and 2.22 kgms. of coke mixed. The quantity of coke used with the charges is usually 42.5 kgms. in 24 hours. It is only in special cases and when the furnace is started that it is necessary to keep up the fire on the grate of the fire box. In the last case a few hours are sufficient to heat the furnace thoroughly and to start the coke mixed with the ore; after that the combustion of the coke in the charges and of the sulphur contained in the ore is quite sufficient to keep the furnace at the necessary temperature. Before a new charge is introduced a corresponding quantity of calcined ore is drawn out from the bottom of the furnace. This waste does not carry over 0.01% of quicksilver. About 2 liters of water per second or 173 cu. meters per day are used to keep the condensers cool. When necessary the circulation of water is replaced by air forced through the passages by a ventilator. A test plate placed near the escape chimney in the current of gases shows that the quantity of quicksilver carried over by this current is hardly appreciable.

The principal advantages of this system may be summed up as follows: The forced draught permits the development in the furnace of a temperature high enough to reduce the ore completely and liberate all the quicksilver. The excellent disposition of the condensers and the cooling of the gases and vapors carried over by the current of air reduces the temperature and prevents the excessive heat, which is the chief cause of the loss of metal through the chimney. In the flue leading to the chimney the current of gases is obliged to follow a sinuous line, and the last particles of the quicksilver are collected. The ore is treated with a smaller consumption of fuel than had previously been attained in this district. The mixture of coke with the ore prevents in a great degree the formation of flue dust, which is a serious cause of loss of mercury, and the formation of different mercurial products by the complex reactions between the essential oil and the carbonized product. Moreover, the continuous operation of the furnace is a great advantage, preventing almost entirely the cracks in the walls caused by alternate heating and cooling, which were a source of heavy loss of metal in the old furnaces, besides reducing their life. There is also much less danger to the workmen from the escape of mercurial vapors. But little labor is required and the losses are light.

Comparison of the Results with Different Furnaces.—Careful trials made over a considerable period of time with the Gascue-Rodriguez furnace showed that the average quantity of quicksilver obtained was 96.88% of that contained in the ore, the loss being equal to 3.12%. In the Rodriguez furnace the loss was not over 1%. In the old aludel furnaces the loss varied, and it is said to have been at times as high as 50%. There was some exaggeration about this, but it certainly approached 5%, and must have been frequently higher when the furnace was not in good condition. At most of the mines in the Asturias the average tenor of the ore is not over 0.7% of quicksilver; that is, it is necessary to treat nearly 5 tons of ore to obtain a flask of quicksilver. This shows the necessity of careful treatment of the ore in these mines. The results obtained with the Gascue-Rodriguez furnace have been so good that the question of erecting several of these furnaces at Almaden is now under consideration.

Arsenical Products.—These products, which are condensed with the quicksilver in the condensers, have an average composition about as follows: Quicksilver, 14%; sulphate of quicksilver, 0.87%; arsenious acid, 62.78%; arsenious sulphides, 0.45%; volatile oils, 2%; water, 1.50%; carbon, 1.50%; silica, alumina, lime, etc., 16.90%. This composition is that of the flue dust, or hollines, as it is called. In treating it, it is first mixed with lime after being spread out on a floor, then washed in a tank through which a current of water flows. The resultant product is mixed with 0.3% of coke and 0.3% of clay, which serve as binding material and permit it to be formed into briquettes. These are placed in the upper part of the old Bustamente furnaces and a new product is obtained in the condensers which has the following composition: Arsenious acid, 90.73%; sulphuric acid, 0.27%; quicksilver, 8.61%; lime, 0.17%; carbon, 0.22%. This new product is again formed into briquettes with a somewhat higher percentage of coke and again treated in the furnace, the resulting product containing only a trace of quicksilver, but a very high proportion of arsenic. This product, which was formerly thrown away, is now sent to the color works at Munon, where it is made into orpiment.

Assays of the Quicksilver Ores.—For this purpose two methods were formerly used at the mines of the Asturias, the Eschka and the electrolytic. The first has been abandoned because the low grade of the ore made it difficult to get exact results, although it is fairly successful with ore of a higher grade. It was a process of amalgamation and required very great care and precision in this case. The electrolytic method gave satisfactory results, but was very slow, each assay requiring at least 18 hours. At present assays of the ore are made by the apparatus shown in Fig. 9. The sample to be assayed is introduced into an iron cylinder, *A*, serving as a retort; in the compartment *b* there is placed a small quantity of slaked lime, which when the retort is heated sets free water and facilitates the

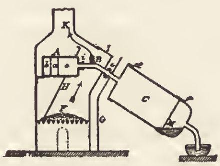


FIG. 9.—FURNACE FOR ASSAY OF QUICKSILVER ORES.

passage of the drops of quicksilver from the ore, which is found at *a*. The ore is mixed with lime, soda, and charcoal in the chamber *c*, the object being to reduce here the cinnabar which it contains. The current of gas passes from this chamber through a tube, *B*, into a condenser, *C*, of glass made in two pieces. From the lower end of this condenser a tube passes into a basin which is kept full of water. The quicksilver collects in the bottom of the condenser at *M*. The grate is placed under the retort at *N*, and the heat rising from the fire is directed to the point where it is most needed by the screen *H*. The general construction will be readily understood from the drawing.

Reducing Works in the Asturias.—The number of furnaces at the different quicksilver reducing works in the Asturias in 1895 was as follows: El Porvenir Company at Mieres, 4 Idria furnaces, 1 Livermore furnace, 3 Rodriguez furnaces, and 1 Gascue-Rodriguez furnace; La Union Asturiana at Mieres, 4 Idria furnaces, 2 Bustamente, and 2 Rodriguez furnaces; Concordia Company at Branalamosa, 1 Bustamente furnace; Soterrana Company at Munon Cisnuro, 2 aludel furnaces and 2 Rodriguez furnaces; Exploradora Company at Vallina de Longren, 1 Rodriguez furnace with two retorts; Pelugano Company at Vallina de Aler, 1 Rodriguez furnace with five retorts; Minera Company, 1 Rodriguez furnace with two retorts.

The Quicksilver Reduction Works at Idria, Austria.

By R. Helmhacker.

The geology of the cinnabar ore deposits in Idria, Carniolia, Austria, is strikingly characterized by irregularity. The older formations are elevated and crowded together with later ones. By the action of disturbances and faults the cretacean rocks (limestones) have been overturned and covered by dynamical action with beds of Triassic age—red sandstone, called "Werfner" sandstone, limestone, dolomite of the lower and dolomitic breccias of the middle Triassic series, and with carbonic strata—bituminous shales, sandstones, and limestones. The distributed deposits of different formations are crossed by faults through which the impregnation of the porous rocks with cinnabar ore probably took place. From these faults the impregnation of the sandstones, shales, dolomite, and breccias went on; the action naturally followed sometimes the planes of contact and fissures which gave more easy access to metallic solutions or hot steam carrying metallic vapor. Besides these impregnations there are also many stringers —fine short veins or natural crevices filled with cinnabar of higher tenor—distributed through the impregnated rock, particularly near the faults, where cinnabar generally occurs more abundantly. Some black bituminous slates or sandstones are percolated with native quicksilver, the evaporation of which makes the air in the hot portions of the mine bad, and working in it is unwholesome. The miners are therefore often transferred for a time to work on the surface, this precaution being due to the hot and bad air in the stopes, making continued underground work unsafe.

The development of the mines consists of 10 shafts with 12 levels to a depth of over 300 meters, and the working drifts extend horizontally over a length of 31 kgms., with 17 kgms. of railroad. From 800 to 850 men find steady employment underground, the work being actively prosecuted throughout the year. The excavations made in extracting ore during a year are from 31,000 to 35,000 cu. meters in extent. One cu. meter of ore—rock impregnated with cinnabar—weighing 2050 kgms., fit for reduction, carries on an average 20 kgms. quicksilver. The mines produce, taking the average of several years, 65,000 to 70,000 metric tons of ore yearly, with the average tenor of 0.6% quicksilver and 3600 to 4000 tons of dead rock or *débris*, the latter being kept underground to pack or fill up the old stopes.

According to the latest record the plant on the shafts comprises 12 steam engines, for hoisting, pumping, ore-dressing and other purposes, of 340 horse-power in all. The number of boilers is 10. There are also 20 water motors, turbines, etc., in use, with a total of 370 horse-power. Other appliances at the mines include 44 drilling machines. There is also an ore-dressing plant, besides forges, foundries, machine shop, sawmill, carpenter and joiner shops, etc. Since the Tirman drilling machines have been used underground the work done as compared with the hand-drill boring has been increased 42% and the average cost of mining per cu. meter of ore decreased from 2.12 to 1.73 florins.

The ore-dressing process is a dry one and very simple. The hand-picked ore is crushed in dry rock breakers, repeatedly hand picked and separated on gratings and sieves of several styles into lumps of 28 to 120 mm., assaying 0.35%

quicksilver; coarse ore of 12 to 28 mm., assaying 0.5%; and fine ore up to 12 mm., assaying 0.9%. The different samples of concentrated ore obtained by ore dressing and hand picking are in the yearly average in proportion as follows: 4.4% high-grade ore yielding 8.4% quicksilver; 41.5% coarse ore carrying 0.35%; and 54.1% fine ore carrying 0.67% metal. The yearly average tenor of concentrated ore treated in the reducing furnaces in 1881 was 0.928%; in 1886 it was 0.850%. The average analyses of the three samples of ore made in 1894 by F. Tanota were as follows:

	High-Grade Ore.	Coarse Ore.	Fine Ore (Poor Ore).
HgS	7.70	0.71	0.37
$FeCO_3$	0.62	1.54	1.44
$MgCO_3$	14.23	22.10	29.23
$CaCO_3$	16.67	30.42	38.22
$MgSO_4$	0.48	1.22	0.49
$CaSO_4$	0.10	0.09	0.33
$Ca_3(PO_4)_2$	0.23	0.04	0.03
Al_2O_3	10.15	9.43	6.90
SiO_2	39.52	29.92	18.77
H_2O and bituminous matter	2.46	0.63	0.62
Totals	100.00	100.00	100.00

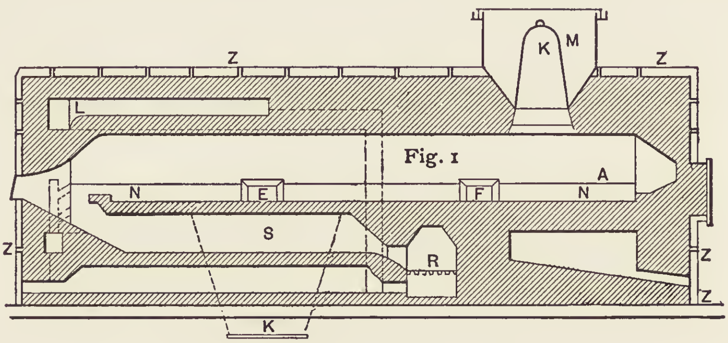
In the ore-dressing plant the undressed ore was concentrated and raised from a tenor of 0.6% to an average of 0.85% for the last year recorded.

The cinnabar deposit of Idria was discovered and first worked—though the operations were on a small scale—in 1490. The mining company then formed was persuaded by the Emperor Maximilian I. in 1509 to work more actively. But with the increasing depth of the shafts the conditions of mining presented disadvantages, and there were losses to be paid by the adventurers. Owing to this many claims were abandoned by the several companies, and the Austrian Archduke Charles took possession of them. Since that time the mines have been in government ownership and supervision, and the Idria mine is just now in a flourishing condition.

In the old time the friable shales containing metallic quicksilver were washed on a grating of iron rods. The rock carrying cinnabar, or the ore, was roasted in kilns, where it was spread in layers with alternating beds of fuel. The roasted ore was percolated and coated with small globules of metallic quicksilver, which condensed on the colder lumps; these were then washed on a sieve or grating as before. About 1580 the operator learned to increase the output of quicksilver by roasting the ores with lime. But from 1641 the burning of the ores took place in cast-iron cylindrical tubes, called retorts, their shape being changed in 1696 into a conical one. Beginning with 1750 some operators investigated the Spanish method of reduction in "aludel" furnaces, and these were improved in 1770 by adding slucies with earthen covers, in which the metal condensed better. But with those reduction plants the production of quicksilver was a moderate one, and about the end of the eighteenth century the disposition of the whole plant was changed completely, in order to increase the production and meet the increased demand. There were built reverberatory roasting furnaces with condensing and flue-dust chambers of brick. These were from time to time improved and were constantly in use to 1870. The waste gases and fumes were drawn from all these furnaces out of the dust chambers into a long, ascending covered channel for the smoke draught connected with a high chimney. But the poisonous quality of the smoke from the central chimney, the ill effect on vegetation, and the complaints made by the inhabitants of the surrounding country proved that this type of furnace was unfit to work in the summer months; the reduction of ore could therefore be carried on only in the winter. In 1842 Alberti introduced a continuous working reverberatory furnace for coarse ore; this pattern, though in an improved form, is still in use. Since 1871 attempts have been made to reduce the ore in hot or shaft furnaces and the flue dust, called in Idria "stupp," as well as the high-grade ore, in muffle furnaces. Considering the inventor's lack of experience and that this was the first real working shaft furnace built, the results were not satisfactory, though they suggested new inventions. The metallic quicksilver condensed in the furnace masonry, as well as in the floor or bottom, and the rock and earth under the foundation; the latter becoming to a certain considerable width and depth impregnated with the valuable metal. In this way the new shaft furnace caused great loss of metal. When years afterward (1868–78) the old shaft furnaces were demolished and the metal which had percolated through the furnace masonry, as well as the earth and the rock beneath the foundations, was recovered by burning, there was obtained a total of 63 and 97 tons of quicksilver that had been absorbed in the masonry and the rock.

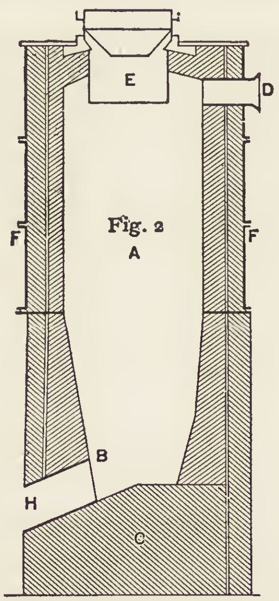
The new shaft furnaces for quicksilver reduction introduced in Idria with great success by Exeli and Novák have since been widely adopted by other works both in Austria and abroad; for instance, at the Nikitovka quicksilver reduction works in the Donetz coal basin in Southern Russia, and at several mines in California. The new plant works excellently so far as the comfort of the workmen and of the neighboring inhabitants is concerned. The furnaces are now in operation the whole year, in winter as well as in summer. In recent construction of this pattern of furnace the furnace itself is covered by a sheet-iron or cast-iron jacket and is placed on a cast-iron foundation disk. The use of the foundation disk and of the jacket prevents the condensation and consequently the percolation of metal below the foundation, and the smelter has always the opportunity of looking in the open space under the furnace to ascertain whether metal is collecting there.

The first sheet-iron covered furnaces were introduced by Exeli. The waste gases and fumes containing the vapors of quicksilver were drawn through cast-iron tubes bent at a right angle in the condensing room of the old large dust chambers. In 1876 another improvement was made in the new reverberatory reducing furnaces by drawing the fumes and waste gases with the quicksilver vapors through an earthen tube cooled with water, where the condensation of the metal takes place. In 1878 the condensing chambers were further improved. The draught of the shaft furnace was led through brick chambers, where it was cooled by the ceiling of the chambers, which was formed of iron plates over which a current of cold water was passed. The illustrations show the furnaces now in use. The reverberatory reducing furnace (Chermak furnace), represented in Fig. 1, is intended for fine ore and also for lumps of higher grade which can be treated. The ore is spread upon the level roasting hearth *N*, where the heat of burning wood on the grate *R* is led. Ore is fed into the back end of the roasting furnace by a funnel-like conveyer, *M,* closed by the bell *K;* it is conveyed by shovels moving through the working holes *E, F* toward the flame *A* in the fore

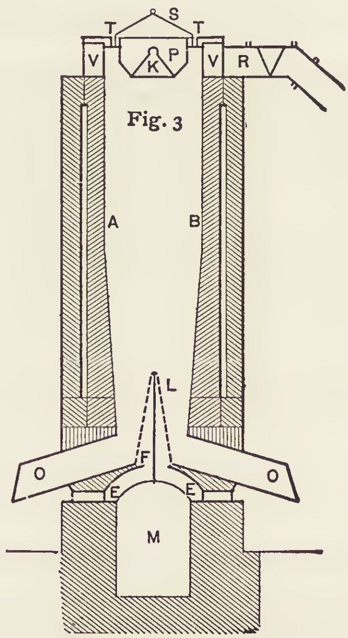


CHERMAK REVERBERATORY FURNACE.

part of the furnace. The reduced ore is raked out through the hole *E* into a bucket wheel or carrier, *K.* The fumes and gases pass through holes into the channel *L* and into the condensation plant. To prevent loss of metal by



EXELI SHAFT FURNACE.



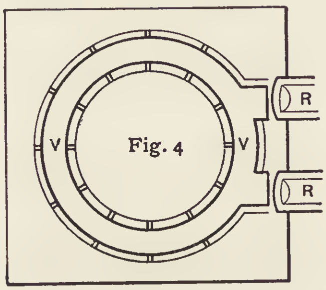
NOVAK SHAFT FURNACE.

evaporation the furnace is covered with a coating of sheet iron or cast iron, *Z;* the bottom is also iron clad to prevent percolation of the quicksilver into the ground.

The coarse ores and lumps are reduced in shaft furnaces which have a natural draught, so that no blast is required. The inner wall is constructed of firebrick, the outer one of common brick, covered again with either cast-iron or sheet-iron plates bolted together. The first shaft furnaces were heated from side grates below, but they are now charged from the upper end by throwing in the oven charges of ore and fuel—charcoal mixed with wood. All the shaft furnaces now in use resemble each other except in the horizontal, round, rectangular, or polygonal cross section, but the general principles governing the construction are the same in all.

The Exeli shaft furnace (Fig. 2) is cylindrical in the upper part *A* and conical below at *B*. The ore and fuel are charged through the sheet-iron cylinder *E*, closed by a conical cover. The waste gases, fumes, and vapors of quicksilver are drawn through the pipe *D* into the condensers. The burned or reduced ore is raked out through the three holes at the side *H*, forming an obtuse angle of 120° with each other. Only the upper portion of the furnace has a jacket of cast-iron plates.

The Novák shaft furnace (Fig. 3) is an example of the most recent construc-



Top of Novak Shaft Furnace.

tion. The masonry shaft rests upon a cast-iron plate or frame, *F*, supported by legs, *E E*, and standing on a masonry foundation, accessible also from below at *M*. In this way every loss of quicksilver is or may be seen and prevented; the shaft furnace being accessible on all sides can be easily repaired. The foundation below the furnace may also be repaired and examined if necessary. The shaft is conical both above and below, but in the middle portion at *A B* it is cylindrical. The furnace is charged by lifting the funnel *K* by a chain or lever into the basket *P*, which is covered by the cover *S*, the end of which dips in a circular sluice-like pot, *T*, filled with water. The oxygen or air needed to roast the cinnabar in the shaft comes through the holes *L* communicating with the furnace. The burned ore is raked out through the holes *O*. The gases and the quicksilver vapors are drawn through the cast-iron shell *V*, shown in horizontal cross section in Fig. 4, and are conducted from there through the tubes *R R* to the condenser.

The capacity of one Chermak reverberatory roasting furnace is 32½ tons in 24 hours; the average quantity of ore that can be treated in the shaft furnace is 13¼ tons ore in 24 hours. The economic conditions of roasting or reducing 1 ton of ore are as follows: In the reverberatory furnaces there is required 29 cu. meters of wood and 740 kgms. of brown coal; the amount of fuel in the shaft furnace is 1.9 cu. meters of wood and 10 cu. meters of charcoal.

The burned ore should not contain any metal, but it does contain in practice from 0.02 to 0.1% of quicksilver. It is said that the yearly average tenor of quicksilver of the burned ores was in 1893 changed from 0.0086 to 0.0063%. To recover the quicksilver there were used by Chermak cast-iron condenser tubes, totally neglecting the older brick condensing chambers. But the cast-iron tubes become in a short time porous owing to the action of the acid gases, containing SO_2 and SO_3, and therefore they were lined inside with a thick coating of cement to prevent this corrosion of the iron. At present only glazed earthen ware (or glazed stone ware) tubes are used as condensers (Fig. 5). The set is connected as shown at R_1, R_2, R_3, R_4, and joined above and below by knee tubes. The set of tubes becomes narrower at the lower end at *S* and dips in large dishes, *M*. To

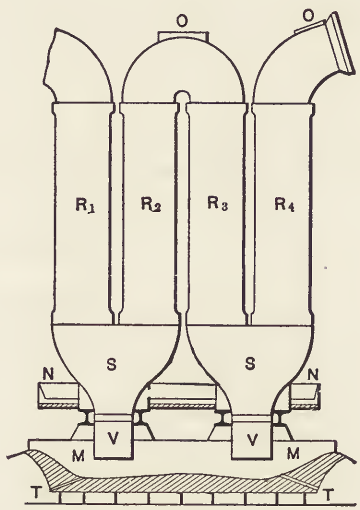


Fig. 5
CONDENSER TUBES FOR QUICKSILVER.

clean the tubes they are provided with openings in the upper part, closed or sealed by clay and earthen covers, *O*. The gases and fumes condense in the tub condensers, cooled by a cold-water spray playing upon their surface. The cooling water running down the condenser tubs gathers in the vat *N*, where the surplus overflows over the brim. Before allowing the first charge of the ore in the reduction furnace to burn out, the dishes *M* are filled with water to cover the lower part *V* of the condenser dipping into it. In the first cooling in the condenser tubs water is condensed which flows over the brim of the dishes *M*, while the precipitated quicksilver, containing considerable impurities, remains on the bottom. The condensed water contains a very small portion of a soluble quicksilver sulphate and mechanically divided mixtures. This water is conducted into wooden vats to precipitate the heavy suspended impurities, and the clear water is led into cemented tanks, where then Na_2S is added and the precipitate, converted into HgS, is found. On the bottom of the dishes *M* there is caught liquid quicksilver and impure (dust-like) quicksilver in a state of excessive mechanical division, called "stupp" in Idria. The liquid quicksilver is drawn off through the tapping holes *T*, sealed with plugs of clay or wax when not in use. The stupp consists of an excessively fine mechanical mixture of quicksilver with dust, unburned particles of fuel, ashes, and some newly formed bituminous products due to the imperfect burning of fuel. It shows the following analysis (by Francis Tanota):

Hg	81.04	figured to metallic Hg 81.04
HgS	5.76	figured to metallic Hg 4.96
Hg_2SO_4	0.52	figured to metallic Hg 0.42
HgCl	0.12	figured to metallic Hg 0.10
$HgCl_2$	Trace	figured to metallic Hg .... Trace
$CaSO_4$	2.74	Containing Hg 86.25
$MgSO_4$	0.21	
$Fe_2(SO_4)_3$	Trace	
C	2.66	chemically bound in other bituminous matter.
C	6.46	in coal soot.
$Al_2(SiO_3)_3$	0.15	
Total	99.70	

The roast gases show the following analyses:

From reverberatory reducing furnaces:		From shaft furnaces:	
CO_2	16.4–12.7	CO_2	15.3–10.8
O	7.1–10.5	O	8.1–14.6
CO	0.0– 1.1	CO	0.0– 0.9
N	75.4–77.6	N	72.3–74.7
Temperature of gas leaving furnace, 333° C.		Temperature of gas leaving furnace, 148° C.	

The gases drawn by the central chimney showed in 1890 at one assay the following composition: CO_2, 11.3; air, 67.1; CO, 0.2; N, 21.4; SO_2, 0.12; and the sp. gr. of 1.0525 at the temperature of 20.5° C. at the atmospheric pressure of 715 mm. and the draught speed of 2 meters per second. The same chimney gases contained in 1890 at the temperature of 17° C. in 1 cu. meter 0.0087 gm. of volatilized or evaporated metal and mechanically mixed dust. When the assay was repeated at a temperature of 3.4° C. in the chimney gases there could be found only traces of metallic vapors.

The soot caught in the dishes *M* (Fig. 5) below each set of condensers must be ground, with the addition of some lime in solution in water to reduce the chemical quicksilver compounds. After the addition of lime water, also very convenient for cleaning quicksilver, the finest metallic powder unites freely in minute globules and then in greater ones. The grinding takes place in a dish provided with an agitator, revolving stirrers with knives on two arms moving on a vertical axis. The revolving knives of the machine agitating the mass and also grinding, cutting, and pressing it, for ce the metal out and it drops through the wooden false bottom into another dish placed below. The quicksilver is cleaned on the surface and collected in rawhide bags holding 25 kgms., or in cylindrical iron flasks which hold 34.5 kgms. and are closed with a screw plug.

When the old plant was yet in use the soot precipitated in the condensing chamber and in the main channel to the chimney was collected by scraping and sweeping by hand; afterward the grinding of the soot was also performed by laborers; both of these processes were very dangerous to health. Upon the completion of the new plant the old one was abandoned, and the new reduction works, consisting of a plant of a few reverberatory furnaces and of more shaft furnaces, include the most improved methods for working quicksilver ores and may be considered as the most complete in the world. There are 42 furnaces and machines in the reducing works and 2 in the assayer's department. The number of laborers in the reduction works varies between 400 and 450.

The system of assaying is very perfect since Eshka employed a new fire assay of quicksilver ores. There are from 7000 to 8000 assays of ore and products made during a year. For sampling ore is taken in lots of 120 tons in lumps, 100 tons coarse ore, 70 tons fine ore, or 12 tons higher tenor ores. From every sample of 100 kgms. of ore there are taken 2 kgms. for assaying. This is crushed, thoroughly mixed, ground and quartered, then repeatedly quartered, till a sample of a size convenient for assaying has been obtained.

It is supposed that the loss of quicksilver from 1875–78, when the new shaft furnaces were first tried and not yet improved, amounted to 16% in the yearly average; from 1879–82 to only 12.2%; and from 1883–86, after the adoption of the iron-coated shaft furnaces, to only 9.6%. Now it is said that the loss of metal by volatilization is 9% in the new furnaces. Formerly the loss of metal was a considerable one, because the ores were not completely reduced. Since 1881–86 there have been reworked 17,000 tons of burned ores from old tailings heaps, giving 90.1 tons reduced metal, showing an average of 0.188% of metal not recovered.

The quantity of ore produced during a year varies from 66,000 to 75,000 tons; in 1893 the amount was 76,215 tons. The production of quicksilver 15 years ago (1881) was 400 tons; since 1886 it has increased to 500 tons and is now about the same, namely, 525 to 550 tons. In 1892 it was 543 tons and in 1893 it was 512 tons.

The quantity of fuel consumed in quicksilver reduction during recent years is on an average 3400 to 3500 cu. meters charcoal, 16,000 to 17,000 cu. meters wood, and 760 to 800 tons brown coal. This does not include the fuel burned under boilers for hoisting, pumping, and other engines. In the reducing works there is also a cinnabar color manufactory. The manufacture is both by the fire process, which it is hardly necessary to describe in detail, and by the humid process. But the latter process is regarded as a secret and no permission is given to describe it. Both by the dry and the wet processes there are obtained excellent red colors; the wet method gives also colors showing a violet hue. The cinnabar is packed either in wood boxes containing 12½ kgms. or in tin boxes with ½ to 12½ kgms. The statement of the production of artificial cinnabar shows a yearly production varying from 36 to 175 tons; the average output for several years amounted to 70 tons per year.

THE RARE ELEMENTS.

By L. M. Dennis.

The following data upon the rare elements are intended merely to supplement the statements given in the article under the same title in Vol. II. of The Mineral Industry (p. 555). As only such researches are here incorporated as have appeared since the publication of the preceding volume, the reader is referred to that article for the general details concerning the occurrence of the rare elements and the older methods for preparing them. The names of those elements concerning whose preparation nothing recent has appeared are omitted from the present list. The elements known as the "rare earths" resemble one another so closely in their chemical behavior that they have been considered together at the end of the article.

Boron.—H. Moissan (*Annales de Chimie et de Physique,* Vol. VI., p. 296) gives a historical review of the different attempts to prepare free boron and then describes experiments of his own upon the subject. He used the method which had previously been employed by Phipson and by Winkler, the reduction of boric oxide by metallic magnesium. The boric oxide should first be fused in a platinum crucible to free it from water, for if it is not perfectly dry an explosion is produced when it is heated with the magnesium. Two hundred and ten gms. of the powdered boric acid is mixed with 70 gms. of magnesium powder and the mixture is placed in a fireclay crucible. The crucible is then placed in a Perrot furnace which has previously been brought up to a bright red heat. After 4 or 5 minutes reaction occurs accompanied by an evolution of heat, the crucible becoming white hot. The crucible is allowed to remain 10 minutes longer in the furnace and is then taken out. After cooling the central part of the mass is carefully removed and washed with hydrochloric and hydrofluoric acids. Thus purified, the product contains from 94 to 95% of boron, together with some magnesium boride. The latter is removed by fusion with 50 times its weight of dry boric oxide, the excess of boric oxide being then gotten rid of as above. The boron thus made showed on analysis: boron, 98.3%; magnesium, 0.37%; insoluble, 1.18%. In another series of experiments the presence of atmospheric nitrogen and consequently the formation of boron nitride were avoided by luting the cover of the crucible with a mixture of titanium oxide and carbon. In this way Moissan obtained a product containing from 99.2 to 99.6% boron.

This amorphous boron is of a light chestnut color. Its sp. gr. is 2.45. It combines much more easily with the metalloids than with the metals and has great affinity for fluorine, chlorine, oxygen, and sulphur. It is a more energetic reducing agent than carbon or silicon, since at a red heat it extracts oxygen from the oxides of carbon and silicon. It acts with great violence upon oxides which are easily reducible by carbon, but it unites directly with nitrogen only at a very high temperature. In general it may be said that boron resembles carbon quite closely.

Moissan has also prepared (*Bull. Soc. Chim. de Paris*, 1894, p. 998) boride of carbon (B_6C), which, although not quite as hard as the diamond, is harder than carborundum, and is, Moissan believes, the first example of a definite compound which can polish diamonds.

Cesium.—A. Schtscherbatschow and N. Beketow (*Prot. Russ. Phys. Chem. Ges.*, 1894, No. 3) describe a modification of Winkler's method for the preparation of metallic cesium. Cesium aluminate is first prepared, more aluminum oxide being used than is called for by the formula $Cs_2Al_2O_4$. This is then reduced by metallic magnesium, an amount sufficient to unite with all of the oxygen present being employed. The yield of metallic cesium is close to the theorctical. Its sp. gr. was found to be 2.36 instead of 1.88 as found by Setterberg.

N. Beketow states (*Bull. Acad. Petersb.*, N. S., No. 4, p. 247) that hydrogen acts upon cesium oxide, even at ordinary temperature, as expressed by the equation $2Cs_2O + H_2 = 2CsOH + 2Cs$. The oxides of sodium, potassium, and rubidium act similarly, but lithium oxide does not. The reaction takes place more easily the higher the atomic weight of the metal.

Chromium.—A few years ago H. Moissan described the preparation of chromium carbide in the electric furnace. He now (*Bull. Soc. Chim.*, 1894, p. 1014) has succeeded in preparing chromium quite free from carbon by first fusing the chromium carbide in a lime crucible, the chromium here uniting with the lime to form a double oxide. A furnace of quicklime is then lined with this double oxide and the chromium carbide is melted in that. Under these circumstances pure chromium free from even traces of carbon is obtained. The metal is brilliant in luster and can be filed and polished with ease. Its density is 6.92. Its melting point is considerably higher than that of platinum.

Columbium.—Mary E. Pennington (*Journ. Amer. Chem. Soc.*, 1896, p. 38), in the course of researches upon columbium and tantalum, has compared the potassium-acid sulphate method of decomposing columbite with the method proposed by Gibbs (*Amer. Journ. Science*, Vol. XXXVII., p. 357), and states that the latter is the much more satisfactory of the two.

Glucinum.—P. Lebeau in *Comptes rendus*, Vol. CXXI., p. 641, describes methods for the extraction of glucina from beryl and for the preparation of pure glucina. For the extraction of glucina from beryl he fuses from 5 to 6 kgs. of a mixture of 1 part of beryl with 2 parts of calcium fluoride in a large graphite crucible. The molten mass is poured into water so as to make it porous and easy to pulverize. On treatment with sulphuric acid, silicon tetrafluoride escapes and the resulting sulphates of aluminum, iron, and glucinum are dissolved in water. This solution is concentrated, the excess of acid is partly neutralized with potassium carbonate, and the liquid is allowed to cool, whereupon a heavy deposit of alum, containing most of the aluminum present, separates out. The filtrate from this precipitate is saturated with ammonia, an excess of ammonium carbonate is added, and after standing for some days the clear supernatant liquid is boiled, the impure glucinum carbonate being thus precipitated.

Lebeau prepares pure glucina from this impure product by dissolving it in nitric acid, precipitating the iron present by potassium ferrocyanide, removing the excess of ferrocyanide by copper nitrate, and precipitating the copper by hydrogen sulphide. This gives a solution containing only glucinum and aluminum. Ammonium hydroxide is added and the precipitated hydroxides are allowed to remain in the liquid for 3 or 4 days. The supernatant liquid is decanted off and a concentrated solution of ammonium carbonate is poured over the hydroxides. The aluminum hydroxide has by standing become insoluble in the ammonium carbonate. After the glucinum hydroxide has been dissolved by the ammonium carbonate the clear liquid is filtered off from the insoluble aluminum hydroxide and the pure glucina is precipitated from the filtrate by boiling.

W. Borchers (*Zeit. Elektrotech. und Elektrochemie,* 1895, p. 39) prepares metallic glucinum by first evaporating the solution of glucinum chloride with an alkali chloride and some ammonium chloride (to avoid the formation of oxide) and then electrolyzing the molten mass. During the electrolysis the temperature should be only as high as the melting point of the glucinum, which otherwise will unite with the iron.

Edward Hart (*Journ. Amer. Chem. Soc.,* Vol. XVII., p. 604), in the preparation of pure glucinum salts from beryl, fuses the powdered beryl with mixed alkali carbonates. The pulverized mass is then treated with sulphuric acid and evaporated to dryness to render the silica insoluble, the sulphates are dissolved in water, and an excess of potassium sulphate is added. Alum crystallizes out and is purified by recrystallization. The iron in the mother liquor is oxidized by adding potassium chlorate and heating, and the iron and aluminum still present are precipitated by adding, little by little, sodium-carbonate solution, the addition being discontinued when a filtered sample of the solution shows no yellow color. The precipitate is removed by filtration and the glucinum, which is now in the filtrate, is precipitated by the further addition of sodium carbonate.

Lithium.—Guntz (*Comptes rendus,* Vol. CII., No. 26) prepares metallic lithium by the familiar process of the electrolysis of the chloride. He found, however, that the yield of metal is higher as the temperature of the electrolysis is lower. Hence he mixes with the lithium chloride, which melts at about 600°, an equal weight of potassium chloride, which has a melting point of 740°. The mixture of the two salts melts at about 450°. The metal obtained is free from iron and silicon, but contains 1% of potassium.

W. Borchers (*Zeit. Elektrotech. und Elektrochemie,* 1895, p. 39) prepares metallic lithium as follows: The chloride solution of the alkalies and alkaline earths obtained from a lithium mineral is made slightly alkaline, to prevent its taking up too much iron, and is then evaporated in an iron vessel and fused with some ammonium chloride to neutralize it. The mixture is then electrolyzed with a current of 1000 ampères per sq. meter of cathode surface and 5 volts. A metal tube through which water is kept running passes around the upper edge of the crucible. This cools the surface of the molten mass so that there is formed a thin, stiff crust which prevents the lithium from rising to the surface. The globules of metallic lithium are then placed in a paraffin bath heated to from 130 to 200°; the adhering salts sink to the bottom, while the lithium rises to the surface. It is taken out, washed in benzine, and again melted. In this way the metal can be easily and directly obtained in a state of purity.

Manganese.—L. Voltmer (*Ber. d. deutsch.chem. Ges.*, Vol. XXVII., p. 829) prepares manganese by the electrolysis of a molten halogen salt of manganese. Oxide of manganese is added to the electrolyte.

Molybdenum.—Moissan (*Comptes rendus*, Vol. CXX., p. 1320) describes the reduction in the electric furnace of a mixture of MoO_2 and charcoal, and gives the properties of cast molybdenum and a molybdenum carbide of the composition Mo_2C. He also describes in considerable detail the properties and reactions of fused molybdenum, which, according to his analyses, he has obtained very pure, three analyses giving 99.78,99.89, and 99.98% of molybdenum. This molybdenum has a density of 9.01, is as malleable as iron, can be filed and polished, and can be forged when hot. It scratches neither quartz nor glass. If quite free from carbon and silicon it oxidizes but little in the air below a dull red heat, merely becoming covered with an iridescent layer as does steel. Toward 600° it begins to oxidize, forming molybdic acid, which slowly volatilizes.

Osmium.—W. Gulewitsch (*Zeit. für anorganische Chemie*, Vol. V., p. 126) describes a method for the recovery of osmium from residues and gives exact details for the extraction of the metal by reduction with zinc and the conversion into osmium tetroxide by heating in oxygen. If there is much organic substance present the mass is first distilled with aqua regia; the distillate is then reduced with zinc and the separated osmium converted into osmium tetroxide.

Rubidium.—H. L. Wells (*Zeit. für anorganische Chemie*, Vol. IV., p. 344) prepares pure rubidium and cesium salts from natural products as follows. The alkali metals are first freed from the other bases present in the mineral. (Methods for doing this can be found in any of the larger works on inorganic chemistry.) When the alkali metals have been obtained as chlorides in concentrated aqueous solution, an equal volume of concentrated hydrochloric acid is added and any potassium chloride or sodium chloride precipitated is removed. The solution is now somewhat diluted to prevent the further separation of these chlorides, and a solution of lead chloride, obtained by boiling lead oxide with a large excess of hydrochloric acid, is slowly added. While this is being done, chlorine is passed through the liquid until the latter is cold and until a further addition of lead chloride produces no yellow precipitate. The rubidium is precipitated as Rb_2PbCl_6 and the cesium as Cs_2PbCl_6. The precipitate is usually free from potassium. To complete the purification of the rubidium and cesium, the precipitate is washed with hydrochloric acid containing chlorine and lead chloride and is then treated repeatedly with small portions of boiling water until it has been completely decomposed. The solution is then once more subjected to the above procedure. The mixed lead salts are decomposed by hot water and the filtrate is evaporated to dryness to remove the hydrochloric acid. The residue is dissolved in hot water, the lead precipitated by adding a small amount of ammonium sulphide, and the precipitate filtered off. The filtrate is evaporated to dryness. The residue now consists of the chlorides of rubidium, cesium, and ammonium.

To separate the rubidium from the cesium, Wells uses the following procedure if there is more rubidium present than cesium, as is usually the case. The mixed chlorides of rubidium and cesium are dissolved in at least 5 parts of concentrated nitric acid and the solution is evaporated and heated until the excess of nitric acid has been driven off. The residue is dissolved in a little water and an amount of oxalic acid equal to twice the weight of the original chlorides is added. The whole is brought to dryness, and the residue is ignited in a platinum crucible until the oxalates are completely changed to carbonates. The carbonates are dissolved in water, the solution filtered, exactly neutralized with a measured amount of tartaric acid, then the same amount of tartaric acid is still further added and the solution evaporated until it is saturated when hot. Upon cooling, acid rubidium tartrate separates out. This is washed with a little water and recrystallized two or three times in the same manner from a hot saturated solution until it no longer shows the cesium spectrum. The united mother liquors from the acid rubidium tartrate are evaporated to dryness and ignited in a platinum crucible. The carbonates are changed to chlorides, dissolved in hydrochloric acid (1 : 1), and a solution of antimony trichloride in the same acid is added as long as a precipitate is formed. The precipitate is collected on a filter and washed with hydrochloric acid. To remove traces of rubidium the precipitate is completely decomposed by treating it with successive portions of hot water; the precipitation is then repeated by adding hydrochloric acid and some antimony trichloride. The last precipitate is washed with hydrochloric acid; it usually shows no rubidium before the spectroscope. The cesium-antimony-chloride is decomposed with hot water and hydrogen sulphide is passed through the solution. The filtrate from the antimony sulphide yields on evaporation pure cesium chloride.

Silicon.—M. Vigouroux (*Comptes rendus,* Vol. CXX., p. 94) has succeeded in making quite pure amorphous silicon by reducing silica with metallic magnesium. The tendency of the mixture to explode when reaction takes place, as noted by Winkler, is avoided by using absolutely dry materials. The mixture consisted of 180 gms. of silica, 144 gms. of magnesium, and 81 gms. of magnesium oxide, the last substance being used to lessen the violence of the reduction. The mixture is placed in a crucible and after being thoroughly dried is heated at once to redness. The reaction takes place at 540°. The resulting mass when cold is porous and brittle and of a light maroon color. It is treated with hydrochloric acid, then with boiling sulphuric acid, and then alternately with hydrofluoric acid and boiling sulphuric acid. The product thus obtained contains from 99.09 to 99.69% of silicon.

In a later paper (*Comptes rendus,* Vol. CXX., p. 367) Vigouroux describes the properties of this amorphous silicon.

The same chemist has also succeeded in reducing silica by aluminum (*Comptes rendus,* Vol. CXX., p. 1161). By heating a mixture of 3 molecules of pulverized silica and 4 atoms of pulverized aluminum to 800° a chestnut-brown powder possessing the properties of amorphous silicon is obtained. He also prepares crystalline silicon by heating pulverized quartz with pieces of aluminum in a carbon crucible in the electric furnace, or at a lower temperature by heating in a Perrot furnace a mixture of 120 gms. of aluminum, 30 gms. of pulverized quartz, and 220 gms. of potassium fluosilicate. By this latter method there was obtained 40 gms. of silicon having a bright metallic luster and the chemical properties of amorphous silicon, and showing under the microscope transparent hexagonal plates.

Tantalum.—See *Columbium.*

Tellurium.—Ludwig Staudenmaier has described (*Zeit. für anorganische Chemie,* Vol. X., p. 189) a method for the preparation of telluric acid, a compound which had hitherto been quite expensive because of the difficulty of preparing it. He dissolves tellurim in an excess of dilute nitric acid and adds to the resulting tellurium dioxide an excess of chromic acid. Oxidation to telluric acid takes place at once. The solution is then evaporated upon the water bath until the nitric acid in excess becomes quite concentrated, and the telluric acid then separates almost completely in coarsely crystalline condition. The crystalline mass is washed with nitric acid to remove the chromium nitrate and the excess of chromic acid, and is then dissolved in the smallest possible amount of hot water. The small amount of chromic acid still present in the solution is reduced with a few drops of alcohol and the telluric acid is precipitated by the addition of a large amount of nitric acid. The crystals have the composition $H_2TeO_4.2H_2O$.

Cabell Whitehead (*Journ. Amer. Chem. Soc.,* Vol. XVII., p. 849) describes the preparation of tellurium from the telluride ores of gold and silver. The ore is smelted with copper ore and the matte is then bessemerized. The resulting copper contains from 98.5 to 99.5% of copper, 0.04% of tellurium, and about 100 ozs. of silver and $\frac{3}{10}$ oz. of gold per ton. This copper is dissolved electrolytically, the tellurium and other elements present being converted into oxides or basic salts, which fall to the bottom of the bath in the form of a black slimy residue. This slime is boiled with a 20% solution of sulphuric acid, gold, silver, tellurium, and lead sulphate remaining undissolved. The residue is pressed into cakes, dried, and subjected to an oxidizing fusion which quickly removes all but a trace of the lead present, together with portions of the tellurium. This bullion is treated with hot sulphuric acid and the solution is allowed to cool and settle. The gold falls to the bottom and the tellurium crystallizes out in white lustrous crystals of tellurium dioxide. This residue is then washed with dilute sulphuric acid and water and afterward boiled with concentrated sulphuric acid. This dissolves the tellurium. From this solution the tellurium may be obtained either by precipitation with copper or by passing sulphur dioxide through the solution.

Titanium.—E. A. Schneider (*Zeit. für anorganische Chemie,* Vol. VIII., p. 81) calls attention to the uncertainty which still exists as to whether the substance which has been described as "amorphous titanium" is the element itself or a mixture of the element with one or more oxides of titanium, or lastly a lower oxide of the element. He attempted to prepare pure titanium by the action of metallic sodium upon potassium fluotitanate, K_2TiF_6, but obtained a product that contained only 84.88% of titanium.

H. Moissan (*Bull. Soc. Chim.,* 1895, p. 959) prepares titanium by reducing titanium dioxide with carbon in the electric furnace. From 300 to 400 gms. of the mixture of the two substances is thoroughly dried and pressed down in a cylindrical crucible of carbon 8 cm. in diameter. The crucible is then placed in the electric furnace and exposed for about 10 minutes to the action of a current of 2000 ampères and 60 volts. The mass fuses nearly completely and the yield of each charge is about 200 gms. of titanium. Three analyses of the product gave—

Titanium	94.80	96.11	96.39
Carbon	3.81	2.82	1.91
Ash	0.60	0.92	0.41

Titanium thus prepared shows a brilliant white fracture and is hard enough to scratch quartz and steel. Its density is 4.87. Heated in oxygen it ignites at 610°, forming amorphous titanium dioxide. It is attacked by chlorine at 325°, forming titanium tetrachloride. Fused titanium is the most refractory substance that has thus far been obtained with the electric furnace, it being more infusible than vanadium and much more so than chromium, tungsten, molybdenum, and zirconium.

THE "RARE EARTHS."

The term "earth" was early applied to those oxides which were basic in character and infusible at high temperatures. To those oxides which, when dissolved in water, yield an alkaline solution, viz., calcium oxide, strontium oxide, and barium oxide, the name "alkaline earths" was given. Hence it naturally followed when the elements of the cerium and yttrium groups were discovered that the infusibility and scarcity of these oxides, together with the belief that they were of the same R O type as the alkaline earths, acquired for them the name of "rare earths."

That these rare oxides were in composition similar to calcium oxide and barium oxide was an idea generally prevalent down to 1871, when Mendeleeff's celebrated paper upon "The Periodic Law" appeared. He there showed that to make these rare elements conform to his system it was necessary to change the formulas of many of their oxides from R O to R_2O_3, the elements then being trivalent instead of bivalent. Although there was at that time but slight experimental justification for such a change, the later researches of Cleve, Bahr, Hillebrand and Norton, and others have shown that Mendeleeff's predictions were, in the main, correct, and most of these rare earths are now considered to be trivalent. Cerium, however, forms, in addition to the oxide Ce_2O_3, the higher oxide CeO_2, while thorium is tetravalent, its oxide being ThO_2 and its salts of the general type ThX_4.

The rare earths which have been isolated up to the present time and identified with more or less completeness are:

Name.	Symbol.	Atomic Weight.	Name.	Symbol.	Atomic Weight.
Scandium	Sc	44	Gadolinium	Gd	156
Yttrium	Y	89	Terbium	Tr	163
Lanthanum	La	138.5	Holmium	Ho	165 (?)
Cerium	Ce	140.2	Erbium	Er	166
Neodidymium	Nd	140.8	Thulium	Tm	170
Praseodidymium	Pr	143.6	Ytterbium	Yb	173
Samarium	Sm	150	Thorium	Th	232

Many of the so-called elements in the above list are undoubtedly mixtures of two or more substances, but attempts to still further split them apart have not as yet proved successful.

In the century which has elapsed since the discovery of yttria by Gadolin, in 1794, many of the ablest investigators have turned their attention to this peculiar group of elements; but although many brilliant discoveries have been made, the progress has not been as great as in other branches of inorganic chemistry. The explanation of this lies in the fact that most unusual difficulties are encountered in the separation of the elements one from another. Chemically they resemble one another very closely; their oxides vary but slightly in basicity, their salts and double salts have almost the same solubility, and for many of them there are no delicate qualitative methods of detection, especially when the element is mixed with other rare earths. Moreover, in the separation of the earths methods of fractionation are usually employed, and where such procedure is followed the separation can never, theoretically at least, be either exact or complete. The main object at present in the development of this field should be, both from the purely scientific and from the commercial standpoints, the discovery and perfection of methods for sharply and completely separating the earths, for it is only by a study of these elements and their compounds in a state of purity that a thorough understanding of their properties, uses, and value can be obtained.

The interest in the chemistry of this group of peculiar elements has of late been greatly increased and widened by the invention and successful introduction of the Welsbach light, and the discovery within the United States of many minerals containing sufficient amounts of those rare earths which are used in the Welsbach "mantle" to give to the minerals a distinct commercial value. As the consulting chemist is often called upon nowadays to state whether or not rare earths are present in a mineral, it may not be out of place to describe very briefly simple methods by means of which these rare elements may be separated from the more common ones with which they are usually associated.

The minerals in which the elements occur are for the most part phosphates, silicates, columbates, or tantalates of the rare earths and some of the more common bases, such as iron, calcium, aluminum, manganese, etc. The mineral should first be very finely pulverized. Then, if it is decomposable by concentrated hydrochloric acid, treat with that acid and remove the silica in the usual manner. Upon treating the residue with hydrochloric acid and water an acid solution of the chlorides of the bases is obtained. If the mineral is not decomposable by hydrochloric acid, then heat with an excess of concentrated sulphuric acid, drive off the excess of acid by careful heating, pulverize the dry residue, and drop it little by little, with occasional stirring, into iced water. On standing, the sulphates of the rare earths and of some of the other bases present will dissolve. Some minerals cannot be completely decomposed even by sulphuric acid, but must be fused with an excess of acid potassium sulphate. The fused mass when cold is pulverized and thrown into iced water as above.

In this way there is obtained a solution, with acid reaction, of either the chlorides or sulphates of the bases. A saturated solution of oxalic acid is added in excess, this precipitating the oxalates of the rare earths together with small amounts of iron, lime, etc. The oxalates are allowed to settle, the supernatant liquid is drawn off, and the precipitate is washed by decantation with hot water containing 1% of hydrochloric acid until the wash water gives no reaction for iron. The oxalates are then brought upon a filter, dried, and ignited. The resulting oxides are dissolved by heating them with concentrated nitric acid; the solution is diluted and precipitated with ammonia. The hydroxides are washed by decantation with water and then dissolved in hydrochloric acid. Hydrogen sulphide is passed through a portion of this solution, and if a precipitate results the whole of the solution is treated with the gas. The precipitated sulphides are filtered off, the filtrate is freed from hydrogen sulphide either by heat or by blowing carbon dioxide or air through the liquid, and any sulphur that may have separated is removed by filtration. The clear solution thus obtained contains the rare earths practically free from other elements.

For the separation from one another of the earths which have thus been freed from the commoner elements a large number of methods have been proposed, but even a condensed summary of these would occupy too much space to permit of introduction here. A list of methods, complete up to 1893, has been compiled by Dr. A. Loose and is published in the *Zeit. für anorganische Chemie*, Vol. III., p. 56, and also in the *Chemical News*, Vol. LXIX., p. 179. Since the appearance of the above list the following methods for the separation or purification of certain of the rare earths have been published.

Thorium.—C. Böttinger (*Zeit. für anorganische Chemie*, Vol. VI., p. 1) prepares pure thorium oxide from a mixture of the oxalates of the rare earths by treating the oxalates with an excess of a hot concentrated solution of ammonium oxalate. The thorium oxalate alone is dissolved and can be precipitated from the filtrate by the addition of concentrated hydrochloric acid. On ignition this is said to give a perfectly white and pure thorium oxide.

P. Jannasch, James Locke, and Joseph Lesinsky (*Zeit. für anorganische Chemie*, Vol. V., p. 283) describe the preparation of thorium oxalate from thorite or orangite. Their method is, however, too complex and expensive to be of value.

L. M. Dennis and F. L. Kortright (*Amer. Chem. Journ.*, Vol. XVI., p. 79) separate thorium from the other rare earths by adding to the slightly acid nitrate solution of the earths a solution of potassium hydronitride. Thorium hydroxide is precipitated, the other earths remaining in solution.

Yttrium.—Wolcott Gibbs (*Amer. Chem. Journ.*, Vol. XV., p. 559) obtained nearly pure yttrium by precipitating the cerium group from a chloride solution with an excess of potassium sulphate in the cold, and then, after filtering off the double sulphates, adding sodium sulphate to the filtrate and boiling. An abundant precipitate of a white crystalline salt was thrown down; the atomic mass of the base was found to be 89.55, quite close to that of yttrium. Hence nearly pure yttria can be separated in a single operation after precipitating the cerium group as double sulphates.

H. A. Rowland (*Johns Hopkins University Circulars*, Vol. XIII., No. 112) removes the cerium group of earths by precipitation with sodium sulphate and obtains yttrium from the filtrate by slightly acidulating with nitric acid, diluting, and adding a weak solution of potassium ferrocyanide. This precipitates the erbium. The filtrate is precipitated with oxalic acid, the oxalate is ignited, dissolved in nitric acid, and again treated with sodium sulphate and potassium ferrocyanide. The final filtrate then contains pure yttrium, its oxalate yielding on ignition a perfectly white oxide.

Cerium.—L. M. Dennis and W. H. Magee (*Journ. Amer. Chem. Soc.*, Vol. XVI., p. 649) prepare pure cerium oxide by a modification of the Debray method. This latter consisted in fusing the mixed nitrates of the rare earths with potassium nitrate; the cerium nitrate is more easily decomposed than the others, and upon treating the fused mass with water cerium oxide remains, while the undecomposed nitrates dissolve. The authors found, however, that the melting point of the Debray mixture is so high that some didymium nitrate is also decomposed. It seemed necessary, therefore, to lower the melting point of the mixture, and this was done by adding to the potassium nitrate, which melts at 339°, sodium nitrate, which has a melting point of 316°. When these two salts are mixed in molecular proportions the mixture melts at 231°. The rare earths nitrates were then mixed with an excess of this mixture of the alkali nitrates, and the mass was fused in an air bath at a temperature of 300°. The insoluble cerium oxide which is formed was found to be quite free from didymium. Four such fusions gave a yield of 63% of the total cerium present.

It was also found that the most delicate qualitative test for cerium consisted in adding very dilute ammonium hydroxide to a solution of the rare earths until a faint permanent precipitate of hydroxide remains after shaking, and then adding a few drops of hydrogen peroxide and again shaking. If cerium is present the precipitate takes on an orange-red color.

The *United States Consular Reports for 1895* (see *Journ. Soc. of Chem. Industry*, 1895, pp. 610, 835) contain data upon the prices and uses of monazite, the mineral which is at present the chief source of the rare earths used in the Welsbach and similar lights. The prices of the different kinds of monazite are fixed according to the percentage of thorium they contain. The highest grades of the mineral thus far obtained are stated to be those from Burk and Cleveland counties, N. C., these showing from 4 to 6.5% of thoria. Average monazite sands run from 2.5 to 3.5%. The consul at Berlin gives the following prices per kilogram (2.2046 lbs.) of the various constituents of monazite:

	Price in Marks.	Price in Dollars.
Cerium	80	19.20
Didymium	650	156.00
Erbium	600	144.00
Lanthanum	800	192.00
Thorium	1,800	432.00
Thorium (clean)	1,000 to 1,200	240.00 to 288.00
Thorium (brilliant)	3,200	768.00
Yttrium	750	180,00
Zirconium	105	25.20

SALT.

So far as quantity and demand are concerned, it would seem that the salt production should vary less than that of almost any other mineral product. Ordinarily speaking, the change from year to year should be very nearly equivalent to the increase in population, plus the gain in the amount required for use in the chemical industry. We find, however, that in 1895 there was an actual decrease in the amount of salt produced and sold in the United States, the total for the year having been 13,480,136 bbls. of 280 lbs.—the measure used in the trade—against 14,140,581 bbls. in 1894. It is quite probable that a considerable portion of this decrease was owing to the large amount of salt made in the previous year and the heavy stocks on hand at the opening of the year, for we find that notwithstanding the loss as compared with 1894, the year 1895 showed a gain of 1,841,055 bbls. over 1893, and its production was in fact greater than that of any preceding year on record except its immediate predecessor. The figures, it may be added, include the amount of salt used in the form of brine at chemical works in New York, Michigan, Virginia, and Ohio.

The following table shows the production of salt in the United States, arranged by States and Territories, for the five years ending with 1895. The statistics for the years previous to 1891 will be found in Vols. I., II., and III. of THE MINERAL INDUSTRY:

PRODUCTION OF SALT IN THE UNITED STATES BY STATES AND TERRITORIES.

(In barrels of 280 lbs.)

Year.	California	Illinois.	Kansas.	Kentucky	Louisiana.	Michigan	Nevada.	New York.	Ohio and W. Virginia	Utah.	Other States.	Total Barrels.	Total Short Tons.
1891....	200,000	......	1,000,000	......	221,430	3,927,671	15,000	3,532,600	672,000	465,000	200,000	10,233,701	1,432,718
1892....	235,000	60,000	1,232,850	......	192,850	3,812,054	20,000	4,400,000	738,000	900,000	225,000	11,784,954	1,649,894
1893....	312,850	65,000	1,607,000	......	172,500	(a)3,514,485	7,988	4,413,181	(b)925,620	438,002	182,435	11,639,081	1,629,471
1894....	324,623	65,000	907,000	34,400	185,000	3,485,428	5,100	6,529,694	1,342,400	821,565	439,421	14,140,581	1,979,680
1895....	365,280	68,000	847,949	20,024	178,948	3,929,342	8,428	5,319,155	1,704,000	926,895	521,115	13,480,136	1,888,479

(*a*) Amount inspected. (*b*) Includes the production of Pennsylvania.

While the total change in the production for 1895 was comparatively small, it was not by any means evenly distributed. The following table gives the production of the United States for 1894 and 1895 in greater detail, showing the sources of the production as well as the total amount:

SALT PRODUCTION IN THE UNITED STATES.

(In barrels of 280 lbs.)

States.	1894.					1895.				
	Evaporated.	Rock Salt.	Total Barrels.	Value.		Evaporated.	Rock Salt.	Total Barrels.	Value.	
				Total.	Per Bbl.				Total.	Per Bbl.
California	316,623	8,000	324,623	$113,625	$0.35	329,566	35,714	365,280	$114,150	$0.35
Illinois	65,000	....	65,000	52,000	.80	68,000	....	68,000	47,600	.70
Kansas	607,000	300,000	907,000	544,200	.60	496,573	351,376	847,949	460,773	.54
Kentucky	34,400	....	34,400	22,500	.65	20,024	....	20,024	12,800	.64
Louisiana	....	185,950	185,950	104,134	.66	....	178,948	178,948	100,210	.56
Massachusetts	1,150	....	1,150	1,385	1.20	1,115	....	1,115	1,595	1.43
Michigan	3,485,428	....	3,485,428	2,091,257	.60	3,929,342	....	3,929,342	2,357,605	.60
Nevada	5,100	....	5,100	4,051	.79	8,428	....	8,428	7,495	.89
New York—										
Onondaga District	2,205,451	....	2,205,451	771,939	.35	2,562,825	....	2,562,825	896,888	.35
Warsaw District	2,521,843	....	2,521,843	882,645	.33	1,959,530	....	1,959,530	646,644	.33
Rock salt	....	1,802,400	1,802,400	486,648	.27	....	796,800	796,800	215,136	.27
Ohio	1,112,200	....	1,112,200	633,954	.61	1,479,000	....	1,479,000	798,660	.54
Pennsylvania	125,700	....	125,700	79,192	.63	145,000	....	145,000	87,000	.60
Texas	276,857	....	276,857	230,000	.83	255,000	....	255,000	211,560	.83
Utah	775,993	45,572	821,565	190,641	.23	922,095	4,800	926,895	218,072	.24
Virginia	35,714	....	35,714	17,142	.47	120,000	....	120,000	56,400	.47
West Virginia	230,200	....	230,200	145,026	.63	225,000	....	225,000	130,500	.58
Total barrels	11,798,659	2,341,922	14,140,581	$6,370,339	$0.45	12,521,498	1,367,638	13.489,136	$6,363,088	$0.45
Total metric tons	1,498,193	297,376	1,795,569	....	a3.55	1,539,178	173,662	1,712,840	....	a3.71
Total short tons	1,651,812	327,868	1,979,680	....	b3.22	1,697,010	191,469	1,888,479	....	b3.32

(*a*) Per metric ton. (*b*) Per short ton.

The price showed no change, the average having been very nearly the same in both years. There was a falling off in the production of New York which accounted for more than the decrease in the total output. In that State the Onondaga district showed a considerable gain, but there was, on the other hand, a production of some 560,000 bbls. less in the Warsaw district, while that of rock salt diminished about 55%. Michigan showed an increase of nearly 450,000 bbls., and almost all the other Western States gained slightly with the exception of Kansas; but in that State the loss was comparatively small.

The following table shows the salt production of the chief countries of the world for the five years ending with 1894. The general results show little variation:

SALT PRODUCTION OF THE CHIEF COUNTRIES OF THE WORLD. (*a*) (IN METRIC TONS.)

Year.	Algeria.	Austria.	Canada.	France.	Germany.	Greece	Hungary.	India.	Italy.	Russia.	Spain.	United Kingdom.	United States.
1890..	23,974	304,084	39,704	842,529	1,049,644	18,000	159,912	1,052,849	26,978	1,388,365	615,727	2,182,045	1,113,148
1891..	34,665	301,422	40,854	810,675	1,170,179	19,772	162,788	1,032,268	40,543	1,351,187	582,833	2,077,072	1,299,762
1892..	13,000	288,424	41,254	974,000	1,167,264	21,660	179,744	916,322	23,721	1,459,705	682,634	1,988,024	1,496,771
1893..	19,008	306,856	56,539	1,114,000	1,168,310	18,329	157,209	853,210	25,392	....	361,000	2,015,027	1,478,230
1894..	17,830	....	51,890	890,607	1,253,026	21,310	....	....	30,793	....	520,000	2,271,686	1,498,193

(*a*) For Austria, Hungary, Russia, and Spain the production of all kinds of salt is given; Germany, rock salt and common salt; Greece, sea salt; France, rock and sea salt; Algeria, 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.

The United Kingdom is the largest producer and is also the largest consumer of salt in the chemical industry.

SLATE.

THE principal features of the slate industry in 1895 were a slight increase in the production of roofing slate, with a small decrease in the amount of other products, showing what is believed by the producers to be the beginning of a recovery from the extreme depression of the trade which marked the last half of 1893 and the whole of 1894.

The following table shows the slate production in the United States by States for 1894 and 1895:

SLATE PRODUCTION IN THE UNITED STATES.

States.	1894.				1895.			
	Roofing Slate.		Other Manufactures.		Roofing Slate.		Other Manufactures.	
	Squares	Value.	Sq. Ft.	Value.	Squares	Value.	Sq. Ft.	Value.
California	3,400	$22,400	....	....	3,450	$22,695	....	....
Georgia	5,000	23,250	....	....	6,500	27,505	....	....
Maine	10,347	52,080	11,000	$1,650	5,006	30,036	....	....
New York	70,727	199,193	....	....	105,396	308,671	....	....
Pennsylvania:								
Bangor region, including the Pen Argyl and hard-vein sections	249,381	814,735	772,315	88,372	253,699	823,347	1,243,820	$141,782
Lehigh region, including Walnutport and Danielsville	113,345	361,975	2,658,810	166,156	109,441	346,667	1,699,179	85,740
Peach Bottom region	15,426	76,027	....	....	12,928	74,642	....	....
Vermont	97,771	296,811	856,500	124,280	98,127	258,799	748,600	122,540
Virginia	46,379	160,850	96,500	19,300	50,814	169,877	95,000	19,000
Totals	611,776	$2,007,321	4,395,125	$399,758	645,361	$2,062,239	3,786,599	$369,062

The figures show very little change in the relative importance of the producers. Pennsylvania continues to furnish over two-thirds of the entire slate production of the country, both in roofing slate and in other forms. There is but little change in the quality reported. The Bangor region along the Delaware gained slightly, but this was offset by a loss in the Lehigh district and another in the Peach Bottom district, which is, however, of minor importance. The producing district of New York and Vermont showed a larger relative gain, but its total production is only about one-half that of the Pennsylvania slate quarries. No other State has a very large output, but in Virginia the industry shows a steady and healthy growth. The slate quarried in Maine reached only a small amount in 1895, most of the quarries having closed down in 1894 on account of the dull business, and but few of them having yet reopened. Georgia showed some progress, and there was also a small increase in California. The latter may be expected to continue, as the demand for slate is improving on the Pacific Coast and must be supplied from the California works, as the low value of this article prevents its transportation over very long distances by land.

Some sensation was caused near the end of the year by the announcement that a considerable shipment from some of the Vermont quarries had been made to England, the object being to ascertain if a market could not be made for it in that country in spite of the competition of the Welsh quarries. The slate is said to have been sold to a good advantage, but it is still a question whether the venture will be repeated.

The larger part of all the slate quarried in the United States is used for roofing, but there are a number of minor uses which are gradually extending. Among these may be mentioned the tops of billiard tables; hearthstones, tiling, and other uses in building; laundry tubs, refrigerators, shelves in dairies and other places where constant exposure to moisture prevents the use of wood; besides other minor applications. A considerable part of the production is used for blackboards and school slates. These are made chiefly in Pennsylvania and are shipped all over the country. Within the past few years ground slate has also been used as the basis of a pigment which is being introduced in different parts of the country for special purposes. The manufacture of artificial marble, or marbleized slate, for mantels and other house work may also be mentioned.

Some reorganization was made necessary during 1895 in the Bangor district in Pennsylvania in consequence of the business depression which caused the stoppage of some quarries. In most of these work has now been resumed. An attempt, which will very probably be successful, has been made to combine the small producers in the Peach Bottom district into one strong company. This district covers a considerable area, partly in Pennsylvania and partly in Maryland, and has been worked for a long time, chiefly by small producers who have not had the capital for extensive operations. It is believed that the production can be greatly increased if the quarrying and manufacture are carried on by a large company with abundant means.

The demand for roofing slate hardly increases as fast as it should if its advantages for this purpose were more fully appreciated. Outside of our large cities the universal American roof has been the wooden or shingle roof, and as this has grown more expensive, owing to the increased scarcity and higher price of lumber, it has been in the majority of cases replaced by tin or other metal roofing or by the so-called tar-and-gravel roof. In the larger cities also the metal roof is almost universally in use. Under these circumstances it is not strange that the production does not increase very rapidly. The list of producing districts might be considerably increased were there a sufficient demand to warrant the opening of new quarries and the development of new districts. Until such an increase is secured production will probably be confined to those regions where it is already an established industry.

STONE.

The stone industry, as we have noted in previous volumes, is a branch of the mineral industry in which it is impossible to collect statistics with any satisfactory degree of accuracy. It is so widely extended, carried on in so many different places and under so many different conditions, that to ascertain merely the names and locations of all who are engaged in it is a labor of great difficulty, and to get accounts, returns of output, and values is still more so. Where the business is chiefly in the hands of large concerns it is possible to obtain correct figures, but outside of these there is much uncertainty both as to the fullness of the list and the accuracy of the returns. Outside of the large quarries there are a great number of small quarries, some of which are worked regularly and others only intermittently as local demand requires; again, there are quarries which are opened for a specific purpose, to furnish stone for a single building or group of buildings; and finally, there are a multitude of small openings, hardly deserving the name of quarries, from which stone is taken from time to time, their output representing a certain value in labor, though it is usually difficult to put any price upon it. Even where quarries are worked with some regularity, the smaller producers seldom keep any accurate accounts of their production.

We have estimated the value of building and other stones—in which we have included the stone quarried for paving and road-making purposes—at $37,097,011 for 1895, this amount comparing with $33,605,853 for 1894 and $40,116,508 for 1893. To the output of building stone should be added the value of the limestone quarried and used as flux in the iron furnaces and other metallurgical plants. This we have estimated at a total value of $2,542,509 in 1895, which compares with $2,126,630 in 1894 and $2,250,000 in 1893. The value of the slate, which is a distinct branch of the industry, is given under a separate head. Thus the total value of the stone product (excluding slate) was $39,-639,520 in 1895, this amount comparing with $35,732,483 in 1894 and $42,366,-508 in 1893. The decrease in values for 1895 as compared with 1893 was due to lower prices at the quarries. These estimates have been made on a conservative basis, and they are probably rather under than over the true amount.

The best-known and most extensively worked varieties of stone may be briefly enumerated. The New England granites are quarried in Maine and Eastern Massachusetts near the seacoast, in New Hampshire and Northern Vermont, in Rhode Island and in Southeastern Connecticut.

The brownstone or sandstone of the Connecticut Valley has been widely used in the East, but has not made its way very far from the seacoast.

The bluestone or flagstone of the Hudson River Valley and several places in Pennsylvania is a stone which has been and is extensively used.

The limestones of Ohio and Indiana—of which the Berea stone in Ohio and the Bedford oölitic limestone in Indiana are the best known—have been worked very actively and used in a large number of Western cities.

The Vermont marble, which is the most extensively quarried stone of this class, goes to all parts of the country, since this stone is less used for building than for monumental and decorative purposes, for which smaller quantities are required, and the freight does not constitute a prohibitory addition to the cost.

The following table shows the production of marble in the United States in 1894 and 1895; also of oölitic limestone in Indiana for the same years:

PRODUCTION OF MARBLE AND OÖLITIC LIMESTONE IN THE UNITED STATES.

States.	1894.			1895.		
	Cubic Feet.	Value.		Cubic Feet.	Value.	
		Totals.	Per Cu. Ft.		Totals.	Per Cu. Ft.
MARBLE.						
California	26,580	$50,830	$1.91	....	....	....
Georgia	424,139	478,163	1.13	496,228	$516,534	$1.04
Maryland	291,443	174,475	.60	388,290	232,944	.60
New York	119,231	237,876	2.00	199,156	407,539	2.05
Pennsylvania	20,000	30,000	1.50	25,000	35,000	1.40
Tennessee	147,068	346,868	2.36	207,072	521,972	2.52
Vermont	975,028	1,311,529	1.35	836,365	1,367,080	1.63
Totals	2,003,489	$2,629,741	$1.32	2,152,111	$3,081,069	$1.38
OÖLITIC LIMESTONE.						
Indiana	4,327,790	$947,112	$0.22	4,790,422	$1,005,192	$0.21

Georgia comes next to Vermont as a producer of marble, and the output of stone is increasing, while that of Vermont is nearly stationary. There are three companies engaged in quarrying marble in Georgia on a large scale—the Georgia, the Southern, and the Piedmont marble companies. The belt from which the stone is obtained is in the northwest corner of the State, between Atlanta and the North Carolina line. It is found also in North Carolina and Tennessee and there are occurrences in Alabama, though none has been developed in that State.

Granite is quarried in North Georgia at Lithonia and also at Stone Mountain. At the last-named place four quarries, all owned by the same company, in 1895 furnished 95,000 cu. ft. of stone for building, besides 4,000,000 blocks (about 60,000 tons) for paving uses in Atlanta.

Stone for road making is getting to be more in demand each year. There was formerly an impression that any kind of stone would answer for this purpose, but the fallacy of this idea was soon shown. Not every quarry furnishes good road metal; but in many cases the waste and broken stone can be used for road material and its sale may be an important addition to the quarry owners' returns.

Connecticut Brownstone.

A description of the extensive quarries at Portland and Cromwell, in Connecticut, and a history of the operations there were given in The Mineral Industry, Vol. III., pp. 510–513. Taking up the industry for the year 1895, it is found that in common with all other quarry companies the business of the old-established corporations located there was not exempt from the general conditions of depression and a lessened output during 1894 and 1895. All of the quarries, however, have been able to continue active operations and with reduced force, economy, and conservative management to return some profits to their shareholders. It has been indeed an exceptional business in stone producing which could accomplish this much, for the prices of many varieties of stone now coming to the principal markets have suffered greatly from unwise and injudicious competition. The duties on stone also were reduced under the new tariff law, although it is but fair to state that no increase of foreign material has found a market in this country on that account.

It is entirely to the credit of the five companies engaged in quarrying brownstone that they have refrained from cut-throat competition and maintained a fair average price for their product in the market notwithstanding the dull times. This has been effected without any pooling arrangement, trust, or combination by the companies named, but is the result of a working arrangement regarding prices which has been honestly maintained and adhered to, and furnishes a notable illustration of what can be accomplished by business men of integrity and honor who realize the importance of fair dealing with each other. They have had the advantage, moreover, of a staple demand from the building trades of New York and the principal cities East where the stone has for so many years had a decided preference.

The number of men employed at the quarries in all capacities was probably cut down from 25 to 33⅓% in each case, and the number of working days and hours were also reduced. It was found impossible to market the output which would result from working full capacity, and this enforced economy was unavoidable. Wages remained about as heretofore, but of course the average yearly earning of the entire force was less than in ordinary times by fully 25%. A most important economy has also been effected by the introduction of machinery, entirely superseding the use of animals for any part of the work. The maintenance, care, and additions to stock hitherto used for that purpose have been large items of expense with the companies in years gone by, but were continued under the custom existing for over 50 years, during which time extensive stabling, harness, chain, and shifting paraphernalia had been accumulated; and these objections would weigh against a change involving expense for more modern equipment.

The Middlesex Quarry Company has maintained at one time in the quarry alone as many as 200 head of draught cattle of very valuable stock, with the necessary attendants, and similar equipment was in use in the other quarries. This has all been done away with and the steam engine is now alone and supreme. It was not an uncommon thing in shifting large blocks to different parts of the quarry grounds or to the railroad tracks or vessels for shipment to employ 24 head of draught cattle harnessed together at a single block, and many more than that number had to be employed on some of the inclines. To-day the entire shifting is done by locomotive cranes, the product of the Yale & Towne Manufacturing Company, which the companies put in in 1894, and the quarry steer is about as extinct as the American buffalo. The saving over the old method is the strongest recommendation of the change. It approximates 60% in this branch of the work, and the machines are highly commended by the superintendents in charge.

It is the lesson which has to be learned by all producers and manufacturers—that modern industrial operations can only be conducted in these days of active competition, close profits, and economies by the introduction of the latest improvements in labor or time saving machinery, and that the cost of the new equipment can rapidly be recouped from the money saved by their adoption.

No new operations or extensions have taken place in this section during the past two years, but a large increase in the finished product has been possible through the efforts of the Connecticut Steam Brownstone Company, located at Portland, Conn., and the Middlesex Steam Brownstone Company of Cromwell, who have supplied contractors and builders all through the New England States with cut brownstone, and who have themselves been the contractors for several large public buildings and many churches, school buildings, etc., when the Connecticut stone has been selected. It will undoubtedly be the case in the future that much more stone will be shipped as finished product from these stone-cutting works located directly at the quarries. In this branch of the business the advantages of machinery are again recognized. The diamond saw, for instance, is an expensive piece of machinery, costing about $6000, and many small establishments in the cities cannot afford this modern luxury; but it will accomplish about six times the work of an ordinary steel band with chilled shot and is a great advantage to the possessor. Planing machines for working out moldings and a machine for tooling are also latter-day improvements belonging to a well-equipped stone works, and all of these varied improved mechanisms can be assembled in a large plant to obvious advantage, while the smaller establishments cannot afford them.

A certain amount of the fine carving and embellishment of stone must necessarily be done by hand, and in very fine work this is generally done after it is set in the building. Notwithstanding this fact, machinery is entering more and more all the time into the dressing and preparation of stone used for building purposes and improvements are constantly being made in this direction, the tendency being unquestionably in favor of establishments thoroughly equipped and with abundant capital. In New York City, which is by far the largest market for Connecticut brownstone, no finished product is sold, as there exist in that city and vicinity at least 50 well-equipped steam stone works which are thoroughly organized into a local association controlling cut-stone work for that locality. These yards have worked brownstone continuously for years in the past and are the best customers of the stone producers. Similar organizations exist in Philadelphia, Boston, Baltimore, and other large centers, each of which controls the work in its immediate vicinity. But there is still a very large field for finished cut stone in the smaller cities and towns.

It is gratifying to notice during the past two years a decided tendency to the better use of brownstone as regards the method of setting it in the building on its natural or quarry bed. A grave abuse has existed, to which reference was made in the article on this subject in Volume III.—the indiscriminate laying of stone on edge instead of on the natural bed. This custom has prevailed in the trade, and although architects have very generally specified all stone to be laid on its natural bed, it has been a mere form of words in the specifications and has been uniformly disregarded.

The uptown portion of New York City, which is practically built in certain districts entirely of Connecticut brownstone, reveals many instances of an improper use of the stone in this respect. But a glance through the newer section, where architectural design and supervision have within the last few years made decided progress, shows a much more intelligent and discriminating treatment, and the brownstone front of to-day instead of being a plain, straight façade of smooth-rubbed ashlar, built in rows of unvarying design, now presents to the eye a variety in form, design, finish, and embellishment which is at once artistic and pleasing, and the durability of the stone when laid on its natural bed can never be brought into question. It is pleasant to record this improvement in the use of this stone.

Several important tests have been made upon various samples of this stone during the past two years, notably by the Ordnance Department of the United States Army at the Watertown, Mass., Arsenal. The transverse tests, under loads ranging from 1000 up to 5000 lbs. per sq. in., showed an extreme compression of 0.0137 in. The ratio of lateral expansion to compression was determined at 1.44. The coefficient of expansions between 32 and 212° F. was 0.00000544, determined in water baths. Under shearing tests a shearing strength of 1450 to 1601 lbs. per sq. in. was found. In another test with a block 3.92 by 5.98 in. area, on supports 20 in. apart, the total ultimate strength was 10,480 lbs., the modulus of rupture 2243 lbs. Under compression, again, the ultimate strength was found to be 17,557 lbs. per sq. in. In another series of tests the ultimate strength under compression varied from 14,375 lbs. per sq. in. with first-quality stone down to 7843 lbs. with bridge stone.

These tests of the crushing strength, while important of themselves as relating to the inherent strength of a stone used for building purposes, are not in my judgment the most important ones in determining the selection of the stone to be used for any particular structure. I adhere very strongly to the opinion that a microscopic investigation of the structure of a stone and a chemical analysis of the constituent parts of its composition are of much more relative importance than the power to resist superimposed weight. I have rarely observed a crushed or even a cracked stone in the buildings of our cities, but we see on every hand the most lamentable instances of an injudicious selection of stone from the point of view of its weathering qualities, its permanence of color, and its freedom from imperfections. These tables of crushing resistances are very frequently quoted by all quarry companies and usually dwelt upon with great force, but it must be particularly urged that it is only one of the factors, and to my mind one of the least important, the ratio of absorption and the character of cementing material in any sandstone being much more important in determining its adaptability. What is said in this respect does not apply especially to Connecticut brownstone only, but to all other building stones, the sandstones in particular, limestone, marble, and even granite.

In 1894 the five Connecticut quarries produced and marketed 610,000 cu. ft. of building stone, and about double that quantity of bridge stone was sold by the quarries in gross tons and roughly calculated at about 10 cu. ft. to the ton. The figures for 1895 were about 10% increase on these amounts, showing a total of 670,000 cu. ft. building stone. With the improvement which is confidently looked for in business circles, the output for 1896 is expected to be largely in excess of the latter figures.

The price of building stone in New York City is $1 per cu. ft.; at the quarry it is usually about 90c. per cu. ft. The average price for all stone quarried, including bridge and building stone, was about 35c. per cu. ft. Comparing these figures for Connecticut brownstone with the Bedford oölitic limestone, which has been used in the East to some extent, it is found that the Bedford stone is sold in New York at 75 to 85c. per cu. ft. It costs about 20c. per cu. ft. at the quarries, and the freight to New York is 58c.

The various items of expenditure remain, as heretofore, labor first; freight and transportation second; coal third; general supplies, exclusive of betterments, fourth; salaries fifth; taxes sixth; insurance seventh.

An important business transaction has recently taken place which is worthy of note. The consolidation has been effected of the various interests controlling the Brainerd Quarry Company and the Shaler & Hall Quarry Company, and these two old concerns, one of which was incorporated in 1844 after having existed as a firm under the name of Shaler & Hall since 1788, and the other, which has existed as a firm and corporation since 1812 under the name of E. & S. Brainerd, E. & S. Brainerd & Co., and the Brainerd Quarry Company, have joined forces and will hereafter be practically one interest. Whether this is the advance movement of a further concentration which is in keeping with the economic tendency of the times remains to be seen, but it is the first step, and nothing is more probable than a continuation in the same direction.

The Sandstones of Western Indiana.

By T. C. Hopkins.

The sandstones of Indiana, while of less commercial importance than the limestones of the State, yet rank among the important economic products. Investigation by the writer during the past season shows the presence of several beds of valuable sandstone in the Carboniferous system of Western Indiana.

Some measure of the present industrial position of the sandstone industry is furnished by the following table:

SANDSTONE PRODUCTION IN INDIANA.

Location.	Kind of Stone.	Capital Invested.	Value of Product.		
			1891.	1894.	1895.
Warren County	Mansfield buff	(*a*) $15,000	$33,660	$36,920	$31,000
Parke County	Mansfield brownstone	(*b*) 150,000	30,112	Idle.	Idle.
Fountain County	Riverside and coal measures	(*b*) 260,000	98,090	7,000	13,000
Perry and Dubois counties	Coal measures, brown and buff	(*a*) 35,000	7,850	17,000	53,000
Vermillion, Clay, and other counties	Chiefly coal measure sandstones	(*a*) 50,000	....	20,000	20,000

(*a*) In 1895. (*b*) In 1891.

In 1895 the number of men employed in the whole sandstone area equaled 414; the average wages, $1.75 per day; average price per foot, 26c.; number of quarries in operation, 15.

In the following pages notes are given on the different sandstones which have so far been discovered and worked in Indiana.

The Mansfield Sandstone.—The most important sandstone in the State is that which has been designated in the *Twentieth Geological Survey Report of Indiana* as the Mansfield sandstone, the heavy bed of sandstone and conglomerate at the base of the coal measures thought to correspond stratigraphically to the millstone grit of other States. It lies unconformably upon the limestones or shales of the Lower Carboniferous system and extends in an area varying from less than a mile to 10 miles or more in width from north of the Wabash River in northwest Indiana to and beyond the Ohio River in Southern Indiana. The stone receives its name from Mansfield, in Parke County, a little village 12 miles north of Brazil, where it was quarried rather extensively a few years ago.

On a basis of color there are many varieties of the stone, which may be included in two general classes, (1) red or brown stone and (2) yellow and gray, with more or less variegated stones in both classes. The red color is due to the iron oxide in the cement, the grains themselves being white or colorless quartz. There is a small and varying percentage of the hydrous brown or yellow (limonitic) iron oxide mingled with the anhydrous red (hematite) oxide that produces the varying shades so common in the stone in many localities. In many places these differences in color are so numerous that it is impossible to get stone of a uniform color in commercial quantities, while in other localities the changes are less frequent and one color will prevail through a thickness of several feet. The most common variety is a deep red-brown with a faint purple tinge, closely resembling the typical brownstone of Pennsylvania and Connecticut, but having in general a little deeper and richer tint. Another common variety is a much lighter shade than the preceding, the color being due to the greater prevalence of light-colored particles of crypto-crystalline quartz. A less common but yet abundant variety is a darker shade approximating a walnut-brown color. Another variety limited to special localities is a light bright-colored red, the lighter color being due to the absence of the brown oxide and the occurrence of the red in smaller quantities.

The grains in the brownstones are almost entirely quartz, about nine-tenths white or transparent crystalline and one-tenth granular crypto-crystalline. The grains are angular, sub-angular, and rounded, and vary from medium to coarse in size. The average size of the grains from several different localities is as follows: Mansfield, 0.29 mm.; Portland Mills, 0.34 mm.; Bloomfield, 0.28 mm.; St. Anthony, 0.32 mm. These may be compared with the Cromwell, Conn., brownstone, with grains 0.25 mm. in size. The buff and gray stones are as a rule finer grained than the brownstones, the grains measuring from 0.15 to 0.20 mm.

Associated with the even-grained sandstone are patches of quartz or chert conglomerate of varying extent. In some places these are wholly absent; in others they have a thickness of several feet. In general the conglomerate is a more or less lenticular mass of pebbles with but little accompanying sand; in some places, however, the small quartz pebbles occur scattered through the mass of the sandstone. In many places the sandstone is underlain by a thin bed of coal accompanied by fireclay and black shale, while frequently carbonized coal plants are found at the base of the sandstone scattered through a thickness of several feet.

The thickness of the bed varies in different localities from 10 to more than 100 ft. In two different localities a thickness of 100 ft. was measured, but the base of the bed was concealed beneath the drainage level of the valley and the top scraped by the glacier, so that the original thickness cannot be estimated.

In many places the stone contains "iron blisters" or "iron kidneys," segregations of brown hematite, in sizes varying from that of sand grains to those of an inch or two in diameter. These are caused by the conglomerate character of the rocks, the iron secreting about and disintegrating and replacing the pebbles. Where they occur in quantity they injure the commercial value of the stone.

The chemical analyses that have been made of the sandstone show it to be highly siliceous and practically composed of quartz and iron oxide, the percentage of any other substance being so small as to have no significance in the economic value of the stone.

CHEMICAL ANALYSES OF MANSFIELD SANDSTONE.

Locality.	Color of Insoluble Residue.	Residue Insoluble in HCl.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	Totals.
Brownstone:							
1. Mansfield	White.	92.16	....	6.29	0.05	....	98.59
2. Judson	White.	93.21	0.51	4.91	0.12	....	98.75
3. Hillsboro	White.	91.65	0.56	6.60	0.12	Trace.	98.93
4. Greenhill	White.	98.73	0.28	0.36	0.03	....	99.40
5. Portland Mills	....	....	2.89	19.39	....	Trace.	....
6. Bloomfield	White.	85.29	0.19	11.83	0.06	....	97.43
7. St. Anthony	....	88.41	0.63	8.40	0.13	....	97.57
8. Fountain	....	91.66	0.60	6.41	0.05	....	98.72
Buffstone:							
9. Williamsport	....	98.57	0.05	0.65	0.02	....	99.29
10. Fern	....	....	0.48	1.43	....	Trace.	....
11. Fern	....	....	0.12	0.64	....	0.02	....

No crushing tests have been made on the stone, but they would vary with the length of time it has been out of the quarry. The crushing strength of the fresh stone would fall below the average for a sandstone, and the well-seasoned stone would be equal to or above the average, exclusive of the quartzitic stones.

Absorption tests were made on the stone from one locality only. Two samples after 25 hours' immersion gave 8.6 and 7% respectively of water absorbed.

Fire tests on the stone from one locality show that the stone heated to the temperature of melted lead and cooled either in air or water cracked at the corners.

The stone in the bed or when freshly quarried is soft and friable, but hardens greatly on exposure. In some places the stone on the face of the bluff, or loose bowlders, is scarcely affected by a hand hammer, while the interior can be cut or broken with the greatest ease. In many localities the stone is not used because the people think it is too soft to stand the weather, a mistaken idea that many have regarding building stone. The Mansfield, despite its softness and friability, is one of the most durable rocks in the State, as shown by its chemical constitution, by the history of its use in old structures, by the numerous well-preserved glacial striæ on its upper surface, and better than all, by the character of the outcrops. The most serious drawback to the more extensive use of the stone is not its lack of durability, but the difficulty in obtaining it free from iron secretions and false bedding and with a uniform color. Early exploitations were not conducted very intelligently and the stone does not have as good a name in the market as it really deserves.

Brownstone has been quarried in Indiana at Mansfield, Judson, Hillsboro, Greenhill (red), Portland Mills, Fountain, and St. Anthony. Mansfield was one of the most productive quarries from 1887 to 1893, but is not now in operation. It employed about 40 men, used 2 steam drills, 2 channelers, and 1 saw gang, and shipped stone during the busy season at the rate of one carload per day. A railroad was built to the quarry and considerable stone was shipped to different towns in Indiana, Illinois, and Ohio. The property is now in the hands of a receiver.

Small quantities of stone have been shipped at various times from Judson, Parke County, but there are no large quarries there. At Hillsboro large quantities of stone have been taken out and shipped, mostly to Chicago. The quarries were not in operation in 1895, the drawback being the large amount of waste material, to handle which rendered the industry unprofitable. Near Greenhill, in Warren County, is an extensive deposit of handsome red sandstone that has been quarried for local use, but is too far from the railroad for shipment. The quarry at Portland Mills was opened in 1895, and while some stone has been taken out none has yet been shipped.

At St. Anthony, in Southern Indiana, there is the most productive brownstone quarry at present in the State. J. B. Lyne & Son, the present proprietors, began operations in 1894, in which year the output was valued at $5000, which was increased the next year to $15,000. They have a quarry well equipped with steam drills, channelers, derricks, and sawmill and are producing some good stone.

Near Bloomfield, in Greene County, is a deposit of brownstone which has not yet been worked, but which, judging from the exposure, is one of the most promising in the State. Another promising section for brownstone is on Rocky Fork, in Parke County, a few miles from Mansfield. It has been quarried for local use in limited quantities at different localities.

The largest quarry in the buff Mansfield stone is at Williamsport, where the Williamsport Stone Company has an opening with a clean 50-ft. face, with very little stripping and situated close to the Wabash Railroad. The output for 1894 was 210,000 cu. ft., of which 110,000 cu. ft. were bridge stone, 45,000 cu. ft. building stone, and 55,000 cu. ft. rubble; the output for 1895 was 200,000 cu. ft. The quarry is well equipped with machinery. The markets are mainly along the Wabash Railroad from Toledo, Ohio, to Taylorville, Ill. There is a quarry at Attica which in 1894 produced 54,000 cu. ft. of stone. This quarry was opened in 1856 and has been in active operation ever since, having produced more stone than any other quarry in this part of the State. The quarry at Kickapoo, near Attica, produced 13,500 cu. ft. in 1895.

Besides the quarries mentioned there are dozens of smaller openings, worked spasmodically to supply the local demand.

Portland Stone of Worthy, Vermillion County.—In the productive coal measures overlying the Mansfield sandstone and west of it are several valuable deposits of sandstone which have not been correlated and which have not such a large areal extent as the Mansfield stone, but are none the less valuable in certain localities. One of the productive quarries in the coal measures sandstone is that owned by the Portland Stone Company at Worthy, on the Chicago & Eastern Illinois Railroad north of Terre Haute. The stone belongs stratigraphically to a horizon above that of the Mansfield stone and is associated with beds of clay and coal. A section of the present quarry face shows 50 ft. of workable stone overlain by 25 ft. or more of shale, fireclay, coal, and bowlder clay of the Glacial period.

The stone has a light gray color with bluish tint, is medium to fine grained in texture, consisting largely of fine angular quartz grains varying in size from 0.214 to 0.3 mm. in diameter, mingled with scattered flakes of mica and occasional grains of feldspar, all bound together by a cement of clay, calcium carbonate, and quartz. The clay comes from the decaying feldspar. The mica is of the muscovite variety and occurs in ragged fragments twisted among the grains, serving as an elastic bond of strength. The presence of some iron is indicated in the analysis; it occurs partly as iron oxide and partly as ferrous carbonate. A chemical analysis* of the rock shows as follows: Silica (SiO_2), 91.182%; lime carbonate ($CaCO_3$), 0.864%; magnesia (MgO), 1.413%; ferric oxide (Fe_2O_3), 1.130%; alumina (Al_2O_3), 2.134%; moisture and loss, 3.287%; total, 100%. The quarry was opened by the Portland Stone Company in 1894, and is well equipped with modern machinery and sawmill and employs 30 to 60 men. They produce large quantities of good dimension stone, which is shipped to Chicago, Terre Haute, and intermediate points for building and used for bridges along the Chicago & Eastern Illinois Railroad. The production for 1894 and 1895 was 200,000 cu. ft. for each year.

The thickness of the Portland stone, its massive structure, its homogeneity of texture, composition, and color, the ease with which it can be quarried and

* From the *National Builder*, Jan. 19, 1895, furnished by S. S. Gorby, State Geologist.

dressed, its location on the railroad and proximity to important markets, all combine to give it commercial importance.

Cannelton Stone.—Another important sandstone locality and one of the most productive in the State is near Cannelton, on the Ohio River, in Perry County. Some stone has been produced at the town of Cannelton, but the most productive quarries are in the river bluff 2 to 4 miles east of that town, at and near Rock Island.

The coarse conglomerate sandstone corresponding stratigraphically to the Mansfield sandstone occurs at Rock Island, at the base of the bluff, but it has not been utilized except for riprap work. The building stone has been quarried from a bed 40 ft. or more in thickness that overlies the Mansfield stone. In fact, there are two or more beds separated by black or drab shale, aggregating more than 100 ft. in thickness, but it is from near the base of this series that the best dimension stone has been obtained.

The stone lies in a massive bed with only an occasional open bedding plane, but in all places having a pronounced cleavage parallel to the bedding, which greatly facilitates the quarrying, as it splits readily and easily into slabs of any desired thickness. The color varies from a light gray to a pale yellow, the yellow tint being more pronounced nearer the exterior, owing probably to the greater oxidation of the diffused iron.

A chemical analysis of the stone shows insoluble residue, 96.18%; iron oxide, 1.56%; alumina, 0.54%; lime, 0.15%. This would indicate a stone of great durability so far as dependent upon chemical composition. It is composed almost entirely of small angular quartz grains, which are smaller than the grains of the brownstones or of the Portland stone, averaging 0.14 mm., the largest measuring 0.2 mm., which indicates a remarkable uniformity of grain. There is but little foreign material mingled with the small angular quartz particles, as shown both by the chemical analysis and the microscopic examination. However, not much can be drawn from the chemical analysis alone as to the proportion of quartz in the stone, as the mica flakes would appear in the insoluble residue, but both the megaoscopic and microscopic examination show comparatively little mica to be present, so that the percentage of quartz will probably not vary more than 1 or 2% from that given for the insoluble residue; both muscovite and biotite occur. Besides the regular quartz grains there are numerous aggregations of finely granular quartz, which, as in other sandstones, are thought to be chert grains. There are minute granules of yellow and brown iron oxide scattered through the rock and microlites of zircon and rutile.

The occurrence of the stone on the face of the steep river bluff limits the extent of the quarry in one direction, and in a score or more openings along the hillside the stone has been worked back until the thickness of the overlying shale prevented further work with profit. In place of one large opening there are many small ones, some of which are of considerable length. While the supply of good stone that can be economically obtained is by no means exhausted, it is year by year becoming less accessible. The utilization of the overlying shale in the manufacture of paving brick, which would seem to be practicable and profitable, would uncover vast quantities of superior stone, the profits on which might cover any possible loss in mining the shale.

The value of the product increased from $6100 in 1891 to $12,000 in 1894 and $38,000 in 1895.

The Cannelton stone, because of its lack of bright or attractive color, will never be shipped to any great distance for building purposes. Its advantages are its durability, massiveness, ease of working, and proximity to the Ohio River. It has been used in Cannelton and many neighboring towns for curbing, paving, retaining walls, etc., and to a considerable extent for building; the large cotton mill, Catholic church, and many smaller structures in Cannelton are constructed of it. The locks on the Louisville Canal and on Green River, in Kentucky, are built of it, as well as other works along the Ohio and Mississippi rivers.

The product of the sandstone quarried at Cannelton in 1891 aggregated 61,000 cu. ft., valued at $6100. In 1895 the returns give 383,500 cu. ft., valued at $38,000.

Sandstone has been quarried from rocks of the coal measures at Jasper, in Dubois County; at Brazil, in Clay County; at Coxville, in Parke County, and elsewhere, but more or less spasmodically and mostly for local use.

Riverside Sandstone.—At Riverside, in Fountain County, on the Wabash Railroad, are two large quarries in sandstone of Lower Carboniferous age. Only one of the quarries was in operation in 1895. The sandstone at Riverside is essentially different in color, texture, and structure from the newer coal measures sandstone. It has an attractive light blue color in the interior, which has oxidized to a drab or light buff on the exterior. It has a fine, even texture, cuts and dresses easily, and takes a remarkably smooth finish, well adapted to fine carved work. It occurs in regular layers ranging from 4 in. to 4 ft. in thickness; the total thickness of good stone quarried ranges from 6 to 15 ft.

The chemical analysis of the stone shows insoluble residue, 93.16%; iron oxide, 2.69%; alumina, 1.60%; lime, 0.13%. The iron, which was determined as ferric oxide, as is customary, really occurs mostly as the ferrous carbonate and sulphide. The insoluble residue is mainly quartz, but contains considerable mica. The microscope shows the presence of quartz, muscovite, biotite, plagioclase, calcite, possibly dolomite and siderite, and minute grains of limonite. The average size of the grains is 0.07 mm. and the largest 0.13 mm. in diameter.

The stone has been used largely for building purposes and for trimmings, curbing, and paving in Lafayette and neighboring towns. Smaller quantities have been shipped to more distant points. Similar stone has been quarried in smaller quantities at Raccoon Station, on the Indianapolis, Decatur & Western Railroad, on Big Walnut Creek east of Bainbridge, and elsewhere over the area.

Sandstone of Lower Carboniferous age occurs in considerable quantity in the southern part of the area in Orange and adjoining counties, where it has a local use for building purposes, for whetstones and grindstones.

Conclusion.—It will thus be seen that there are several beds of sandstone of Carboniferous age in Western Indiana capable of furnishing good durable building stone, much of it adapted only to local use for bridges, foundations, retaining walls, etc., but some of it suitable for the finest buildings. Good brown, buff, gray, and blue stones occur and could be profitably quarried much more extensively than is done at present.

The Stone City Limestone Quarries in Iowa.

By J. A. Green.

The quarries of the Stone City district are on the well-known Anamosa limestone, and were originally known as the Anamosa Quarries. They are still known by that name in some sections, though since the establishment of a post-office at Stone City in 1873 that town has been the center of the district. The quarries are nearly all situated on the Buffalo and Wapsipinicon rivers, and the quarry nearest to Anamosa on the Wapsipinicon River is 3 miles west of the city, while those on the Buffalo River are distant 1¼ miles.

The first stone quarried from these hills was used by the army in territorial times in the construction of bridges on the highways. These bridges still stand as monuments of the lasting qualities of this stone.

In 1859 the first stone was shipped to a distance, being sent to Dubuque and Cedar Falls by rail. David Graham, the shipper, opened the first commercial quarry on the center of Section 5–84–4, and this quarry is still in operation. It has been successively owned and operated by D. Graham, by Haines & Lewis, by M. Hisey, and by J. Ronen, the present operator. So far 28,134 cars have been shipped, of which the present operator has shipped 23,234 carloads since 1881.

In 1852 Mr. Haggard quarried from the top of a hill on the extreme west end of the basin stone which was hauled by wagon to Cornell College at Mount Vernon. All the trimming for the building, which was then in process of erection, was hauled over the prairie, there being no railroad. The hill from which these stones were taken was afterward called Mount Hope; the quarry was owned by Dr. S. G. Matson, then by James & Ross, and afterward by James & Ronen, who shipped 5000 carloads of stone. This quarry is not now worked.

Next to enter the field were Crouse, Shaw & Weaver, who opened a quarry adjacent to the first one mentioned. They commenced operations in 1866 and continued until 1872, when they sold the property to the State of Iowa. The quarry was then worked by the convicts from the Anamosa Penitentiary. Crouse, Shaw & Weaver shipped from their quarry in the years 1866 to 1872, inclusive, about 5000 carloads. From 1872 to 1878 the State shipped for its own use and that of the public about 5000 carloads. This quarry sold stone for two years, when the Legislature passed a resolution preventing the State from entering the market against free labor. The quarry was afterward sold to J. A. Green, who operates it on a small scale to fill the deficiency of Champion Quarry No. 1. He has shipped about 5000 carloads from this opening, which is in the extreme east of the stratified stone basin. In 1866 Parsons & Webb opened the Crow Creek Quarry, near the middle of the west line of Section 6 on the Jones and Linn county line and in the same hill as the Mount Hope Quarries. This was worked until 1877, since which time it has been closed. The shipments from this quarry are estimated at about 4000 carloads. In the spring of 1869 H. Dearborn commenced business on the northeast quarter of Section 6–84–4, on the north bank of the Wapsipinicon, and is still at work.

In 1869 J. A. Green opened the Champion Quarry (No. 1), on the south side of the Wapsipinicon River and about the center of the stratified stone basin. The stone here has proved to be exceedingly good. In addition to this Mr.

Green in 1887 opened a quarry, called the Johnellen, on the Buffalo River, 1½ miles north of Anamosa, on the Chicago & Northwestern Railway. It has the highest face in the region.

The next quarry to be opened at Stone City was the one known as Gold Hill, which was opened in 1883 by Dawson & Hess and in 1887 bought by F. S. Brown & Co. From this quarry and another face adjacent, which F. S. Brown & Co. opened and named Mammoth Quarry, were shipped 14,000 carloads.

In 1884 the State of Iowa abandoned its quarry on the Wapsipinicon and purchased one on the Buffalo River near Anamosa, which it still operates and from which it is taking the stone for its own buildings and supplying State institutions. The shipments from 1884 to 1895, inclusive, were some 15,000 carloads. In the spring of 1894 James Lawrence opened a leased quarry on the Buffalo adjoining the State quarry. These are all the quarries opened for railroad transportation.

This stone has been shipped to points in eight States—Iowa, Illinois, Wisconsin, Minnesota, South Dakota, Nebraska, Kansas, and Missouri. It has been used in many important buildings, as in Minneapolis; at the Iowa Asylum for the Blind at Vinton and for the insane at Anamosa; at the Nebraska Asylum for the Insane, and at the United States Arsenal at Rock Island. Some of the columns under the rotunda in the Iowa State Capitol building, where strength is required, were furnished from quarries at Stone City. There are very few towns or cities in Iowa that have not used it wherever stone was required.

The limestone from the Stone City quarries has found especial favor for bridge masonry. It was used in the viaduct below the Falls of St. Anthony at Minneapolis and in six of the other bridges over the Mississippi—the railroad bridges at Sabula, Keithsburg, and Fort Madison, and the highway bridges at Lyons, Clinton, and Muscatine. It has been very largely used for bridge masonry on all railroad lines of any importance running through Iowa and the adjoining States.

The following table shows the shipments of the four principal quarry companies for 27 years ending with 1895:

Year.	Car-loads.	Year.	Car-loads.	Year.	Car-loads.	Year.	Car-loads.	Year.	Car-loads.	Year.	Car-loads.	Year.	Car-loads.
1869 ...	202	1873....	608	1877....	1.024	1881....	4,757	1885....	5,323	1889....	7,549	1893....	4,031
1870....	254	1874....	710	1878....	1,396	1882....	10,390	1886....	5,647	1890....	6,681	1894....	2,957
1871....	474	1875....	883	1879....	2,409	1883....	7,780	1887....	8,748	1891....	5,389	1895....	(a) 2,665
1872....	603	1876....	864	1880....	3,414	1884....	8,665	1888....	9,527	1892....	7,416	Total..	110,627

(a) Eleven months.

The total shipments were divided as shown in the table given below, to which has been added an estimate of the total sent out from the smaller quarries:

Producers.	Carloads.	Producers.	Carloads.	Producers.	Carloads
J. A. Green, 1869-95............	47,618	John Ronen, 1877-95.........	23,234	Other quarries	45,962
H. Dearborn & Sons, 1869-95....	27,432	F. S. Brown & Co., 1877-95...	11,983	Total........	156,229

At an average valuation of $20 per carload, which would be very low, this would give a total of $3,124,580 for the output of this group of quarries.

SULPHUR.

The subject of sulphur, including its occurrence, production, and methods of mining and preparation for market, has been very fully treated in the previous volumes of The Mineral Industry, and little or nothing can be added this year in the way of new information. The United States continued to produce a small quantity, the total reported for 1895 being 1650 long tons, showing a comparatively large increase over 1894, but a total amount about the same as in 1892. Of this total production 1150 tons were from Utah and 500 tons from the Louisiana mines, the latter having been worked to a small extent in an experimental way by the Frasch process, in which hot water is used to melt the sulphur in place and the melted sulphur is pumped to the surface. A 10-in. pipe is put down to near the bottom of the sulphur bed and a smaller (5-in.) pipe is run down inside it and extending below it in the sulphur. The hot water is pumped down between the pipes and the sulphur pumped up through the center pipe. Several thousand tons of pure brimstone have been already (May, 1896) obtained from one hole in this way since the commencement of the present year. There is of course no way in which to ascertain what is left nor when the barren rock, which is bound eventually to cave in around the pipes, will stop the operation, nor is there any way except by experiment to learn how much can be obtained from a single hole. In this case the bed of sulphur is over 100 ft. thick and very pure.

The following table shows the production and consumption of sulphur in the United States for the five years ending with 1895:

SULPHUR PRODUCTION, IMPORTS, AND CONSUMPTION IN THE UNITED STATES.

Year.	Production.			Imports.								Consumption.	
	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.
1891....	1,071	$39,600	$37.00	116,971	$2,675,192	206.00	$6,782	10.00	$1,997	117,187	$2,683,971	118,208	$2,722,026
1892....	1,630	54,750	33.00	100,938	2,189,481	158.00	5,439	26.00	4,106	101,122	2,199,026	102,752	2,253,773
1893....	1,200	26,880	22.50	107,601	1,903,191	240.96	5,746	41.73	1,017	107,885	1,909,954	109,020	1,935,474
1894....	441	7,056	16.00	124,467	1,734,643	165.00	4,145	41.00	1,207	124,673	1,739,641	125,114	1,747,405
1895....	1,650	26,400	16.00	125,950	1,593,148	581.00	12,888	229.00	4,378	128,410	1,636,814	128,410	1,636,814

The consumption of sulphur in the United States increased to a moderate extent, the total amount used having exceeded that reported in any previous year. There was a decrease in value, owing to the large supply, which was sufficient to meet all demands and to leave some surplus.

The following table shows the production of sulphur in the world for the five years ending with 1894:

WORLD'S PRODUCTION OF SULPHUR. (IN METRIC TONS.)

Year.	Austria	Hungary	Germany	Greece.	Italy. (*a*)	Japan.	Mexico.	Russia.	Spain.	Sweden	United States.
1890........	40	63	1,915	2,044	369,239	20,741	628	161	9,855	42	....
1891........	37	40	2,020	1,498	395,528	21,963	....	327	9,900	23	1,088
1892........	45	42	5,155	1,664	418,535	20,521	....	388	7,822	46	1,656
1893........	53	70	2,151	2,400	417,671	23,927	898	....	4,686	75	1,219
1894........	44	93	2,168	1,528	405,781	....	234	....	....	36	448

(*a*) Crude.

Italy continues to be the main producer, furnishing nine-tenths of the commercial supply of this mineral. The output from all the other countries reported is very small, with the single exception of Japan, and Italian brimstone is shipped to all the countries of Europe and America. The principal reason for this has not been the absence of sulphur deposits in other countries, but the cheapness with which the Italian sulphur has been mined and put upon the market, preventing competition.

The importance of the sulphur industry in Italy and the controlling influence of the Italian sulphur on the markets has led to the keeping of fairly accurate statistics, extending over a long series of years. The table given below shows the exports from Italy to various countries for the five years ending with 1895:

EXPORTS OF SULPHUR FROM ITALY TO VARIOUS COUNTRIES. (*a*) (IN METRIC TONS.)

Year.	Austria-Hungary.	Belgium.	France.	Germany	England.	Holland.	Portugal	Sweden and Norway.	Turkey.	Spain	Greece	United States and Canada	Russia.	Australia.	Other Countries.	Totals
1891	15,490	5,241	58,262	12,067	26,681	1,837	7,309	1,296	2,996	7,726	11,326	101,578	12,752	20	4,795	269,376
1892	13,499	5,582	77,424	18,668	24,739	2,465	11,240	4,295	3,068	9,437	12,887	89,557	11,186	2,282	4,751	291,080
1893	13,807	3,957	91,722	17,531	25,286	3,070	12,615	3,343	4,931	6,762	11,450	89,044	19,174	1,726	6,449	310,867
1894	10,427	5,120	51,648	14,912	20,108	2,145	7,865	7,155	11,664	3,125	4,640	95,956	16,308	.....	3,063	254,136
1895	12,170	6,410	69,696	15,472	24,043	3,335	15,472	5,730	16,195	5,755	....	99,227	17,962	.....	7,732	347,636

(*a*) From *Notizie e Studi sulle Conditioni dell' Industria dello Zolfo*, Rome, 1895.

No new mines have been opened or worked to any extent outside of Italy, nor has any work been done on the various deposits in the New Hebrides and some other islands in the Indian Ocean which have been heretofore discovered and superficially examined. Several of these are large and important and can be relied upon to furnish almost any quantity which may be required in the future.

The course of prices of sulphur and a general account of our own market for 1895 will be found on another page under the heading of "The Chemical Market."

TIN.

The following table gives the production and consumption of tin for the five years ending with 1895. It also includes the stocks on hand at the close of each year, showing what are called the "statistics" of the trade. The figures are in long tons of 2240 lbs. The statistics for the years prior to 1891 will be found in The Mineral Industry, Vols. I., II., and III.:

STATISTICS OF TIN FOR THE WORLD. (*a*)

	1891.	1892.	1893.	1894.	1895.
Production:					
English production	9,353	9,270	8,213	8,000	7,500
Straits' shipments to Europe and America	31,457	34,648	39,670	46,640	47,340
Australian shipments to Europe and America	5,991	5,972	5,579	5,824	4,992
Banca sales in Holland	5,350	6,300	5,244	5,626	6,221
Sales of Singkep in Holland	....	....	....	....	644
Billiton sales in Java and Holland	5,753	5,560	5,462	4,735	4,539
Bolivian arrivals in England	1,559	2,819	2,909	3,482	4,097
Totals	59,463	64,569	67,077	74,307	75,333
Consumption:					
Deliveries from London after deducting all shipments to America	17,667	14,122	18,663	18,050	17,222
Deliveries from Holland after deducting exports to London and America	8,246	8,719	7,853	8,207	9,029
English consumed at home	3,834	3,158	2,260	2,314	1,845
Exports of English, minus quantity shipped to America	4,990	5,648	6,554	5,686	5,530
American consumption of all sorts	15,457	18,750	19,000	16,650	22,500
Billiton sent to other ports than Holland	1,972	2,605	1,919	862	1,532
Straits direct to Continent, less reëxports to America and England	3,579	5,500	8,900	11,725	7,622
Bolivian delivered from Liverpool	1,658	2,656	2,704	3,323	4,099
Totals	57,403	61,158	67,853	66,817	69,377
Stocks, Dec. 31:					
Stock of foreign in London	2,155	2,776	4,392	8,985	13,539
Foreign landing in London	1,162	4,346	817	1,189	1,025
Straits afloat for London, including wire advices	2,225	2,170	3,470	3,778	2,825
Australian afloat for London, including wire advices	802	957	909	650	825
Banca on warrants in Holland	511	868	319	1,006	1,154
Billiton in Holland	357	326	640	1,632	1,507
Billiton afloat for Holland	1,912	1,240	1,600	1,129	1,007
Straits stock in Holland	160	190	670	....	277
Bolivian in Liverpool	....	....	....	....	492
Total stocks	9,284	9,873	12,817	18,369	22,741
Estimated stock in America and quantity floating	3,228	5,492	2,730	3,820	6,823
Grand totals	12,512	15,365	15,547	22,189	29,564
Trading Company's reserves of unsold Banca stock in Holland	3,140	3,480	4,200	5,770	6,140
Floating for Holland	....	139	....	....	....

(*a*) From the annual metal circular of W. T. Sargent & Sons.

The tin industry during 1895 was characterized chiefly by the continued development of the production in the East, without any marked changes in methods of mining or other work. By far the greater part of the supply has continued to come from the workings in the Malay Peninsula and from the islands of Sumatra and Borneo. The production in Bolivia increased moderately and the exports from Australia have continued about the same. Some new discoveries have been reported in Australia, but development has been on a small scale and these new districts have not added to the list of actual producers.

In the United States no tin was produced during the year, and there seems to be no immediate prospect of any of our mines adding to the supply. The Temescal mines in California continued idle, and no attempt was made to do anything in Virginia or North Carolina. The Harney Peak Tin Mining Company in South Dakota continued in the hands of a receiver, and no further steps have been taken toward working the mines, which so far as known would not pay.

The consumption of tin in the United States shows a very considerable increase, the gain in imports in 1895 over 1894 having been 14,983,417 lbs., an increase of more than 35%, as shown in the following table:

IMPORTS OF TIN INTO THE UNITED STATES.

Year.	Pounds.	Value.	Year.	Pounds.	Value.
1890	33,821,319	$6,869,645	1893	40,184,556	$8,007,292
1891	41,146,123	8,091,363	1894	39,268,628	5,944,065
1892	46,821,958	9,415,889	1895	54,252,045	7,405,619

Part of this increase was due to the general improvement of business, but a considerable portion also to the growth of the manufacture of tin plate in this country. This is further shown by the following table, showing the exports of tin plates from the United Kingdom:

EXPORTS OF TIN PLATES FROM THE UNITED KINGDOM.

(In tons of 2240 lbs.)

	1891.	1892.	1893.	1894.	1895.
To the United States	325,145	278,479	255,583	226,880	222,901
To other places	123,587	117,101	123,650	127,048	143,081
Total tons	448,732	395,580	379,233	353,928	365,982

It will be seen by these figures that the exports to the United States continue to decrease in spite of the improvement in business, and that the proportion of the imports destined for this country was considerably less than was the case five years ago. At the present time the tin-plate industry in Great Britain is not in a flourishing condition. The production of metallic tin in Great Britain also continues to decline gradually, owing to the partial exhaustion of the mines and also to the higher cost of production, which prevent the Cornwall operators from competing with those of the East with their greater abundance of ore and cheaper labor. The continued low price of silver and the course of the Eastern exchanges has also favored the miners of the Straits Settlements and of the Dutch

East Indies. One Cornwall mine, the Dolcoath, has abandoned the old cost-book system which had prevailed there for many years and has been reorganized as a joint-stock company, the stockholders putting in a considerable amount of new capital in order to furnish means for sinking a new shaft, for putting in improved machinery, and generally for adopting more modern methods. Should this company be successful in thus reducing the cost of production several of the larger mines will follow its example, but there is little doubt that many of the Cornish mines will before long be obliged to abandon the struggle and close down their workings.

Tin in Bolivia.—While the production of the Bolivian mines is comparatively small, it has shown a steady increase, and in 1895 was much larger than ever before. The production for a series of years is shown in the following table:

PRODUCTION OF TIN IN BOLIVIA.

Year.	Long Tons.	Year.	Long Tons.	Year.	Long Tons.	Year.	Long Tons.	Year.	Long Tons
1886......	354	1888.....	1,363	1890.....	1,664	1892....	2,819	1894....	3,482
1887......	982	1889.....	1,389	1891.....	1,559	1893....	2,909	1895....	4,100

Tin in Singkep.—It will be noticed that the production of the Straits—that is, of the Malay Peninsula which is marketed at Singapore—continues to form more than one-half of the world's supply of this metal. The only new producer which made its appearance in 1895 was the island of Singkep, which is an island belonging to the territory of the Sultan of Lingga, who is a native ruler of the territory under a Dutch protectorate. The Singkep Tin Company, which has its headquarters in Holland and which operates the mines, was organized in 1889, and has since erected mining plants in the island, making, as above noted, its first appearance as a producer on a large scale in 1895.

Tin is also found on the island of Karimon, a small tract of land about 3 miles square some 10 miles to the southwest. This is also a Dutch possession, and several English mining engineers have been trying to obtain a concession of the property.

Tin in the Malay Peninsula (*Straits Tin*).—The figures given in the large table at the beginning of this article show only the shipments from the Straits Settlements to Europe and America, not including the quantity sent to India and China. The following table gives a complete statement of the exports for three years past:

EXPORTS OF TIN FROM THE STRAITS SETTLEMENTS.

Shipped to—	1893.	1894.	1895.
	Long Tons.	Long Tons.	Long Tons.
United States......................	4,434	7,359	12,973
United Kingdom....................	25,992	25,930	23,233
European continent...............	9,518	13,180	11,626
China..............................	2,045	2,700	2,656
India..............................	2,240	1,955	2,018
Totals.........................	44,229	51,126	52,506

As to the actual production, it is difficult to secure exact figures, as a large part of the tin is obtained from native States, which, although they are under a strict British protectorate, do not follow British methods in statistics. A part of the tin exported from the Straits also comes from the Malayan States which are under Siamese authority.

For some particulars with regard to the tin deposits and the tin mines of the Malay Peninsula we are indebted to a recent article by Mr. Henry Louis,* who resided for some years in that country. The Malay Peninsula is altogether about 600 miles in length and varies in width from 100 to 200 miles. A small portion of the southern extremity is a British colony, north of which are a number of independent States under British rule, while the extreme northern extremity is under a Siamese protectorate. Beyond the fact that the central portion of the peninsula is constituted by a mountain chain of considerable elevation running from north to south, little is really known about its geology. Exploration at any distance from the coast is very difficult, owing to the dense tropical vegetation, and the savage hill-men prevent any expedition from penetrating very far into the interior unless in considerable force. Several rivers of good size run from this mountain chain. So far as exploration has extended, tin is the most important mineral existing in the peninsula, although gold is also found in many places and other minerals are known to exist. The tin deposits so far worked are in alluvial gravel, usually resting on clay, though occasionally resting on shale. The tin-bearing gravels are generally covered by an overburden of sand, loam, etc., varying in thickness. As a rule, the miners say that the deeper the overburden the thicker the paying gravel. While it is of course impossible to make an exact average, a very good return is considered to be 25 lbs. of black tin (oxide containing 68 to 69% of metal) to the cubic yard of gravel. The mining is almost entirely in the hands of the Chinese, who own most of the mines and work them in their own fashion, using only the most primitive machinery. The general practice is very much as follows: A gang of men clear off the jungle from a definite area of tin-bearing land; they then strip off the overburden, a heavy hoe being almost the only tool employed; having reached the gravel, that is excavated in the same way and is washed out in short sluice boxes with transverse riffles. The tin ore thus obtained in small pebbles is smelted in blast furnaces built of clay after a very old-fashioned pattern for the most part; in some cases the ore is sold at once without smelting. The largest ore buyer at present is the Straits Trading Company at Singapore, which owns an excellent plant in which the tin is smelted in reverberatory furnaces.

It will readily be seen that with the methods which have generally prevailed only the surface deposits have really been worked. The Chinese miners generally associate in gangs or companies. They are not provided with any considerable amount of capital and do not undertake deep mining anywhere, so that only those deposits which are near the surface and do not require too great an amount of labor to remove the overburden are touched. Recently a beginning has been made on a larger scale by several English companies. At Gopang, in the native State of Perak, a company has commenced hydraulicking the tin deposits which have been passed over by the Chinese. This company has brought water a dis-

* London *Mining Journal.*

tance of 6½ miles and is at work on a tract of 300 acres. At latest accounts it was working about 400 cu. yds. a day and obtaining satisfactory results, although the ground was considered rather poor. At Kuchai, in the State of Selangor, where the overburden is very heavy, shafts have been sunk through it and the pay gravel is being regularly mined. At Rawang, in the same State, where rich tin deposits were known to exist, but could not be worked on the old methods on account of the great quantity of water, another company has erected a large pumping plant, power being obtained at a waterfall 2 miles from the mines and transmitted to the motors by electricity.

Up to within a very short time all the tin furnished from the peninsula was obtained from the gravel deposits, but within the last three years tin lodes have been worked. The first attempts made at Salema and Menglembu, in Perak, were not encouraging, the lodes pinching out at comparatively small depth. Other attempts, however, have been more successful. At Kuantan, in Pahang, a lode is being successfully worked by the Pahang Corporation and from 200 to 300 tons of tin are being got yearly. In 1893 the Pahang Corporation crushed 5467 tons of ore and got 214 tons of black tin, yielding 65% of metal. A similar deposit is being worked at Bundi, in Tringganu, by an English company. At Kuchai a most interesting find has been made in the form of leaders and veinlets of tinstone in a gangue of felspar and quartz, apparently an altered granite, like so many of the occurrences of tinstone in Saxony and Bohemia; the kaolin resulting from the decomposition of the above rock is also impregnated with tinstone. This discovery seems to place the origin of these alluvial tin deposits beyond doubt and may have important results in the future.

So far as can be seen at the present time, the only limit to the production of tin is in the supply of labor. The Malays themselves are not steady workers and are especially poor miners, and the main dependence is upon the Chinese. While there have heretofore been a sufficient number, during 1895 the war with Japan interrupted the supply of new men to a considerable extent, but since the conclusion of the war it is again increasing. Should the hydraulic methods of working the tin-bearing gravels be adopted a great saving of labor will be effected and the output of the peninsula will doubtless be largely increased.

It may be noted that Chinese do the principal work in the tin mines of the Dutch East Indies as well as in the Malay Peninsnla, and they seem to be in fact an essential element in the mineral industry of all parts of the extreme East.

Tin in Tasmania.—A large part of the tin exported from Australia is furnished by the mines of the island of Tasmania. According to the report of the Secretary of Mines, the tin production of that colony for the fiscal year ending June 30, 1895, was 4236 long tons, valued at $1,331,632, an average of $314 per ton; for the preceding year the total output was 4874 tons, valued at $1,602,571, an average of $329 per ton. The decrease shown in 1895 was 638 tons, or 13.1%, in quantity and $270,939, or 16.9%, in values. The decrease was due partly to the lower prices, which rendered the industry less profitable, and partly to a very dry season, which made the supply of water insufficient for the alluvial workings in which a large part of the tin ore is obtained. On June 30, 1895, there were in force 720 leases of tin-bearing lands, covering a total of 31,207 acres; this showed net decreases during the year of 177 leases and 14,326 acres. There were 126 new leases taken out and 403 canceled.

The exports of tin from Tasmania reached a maximum point of 4242 tons in 1885; since then they have never been as much as 4000 tons in any one year, and are now only about three-fourths of the maximum. For 16 years they have been as follows, in long tons, by calendar years:

EXPORTS OF TIN FROM TASMANIA.

Year.	Tons.	Value.	Year.	Tons.	Value.	Year.	Tons.	Value.	Year.	Tons.	Value.
1880....	3,954	$1,640,332	1884....	3,707	$1,446,844	1888....	3,775	$2,046,341	1892....	3,174	$1,392,398
1881....	4,124	1,803,720	1885....	4,242	1,715,457	1889....	3,764	1,655,717	1893....	3,129	1,249,051
1882....	3,670	1,733,020	1886....	3,776	1,744,147	1890....	3,209	1,422,566	1894....	2,934	951,830
1883....	4,122	1,806,940	1887....	3,608	1,967,294	1891....	3,235	1,400,232	1895....	2,510	788,140

It is not to be inferred from this table that Tasmanian tin is a vanishing quantity, since the opinion of geologists and miners familiar with the island is that the production could be largely increased and that there exist reserves of tin ore which have hardly been touched. The industry has been discouraged by several years of declining prices and by the active competition of the Straits, of Banka, and of Billiton.

Tin mining is carried on in Tasmania in two ways: by ore or vein mining and by alluvial washings. The former method is gaining in importance, while the latter is more variable, but on the whole is losing. The alluvial workings are chiefly carried on by lessees or tributors on a small scale, while the vein mining is conducted by companies.

The largest and most important concern is the Mount Bischoff Tin Mining Company. This company's report for the half year ending June 30, 1895, shows that the tin ore obtained for that period was 1138 tons; the ore smelted was 1143 tons, yielding 892 tons of metallic tin. In addition to this there were treated in the company's furnaces for tributors and others 719 tons of ore, yielding 494 tons of tin. The company's net earnings were $112,281, of which there were paid for dividends $93,600 and for income tax $12,480. In the second half of 1893 the company was able to pay $137,280 in dividends; since then the production of tin has increased and the lower dividends measure the fall in prices. This company has a large and permanent plant at its mines.

The Mount Balfour Mining Company is also engaged in lode mining for tin, and the Australian Tin Mining Company has just completed an extensive plant near Weldborough, including ore crushers, smelting furnaces, tramways, etc.

Alluvial mining for tin is carried on in a number of districts—Stanley, Waratah, West Bischoff, Weldborough, Mount Heemskirk, North Dundas, and others. There are several companies working tin-bearing gravel deposits on a considerable scale, but a large part of this work is done by individual miners or parties working under "miners' rights," or licenses granted by the Mines Department. In some cases these men work as tributors on lands belonging to different companies. The year 1895 was an unfavorable one for this kind of mining especially, on account of the short water supply—a much more uncommon occurrence in Tasmania than on the Australian continent.

The New York Tin Market in 1895.

If in the history of the tin market the year 1894 figured as one during which wider fluctuations occurred than for several years past, the year 1895 broke the record, since during its course lower prices were witnessed than at any previous time during 16 years.

There has always been more speculation with tin than with any other metal. The syndicate concerning which we reported in 1894 is still in existence, and though its holdings did not remain nearly so large as in December, 1894, still its influence was felt throughout the year. That it was not successful was due to various causes. First of all, there was the strong bear party, whose operations at times contributed largely to the demoralization of the market, especially during the first half of the year. In the second place, the low prices ruling for silver naturally had a depressing influence on those for tin, without in the least affecting production, which was again quite heavy. Last, but not least, it proved impossible to induce consumers to take an interest in the article. Thus the demand did not come up to expectations, importers and consumers bought most conservatively—hardly anybody laying in stocks—and the syndicate had to carry the whole burden alone. When it became evident that the scheme would result in failure, the members tried to unload with the view of covering later on at lower prices, in order to make up for their losses. However, these manipulations had only the effect of seriously disturbing the market at times. Whenever there were buying orders attributed to syndicate members, the market advanced a little, only to drop again as soon as this support ceased.

Production in the United States continued *nil.*

As to the tin-plate industry, the expectations entertained in this country were not realized to any large extent, chiefly owing to the high prices which had to be paid for black plates. The boom in the iron market interfered most seriously with this trade, while English manufacturers, though similarly affected, did not suffer to the same extent, and were still able to compete successfully.

The year opened with a total visible supply, including shipments afloat, of 24,614 tons, or 8224 tons more than on January 1, 1894. Prices were lower than at any time during the previous year, spot metal selling at 13⅛@13¼c. Toward the end of January the lethargy which hung over the market for such a long time was lifted, and the continual drop in prices ceased, giving way to great excitement brought about by the buying of all spot and near-delivery tin for account of strong operators here. They practically succeeded in cornering the market, as much as 14¼c. having been paid for spot tin. A similar state of affairs existed during the first and second weeks of February.

During March the market reached the lowest point. Tin could be bought at 13c. and even cheaper for future deliveries. These low prices did not fail to attract attention. With orders for manufactured goods coming in at a better rate, with confidence returning and the prospects of future business brighter than for a long time past, consumers started to buy more freely, and in consequence values hardened from week to week.

In spite of unfavorable statistics and an apparent disinclination on the part of consumers to pay the higher prices which had meanwhile been established for the metal, there was a further advance, which was mostly due to the strong tendency existing in other metals. Naturally this could not go on forever, and while in the middle of May considerable business was done at about 15¼c., by June 1 prices had again dropped to 14½c.

In the second half of the year there was not much of interest to report. The market continued steady with small fluctuations, following the London market.

In October values hardened a little, and at one time 14⅞@15c. was paid. The consumptive demand was then quite fair. The crisis in some of the financial centers of Europe which occurred about the end of November naturally also adversely influenced the prices of tin, and values again receded about ½c. per lb. The break in silver in December caused a further decline, and round lots changed hands at prices considerably below 14c. Near the end of December another drop occurred, and the year closed with the price at 13⅝c. per lb.

It was reported at the beginning of November that severe floods had prevailed in some of the Straits mining districts, and it was estimated that there might be a loss in production, which would be noticeable in the December-January shipments, of about 1500 tons. But this proved incorrect, and the statistical position of the metal remained rather an unsatisfactory one, the result of the year's transactions being a further increase of a few thousand tons in the visible supplies.

The table given below shows the monthly average prices of tin in the chief markets of the world for the last five years, compiled from the figures given weekly in the *Engineering and Mining Journal:*

PRICES OF STRAITS TIN IN NEW YORK, IN CENTS PER POUND.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1891	20.20	19.99	19.75	19.50	20.00	21.00	20.20	20.10	20.25	20.10	20.00	19.90	20.12
1892	20.50	20.00	20.25	20.50	20.80	22.00	21.00	20.50	20.35	20.50	20.80	20.00	20.60
1893	19.99	20.30	20.71	20.81	19.96	19.76	19.15	18.81	20.14	20.84	20.61	20.67	20.15
1894	20.16	19.60	19.09	19.75	20.21	19.75	19.22	19.22	16.27	15.35	14.56	13.81	18.08
1895	13.25	13.35	13.20	14.00	14.65	14.15	14.40	14.35	14.45	14.65	14.40	13.91	14.05

For the years prior to 1891 the figures will be found in THE MINERAL INDUSTRY, Vols. I. and II.

THE LONDON TIN MARKET IN 1895.

THIS market, which sustained in 1894 a fall of £12 per ton, was subject during 1895 to much less violent fluctuations. The new year opened with a scarcity of spot and a consequent contango on that position which was dealt in at £61 2s. 6d., while three months, usually at a premium, was done at £61. The statistics published early in the month showing an increase in the stock in and afloat to Europe from 17,739 tons to 19,827 tons had a bad effect, and spot touched £59 17s. 6d. during the first week. A rally to £60 7s. 6d. (for both positions) was followed by a fresh decline, due to free offers from the Straits and to bare tactics in London, and spot was done as low as £58 15s. Some vigorous buying getting it at this juncture, there was a brisk advance of nearly £3 per ton, to £61 12s. 6d., followed by bear sales and a drop to £59 12s. 6d. The rise in silver which then occurred, coupled with a sudden advance of about £8 per ton in America, due to the cornering of a bear, caused a sharp rise of 4% in London, which was nearly all lost again when the New York market subsided to its former level.

February opened in quiet tendency, with business in cash Straits at £60 15s. down to £59 17s. 6d. The severe frost preventing the landing of parcels arrived in the river produced a transitory dearth of spot stuff, which consequently stood at a premium, but £60 12s. 6d. was the highest price realized, and the month closed dull at £60, £59 5s. having been touched in the interval. The proposal made at the end of February for an international conference for the rehabilitation of silver induced hopes of an improvement in the latter article and a consequent advance in tin; and after a drop to £59 10s. during the first half of the month of March these hopes were to a certain extent realized, silver rising to 30¾d. and tin rapidly improving to £63 5s. before the month closed and to £64 12s. 6d. at the beginning of April. Throughout this month the tin market continued to be affected mainly by the fluctuations in the value of silver. A drop to £63 5s. was followed by a rally to £64 5s. and later to £64 12s. 6d., the subsequent values ruling between that figure and £63 7s. 6d. Shipments were on a considerable scale, while London consumers and speculators withheld their support. Both during this and the previous months a fairish quantity of foreign tin was purchased by English smelters for conversion into English tin.

May was a brighter month for trade generally. Peace had been concluded between China and Japan, and the political outlook was on the whole not unsatisfactory. Activity and higher values characterized most metal markets, and tin in sympathy therewith rose rapidly, touching eventually £68 12s. 6d. spot, an advance of about £4 12s. 6d. per ton upon the closing value of April. The collapse which took place in copper during the third week in May led to a reversal of the strong upward movement in tin, and £65 17s. 6d. was quickly reached. A rally to £67 17s. 6d. followed and was in its turn succeeded by a relapse to £64 6s. 3d., the closing value. The bad statistics published at the beginning of June, showing an increase of about 1300 tons in the visible European supplies, depressed the value still further, and there were the additional factors of poor speculation and poor trade demand from the Welsh tin-plate works. Under these circumstances the decline continued with transitory rallies until £61 17s. 6d. was done, when a reaction carried the value up to £63, the month closing 5s. thereunder.

July opened in better tendency, and a certain stimulus was imparted by the decrease of a thousand bars in the statistics and by a prime silver market, and—with slight fluctuations—the value improved to £64 7s. 6d., from which, in harmony with lower silver, it receded to £63 7s. 6d. This level attracted buyers, and the execution of several good buying orders was attended by an advance to £66 15s. The position of the article in itself was far from good and had indeed been undergoing steady depreciation, owing to the greatly increasing excess of production over consumption. The chance of definite improvement appeared to lie, therefore, chiefly in hopes of improved consumption and something like a permanent recovery of silver, which, by lowering the dollar price, would naturally tend to check excessive production in the Straits. From £66 15s. prices were sent down to £64 12s. 6d. by the beginning of August as the result of realizations induced by the former relatively high level. The tone continued decidedly dull during the major part of this month and the value declined to £63 10s., recovering, however, to £64 15s. by the close. The statistical position had remained *in statu quo* and the price fluctuations during the ensuing month, September, were small, the value ranging between £65 10s. and £64 15s.

The interference with trade caused by the shipbuilding strike in Glasgow and Belfast in October, coupled with the unsettled political outlook and the flatness in the various stock exchanges, affected the tin market unfavorably by discouraging speculators. Values, however, were again comparatively steady, and toward the end of the month a rise from £65 3s. 9d. to £66 15s. was caused by anticipations of the severe floods in the Straits checking the production there. The strength derived from this fortuitous circumstance was short-lived, and November witnessed a marked decline in values, from £66 15s. to £63 15s. December brought a continuation of the retrograde movement. Early in the month the easing off of silver and expectations of heavy shipments from the Straits caused a fall from £63 12s. 6d. to £62 10s., and after a rally to £63, the predominance of the selling element sent the value down to £61 6s. 3d., from which it recovered after intervening fluctuations to £61 12s. 6d. spot.

Australian tin, which opened the year at a premium of 2s. 6d. per ton over Straits, rose gradually to 30s. premium, this figure being attained in September and October. From that time it gradually sank until 15s. was reached.

The quotations for English tin (common ingots) varied from about £2 10s. to about £4 5s. per ton over the price of Straits; the terms for the former are less 2¼% discount delivery free on board, as against net in warehouse for the latter.

The following table shows the imports and exports of tin in the United Kingdom for three years past, as given by the Board of Trade returns:

IMPORTS AND EXPORTS OF TIN IN THE UNITED KINGDOM.

Year.	Imports.				Exports.
	Straits.	Australia.	Other Countries.	Totals.	
	Tons.	Tons.	Tons.	Tons.	Tons.
1893............	25,963	4,662	2,933	33,558	25,809
1894............	30,413	5,549	3,186	39,148	27,891
1895............	34,065	4,219	3,367	41,651	26,367

Of the exports in 1895 there were 20,710 tons foreign tin reëxported and 5657 tons British tin.

The following table shows the prices of Straits tin in London for five years. For the years prior to 1891 the prices can be found in THE MINERAL INDUSTRY, Vols. I. and II.:

MONTHLY AVERAGE PRICES OF STRAITS TIN IN LONDON, PER TON OF 2240 LBS.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1891.....	91 1 10	90 3 1	90 6 10	89 16 3	91 13 9	93 3 1	91 17 9	91 11 3	91 11 3	90 19 9	91 8 5	90 15 3	91 4 0
1892.....	89 19 4	89 3 1	89 8 1	91 17 6	95 19 4	100 13 5	97 2 6	94 5 0	92 10 9	94 7 6	94 1 3	92 6 3	93 9 6
1893.....	92 7 6	91 16 3	94 11 6	94 5 6	91 14 4	86 14 0	82 19 4	79 10 0	79 18 9	78 15 0	76 3 0	75 16 3	85 7 7
1894.....	73 2 6	71 2 6	64 15 0	68 7 6	70 10 0	71 5 0	70 1 3	65 7 6	71 7 6	71 2 6	67 2 6	62 13 9	68 18 1
1895.....	60 2 11	60 1 1	61 9 5	63 19 7	65 12 8	62 14 2	64 8 4	64 7 10	65 0 8	65 17 6	64 18 10	61 15 2	63 6 8

The lowest point reached in 1895 was £58 12s. 6d. in January, and the highest was £68 17s. 6d., in May.

TUNGSTEN.

The importance of tungsten in industry is due to its hardness, which is greater than that of any other commercial metal; to its high specific gravity, which is over 19, or about equal to that of gold; and to its property of making steel self-hardening. The last-named property is by far the most important, and the chief commercial use of tungsten is in the manufacture of steel, for which purpose the greater part of the metal produced yearly is used. Its employment for this purpose is more general in Europe than in this country. In Germany, especially in the Krupp Works, nearly all the tool steel manufactured is alloyed with tungsten, and in England several of the special brands for which the Sheffield makers are famous owe their good quality to the use of this metal.

The advantages of tungsten-steel are in its hardness and in its property of hardening in the air after forging or heating. This avoids the necessity of retempering a tool every time it has to be resharpened in use, and also where steel is used for cutlery and similar purposes it prevents the gradual loss of temper which is familiar to all who have to use knives and similar cutting instruments. On the other hand, tungsten-steel is costly and its forging and working require exceptional skill; the better the steel the more carefully it has to be treated.

The use of tungsten in manufacturing armor plates and projectiles has been suggested. There is little doubt that steel alloyed with a suitable proportion, probably 5 or 6%, of tungsten would be quite as hard as nickel-steel plates prepared by the Harvey process, but the great expense has prevented the use of any such plates in practice thus far.

French experiments have also shown that a small percentage of tungsten greatly increases the carrying power of spring steel. Chamond claims that tungsten-steel is about one-third stronger than the best carbon spring steel.

Other uses have been suggested by its hardness; among them the use of a small percentage in place of copper to harden metallic aluminum, its resistance to oxidation making it much superior to copper for that purpose. A small percentage of tungsten also greatly increases the hardness and resistance to abrasion of gold and silver coins. The metal has been used experimentally in the German army and in the United States army for bullets. For this purpose an alloy of about 35% of tungsten and 65% of steel is used to form a thin shell which carries a lead core. A solid bullet of this alloy would be too costly, but the experiments made seem to show that the compound bullet fills satisfactorily the requirements of the modern rifle with its improved powder and high initial velocity. These requirements, as is well known, are not met by the old-fashioned lead bullet.

Tungsten has been used, on account of the property which it possesses of increasing the elastic limit of steel, in making the sounding plates of pianos. Another remarkable property which it has is that of increasing very much the magnetism of steel.

Alloys of tungsten with other metals besides iron are used in the arts, among them several bronzes of various composition, usually of copper and zinc with varying percentages of tungsten. These are found to give excellent results.

Tungsten compounds have been used to render vegetable tissues incombustible. In this case tungstic acid is combined with glue or other substances for the purpose of coating the material. A mixture of tungstate of soda and muriatic acid in a thick solution of glue is used; when heated to about 30° C. (about 86° F.) it is almost as elastic as rubber and can be drawn out in very thin leaves. When cool it becomes hard and brittle.

In THE MINERAL INDUSTRY, Vol. III., reference was made to the experiments of M. Henri Moissan in France in which metallic tungsten was obtained from tungstic acid in the electric furnace. The metal can also be precipitated by electrolysis from alkaline as well as acid solutions; in the latter case it is obtained in the form of a white powder. In the furnace it was obtained as a brilliant metal, very hard. Commercially the pure metal is seldom used, the principal forms of its various industrial applications being as tungstic acid or in ferro-tungsten, carrying about 40% of the metal.

The chief source of supply of tungsten is from the wolfram ore obtained from certain mines in Cornwall, England, in Saxony, in Bohemia, and in Spain. The production of this ore for the five years ending 1894 is shown below:

PRODUCTION OF WOLFRAM ORE IN EUROPE. (IN METRIC TONS.)

Year.	Cornwall.	Saxony.	Bohemia.	Spain.	Totals.
1890	106	36.65	37	....	179.65
1891	140	42.05	56.70	19.70	257.92
1892	127	37	71.90	26	261.90
1893	22.35	42.30	42.7	19	126.35
1894	....	39	40	....	79

Wolfram ore has been found in New South Wales, in Victoria, in Tasmania, in Western Australia, and in New Zealand, but has not been mined in any of the Australasian colonies to any considerable extent. A deposit of wolfram ore was discovered some years ago in the United States, in Eastern Connecticut, but no mining has been carried on there and only a few samples from the outcroppings have been taken. There is no doubt that the use of the metal would be considerably enlarged could it be supplied at a lower price than at present. The quotations of the manufacturers in this country, which did not vary during 1895, are as follows: Tungsten, 98% pure metal, 70c. per lb.; tungstic acid, 45c.; tungsten salt (tungstate of soda), 30c.; ferro-tungsten, in ton lots, 33c. per lb. for 37% tungsten, 45c. per lb. for 50% alloy, and 60c. per lb. for 60% alloy.

ZINC.

THE production of zinc in the United States showed a notable increase in 1895, having reached a total of 81,858 short tons, an increase of 7854 tons, or 10.6%, over 1893; this was the largest output ever reported, with the exception of 1892. The following table shows the production by districts for the five years ending with 1895:

PRODUCTION OF SPELTER IN THE UNITED STATES.

States.	1891.	1892.	1893.	1894.	1895.
Illinois and Indiana	28,660	30,227	29,725	28,948	33,748
Kansas	21,460	22,953	22,085	26,060	25,916
Missouri	16,205	16,169	13,737	12,000	10,726
South and East	13,938	14,733	10,708	6,996	11,468
Total tons of 2000 lbs	80,263	84,082	76,255	74,004	81,858
Total tons of 2240 lbs	71,662	75,073	68,525	66,074	73,088
Total metric tons	72,816	76,258	69,159	67,135	74,245

The increase in production was in the Illinois and Indiana districts and in the South and East. The Missouri and Kansas districts showed a decrease in 1895 as compared with the previous year; in Missouri, indeed, the production was smaller than for several years. These reductions were due to various causes, such as bad weather, heavy rains flooding the mines, and especially low prices of ores, which discouraged mining. The attempt to combine the producers of the Joplin and other districts in order to secure proper estimates on ores, and perhaps to obtain better prices, has not succeeded, chiefly because the miners are scattered and it is difficult to get them in communication; though another difficulty is that the mines of this district are generally small and the operators have very little capital and are forced to accept terms offered by ore buyers because they must have immediate returns.

The so-called smelters' combination continued at work during the year, but with only partial success, as the light demand and low prices during the latter half of the year compelled the closing of a number of its furnaces.

Some new zinc mines were opened in Arkansas during 1895, but their output has been small on account of difficulties in transportation. The zinc mines near Hanover, in New Mexico, have been closed for the same reason.

Zinc Oxide.—The production of zinc oxide in the United States has been as follows for the three years ending with 1895:

PRODUCTION OF ZINC OXIDE IN THE UNITED STATES.

Year.	Quantity.		Value.	
	Short Tons.	Metric Tons.	Totals.	Per Ton.
1893	25,000	22,679	$1,875,000	$75.00
1894	22,814	20,697	1,711,275	75.00
1895	22,690	20,498	1,588,300	70.00

The production remained nearly the same in 1895 as in 1894, though there was a decrease from 1893. Zinc oxide is made in nearly all the producing districts, furnaces for this purpose being found at Joplin, Mo., Mineral Point, Wis., Waukegan, Ill., Lynchburg, Va., and Florence, Pa. The largest output is from Cañon City, Colo., where it is made by the Bartlett process.

Imports and Exports of Zinc.—The imports and exports of zinc in the United States for the five years ending with 1895 are given in the following tables:

TOTAL EXPORTS OF ZINC AND ZINC ORE FROM THE UNITED STATES. (IN POUNDS.)

Year.	Ore and Oxide.		Plates, Sheets, Pigs, and Bars.		Manufactures.	Total Value.
1891	13,071,840	$149,435	4,294,656	$278,182	$38,921	$466,538
1892	2,058,560	41,186	12,494,335	669,549	161,794	877,529
1893	109,760	1,271	7,446,934	413,673	225,357	640,301
1894	....	5	3,621,934	144,278	99,418	243,701
1895	48,000	1,008	3,141,285	155,975	50,126	207,109

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.
1891	814,218	$41,369	$18,424	$59,793	2,839,351	128,140
1892	410,896	23,307	22,709	46,016	2,442,014	111,190
1893	425,998	22,301	20,756	43,687	3,900,749	254,807
1894	512,932	17,271	12,342	29,613	....	....
1895	864,113	29,352	12,183	41,535	....	....

Both imports and exports are small in amount in comparison with the total production here. During 1895 the European prices were too high to permit exports to this country to be profitably made. There has, on the other hand, been some talk of sending zinc to Europe, but it is said that such exports have been withheld because it was feared that any large shipments would break prices abroad and be unprofitable.

No changes of importance and no notable improvements in metallurgy are to be noted during 1895.

Zinc in Tennessee.—According to Mr. Lucius P. Brown, extensive deposits of carbonate and blende were discovered early in 1895 by John G. Lang, 2 miles southeast of Newmarket, Jefferson County. The Ingalls Zinc Company of Ingalls, Ind., is now engaged in developing these and has erected a plant for the treatment of the ore, consisting of a crusher, rolls, and steam jigs. Enough ore is in sight to run for a year. The company owns 2400 acres of land. The carbonate ore worked is an exceptionally pure one. The Bertha Zinc Company has bought the old Jarnigan property at Mossy Creek and is now at work mining carbonate ore. This is essentially the same ore as the company has been mining at Bertha, Pulaski County, Va.

Zinc Production of the World.—The following table shows the production of commercial zinc, or spelter, in the world for the five years ending with 1894:

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

Year.	Austria.	Belgium.	England.		France.	Germany	Russia.	Spain.	United States.	Totals.
			Native Ores.	Foreign Ores.						
1890......	5,449	82,701	8,692	20,922	19,372	139,266	3,774	5,919	61,111	347,206
1891......	5,006	85,999	9,037	20.846	20,596	139,353	3,677	5,592	72,836	363,302
1892......	5,237	91,546	9,496	21,302	20,609	139,938	4,374	5,925	76,279	374,706
1893......	5,870	95,665	9,432	19,397	22,419	142,956	4,522	5,752	69,178	375,191
1894......	6,810	99,630	8,130	24,448	23,387	143,577	5,014	5,100	67,135	383,225

(*a*) Compiled from the official reports of the respective countries, with the exception of the column of zinc in England from foreign ores, which is arrived at by deducting the zinc 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.

Germany is the largest producer of the metal, Belgium coming second and the United States third. The European production is increasing and seems to be quite up to the demand, if not a little in excess, as prices have been steadily falling for several years. Up to the close of 1894 the production was limited by an agreement in which all the leading producers joined, but during 1895 this contract was not in force, as its renewal for the year was prevented by disagreements over the allotment of production. Recently negotiations for a new arrangement have been opened.

The table above shows the production of metallic zinc credited to the countries in which it was made. The following table shows the production of zinc ores in Europe for the five years ending with 1894:

PRODUCTION OF ZINC ORE IN EUROPE. (IN METRIC TONS.)

Year.	Algeria	Austria	Belgium.	Bosnia.	France.	Germany.	Great Britain.	Greece.	Italy.	Norway. (*a*)	Russia.	Spain.	Sweden
1890	13,091	32,632	15,410	61	47,540	759,437	22,402	33,054	110,926	3,941	44,125	81,398	61,843
1891	13,636	28,828	14,280	47	56,300	793,544	22,580	28,344	120,685	498	47,390	78,216	61,591
1892	21,907	33,944	12,260	16	69,236	800,167	27,311	27,695	129,731	576	....	74,265	54,981
1893	24,400	30,531	11,310	....	74,400	787,919	23,880	*b*22,589	132,767	....	....	62,616	46,623
1894	29,703	28,491	11,585	....	80,065	728,616	22,170	*b*20,830	131,777	....	....	51,140	47,029

(*a*) Zinc-lead ore. (*b*) Including blende and calamine, calcined.

While Germany is the largest producer of ores as well as of metal, the second place in this respect is held by Italy, all of whose ores are exported. Spain is also a large producer of ores, but makes very little metallic zinc. The Greek and Algerian ores are likewise chiefly exported.

Nearly four-fifths of the German production is from Upper Silesia, and that district has been for many years a noted producer. The following table shows the output of the district for the five years ending with 1894:

PRODUCTION OF ZINC AND LEAD ORE AND OF ZINC IN UPPER SILESIA. (*a*)

(In metric tons.)

Year.	Blende.	Calamine	Total Zinc Ore.	Iron Pyrites. (*b*)	Iron Ore. (*b*)	Lead Ore.	Zinc.	Zinc Sheets.	Zinc-White, etc.	Totals.	Average Value per Ton of Zinc.
1890..	261,921	368,495	630,416	1,949	11,287	32,498	88,699	32,547	896	122.142	$110
1891..	271,277	391,891	663,168	2,076	8,088	28,716	88,420	37,669	1,151	127,240	111
1892..	291,617	368.230	659,847	2,520	9,371	29,049	88,175	33,266	895	122,336	97
1893..	287,395	348,654	636,049	2,107	7,166	30,742	91,716	35,187	211	127,114	79
1894..	251,040	323,295	574,335	2,874	5,808	33,898	92,546	34,518	1,267	128,331	69

(*a*) From *Statistik der Oberschlesischen Berg- und Hüttenwerke*. (*b*) Products of the zinc-lead mines.

The manufacture of zinc has been carried on in Silesia for nearly 400 years, and has been for over half that time a prominent industry. The furnaces there work almost entirely on the native ores, differing in that respect from the English and Belgian smelters, who find their ore in all parts of Europe. The English manufacturers take practically all the Spanish ore, with some from other countries. The Belgian makers use imported ore largely, as the mines of Belgium are steadily decreasing in their output. The Silesian manufacturers are closely united and generally act together on all questions connected with the trade.

The production of zinc ore in Algeria has increased rapidly, the quantity taken out having more than doubled in five years. The ores go chiefly to France and are of high grade. Concessions have been granted to work the zinc ores discovered at Zaghouan, in Tunis, and it is said that mines will be opened there very shortly.

No other new sources of supply were reported during 1895, and the changes during the year were not of great or special importance.

The leading European companies outside of Silesia are the Vieille Montagne, in Belgium, and the Malfidano Company, which operates mines in the island of Sardinia and has extensive works in France. These two companies, in connection with the Silesian smelters, practically control the trade on the Continent. During the past two years the Malfidano Company has added to its plant concentrating and other machinery for working its low-grade ores.

Besides its use in brass, the different bronzes and other alloys, zinc finds many applications in Europe which are hardly known in this country. Sheet zinc is much used for roofing, and for this purpose it has answered very well, making an excellent and durable roof which requires very few repairs. The demand for the metal is proportionately greater than here, and there is less probability of an over-supply, though, as has been already said, the production is fully up to the demand.

The history of zinc production in Europe and the processes used for extracting the metal from its ores were very fully described in Vol. II. of THE MINERAL INDUSTRY. Little or nothing new is to be added to the descriptions then given.

The New York Spelter Market in 1895.

In reviewing the course of the spelter market during the year 1895, we find that more than ever before has the fact been demonstrated that the law of supply and demand is that which ultimately governs the markets of the world, and that it is exceedingly difficult to maintain inflated values for any length of time. It is true that with the excessive prices which at times the smelters had to pay for ores in comparison with those which they realized for the refined metal, many of them found it exceedingly difficult to make both ends meet. However, the events of last year ought to have taught them a lesson and convinced them of the fact that in the long run conservatism is the best policy.

Our report for 1894 closed with the words: "It is known to the trade that some of the producers have accumulated large stocks, and although during the next two months production may be somewhat less on account of winter interfering with mining operations, the probability is that it will be larger than the demand." This prediction was fulfilled almost to the letter.

In January smelters showed a great desire to sell, and prices sagged off from week to week until they reached 3.25c. New York. It was hoped that this great decline would stimulate consumption and restrict production, especially as, in consequence of the inclemency of the weather, ore went up to $20 per ton. This hope, however, was not realized. The stocks in the hands of the smelters were a constant menace to the market, and inasmuch as there was no opportunity to use the old safety valve, Europe, for our surplus—in fact, hardly any quantities worth speaking of were exported during 1895, for prices on the other side remained below those ruling in the United States—values receded still further. Toward the end of February a round lot changed hands in New York at considerably below 3.20c. per lb., a price which had not been reached for some time past. During March and April the market remained dull at about 3.05@3.10c. St. Louis and 3.25@3.30c. New York, consumers showing no desire at all to buy. At the beginning of May it was reported that a strike had broken out in the Pittsburg, Kan., district owing to a dispute in connection with wages, and this caused some speculative buying in the St. Louis market. The main advance set in only toward the end of May.

The general revival in business could not fail to have a beneficial influence on the spelter market also, but something more substantial than mere sentiment was needed to give the market a lift. This was brought about by the great improvement in the iron and brass trade, which, however, is now past history. The reports from the galvanizing and brass mills were exceedingly cheerful, and orders from consumers in general were coming in in larger proportions than at any time during the past two years. By the middle of June the surplus stocks had disappeared, and spelter was quoted at about 3½c. St. Louis and 3¾c. New York. Though somewhat irregular, the market advanced steadily during July and August, owing to a continued excellent demand on the part of consumers. In September destructive rains wrought great havoc in the Joplin, Mo., district; a great many mines were flooded and mining operations were seriously interfered with. Smelters found great difficulty in securing the necessary raw material, and prices for ore advanced considerably. This naturally had to reflect on the prices of the refined metal, and values advanced to about 4.20@4.25c. St. Louis and 4.35@4.40c. New York.

During this time everything was in full blast in the spelter districts. Undoubtedly prices had reached a point where it paid the smelters to light all their furnaces. While production was thus as large as at any time during the year, there were already signs of consumers not being as eager buyers as for the three or four months previous. Not only did the high prices of copper and spelter seriously interfere with the brass trade, but the heavy break in iron alone would have been enough to put a stop to any further advance. Though most of the manufacturers were still very busy with old orders, there was an utter lack of new business, and consequently no inquiry at all for the raw material. This fact was still more noticeable in October, when a marked decline set in, prices receding to about 3.80c. St. Louis. Production of ore as well as of spelter continued quite heavy, and though speculation again took a hand, it was impossible to check a further decline to the extent of ½c. per lb., which was witnessed in November.

At the end of the year the situation was about the same as at the end of 1894. A stock of about 3000 tons was held in the West by a speculative clique, in which some of the smelters were said to be interested. Production, though somewhat curtailed, was still rather heavy. Consumers showed a little more interest at the low prices. In view of the conditions, however—the uncertainty regarding financial legislation, the large stocks, etc.—this demand was not yet sufficient to cause a substantial risk.

Imports of spelter into the United States during 1895 were 384 tons. The exports for the year were 1366 tons.

The accompanying table gives the average prices of commercial zinc, or spelter, in the New York market for each month of the last five years, compiled from the weekly reports of the *Engineering and Mining Journal.* For the years previous to 1891 the figures will be found in THE MINERAL INDUSTRY, Vols. I. and II.:

AVERAGE MONTHLY PRICES OF SPELTER IN NEW YORK, IN CENTS PER POUND.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1891	5.55	5.03	5.13	5.00	4.85	5.08	5.06	5.01	4.96	5.02	4.83	4.75	5.02
1892	4.69	4.62	4.89	4.68	4.79	4.71	4.78	4.69	4.53	4.41	4.47	4.40	4.63
1893	4.39	4.33	4.28	4.38	4.41	4.27	4.13	3.89	3.69	3.68	3.65	3.80	4.08
1894	3.56	3.85	3.89	3.62	3.47	3.40	3.43	3.38	3.44	3.45	3.36	3.43	3.52
1895	3.28	3.20	3.23	3.30	3.50	3.65	3.75	4.15	4.30	4.10	3.55	3.49	3.63

The average price for 1895 was slightly above that for 1894, but was still lower than that recorded for any previous year.

THE ST. LOUIS SPELTER MARKET IN 1895.

As the zinc-producing district of Southeast Missouri and Southwest Kansas is by far the most important in this country, and as nearly all the business of that district is done through St. Louis, the spelter market of that city has assumed an important position.

Production of ore was reduced early in the year by the low prices, which made it unprofitable to work, and later by the heavy rains and the floods in the producing district, which forced the closing down of many of the mines for a considerable time. The advance in prices in August and September brought out a considerable quantity of reserve or stock ore, but did not stimulate mining.

The following table shows the range of prices in St. Louis for the year:

PRICES OF SPELTER PER POUND IN ST. LOUIS IN 1895.

Month.	Highest	Lowest	Month.	Highest	Lowest	Month.	Highest	Lowest	Month.	Highest	Lowest
	Cts.	Cts.		Cts.	Cts.		Cts.	Cts.		Cts.	Cts.
January..	3.08	2.95	April...	3.10	3.00	July........	3.70	3.40	October...	4.00	3.60
February	2.98	2.90	May...	3.50	3.05	August.....	4.10	3.70	November	3.70	3.20
March....	3.05	2.95	June...	3.55	3.40	September.	4.15	4.00	December	3.65	3.20

The highest price quoted was 4.15c., in September; the lowest was 2.90c., in February.

The sales of zinc ore in the Joplin market, where a very large part of the output of the Missouri-Kansas district is handled, were as follows, the figures being taken from the weekly reports of the *Engineering and Mining Journal:*

SALES OF ZINC ORE AT JOPLIN, MO.

Month.	Sales.	Month.	Sales.	Month.	Sales.
	Lbs.		Lbs.		Lbs.
January...........	76,000,380	May..............	25,142,840	September.......	24,542,730
February..........	16,876,600	June.............	33,673,090	October..........	23,412,300
March.............	25,547,930	July..............	21,960,300	November........	23,431,550
April..............	21,596,000	August..........	24,248,560	December........	21,553,130

The total sales reported for the year were 278,046,510 lbs. of zinc ore. While this does not represent the entire output, it approaches the total and indicates the course of production.

The future of the zinc market in this country now appears to depend largely upon the finding of new uses for the metal. It is employed in Europe largely for roofing and other purposes hardly known here as yet.

The London Spelter Market in 1895.

The year 1894 witnessed a fall of £2 per ton in the value of spelter, from £16 8s. 9d. to £14 8s. 9d. per ton for good ordinary brands. The new year opened decidedly dull at £14 5s. for ordinaries, but a little demand springing up in the second week of the month caused a rally to £14 7s. 6d., but the improvement was only ephemeral, values receding directly consumers appeared to have covered their requirements. A period of unwonted lethargy followed, trade being reduced to small volume and prices steadily declining throughout the remainder of January, all February, and part of March, £13 10s. being finally reached. The prolonged frost was doubtless the main cause of this depression in the trade, and a change for the better ensued when mild weather set in, permitting of the active resumption of trade and outdoor work. A recovery to £13 12s. 6d. took place in March, and the upward tendency was assisted in April by a renewed attempt to bring about an agreement for the restriction of production. Consumers bought more freely than for a long time previously, and the value rose to £14 2s. 6d., the month closing at £14. May witnessed a further advance, due to improved trade, particularly in galvanized iron, the exports of which were attaining very large proportions—those of April amounted to over 19,000 tons, as against 13,000 tons for April, 1894. Consumers were buying largely, large orders being booked not only at home, but also from the colonies, and eventually £15 2s. 6d. was attained for ordinary brands. Consumers having now stocked themselves pretty fully, a reaction ensued which reached its nadir in July (when the quotation touched £14 7s. 6d.), although the activity in galvanized iron still continued.

At this point, however, some large purchases for continental account took place and sellers became very firm in their ideas of value and less inclined to make sales. Consumers, on the other hand, were beginning to buy again, having largely worked off their old purchases. The result was that a large business was done in August at advancing values, £15 10s. being paid before that month closed. The price then eased off to £15 6s. 3d., but consumption continued on an unusually active scale, galvanizers being busier than ever. September was a quiet month, but values remained steady at £15 6s. 3d. to £15 8s. 9d., anything offering a little below the quoted prices being instantly absorbed by prominent supporters of the market. October was a month of quiet demand, and though, on the other hand, there was no pressure of sales, the value slowly declined to £15 1s. 3d. In November the general position underwent no essential change, consumption continuing active, but demand only moderate. The return of galvanized-iron shipments for October gave the record figures of 19,000 tons for the month and 165,000 tons for the 10 months, being 7000 tons better than the same 10 months of 1888 (which had previously been the highest total) and 24,000 tons above those of the same 10 months of 1894. A rally to £15 3s. 9d. for good ordinary brand spelter was followed by a gradual relapse to £14 11s. 3d., at which the year closed, spelter suffering in common with all metals from the disturbance in trade due to the season and the unsettled political outlook.

The attempt above alluded to at a renewal of the producers' agreement for restriction of output proved abortive, and there has been a considerable increase in production as against 1894, a large portion proceeding, however, from new works.

The imports of spelter into the United Kingdom for 1895 were 62,523 tons, as against 52,901 tons in 1894 and 56,926 tons in 1893. The total quantity of galvanized iron exported during 1895 amounted to 204,149 tons, a record figure.

The following table shows the range of prices of "good ordinary" spelter in London for six years past, in pounds per long ton. The lowest price on record was that reached in 1895:

PRICES OF SPELTER IN LONDON.

Year.	Highest.			Lowest.			Year.	Highest.			Lowest.		
	£	s.	d.	£	s.	d.		£	s.	d.	£	s.	d.
1890	25	10	0	19	15	0	1893	18	2	6	16	15	0
1891	24	0	0	22	5	0	1894	16	11	3	14	1	3
1892	22	15	0	17	15	0	1895	15	8	9	13	11	3

LABOR, WAGES, AND ACCIDENTS IN MINING.

Imperfection of Data.—Duration of Work at American Collieries.—Number of Persons Employed in Coal Mining in the United States.—Coal Production per Person Employed.—Lives Lost per Thousand Employed.—Tons of Product per Life Lost.—Causes of Accidents.—Coal-Cutting Machines.—Contract Prices for Mining.—Tons of Product per Pound of Powder Used.—Price of Coal at the Mines.—Wages.—Details of Coal Output, Consumption, and Value in Several Countries.—Labor and Accidents in British Mines.

THERE is certainly no other department of any industry so important as that which relates to the safety and remuneration of those engaged in it, and yet there is probably none so generally neglected or concerning which the statistics are so defective and so generally useless. It has not, therefore, been from any lack of appreciation of the importance of the inquiry that very little space has been given in previous volumes of THE MINERAL INDUSTRY to the subject of labor, wages, and accidents in the production of the useful minerals and metals.

In the following pages are given, in condensed form, substantially all the statistics to be found scattered through a great number of State, United States, and special reports. This is the first attempt that has been made to compile and to study these data collectively; and the result has been useful chiefly as showing how worthless is the material now available and how greatly is needed a systematic, rational plan in the collecting of such statistics if they are to throw much-needed light upon the very important problems of the safety and relative efficiency of labor in different countries and the labor element in the cost of production. The partial neglect of the subject in preceding volumes of this series was due to the knowledge that the results of the expenditure of the large amount of work involved in the compilation of these statistics would produce no adequate useful effect. It is, however, necessary to get a starting point in the inquiry, and the exposure of the insufficiency and defectiveness of what we now have may lead to the collection of fuller, more accurate, and more useful statistics in the future.

With the exception of fragmentary and often carelessly compiled and inaccurate information given in some of the reports of State mine inspectors and the census reports of the United States Government and certain State and United States Labor Bureau reports, there are in this country no official reports bearing on the subject of labor and wages and the loss of life in the mineral industry. Most of these reports are confined to coal mining, which has very naturally attracted most attention and is popularly, though erroneously, supposed to be the most hazardous occupation in the industry. Only in recent years and in a few States have efforts been made to present full reports of even the more important statistics of coal mining, such as the number of collieries in operation and the days worked, the number of persons employed, day wages paid, contract prices for mining, quantity of explosives used, value of coal, lives lost, and persons injured. Not one report gives the actual number of days' work expended in making the recorded output, and not one attempts to give any data by which the actual or relative efficiency of labor working under different conditions can be measured, or by which the economic condition of the industry or the welfare of those engaged in it can be ascertained.

While the statistics of this country and industry leave very much to be desired, it must be confessed that those of foreign countries, even of the old European nations, are but little better. What is necessary to permit of useful analysis of statistics and comparisons of the labor element on the cost of production is a common unit of measure. Working days are of various lengths, from 6 or 7 hours to 12 or 14 hours, and we have bushels of various weights and tons of 2000, 2204.6, or of 2240 lbs. In the volumes of THE MINERAL INDUSTRY we have endeavored to bring some order out of this chaos by adopting generally the metric measures, but in the matter of time worked we have absolutely nothing to go on. The statistics should give the actual days, of specified number of hours worked, as taken from the mine pay rolls, and the amount of work accomplished measured in weights—in short, the unit of measure should be the kilohour, corresponding to the ton-mile or the foot-pound or the kilowatt of other departments of engineering. If our mine managers kept their statistics in kilohours they would not only be better able to check the efficiency of labor, but would afford a basis for extremely valuable comparisons of results.

In the accompanying tables relating to coal mining in the United States blank spaces do not indicate zeros, but that data are not available. Tons, where mentioned, are standard tons of 2000 lbs. For the following-named States the reports are for fiscal years ending June 30: Illinois, Iowa, Missouri, and Tennessee. Under the heads "Days Worked" and "Number of Persons Employed" the figures for all the States, except Illinois, Kansas, Kentucky, Ohio, and Pennsylvania (which are from direct reports), are taken from *Mineral Resources of the United States*. These figures do not at all agree with the inspectors' reports and are probably still more imperfect.

Number of Active Collieries.—The definition of what constitutes a "colliery" is so uncertain, and the variation in product, extent of workings, method of mining, and number of hands employed in each is so great, that a mere enumeration of the collieries would have but little interest, except as showing roughly what the average scale of operations is. In some State mining laws those establishments employing a certain minimum number of men (20, for example) come within the requirements of inspection, etc. As a matter of fact, there are not now so very many of the small "farmers' mines" where a few tons of coal are taken out irregularly for local use, and their aggregate production and the whole number of men thus engaged would have little weight in a general summary for the whole industry. Accidents, too, in these minor workings are mainly confined to falls, and statistics of either wages or accidents would throw no special light upon the conditions of the coal-mining industry at large.

Rather, then, as a matter of curiosity than to attempt to reach anything like a grand total of coal mines, the number of collieries in operation in six of the coal-mining States are given. It will be noticed that such important producing States as Alabama, Indiana, Maryland, Tennessee, West Virginia, Wyoming, and others are not included. Were material at hand for an exhibit of the whole number of collieries (of above a certain standard) in the United States, and showing the proportions active and idle during a given period or at specified dates, this would have some utility and would correspond to tables of dry and flowing petroleum wells, but, as in the case of the latter, the units differ too much to be fairly compared, unless, as in the Illinois reports and some others, the collieries were classified by groups according to their output or by their capacity of output in the case of idle mines.

The table does show, however, that in the older coal-producing regions the steadily increasing production is not due to the opening and working of more collieries so much as to the increased output of individual establishments. It is noteworthy that the greater part of the production comes from a small number of large collieries; and since the output per colliery is increasing, the number does not grow proportionately with the total production. In the number of collieries operated are included all from which an output was reported in the States and years specified.

Duration of Work at American Collieries.—Coal mining is a more or less intermittent industry, the capacity of the mines opened being always much greater than is required to supply the market demand, so that the amount of output and duration of work are either adjusted automatically or are controlled arbitrarily, as in some special cases like that of the anthracite combinations. This intermittent operation is plainly indicated by the following table, in which the average number of days during which the collieries were operated is far short of the usual "work days" (week days, excluding holidays) each year; and according to the figures quoted in the table the general tendency has been toward a shortening of the active campaign. The Pennsylvania anthracite mines have always been characterized by the irregularity of work and generally small total number of days operated each year; but it appears that they are by no means peculiar in that respect, for there are others of as short or shorter periods in 1894, and in that year there were more mines worked for less than 200 days than over.

Persons Employed in Coal Mining in the United States.—Over 400,000 men, according to the table, were employed in and about the collieries of 27 of the States in 1894, and more than half of them were at work in either the anthracite or bituminous coal fields of Pennsylvania alone. Illinois stands next in point of number employed, with Ohio third and West Virginia fourth. Alabama, Colorado, Indiana, Iowa, Kansas, Kentucky, Missouri, and Tennessee are States in each of which the number engaged in coal mining exceeds 5000. The total number so employed in the United States is greater than in any other country except the United Kingdom, where the number of coal operatives is at present nearly or

PARTIAL DETAILS OF LABOR IN COAL MINING IN THE UNITED STATES.

COLLIERIES OPERATED.

Year.	Illinois.	Iowa.	Kentucky.	Missouri.	Ohio.	Pennsylvania. An-thra-cite.	Pennsylvania. Bi-tumi-nous.
1888..	822	....	....	....	....	325	504
1889..	854	....	....	171	683	318	462
1890..	936	344	....	299	724	326	524
1891..	918	377	....	385	802	312	580
1892..	839	298	123	454	832	324	644
1893..	788	337	121	403	957	358	600
1894..	836	....	105	365	1,096	342	619

DAYS WORKED.

Year.	Alabama.	Arkansas.	California.	Colorado.	Illinois.	Indiana.	Indian Territory.	Iowa.	Kansas.	Kentucky.	Maryland.	Michigan.	Missouri.	Montana.
1888..	....	....	....	....	....	....	....	....	....	....	....	....	....	...
1889..	....	....	....	....	....	....	....	....	161	...	....	....	....	...
1890..	217	214	301	220	167	220	238	213	174	219	244	229	229	218
1891..	268	214	222	....	188	190	221	224	173	225	244	205	218	...
1892..	271	199	204	229	183	224	211	236	208	217	225	195	230	258
1893..	237	151	208	188	192	201	171	204	156	161	240	154	206	242
1894..	238	134	232	155	170	149	157	170	164	139	215	224	138	192

DAYS WORKED—*Continued.*

Year	New Mexico.	North Carolina.	North Dakota.	Oregon.	Ohio.	Pennsylvania. An-thra-cite.	Pennsylvania. Bi-tumi-nous.	Tennessee.	Texas.	Utah.	Virginia.	Washington.	West Virginia.	Wyoming.
1888..	....	....	....	....	....	216	201	....	....	....	....	....	....	....
1889..	....	....	....	....	....	193	223	....	....	....	....	....	....	....
1890..	192	200	....	305	203	192	229	263	241	289	296	270	227	246
1891..	265	254	....	125	200	211	209	230	225	....	246	211	237	....
1892..	223	160	216	120	194	205	207	240	208	230	192	247	228	225
1893..	229	80	193	192	174	199	186	232	251	226	253	241	219	189
1894..	182	145	156	243	168	168	149	210	283	199	234	207	186	190

NUMBER OF PERSONS EMPLOYED IN AND ABOUT COAL MINES.

Year.	Alabama.	Arkansas.	California.	Colorado.	Georgia.
1888...	......	......	......	......	....
1889...	......	......	......	......	....
1890...	10,642	938	364	5,827	425
1891...	9,302	1,317	256	6,000	850
1892...	10,075	1,128	187	5,747	467
1893...	11,294	1,559	158	7,202	736
1894...	10,859	1,493	125	6,507	729

NUMBER OF PERSONS EMPLOYED IN AND ABOUT THE COAL MINES—*Continued.*

Year.	Illinois.	Indiana	Indian Territory.	Iowa.	Kansas.	Kentucky. Under Ground	Kentucky. Surface	Kentucky. Totals.	Maryland.	Michigan.	Missouri.	Montana.	New Mexico.	North Carolina.	Ohio.	Oregon.
1888......	29,410	......	......	......	......	......	......	......	......	......	......	......	.....	......	22,738	....
1889......	30,076	......	......	......	......	......	......	......	......	......	......	......	......	......	23,295	....
1890......	28,574	5,489	2,571	8,253	7,639	......	......	5,259	3,842	180	5,971	1,251	827	80	22,192	208
1891......	32,951	5,879	2,891	9,130	8,949	......	......	6,355	3,891	223	6,199	1,119	806	80	23,997	100
1892......	33,632	6,436	3,254	9,307	......	......	......	6,724	3,886	230	5,893	1,158	1,083	90	26,972	90
1893......	35,390	7,644	3,446	10,486	9,891	7,112	1,427	8,539	3,935	162	7,375	1,401	1,011	70	28,810	110
1894......	38,477	8,603	3,101	......	10,340	6,779	1,253	8,032	3,974	223	7,523	1,782	985	95	31,493	88

Year.	Pennsylvania. Anthracite. Under Ground	Pennsylvania. Anthracite. Surface	Pennsylvania. Anthracite. Totals.	Pennsylvania. Bituminous. Under Ground	Pennsylvania. Bituminous. Surface	Pennsylvania. Bituminous. Totals.	Tennessee.	Texas.	Utah.	Virginia.	Washington.	West Virginia. Under Ground	West Virginia. Surface	West Virginia. Totals.	Wyoming.	United States.
1885......	62,901	37,419	100,320	......	......	......	......	......	......	......	......	5,486	1,806	7,292	.....	....
1886......	63,930	39,085	103,015	......	......	......	......	......	......	......	......	6,081	1,181	7,262	.....	.. ....
1887......	68,313	35,789	104,102	......	......	......	......	......	......	......	......	7,023	1,582	8,605	.....	....
1888......	78,813	44,234	123,047	50,569	10,742	61,311	......	......	......	......	......	7,269	1,705	8,974	.....	317,637
1889......	62,785	40,371	103,801	50,218	11,866	62,184	......	......	......	......	......	7,764	1,882	9,646	.....	294,494
1890......	74,154	46,036	120,190	54,756	12,630	67,386	5,082	674	429	1,295	2,206	9,173	2,324	11,397	3,272	317,223
1891......	76,560	46,708	123,277	61,010	13,125	74,135	5,097	787	621	820	2,447	10,434	2,589	13,023	3,411	349,577
1892......	80,718	48,343	129,061	65,857	12,948	78,805	4,926	871	646	836	2,564	11,776	3,617	15,393	3,133	366,667
1893......	86,387	51,682	138,069	69,784	12,078	81,862	4,976	996	576	961	2,757	14,089	3,040	17,129	3,378	400,634
1894......	87,622	51,981	139,603	73,551	12,667	86,218	5,542	1,062	671	1,635	2,662	16,171	3,600	19,771	3,032	408,671

quite 700,000. The probabilities are that the statistics in all cases show a less rather than too large a number, if the whole number of persons engaged at one time or another in mining during a given year is considered; on the other hand, very many of those recorded were at work for but very short periods. Thus the actual amount of work done is not indicated with even a rough approximation; for, provided the number of days each colliery was operated were reported—and even this is seldom ascertained—it would be necessary to know what force is implied by a statement that a colliery was in operation.

While, then, these figures and those for foreign countries throw little light upon the important question of labor performed, they are significant as indicating the magnitude of the coal-mining industry and the large proportion of the efficient population engaged in and supported by it. Another serious defect is the usual absence of classification of employees even into the two main divisions of "underground" and "surface." The true measure of a mine's relative importance, in comparing tonnage per employee or in making up accident averages, is of course the number underground, for the surface force is variable and may or may not include large numbers of men engaged in breaking, screening, washing, and otherwise preparing coal for market, in loading, and even in coke works and sometimes in briquette making. In all these latter operations there is no direct relation to the actual getting of the coal, and hence uncertainty is involved in all per capita production averages, since not only has allowance to be made for widely varying conditions of depth, hardness, thickness of seam, etc., but it is not even known how many men were really mining or directly concerned, and still less how long they worked. As the length of shift varies, accurate comparisons as to efficiency could only be made on the basis of hours' labor, and to obtain data for this is simply hopeless under the present want of system. The table gives the distinction between underground and surface labor for only Pennsylvania, West Virginia, and Kentucky. Using the figures for total employees (whether miners or surface men) as a basis for studying accident averages is a very crude and unsatisfactory method, since the kinds of accident imminent in surface work are only such as might occur in any surface occupation about heavy machinery.

Coal Production in the United States per Person Employed.—The coal-production statistics used in the computations of the next table, as well as for 1895 and as far back generally as the earlier shipments, will be found in the four volumes of THE MINERAL INDUSTRY and are accurately compiled from direct, though imperfect, sources of information. The total number of persons employed in each State is assumed, for the most part, as given in the *Mineral Resources of the United States.* The irregular and in many cases unusually large results thus obtained seem to show that the official publication referred to is not correct in its statistics relative to the number of persons employed in and about the coal mines of the United States. Dividing the number of tons mined by the number of employees gives the apparent average per caput; but as the surface labor is not excluded an additional element of uncertainty enters into the computation. The average being computed without regard to the number of days worked must be regarded as a crude measure by which to compare the performance of operatives in different coal fields and in different States and countries. Such as it is, however, it indicates that the United States heads the world with more product per person employed, and to this may be added, as shown in other tables, at less price per ton at the mines than in any other country whose statistics are compiled. As between the averages for the several States the apparent differences are so wide as to amount to discrepancies, and all of the averages must be accepted only with large allowances.

TONS OF COAL MINED PER PERSON EMPLOYED.

Year.	Alabama.	Arkansas.	California.	Colorado.	Georgia.	Illinois.	Indiana.	Indian Territory.	Iowa.	Kansas.	Kentucky.	Maryland.	Michigan.	Missouri.	Montana.	New Mexico.	North Carolina.	Ohio.	Oregon.	Pennsylvania.	
																				Anthracite.	Bituminous.
1885....	....	....	....	....	....	465	....	......	....	....	....	....	....	....	....	......	......	....	....	382	......
1886....	....	....	....	....	....	432	....	......	....	....	....	....	....	....	....	......	......	....	....	379	......
1887....	....	....	....	....	....	463	....	......	....	....	....	....	....	....	....	......	......	....	....	404	......
1888....	....	....	....	....	....	487	....	......	....	....	....	....	....	....	....	......	......	537	....	379	551
1889....	....	....	....	....	....	466	....	......	....	....	....	....	....	....	....	......	......	524	....	382	582
1890....	384	425	304	528	536	535	602	338	487	329	472	874	417	408	414	454	......	595	296	387	628
1891....	512	412	364	585	201	475	506	377	419	308	459	982	360	427	484	574	......	609	518	411	577
1892....	527	655	703	656	353	534	698	308	410	....	447	781	304	510	560	401	.....	541	386	407	591
1893....	458	475	475	548	506	564	600	357	361	291	387	846	136	433	559	452	243	515	377	342	530
1894....	403	485	758	460	486	445	356	346	....	261	369	781	....	317	387	329	138	378	483	371	486

TONS OF COAL MINED PER PERSON EMPLOYED—*Continued.*

Year.	Tennessee.	Texas.	Utah.	Virginia.	Washington.	West Virginia.	Wyoming.	United States.
1885....	....	....	....	....	....	462	....	......
1886....	....	....	....	....	....	496	....	......
1887....	....	....	....	....	....	574	....	......
1888....	....	....	....	....	....	599	....	458
1889....	....	....	....	....	....	560	....	469
1890....	478	274	742	605	573	527	572	492
1891....	530	219	597	898	432	626	682	485
1892....	490	344	562	957	390	566	783	492
1893....	373	324	732	877	439	574	664	440
1894....	467	442	676	566	445	534	734	416

LIVES LOST PER 1,000 PERSONS EMPLOYED.

Year.	Colorado.	Illinois.	Kansas.	Kentucky.	Maryland.	Missouri.	Ohio.	Pennsylvania.		West Virginia.	United States.
								Anthracite.	Bituminous.		
1885...	....	1.53	....	......	....	....	....	3.39	......	......	....
1886...	....	2.05	....	......	....	....	....	2.71	......	......	....
1887...	....	1.53	....	......	....	....	....	3.04	......	......	....
1888...	....	1.87	....	......	....	....	1.28	2.96	1.40	.....	2.30
1889...	....	1.40	....	......	....	....	1.42	3.70	2.67	.....	2.90
1890...	2.40	1.86	....	4.39	....	1.67	1.89	2.99	2.17	.....	2.56
1891...	5.00	1.82	1.34	4.25	....	2.90	1.83	3.46	3.19	2.76	2.99
1892...	5.92	1.70	....	5.50	1.54	3.39	1.56	3.48	1.70	2.34	2.49
1893...	....	1.95	1.52	1.41	1.27	2.85	1.18	3.30	1.60	4.20	2.45
1894...	....	1.87	2.52	1.26	1.76	2.53	1.43	3.19	1.42	2.98	2.36

TONS OF COAL MINED PER LIFE LOST.

Year.	Colorado.	Illinois.	Iowa.	Kansas.	Kentucky.	Maryland.	Missouri.	Ohio.	Pennsylvania.		West Virginia.	United States.
									Anthracite.	Bituminous.		
1880......	....	....	....	....	....	....	....	356,364	129,949	....	....	....
1881......	....	....	....	....	....	....	....	317,655	116,923	....	....	....
1882......	....	....	....	....	....	....	....	423,360	111,694	....	....	....
1883......	....	90,474	....	....	....	....	....	354,498	109,654	....	....	....
1884......	282,506	265,393	209,579	....	....	....	....	329,541	110,116	....	....	....
1885......	155,442	303,447		....	....	....	....	273,566	112,753	....	....	....
1886......	239,368	214,909	225,375	....	....	....	....	219,708	139,912	....	....	....
1887......	165,978	303,002		....	....	....	....	320,498	133,190	....	....	....
1888......	80,944	260,512	150,797	....	167,290	....	....	421,388	128,076	392,985	....	199,558
1889......	100,026	333,745		233,441	183,785	....	101,067	370,190	103,273	217,916	....	161,541
1890......	192,236	288,202	245,226		275,905	....	87,050	314,370	129,439	289,741	....	191,974
1891......	121,126	261,012		229,477	182,254	....	82,813	332,187	118,654	180,542	226,533	162,244
1892......	110,330	314,912	146,346	....	307,506	168,682	75,153	347,617	125,233	347,586	241,969	197,807
1893......	....	289,124		192,129	275,188	415,969	122,709	436,121	103,464	331,465	136,639	179,693
1894......	....	237,689	....	103,892	296,720	238,614	88,271	264,506	116,468	343,174	178,982	176,356

In the anthracite fields of Pennsylvania, whence comes a quarter or more of the whole coal output of the United States, the annual average output per person employed has in some years exceeded 400 tons, notwithstanding the limited number of days the mines were operated, as already mentioned. This is nearly up to the general average (416 tons in 1894) for the whole country. In some of the bituminous fields the yearly product per man is shown, so far as the figures can be relied on, to exceed 700 tons, as in California, Maryland, and Wyoming.

Lives Lost per Thousand Employed.—Partial statistics are at hand from nine of the States. The averages are simply the quotients obtained by dividing one one-thousandth of the number of persons employed into the number of lives lost, and the figures for the few States named in the table are more reliable than a general average for the United States derived from imperfect returns. The rate per thousand ranges from one and a fraction to nearly six. Here again the period during which the men were exposed does not enter into the calculation. If the men were employed during the full year the death rate would be higher. The reliability of averages of this kind will evidently depend largely upon the magnitude of the basal figures involved, and fortunately in the more important coal-mining States (Pennsylvania, Illinois, Ohio, and West Virginia) the records are available; and as the numbers in these cases are large, the averages are fairly constant. As between anthracite and bituminous mining in Pennsylvania, it will be noted that the former is shown to be twice as dangerous as the latter—a fact due to the great thickness and generally high inclination of the beds and to the hardness and in places crushed character of the coal.

Tons of Product per Life Lost.—The prevailing impression that about one life is lost for every 200,000 tons of coal mined appears to be not very wide of the truth. In the leading coal-mining States the records are carefully kept, and the averages vary from year to year and according to locality only about as much as might be expected from the disturbing effect of single great catastrophes. The range is from less than 100,000 to over 400,000 tons per life lost, and both extremes only rarely. The general proportion of tonnage to fatality for the whole United States (so far as the available data go) is in all the years given in the table somewhat under the 200,000-tons mark. Whatever improvement in the direction of safety there may be is slight, though on the whole progressive.

The records for the tonnage per life in the anthracite fields of Pennsylvania extend further back than in the table; thus the figures for the 10 years beginning with 1870 were: In 1870, 96,607; in 1871, 90,115; in 1872, 110,420; in 1873, 95,980; in 1874, 105,511; in 1875, 96,336; in 1876, 88,552; in 1877, 121,498; in 1878, 105,443; in 1879, 111,755.

Causes of Colliery Accidents.—The deaths from colliery accidents outside the mines are comparatively few and are mostly included in the column of "Other Causes." In American coal mines there are the usual liabilities to accident from falls of roof, from blasts and powder, from mine cars and machinery, and in many of them from gas and coal-dust explosions, but shaft accidents are not numerous, due partly to the fact that a large amount of coal is mined above water level and the shaft-hoisting plant itself is usually of good character.

In the table the heading "Lives Lost" includes both instant death and subsequent death from injuries. The caption "Falls" means accidents caused by coal, slate, and other rock falling from roof and sides, not falls of men in shafts, etc. Under "Blasts" are included accidents caused by coal and rock flying from shots, and by powder and dynamite accidentally or unexpectedly exploded, as after missfires or in handling. "Persons Injured" indicates non-fatal injuries varying from burns and bruises to broken bones, in most cases serious, though there is no specified period of disablement and therefore a want of uniformity in recording accidents. The ratio of non-fatal accidents (serious enough to be recorded) to fatal accidents is rather more than 3 to 1. All the data of record concerning coal-mining accidents in the United States during the years specified are summarized in the following table:

CAUSES OF ACCIDENTS IN AND ABOUT THE COAL MINES.

COLORADO.

Year.	Lives Lost. Falls.	Blasts.	Cars.	Gas Explosions.	Other Causes.	Totals.	Persons Injured.
1883..	....	..	..	....	....	....	....
1884..	1	..	3	....	....	4	12
1885..	4	..	3	1	1	9	62
1886..	3	2	1	....	....	6	49
1887..	10	1	..	....	....	12	52
1888..	15	2	4	8	....	29	80
1889..	8	..	4	....	11	23	98
1890..	10	1	1	1	1	14	75
1891..	23	2	2	2	1	30	129
1892..	21	2	2	4	5	34	125
1893..	....	..	..	....	....	....	....
1894..	....	..	..	....	....	....	....

ILLINOIS.

Year.	Lives Lost. Falls.	Blasts.	Cars.	Gas Explosions.	Other Causes.	Totals.	Persons Injured.
1883..	....	....	....	....	....	134	231
1884..	....	....	....	....	....	46	197
1885..	....	....	....	....	...	39	176
1886..	....	....	....	....	....	52	171
1887..	....	....	...	....	....	41	180
1888..	33	9	7	....	6	55	179
1889..	26	3	5	....	8	42	201
1890..	36	4	4	5	4	53	294
1891..	33	11	4	4	8	60	367
1892..	28	4	7	2	16	57	370
1893..	48	6	3	3	9	69	403
1894..	43	8	8	....	13	72	521

IOWA.

Year.	Lives Lost. Falls.	Blasts.	Cars.	Gas Explosions.	Other Causes.	Totals.	Persons Injured.
1883..	....	....	....	....	....	....	....
1884, 1885	28	1	3	....	8	40	....
1886, 1887	21	7	2	....	9	39	79
1888, 1889	27	14	4	....	15	60	163
1890, 1891	22	5	2	....	3	32	153
1892, 1893	30	18	1	....	3	52	99
1894..	....	....	....	....	....	....	....

KANSAS.

Year.	Lives Lost. Falls.	Blasts.	Cars.	Gas Explosions.	Other Causes.	Totals.	Persons Injured.
1890..	12	4	..	....	4	20	....
1891..	7	2	1	2	....	12	35
1892..	....	..	..	....	....	....	....
1893..	3	2	..	....	10	15	61
1894..	10	7	3	....	6	26	53

KENTUCKY.

Year.	Falls.	Blasts.	Cars.	Gas Explosions.	Other Causes.	Totals.	Persons Injured.
1888..	....	..	..	....	....	14	29
1889..	....	..	..	....	....	12	29
1890..	....	..	..	....	....	9	23
1891..	11	..	2	....	3	16	27
1892..	4	..	..	....	4	8	37
1893..	9	1	..	....	2	12	73
1894..	5	1	1	....	3	10	57

OHIO.

Year.	Falls.	Blasts.	Cars.	Gas Explosions.	Other Causes.	Totals.	Persons Injured.
1880..	....	..	..	....	....	22	61
1881..	....	..	..	....	....	29	....
1882..	....	..	..	....	....	25	....
1883..	....	..	..	....	....	26	....
1884..	....	..	..	....	....	26	40
1885..	24	4	1	....	3	32	51
1886..	29	5	2	....	7	43	65
1887..	25	2	3	....	6	36	75
1888..	20	2	1	1	5	29	79
1889..	25	2	5	....	1	33	52
1890..	32	2	3	1	4	42	52
1891..	33	1	3	....	7	44	66
1892..	26	4	5	....	7	42	93
1893..	19	2	6	....	7	34	123
1894..	26	5	2	1	11	45	116

PENNSYLVANIA—ANTHRACITE.

Year.	Lives Lost. Falls.	Blasts.	Cars.	Gas Explosions.	Other Causes.	Totals.	Persons Injured.
1870..	56	8	15	13	70	162	366
1871..	66	12	23	29	86	216	532
1872..	100	14	32	29	49	224	611
1873..	114	19	45	34	55	267	688
1874..	93	12	37	29	59	230	541
1875..	92	30	25	18	75	240	586
1876..	91	22	27	28	66	234	435
1877..	115	7	11	16	43	192	553
1878..	80	13	27	23	44	187	593
1879..	131	15	47	29	40	262	793
1880..	93	9	37	21	42	202	783
1881..	116	16	57	25	59	273	835
1882..	127	19	60	27	59	292	815
1883..	118	40	69	27	69	323	825
1884..	137	35	64	19	77	332	848
1885..	137	26	41	26	110	340	847
1886..	127	22	36	15	79	279	950
1887..	147	20	60	15	74	316	985
1888..	177	31	69	17	70	364	1037
1889..	182	33	69	30	70	384	997
1890..	126	16	64	66	87	359	1011
1891..	172	44	71	45	95	427	1003
1892..	193	33	73	59	61	419	1027
1893..	201	40	84	46	85	456	1077
1894..	196	43	71	29	106	445	925

INDIANA.—The first detailed reports of mining accidents in Indiana were made in 1895. In that year lives lost in and about the mines: by falls, 12; by blasts, 2; by cars, 3; by gas explosions, none; by other causes, 6; total, 23. Persons injured, 115.

PENNSYLVANIA—BITUMINOUS.

Year.	Lives Lost. Falls.	Blasts.	Cars.	Gas Explosions.	Other Causes.	Totals.	Persons Injured.
1888..	51	20	8	....	7	86	236
1889..	115	2	24	6	19	166	430
1890..	82	4	13	....	47	146	378
1891..	85	6	19	111	16	237	316
1892..	95	2	30	1	6	134	343
1893..	103	2	16	1	9	131	302
1894..	92	2	23	....	5	122	366

WEST VIRGINIA.

Year.	Falls.	Blasts.	Cars.	Gas Explosions.	Other Causes.	Totals.	Persons Injured.
1891..	19	3	4	4	6	36	71
1892..	26	2	6	1	1	36	94
1893..	54	5	9	....	4	72	141
1894..	49	....	6	....	....	59	129

Year	Maryland. Lives Lost.	Maryland. Persons Injured.	Missouri. Lives Lost.	Missouri. Persons Injured.	United States. Total Lives Lost.
1888.	......	......	......	......	729
1889.	......	......	12	22	855
1890.	......	......	10	28	813
1891.	.....	......	18	32	1,045
1892.	6	18	20	41	912
1893.	5	8	21	26	981
1894.	7	13	19	27	964

By far the largest number of accidents, not only of the non-fatal ones, but of all, are due to falls of coal and rock. Great disasters caused by fire and flood or by gas explosions (of which last kind that in the Mammoth bituminous mines, Westmoreland County, Pa., January 27, 1891, causing the death of 109 persons, was an extreme instance) attract the attention of the press and the sympathy of the public to a degree which obscures the more deadly, but less sensational everyday accidents from "falls." These latter usually involve the death or injury of but one or a very few persons at a time, though occasionally more extensive and disastrous "caves" occur, crushing or imprisoning and suffocating many men together; but "falls" happen daily and ceaselessly in the ordinary course of work, whlle the great calamities happily occur only at long intervals. In metal mining the proportion of accidents due to falls, in the total casualties, is larger than in collieries (although there is not the same risk as in undercutting coal), since the metal mines are free from the gas and dust explosions which figure so prominently among colliery accidents. But there are absolutely no systematic records of accidents in the ore mines of this country, though an unsuccessful attempt to collect data was made in the census of 1880. In the collieries most of the accidents from falls are due to carelessness in undercutting and to insufficiency of props near the working faces. Machine mining will do much to obviate the former danger, and as to the latter, constant inspection and regulations for providing a supply of loose timbers, to be always at hand for setting where and when needed, are the best preventives. But no rules can altogether restrain the men from the idea of getting the most coal with the least trouble, and familiarity with the risks adds to their heedlessness. As to all such accidents and also falls of roof in rooms and gangways, the better lighting by improved safety and incandescent electric lamps is of considerable benefit, by showing loose and weak places, but the test by sounding is more reliable.

Car accidents are more likely to occur in the great collieries, where the high-pressure activity in getting out the largest possible product and the rush of underground haulage bring in fresh dangers. Many of the accidents under this head also are due to carelessness and breaking of rules, as in riding on coal cars where prohibited; and it is less often that accidents are caused by failure of mechanism, parting of chains or ropes, or general bad system of transport. Car accidents happen on the surface as well as underground, and are generally less excusable. But accidents from falls of ground and those caused by cars form regular and nearly uniform items in the death and injury lists wherever the number of men is large, in this respect differing from accidents due to blasting and to gas and dust explosions, which are sporadic and irregular. This fact does not imply that because they are so persistent and seemingly inevitable they are not preventable; yet all the forethought of legislation and company regulations and all the watchfulness of State inspectors and mine officials do not seem to be effective in materially cutting down the number of casualties from these causes.

Accidents from missfires, delayed shots, and in the use of explosives generally, are not so frequent, relatively, in coal mining as in ore mining, since the use of powder or high explosives in collieries is brought down to the lowest point by the softness of the mineral, the economy necessary in working a material of so low a value per ton and bulk, and also because much of the coal is got without blasting, to avoid shattering it, because blasting is prohibited in many fiery mines, and because the dead work is in rocks usually easier to drift or sink in than the commoner country rocks of metal mines.

No subject connected with coal mining has received so much study from mining men and legislators or so much attention from inventors as the suppression of accidents from explosion of fire damp and coal dust. It cannot be said that such accidents are usually or often due to want of foresight or watchfulness on the part of managers, inspectors, and fire bosses, and this seems to be borne out by the sudden and unexpected disasters in mines previously rated as non-gaseous, while paradoxically the mines known to be gaseous or "fiery" may be made really the safer because of that foreknowledge and the constant watchfulness and many safeguards employed. The obvious lesson from this is that no coal mine whatever should be considered exempt from dangers of this kind. Some of the explosions in non-gaseous mines (which generally means mines where the proportion of gas does not reach the point of an explosive mixture) have been shown to be due to dust alone; while the consensus of authority now is that small quantities of dust propagate and intensify gas explosions, while proportions of gas and dust each insufficient in itself to originate and transmit an explosion may together cause one. The subject is so wide that hardly a satisfactory outline can be presented here, and the reader is referred to a special article on the subject elsewhere in this volume. The best and most compact of the many books dealing with this matter is Sir Frederick Augustus Abel's *Accidents in Mines.*

The final report of the Royal Commission on Explosions from Coal Dust in Mines is well summarized by Mr. C. Le Neve Foster as follows:

"I. The circumstances of many explosions, and especially of explosions on a very large scale and covering a great length of the workings, cannot be fully explained by reference to fire damp or gas alone.

"II. The presence of coal dust, and especially of fine dust, may be the sole cause of an explosion.

"III. If the coal dust is in sufficient quantities it will certainly extend the effect and increase the intensity of an explosion which is caused by any other means.

"IV. Fire damp in small quantities, so small as not to be dangerous per se, may be highly dangerous in the presence of coal dust."

After discussing these various points seriatim and giving details concerning several of the great explosions which have taken place of late years, the commissioners sum up their conclusions as follows:

"1. The danger of explosion in a mine in which gas exists, even in very small quantities, is greatly increased by the presence of coal dust.

"2. A gas explosion in a fiery mine may be intensified and carried on indefinitely by coal dust raised by the explosion itself.

"3. Coal dust alone, without the presence of any gas at all, may cause a dangerous explosion if ignited by a blown-out shot or other violent inflammation. To produce such a result, however, the conditions must be exceptional, and are only likely to be produced on rare occasions.

"4. Different dusts are inflammable, and consequently dangerous, in varying degrees, but it cannot be said with absolute certainty that any dust is entirely free from risk.

"5. There appears to be no probability that a dangerous explosion of coal dust alone could ever be produced in a mine by a naked light or ordinary flame."

The precautions suggested by the witnesses before the commission are (1) abolition of the use of gunpowder; (2) use of flameless explosives; (3) use of water cartridge; (4) use of lime cartridge. The commissioners come to the following conclusions:

1. That the use of high explosives "would greatly limit the risk of explosion in dry and dusty and in fiery mines."

2. They do not feel justified in recommending the universal abolition of the use of gunpowder, but they recommend that the Secretary of State should be empowered by further legislation "to prohibit the use of gunpowder in the case of every mine which is either fiery or dry and dusty, unless sufficient and effective means of watering are carried out."

As a means of settling what are "fiery" or "dry and dusty" mines, the Secretary of State would have to prepare a list of such mines, and would then have to give the owners notice that their mines were so included, allowing them 12 months to carry out the requisition. Any owner objecting to the notice would have power to appeal to a temporary commission specially appointed for the purpose of deciding the question.

3. Another recommendation is that explosives for use in mines should be examined and certified by the Home Office as fit for the purpose.

4. "All tamping should be done with clay or other non-inflammable substances."

5. They consider that the only effectual way of remedying the danger arising from coal dust is by a complete and satisfactory system of watering.

6. They propose that the inspectors should give notice under Section 42 of the Coal Mines Regulation Act, 1887, when they consider the provision for watering insufficient.

7. They finally recommend that the owners and managers of mines should pay special attention to the following precautions already partly provided for in the existing statute:

"1st. That the firing of shots should be carried out between the shifts and when the majority of the men are out of the mine.

"2d. Where general watering is not prescribed by the inspector, that the roads on either side of the place where a shot is fired should be thoroughly wetted for a space of at least 30 yds.

"Lastly, that large accumulations of dust, whether on the roof or floor, should not be allowed to remain."

Coal-cutting machines are used in several of the States, but the statistics are very meager. In Illinois and Ohio the number of machines in use is given in the official mining reports, from which it appears that the number is increasing—a fact noticed in a special article elsewhere in this volume. Yet the progress in this direction does not appear to be as rapid as might have been expected, although the prejudice against them at first entertained by the miners is passing away. The opposition to machine mining on the ground that it would lessen the amount of work and wages for the men was on a par with the resistance to the introduction of machinery in every other branch of industry, and, just as has been proved in all like cases, it was unfounded either in general economic principles or as regards the well-being of the men themselves in the long run. Any sudden change from hand to machine work necessarily displaces a certain number of men and entails hardship upon individuals; but after time has been allowed for conditions to readjust themselves the machine, by increasing the efficiency, raises the wages of the operatives using it, and, by lessening the cost of production, in the end increases the

SCATTERED DETAILS AS TO USE OF COAL-MINING MACHINES, CONTRACT PRICES FOR MINING, AND USE OF POWDER.

Mining Machines in Use.			Contract Price per Ton for Mining.				Tons of Product per Pound of Powder Used.						
								Illinois.					
Year.	Illinois.	Ohio.	Year.	Colorado.	Illinois.	Tennessee.	Year.	Machines.	Hand Mining.	Kentucky.	Missouri.	Ohio.	Pennsylvania Anthracite.
1885	......	......	1885	......	......	$0.68	1885	......	......	......	......	......	1.71
1886	......	......	1886	$0.89	$0.73	.63	1886	......	......	......	......	......	1.68
1887	......	......	1887	......	.68	.63	1887	......	......	......	......	......	1.67
1888	272	......	1888	.70	.73	.63	1888	3.88	1.50	......	......	......	2.00
1889	235	......	1889	.76	.72	.58	1889	4.10	1.48	......	......	......	1.53
1890	266	......	1890	.73	.73	.58	1890	3.27	1.46	......	2.18	......	1.96
1891	241	114	1891	.78	.68	.50	1891	3.92	1.61	......	1.92	......	1.66
1892	300	129	1892	.75	.72	.50	1892	3.81	1.58	2.56	2.26	2.53	1.64
1893	310	148	1893	......	.72	......	1893	3.52	1.46	2.58	2.04	2.58	1.63
1894	396	173	1894	......	.67	......	1894	3.94	1.49	2.32	1.81	3.13	1.60

consumption of coal and provides employment for more men in accessory operations. So far the use of coal-cutting machines in the United States has not been on a large enough scale to be revolutionary. There are now in the market good patterns, both of the compressed-air and electric types, and also many hand-power appliances, such as cutters, augers, wedges, etc., but the application of any or all of them is limited to certain conditions of regularity of floor, pitch and thickness of the seams, cleanness of the coal, etc. Full statistics would show that the tendency is toward the much larger use of coal-mining machines than the figures cited seem to indicate. The carefully prepared paper of Mr. J. J. Rutledge on "Coal Mining in Illinois" and the special discussion of the subject by Mr. H. Foster Bain, under the title "Machine Coal Mining in Iowa" (both papers elsewhere in this volume), refer in detail to the economy of machine mining, conditions of application, advantages and disadvantages, etc.

Contract Price for Mining.—This is mentioned in some of the State reports, but in such a fragmentary manner that little information of importance is conveyed. In the Illinois reports, which are more comprehensive than those of any other State, the rate paid for mining is considered an essential detail, and the average price per ton is stated for a series of years. Similar reports are given for Colorado and Tennessee. As would be anticipated, in view of the general tendency in all departments of mining, the course is downward, though not sharply so. In order to institute comparisons the bare statement of rates per ton is insufficient; it is necessary to know in all cases whether the custom is to weigh or measure before or after screening, all deductions for picking, and also the character of the coal. The practice varies considerably in different localities, and has at times given rise to serious labor troubles and strikes The practice in Illinois, together with much other information not given in State reports, is described elsewhere in this volume by Mr. J. J. Rutledge.

Powder Used in Coal Mining.—Some figures are available as to the tons of product per pound of powder used, in the reports for five States. The Illinois reports distinguish between machine and hand mining, and it would appear that under the former head the economy in explosives is more than double that where hand mining is practiced; the figures, however, are averaged from returns covering less than the whole field. That more powder is not required in blasting the hard anthracite of Pennsylvania than some of the softer coals is due to the enormous thickness and high inclination of the beds worked in a large part of the anthracite fields. The Pennsylvania reports include a small percentage of high explosives; in 1894, 32,466,508 lbs. of black powder and 1,713,295 lbs. of dynamite. The quantity of powder used in the bituminous coal region of Pennsylvania in 1894 is said to have been 2,571,475 lbs. There were consequently some 16 tons mined per pound of powder; in previous years even more. In Pennsylvania, therefore, a much greater proportion of bituminous coal is mined without powder, or with the use of very small quantities, than in any other bituminous coal field in the United States. This is owing chiefly to the large beds of soft coal in the Connellsville region, from which a great part of the output is produced. Unless the kind and grade of explosive used are specified and all the conditions are explained, comparisons are not very instructive. As to the price of explosives, there is a rough correspondence between their relative strength and cost, especially in the case of the different grades of dynamite. The use of flameless explosives, lime cartridges, water cartridges, etc., has thus far been rather experimental than otherwise in the United States.

Price of Coal at the Mines.—Apart from the great difference in the intrinsic value of the coals of different regions, there are disturbing factors which account for the wide range in prices. Location, in respect to density of population and metallurgical and manufacturing centers and to transportation routes to open markets, has a controlling influence. There may be a heavy local demand or cheap freights to a market, or the contrary; both may exist together, distinct or in varying shades. On the other hand, a coal field may be so isolated by distance or high ton-mile rates that competition by coal from other regions is precluded, since the latter would have to sell on even terms with the local product of equivalent grade. So far as the figures (largely estimated) may be relied upon, the general average for the United States has been steadily lowered, taking a period of years together, in harmony with the prevailing decline in prices of other commodities the cost of whose production has been cheapened, until for 1894 it reached, roughly speaking, 88c. per ton of 2000 lbs. for bituminous and $1.55 for anthracite; for 1895 the figure reported is 90c. for bituminous and $1.54 for anthracite. The general averages for the whole country are based upon reports from the coal operators furnished to THE MINERAL INDUSTRY. The figures, by States, for the first six years of the table are as given in *Mineral Resources of the United States,* except for Colorado, Illinois, Iowa, Kentucky, Missouri, and Pennsylvania (which are from direct returns), and from 1892 on all are derived from special reports to THE MINERAL INDUSTRY.

The reader is referred to previous volumes of this series for full descriptions of all the characteristic features which determine the value of the product from every coal field in the United States, and hence also the price so far as that is unaffected by local conditions.

COAL VALUES PER TON AT THE MINES.

Year.	Alabama.	Arkansas.	California.	Colorado.	Georgia.	Illinois.	Indiana.	Indian Territory.	Iowa.	Kansas.	Kentucky.	Maryland.	Michigan.	Missouri.
1885........	......	......	......	$2.35	......	$1.17	......	......	......	......	......	......	......	......
1886........	$3.09	$1.60	$3.00	2.35	$1.50	1.10	$1.15	$1.60	$1.25	$1.20	$1.15	$0.95	$1.50	$1.30
1887........	1.30	1.68	3.00	2.20	1.50	1.09	1.34	1.87	1.34	1.40	1.15	.95	1.50	1 34
1888........	1.15	1.50	4.00	2.20	1.50	1.12	1.40	1.88	1.30	1.50	1.20	.95	1.66	2.21
1889........	1.11	1.42	2.36	1.94	1.50	1.08	1.02	1.76	1.33	1.48	.99	.86	1.71	1.31
1890........	1.03	1.29	2.56	1.87	1.04	1.02	.99	1.82	1.24	1.30	.92	.86	1.99	1.32
1891........	1.07	1.19	2.20	1.68	1.50	1.01	1.03	1.74	1.27	1.31	.92	.81	1.66	1.31
1892........	1.00	1.25	2.43	1.65	1.01	1.03	1.03	1.50	1.62	1 25	.94	.88	1.61	1.26
1893........	.95	1.25	2.34	1.44	.91	1.01	1.01	1.50	1.71	1.28	.87	.87	1.49	1.25
1894........	.90	1.20	2.50	1.23	.85	1.03	.97	1.55	1.25	1.20	.88	.88	1.47	1.25

Year.	Montana.	New Mexico.	North Carolina.	North Dakota.	Ohio.	Oregon.	Pennsylvania. An-thra-cite.	Pennsylvania. Bi-tumi-nous.	Tennessee.	Texas.	Utah.	Virginia.	Washington.	West Virginia.	Wyoming.	United States.
1886......	$3.50	$3.00	.....	$1.59	$0.95	$2.50	$1.95	$1.06	$1.15	$1.85	$2.10	$1.00	$2.25	$0.94	$3.00	$1.37
1887......	3.50	3.00	......	1.50	.88	2.20	2.00	1.12	1.30	2.00	2.00	.94	2.20	.95	3.00	1.41
1888......	3.50	3.00	......	3.50	.93	3.00	1.90	1.00	1.10	2.05	2.10	1.00	3.00	1.10	3.00	1.29
1889......	2.42	1.79	......	1.43	.93	......	1.44	.99	1.21	2.66	1.59	.93	2.32	.82	1.26	1.12
1890......	2.42	1.34	$1.74	1.40	.94	2.89	1.42	.99	1.10	2.53	1.74	.75	2.71	.84	1.70	1.12
1891......	2.27	1.68	1.93	1.40	.94	3.00	1.50	1.00	1.11	2.40	1.80	.83	2.31	.80	1.53	1.15
1892......	2.07	1.41	1.54	1.00	.94	3.20	1.71	.97	.91	2.25	1.51	.85	2.81	.78	1.41	1.19
1893......	2.11	1.56	1.50	1.00	.89	2.50	1.58	.96	.80	2.00	1.50	.80	2.98	.77	1.39	1.13
1894......	2.00	1.50	1.56	1.10	.85	2.25	1.55	.88	.78	2.13	1.40	.75	2.40	.70	1.29	1.09

Wages.—The accompanying table shows the average daily wages of and the average number of days' work done by employees in and about collieries, copper mines, precious-metal mines, and quarries of granite, limestone, and sandstone in the census year 1889. This is the last official compilation of generalized statistics of the kind, and also the first attempt that has approached success on the large scale in the series of decennial censuses, so far as mining wages are concerned, though Mr. Carroll D. Wright, Chief of the United States Bureau of Labor, has collected some valuable statistics of costs of production of certain ores and metals in which the labor cost has been ascertained.

In comparing the average rates of wages in the several States, as given in the census table, for surface work the best guide is the average daily wages paid for common labor, since the duties and qualifications of both foremen and "mechanics" may be very different at different places and even at the same establishment; and besides, the larger number of laborers makes averages more reliable. For underground work it is better to measure differences by the scale paid "miners," for here again is the greater resemblance of duty and capacity all over the country (though of course there is no exact standard of what constitutes a "miner," and as a matter of fact their earning abilities vary widely). There are less "labor-

GRANITE QUARRYING.

States.	Foremen. Av. Number Employed.	Foremen. Av. Days Worked.	Foremen. Av. Daily Wages.	Foremen. Average Yearly Earnings.	Quarrymen. Av. Number Employed.	Quarrymen. Av. Days Worked.	Quarrymen. Av. Daily Wages.	Quarrymen. Average Yearly Earnings.	Mechanics. Av. Number Employed.	Mechanics. Av. Days Worked.	Mechanics. Av. Daily Wages.	Mechanics. Average Yearly Earnings.	Laborers. Av. Number Employed.	Laborers. Av. Days Worked.	Laborers. Av. Daily Wages.	Laborers. Average Yearly Earnings.
California........	64	214	$4.34	$928.76	1,165	217	$2.38	$516.40	316	215	$3.52	$756.80	225	194	$2.11	$409.34
Colorado.........	12	202	3.42	690.84	151	214	2.50	535.00	13	239	2.98	712.22	32	228	1.96	446.88
Connecticut......	43	243	3.15	765.45	694	230	1.70	391.00	600	247	2.67	659.49	251	232	1.48	343.36
Delaware........	9	242	3.27	791.34	166	229	1.66	380.14	67	232	2.82	654.24	6	240	1.50	360.00
Georgia..........	35	268	3.72	996.96	442	222	1.36	301.92	352	218	3.59	782.62	482	231	1.05	242.55
Maine............	110	215	3.15	677.25	1,453	177	1.78	315.06	1,611	220	2.49	547.80	483	187	1.62	302.94
Maryland........	26	232	3.00	696.00	513	244	1.51	368.44	97	247	3.02	745.94	171	196	1.34	262.64
Massachusetts...	136	248	3.09	766.32	1,613	221	1.76	388.96	903	247	2.59	639.73	613	240	1.50	360.00
Minnesota........	18	204	3.67	748.68	223	196	1.84	360.64	239	206	3.54	729.24	64	200	1.57	314.00
Missouri..........	16	220	3.19	701.80	228	219	1.74	381.06	263	199	3.15	626.85	79	185	1.48	273.80
New Hampshire..	83	170	3.41	579.70	519	178	1.75	311.50	487	223	2.60	579.80	148	163	1.68	273.84
New Jersey......	20	250	2.47	617.50	214	231	1.65	381.15	57	238	2.19	521.22	319	224	1.43	320.33
New York........	19	245	2.91	712.95	134	200	1.87	374.00	108	178	2.92	519.76	130	258	1.71	441.18
North Carolina..	13	241	2.52	607.32	110	208	1.12	232.96	91	197	1.82	358.54	149	202	.84	169.68
Pennsylvania....	47	189	2.36	446.04	562	187	1.75	327.25	200	200	2.64	528.00	377	182	1.37	249.34
Rhode Island....	38	255	3.35	854.25	313	212	1.84	390.08	614	257	2.46	632.22	204	227	1.54	349.58
South Dakota....	13	313	3.50	1,095.50	93	200	2.00	400.00	143	200	4.00	800.00	153	200	1.50	300.00
Vermont.........	60	202	3.68	743.36	596	186	1.75	325.50	155	216	2.64	570.24	128	170	1.45	246.50
Virginia..........	21	240	3.00	720.00	333	189	1.22	230.58	91	222	2.61	579.42	239	216	1.08	233.28
Wisconsin........	17	301	4.34	1,306.34	345	274	1.70	465.80	84	216	3.09	667.44	28	156	1.37	213.72
Totals and avs.	800	226	$3.30	$745.80	9,867	208	$1.79	$372.32	6,491	226	$2.77	$626.02	4,281	211	$1.38	$291.18

LIMESTONE QUARRYING.

States.	Foremen. Av. Number Employed.	Foremen. Av. Days Worked.	Foremen. Av. Daily Wages.	Foremen. Average Yearly Earnings.	Quarrymen. Av. Number Employed.	Quarrymen. Av. Days Worked.	Quarrymen. Av. Daily Wages.	Quarrymen. Average Yearly Earnings.	Mechanics. Av. Number Employed.	Mechanics. Av. Days Worked.	Mechanics. Av. Daily Wages.	Mechanics. Average Yearly Earnings.	Laborers. Av. Number Employed.	Laborers. Av. Days Worked.	Laborers. Av. Daily Wages.	Laborers. Average Yearly Earnings.
Alabama.........	23	257	$2.24	$575.68	209	202	$1.17	$236.34	26	181	$2.09	$378.29	534	205	$1.00	$205.00
California........	21	255	3.47	884.85	89	228	2.18	497.04	16	253	2.31	584.43	170	242	2.02	488.84
Colorado.........	12	231	2.78	642.18	50	271	2.33	631.43	26	150	2.71	406.50	24	257	2.03	521.71
Connecticut......	5	306	1.90	581.40	38	250	1.58	395.00	23	280	1.84	512.20	27	265	1.49	394.85
Illinois..........	125	259	2.55	660.45	2,081	210	1.64	344.40	151	230	2.35	540.50	808	224	1.54	344.96
Indiana..........	162	208	2.48	515.84	1,375	198	1.59	314.82	238	178	2.33	414.74	1,440	298	1.37	408.26
Iowa.............	70	197	2.01	395.97	692	175	1.53	267.75	78	180	2.48	446.40	371	182	1.19	216.58
Kansas..........	54	190	2.63	499.70	801	175	1.56	273.00	87	173	2.70	467.10	223	182	1.43	260.26
Kentucky.........	46	225	2.40	540.00	423	167	1.39	232.13	59	172	2.21	380.12	219	137	1.01	138.37
Maine........	131	287	2.30	660.10	607	280	2.00	560.00	50	250	2.00	500.00	260	269	1.75	470.75
Maryland........	13	235	1.65	387.75	123	182	1.29	234.78	17	173	1.52	262.96	122	221	1.21	267.41
Massachusetts...	9	243	1.98	481.14	66	257	1.50	385.50	4	121	3.19	385.99	24	152	1.32	200.64
Minnesota........	68	210	3.19	669.90	864	173	1.60	276.80	94	169	2.65	447.85	190	168	1.48	248.64
Missouri..........	133	226	2.73	616.98	1,387	254	1.49	378.46	202	209	2.15	449.35	1,422	213	1.70	362.10
Nebraska........	20	176	2.30	404.80	272	152	1.59	241.68	23	124	2.74	339 76	177	118	1.54	181.72
New Jersey......	11	258	1.79	461.82	158	215	1.28	275.20	8	291	1.60	465.60	48	185	1.22	225.70
New York........	123	206	2.41	496.46	1,052	203	2.03	412.09	323	171	2.23	381.33	1,023	201	1.31	263.31
Ohio.............	145	218	1.96	427.28	1,490	215	1.44	309.60	161	206	1.86	383.16	737	220	1.35	297.00
Pennsylvania....	166	225	2.31	519.75	3,270	222	1.20	266.40	191	215	1.76	378.40	1,094	192	1.29	247.68
Texas............	12	181	2.70	488.70	154	191	1.82	347.62	26	224	2.67	598.08	81	185	1.39	257.15
Vermont.........	12	258	1.78	459.24	79	221	1.33	293.93	26	271	1.52	411.92	49	235	1.03	242.05
Virginia.........	10	238	1.99	473.62	63	258	1.38	356.04	24	266	1.58	420.28	141	279	1.02	284.58
Washington......	12	210	3.11	653.10	48	195	2.25	438.75	54	228	2.96	674.88	86	110	2.06	226.60
West Virginia....	7	252	2.31	582.12	58	181	1.06	191.86	18	274	1.39	380.86	41	207	.93	192.51
Wisconsin........	42	234	2.05	479.70	637	212	1.44	305.28	77	238	1.85	440.30	270	208	1.39	289.12
Totals and avs.	1,432	245	$2.41	$589.71	16,086	209	$1.52	$316.71	2,002	199	$2.21	$439.92	9,581	196	$1.41	$276.36

SANDSTONE QUARRYING.

States.	Foremen. Av. Number Employed.	Foremen. Av. Days Worked.	Foremen. Av. Daily Wages.	Foremen. Average Yearly Earnings.	Quarrymen. Av. Number Employed.	Quarrymen. Av. Days Worked.	Quarrymen. Av. Daily Wages.	Quarrymen. Average Yearly Earnings.	Mechanics. Av. Number Employed.	Mechanics. Av. Days Worked.	Mechanics. Av. Daily Wages.	Mechanics. Average Yearly Earnings.	Laborers. Av. Number Employed.	Laborers. Av. Days Worked.	Laborers. Av. Daily Wages.	Laborers. Average Yearly Earnings.
Alabama.........	5	254	$2.48	$629.92	53	239	$1.06	$253.34	9	230	$3.50	$805.00	54	242	$1.16	$280.72
California........	10	231	4.05	935.55	114	223	2.42	539.66	31	237	3.92	929.04	64	229	2.05	469.45
Colorado.........	90	208	3.09	642.72	854	216	2.35	507.60	187	236	2.45	578.20	313	238	2.01	478.38
Connecticut.....	45	249	2.98	742.02	814	249	1.87	465.63	58	232	2.80	649.60	150	238	1.74	414.12
Illinois...........	4	175	2.56	448.00	33	116	1.67	193.72	1	36	2.15	77.44	8	60	1.38	82.80
Indiana..........	12	280	4.00	1,120.00	71	175	1.49	260.75	25	280	1.75	490.00	67	263	1.25	328.75
Iowa.............	8	191	3.30	630.30	41	160	2.20	352.00	21	210	2.43	510.30	63	209	1.48	309.32
Kansas..........	11	190	2.72	516.80	159	216	1.87	403.92	57	231	2.02	466.62	88	218	1.43	311.74
Kentucky........	15	164	3.06	501.84	126	107	1.61	172.27	43	157	3.15	494.55	105	157	1.28	200.96
Massachusetts...	28	267	3.02	806.34	358	209	2.00	418.00	161	221	3.06	676.26	347	211	1.70	358.70
Michigan	9	255	2.92	744.60	132	171	1.68	287.28	31	232	2.63	610.16	166	243	1.46	354.78
Minnesota........	10	235	3.00	705.00	151	231	1.53	353.43	16	260	2.00	520.00	22	300	1.55	465.00
Missouri..........	12	214	2.88	616.32	80	182	2.00	364.00	17	218	2.33	507.94	77	190	1.38	262.20
Montana.........	6	138	4.55	627.90	57	149	2.66	396.34	1	30	3.00	90.00	2	100	1.50	150.00
New Jersey......	38	268	3.00	804.00	299	246	2.03	499.38	130	241	3.20	771.20	378	251	1.45	363.95
New Mexico......	11	120	4.08	489.60	217	96	2.26	216.96	47	116	3.30	382.80	87	56	1.79	100.24
New York........	58	170	2.79	474.30	568	161	1.99	320.39	183	165	2.96	488.40	738	173	1.52	262.96
Ohio............	187	222	2.59	574.98	1,660	204	1.73	352.92	506	231	2.06	475.86	1,610	182	1.33	242.06
Pennsylvania....	140	201	2.67	536.67	1,262	194	1.83	355.02	337	175	2.66	465.50	1,102	181	1.41	255.21
South Dakota....	9	197	3.98	784.06	64	101	2.05	207.05	18	136	2.91	395.76	43	118	1.96	231.28
Washington......	6	262	3.57	935.34	57	157	2.28	357.96	10	153	3.16	483.48	29	200	2.08	416.00
West Virginia....	23	149	2.51	373.99	136	154	1.44	221.76	28	145	2.73	395.85	133	144	1.24	178.56
Wisconsin........	15	174	3.10	539.40	199	144	1.92	276.48	39	167	2.91	485.97	103	145	1.71	247.95
Totals and avs.	752	212	$2.88	$610.83	7,505	198	$2.04	$404.30	1,956	208	$2.50	$519.71	5,749	192	$1.48	$284.50

LABOR AND WAGES IN MINING IN THE UNITED STATES, 1889. (*a*)

COAL MINING.

States.	Employees Above Ground. Foremen. Av. Number Employed.	Av. Days Worked.	Av. Daily Wages.	Mechanics. Av. Number Employed.	Av. Days Worked.	Av. Daily Wages.	Laborers. Av. Number Employed.	Av. Days Worked.	Av. Daily Wages.	Employees Below Ground. Foremen. Av. Number Employed.	Av. Days Worked.	Av. Daily Wages.	Miners. Av. Number Employed.	Av. Days Worked.	Av. Daily Wages.	Laborers. Av. Number Employed.	Av. Days Worked.	Av. Daily Wages.
Alabama	57	276	$2.52	123	231	$2.12	797	218	$1.25	73	272	$2.74	4,110	248	$2.15	1,564	237	$1.33
Arkansas	5	248	2.69	21	208	2.22	79	210	1.49	10	228	2.71	462	180	2.20	64	186	2.00
California and Oregon	6	296	5.12	20	236	2.90	48	248	2.04	9	271	3.17	235	224	2.58	85	268	2.32
Colorado	53	278	3.50	161	229	2.98	571	234	2.21	46	287	3.36	3,390	212	2.65	564	214	2.65
Georgia and North Carolina	12	264	2.29	34	210	2.15	277	255	.96	13	210	1.64	271	291	1.46	120	288	.98
Illinois	217	262	2.33	625	266	2.02	1,678	201	1.52	305	256	2.38	15,386	177	1.95	5,062	199	1.76
Indiana	74	255	2.36	160	256	1.84	426	192	1.47	135	170	2.37	4,738	175	1.89	820	182	1.70
Indian Territory	11	291	2.55	63	170	2.50	145	164	1.90	10	252	3.10	1,200	166	3.25	393	177	2.41
Iowa	147	228	2.20	202	253	2.21	709	209	1.57	139	251	2.46	6,588	196	2.23	1,191	217	1.89
Kansas and Nebraska	69	190	2.37	160	200	2.23	488	197	1.55	103	230	2.46	4,447	207	1.89	456	222	1.75
Kentucky	76	270	2.44	152	242	1.81	627	204	1.30	59	255	2.33	3,046	193	1.75	674	219	1.56
Maryland	15	266	3.04	65	264	2.03	225	196	1.59	22	289	3.04	2,689	203	2.45	386	222	1.86
Michigan	7	199	2.10	11	213	1.91	28	249	1.92	4	218	2.34	191	184	1.74	10	216	1.69
Missouri	122	228	2.09	107	246	2.11	692	214	1.52	103	230	2.34	4,780	201	2.04	656	206	1.72
Montana	9	251	5.28	38	252	3.58	123	240	2.50	11	248	4.31	521	213	3.19	143	235	2.60
New Mexico	13	208	3.27	26	231	2.88	112	214	2.37	9	287	3.58	688	192	3.08	146	207	2.59
North Dakota	7	115	2.29	3	88	2.67	3	100	1.50	3	117	3.00	55	108	2.15	4	111	1.88
Ohio	221	244	2.28	334	235	1.91	1,420	192	1.51	221	245	2.32	14,733	181	1.95	1,955	185	1.63
Pennsylvania:																		
Anthracite	564	291	2.71	4,720	257	1.91	23,779	198	1.29	737	291	3.05	36,639	179	2.39	35,376	184	1.64
Bituminous	378	250	2.57	1,028	237	2.13	3,366	208	1.67	606	256	2.57	40,100	210	1.93	5,303	220	1.84
Tennessee	48	249	2.47	101	244	1.86	393	222	1.21	55	245	2.14	2,538	227	1.98	696	228	1.26
Texas	7	283	2.91	5	260	2.50	109	248	1.52	6	248	2.65	340	264	2.00	56	236	1.77
Utah	3	246	3.63	18	238	2.84	59	198	2.35	5	260	3.47	332	163	3.21	101	169	2.51
Virginia	16	245	1.99	51	269	2.04	407	282	1.16	12	265	2.44	712	285	1.53	253	269	1.59
Washington	21	293	3.76	94	255	3.04	396	242	2.29	31	286	3.97	1,549	197	3.26	509	222	2.46
West Virginia	117	270	2.48	244	246	1.90	1,135	211	1.36	118	269	2.46	6,367	223	1.86	1,504	224	1.47
Wyoming	10	263	4.42	37	269	2.98	321	253	2.21	14	310	3.31	1,593	231	2.71	680	220	2.47
Totals and avs.	2,285	260	$2.58	8,603	250	$2.02	38,413	203	$1.40	2,859	259	$2.65	157,688	196	$2.12	58,771	195	$1.70

COPPER MINING.

Arizona	11	276	$5.43	57	260	$3.97	252	286	$2.63	23	274	$4.89	408	290	$3.19	82	308	$2.62
Michigan	63	313	5.31	547	311	2.30	1,247	301	1.58	57	312	4.04	2,101	314	1.90	1,582	307	1.67
Montana	7	289	4.86	131	300	4.76	162	274	3.13	30	300	4.93	1,609	281	3.53	9	129	3.00
New Mexico	3	269	5.00	6	221	3.75	57	314	2.50	4	259	3.71	118	274	2.58	52	293	2.25
Totals and avs.	84	305	$5.28	741	304	$2.88	1,718	297	$1.91	114	299	$4.43	4,236	298	$2.71	1,725	306	$1.74

GOLD AND SILVER MINING.

Alabama	3	155	$3.00	3	210	$1.50	4	150	$0.90	1	210	$3.00	7	165	$1.25	6	137	$0.83
Alaska	16	238	5.50	21	305	5.00	158	285	2.82	9	360	4.86	127	300	3.60	55	282	2.00
Arizona	64	219	4.59	118	187	3.89	703	205	2.46	34	193	4.44	1,467	215	3.17	132	199	2.24
California	565	192	3.30	660	196	3.26	6,231	147	2.05	303	217	3.49	5,522	209	2.74	944	237	2.28
Colorado	330	234	4.33	781	254	3.80	1,505	237	2.91	396	226	4.22	9,585	241	3.08	569	244	2.88
Georgia	22	173	1.33	22	250	1.47	152	228	.92	17	148	1.60	41	179	1.05	93	212	.80
Idaho	128	221	4.64	354	203	4.04	964	187	3.04	163	247	4.79	2,566	204	3.59	318	206	3.10
Maryland	2	249	2.25	.....	.....	.....	50	257	1.05	.....	.....	.....	2	250	1.50	10	260	1.25
Michigan	2	312	3.25	7	350	2.25	32	319	1.81	1	310	2.25	40	310	2.00	13	310	1.80
Montana	96	286	5.39	307	296	4.14	2,613	287	3.25	65	303	5.11	2,552	295	3.48	254	292	3.13
Nevada	83	304	5.07	261	298	4.56	779	270	3.22	84	312	4.83	2,003	289	3 60	214	248	2.91
New Mexico	45	169	4.09	90	193	3.50	520	204	2.31	48	233	4.15	1,202	214	3.15	154	228	2.26
North Carolina	21	242	2.27	53	193	1.44	230	179	.88	18	197	2.26	238	155	1.02	178	205	.85
Oregon	59	140	3.32	132	199	2.92	1,490	130	2.92	22	194	3.92	653	157	3.16	57	200	2.23
South Carolina	7	65	3.02	13	113	2.54	114	92	.99	2	73	3.10	34	70	1.15	20	24	.90
South Dakota	31	272	4.57	260	311	3.23	554	204	2.85	31	299	4.75	645	293	3.49	369	321	2.99
Texas	7	130	4.62	10	174	2.83	36	147	2.07	5	163	2.60	78	175	1.27	192	156	1.25
Utah	85	307	5.27	171	319	3.93	475	311	3.14	132	279	4.21	2,065	273	3.04	274	316	2.80
Virginia	2	50	1.38	.....	.....	.....	30	70	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....
Washington	3	221	5.00	3	280	4.00	394	139	3.00	8	124	4.69	187	134	3.43	7	154	3.28
Wyoming	14	105	3.86	7	56	3.07	51	81	2 36	13	80	4.84	130	58	3.05	11	108	2.36
Totals and avs.	1,585	216	$4.04	3,273	244	$3.67	17,085	195	$2.51	1,352	238	$4 16	29,144	236	$3.12	3,870	244	$2.46

(*a*) From the Census Report, 1890.

ers" underground than "miners," while under "foremen" there are included men whose duties range all the way from those of shift bosses to mine captains. The table is evidently incomplete, as shown by the totals of employees falling below those given in other records. As between surface and underground employment at collieries and metal mines, the best idea of the difference in wages scales is shown by the rates paid the actual miners. For corresponding reasons, in comparing quarry statistics the wages paid to men classed as "quarry-men" are the safest index.

According to the census figures, then, the average daily wages of all "miners" in the collieries of the United States in 1889 was $2.12 (the length of shift not stated), and they worked, on the average, 196 days in the year. This would make the yearly earnings in 1889 amount to $415.52. The average did not fall below $1 a day in any State; was between $1 and $2 in most of the Southern States, and exceeded $3 only in Indian Territory, Montana, New Mexico, Utah, and Washington—though throughout the far West the rates were well up. Rates for surface labor about coal mines in different parts of the United States naturally vary very much as those for miners, but on a lower scale. Only one average fell below $1 a day, but in the Southern States, where much of this work is done by colored laborers, the general average was but little above that mark. Since the census was taken wages have fallen considerably all through the country, but the relative positions of the several geographical divisions remain about the same. The wages of men employed in machine coal mining have not varied greatly during the seven years ending with 1894, and averaged for a day's work: Blasters, $2.15; cutters, $2.33; helpers, $1.77; laborers, $1.69; loaders, $1.78; timber-men, $2.05.

In copper mining the figures for four of the producing States are given. Miners in Michigan received an average of $1.90 a day, as against $3.10 in Arizona, $3.53 in Montana, and $2.58 in New Mexico. The general average for the United States was $2.71 per day, and the miners worked 208 days in the year on an average.

Wages of gold and silver miners vary as greatly as the localities of the mines. In the far West the average daily rate was considerably over $3 a day in 1889, though in the older settled States of California and Oregon, where living is comparatively cheap, the average was below $3. Since then, and especially in 1893, the closing of so many silver mines threw a large number of men temporarily out of employment, and all wages were severely cut down for a time, though afterward recovering somewhat. The general average of daily wages in all the gold and silver mines of the United States in 1889 was $3.12 and the men averaged 236 days' work in the year. Both of these averages make a very good showing for the precious-metal industry, which thus not only paid higher wages, but gave steadier employment than any similar industry in the last census year; and this would be true also under all normal circumstances. The length of shift is either 8, 9, or 10 hours in different localities and according to varying conditions.

For quarry-men the following general averages are given for 1889: In granite quarries, $1.79 a day and 208 days' work in the year; in limestone quarries, $1.52 and 200 days; in sandstone quarries, $2.04 and 198 days.

COAL STATISTICS OF DIFFERENT COUNTRIES COMPARED.

The table of statistics of coal output, consumption, and prices at the mines in various countries is an attempt to present a bird's-eye view of the salient features of the world's coal industry. Besides the number of persons employed in and about the collieries, the total population in each country is stated as a basis for comparisons and averages. The most instructive point brought out in this exhibit is the relative consumption of coal per head of population in different countries. As regards this, Mr. Robert Giffen, the compiler of the *Coal Tables*, remarks that "as might be expected, the highest proportion is found in those countries where steam traction and machinery worked by steam are mostly in use, such as the United Kingdom, the United States, and Belgium; and the lowest in those countries where steam traction is, comparatively speaking, but little used, such as Russia and Austria." The relatively low per capita consumption of coal in such an advanced country as France is accounted for in a great measure by the large supplies of wood, lignite, and peat which are all there used extensively. This also applies to other countries, such as Sweden, Norway, etc., where wood is largely used for fuel; while in some countries having milder climates the fuel demand for domestic consumption is light. Still, speaking broadly, the coal consumption per head is a rough index to the stage of civilization and material progress in any given country. The coal consumption in the United States is shown to be increasing much faster than the population, while that in Great Britain is practically stationary. The minor fluctuations from year to year reflect very plainly the changes in industrial activity and commercial prosperity.

Under the head of "Tons of Coal Produced per Person Employed" the averages must be taken with much the same reservations as in the case of the State returns for this country. The comparatively small output of the Belgian miner, as compared with that of the English miner, is due to the thinness of the Belgian seams, none of which exceeds 1 meter, while the English coal beds are very thick. Another feature which tends to throw doubt upon the manner of compiling statistics intended to show relative efficiencies is that in so many cases the amount produced per man is made to appear to be decreasing, whereas it is a matter of common observation that improved machinery and methods are constantly augmenting the efficiency per man; and that whatever drawbacks attend deeper mining, with its need of increased power for pumping and hoisting, or the working in thinner seams as the thicker become exhausted, these are more than offset by the advantages made available by engineering progress. It may well be that in exceptional localities the amount of labor necessary to get a given quantity of coal has increased as the best and most accessible beds are being worked out, but the contrary is believed to be the general rule; and this opinion, the prevailing one among engineers, can be controverted only by statistics which are unchallenged. Many of the discrepancies are no doubt due to the confusion between figures of underground and total force. But while there are many points which need further explanation before acceptance, there is a certain agreement, though only very roughly approximate, with current judgment as to the working effectiveness of miners in different countries and of different races. In this respect the influence of climate, among the European nations, and the employment of "native" labor in British India, Cape Colony, and Natal, show themselves plainly even with all the other variants in the computation.

The average price per ton of coal at the mines in various countries is subject to a complexity of influences, such as quality, local demand, freights, etc. That the differences are not greater must be attributed to the cheapening of long-distance transportation, which brings the points of production and the markets constantly nearer together and has a general leveling effect, or rather a tendency in that direction. The cost of production is the main, but by no means the sole factor. The prices for American coals are averages of both bituminous and anthracite values, and hence are considerably higher than if for bituminous coal alone. To make a just comparison only coals of the same general class should be considered, but for consistency and to avoid confusion, all the figures in the United States column in the table are based on the totals of both bituminous coal and anthracite.

Even with its admitted defects, this table of the world's labor in coal mining, its consumption, and the local values, is instructive and is worthy of careful study. Some of the causes of discrepancies have been suggested, and making proper allowance for them the figures are significant, not merely of the vastness of the coal industry, but also of the differences of conditions in different places.

LABOR AND ACCIDENTS IN THE MINES OF GREAT BRITAIN.

The accompanying table is condensed from the statistics given in the first annual report on *The Mineral Industry of Great Britain* (for 1894), by C. Le Neve Foster. In that report "mines" are defined as all workings below ground by artificial light, in accordance with the British mining laws. The question whether certain workings do or do not constitute mines is therefore decided by the kind of excavation and not by the nature of the mineral wrought. Thus a working by open cast is no mine in Great Britain under the laws, while an underground excavation for building stone or fireclay would come under the definition, which would hardly convey a correct impression elsewhere. However, as 93.8% of the people engaged in mining were connected with the coal industry, and only 2.1% were at iron mines and 4.1% at all other mines, the table is essentially an exhibit of the conditions existing in British collieries.

During the year 1894 the total number of persons employed was 739,097, of whom 589,689 worked below ground and 149,408 above ground. These figures show an increase in mining activity over the preceding year, there being 18,711 more men employed below ground and an increase of 1724 men above ground, while there was a decrease of 85 women employed above ground, showing that even in a time of increased demand for labor the custom of employing the weaker sex is apparently dying out. As is properly remarked by Mr. Foster, the true criterion of the importance of a mine is the number of employees underground. When the question of accidents comes to be considered in connection with these statistics it is very important to have this feature fairly brought out, as the risk run by those above ground is very different from that of the underground workers.

Mr. Foster has made a special study of the subject of accidents, and the manner

STATISTICS OF COAL OUTPUT, CONSUMPTION, AND VALUE IN SEVERAL COUNTRIES. (*a*)
(All measures and values in terms of metric tons.)

Year.	Austria-Hungary	Belgium	France.	Germany.	Italy.	Russia.	Spain.	Sweden.	United Kingdom.	United States.	Year.
						POPULATION.					
1883....	38,557,000	5,721,000	37,877,000	46,016,000	28,837,000	103,716,000	17,144,000	4,604,000	35,450,000	53,693,000	...1883
1884....	38,985,000	5,785,000	37,945,000	46,336,000	29,026,000	....	17,194,000	4,644,000	35,724,000	54,911,000	...1884
1885....	39,348,000	5,853,000	38,153,000	46,858,000	29,215,000	108,787,000	....	4,683,000	36,016,000	56,148,000	...1885
1886....	39,757,000	5,910,000	38,219,000	47,134,000	29,403,000	112,900,000	....	4,717,000	36,314,000	57,404,000	...1886
1887....	40,128,000	5,975,000	38,300,000	47,630,000	29,592,000	....	17,545,000	4,735,000	36,599,000	58,680,000	...1887
1888....	40,510,000	6,030,000	38,400,000	48,168,000	29,781,000	....	....	4,748,000	36,881,000	59,974,000	...1888
1889....	40,979,000	6,094,000	38,450,000	48,717,000	29,970,000	....	....	4,774,000	37,179,000	61,289,000	...1889
1890....	41,359,000	6,069,000	38,430,000	49,428,000	30,158,000	116,500,000	....	4,785,000	37,485,000	62,622,000	...1890
1891....	41,443,000	6,136,000	38,343,000	49,767,000	30,347,000	119,033,000	....	4,803,000	37,881,000	63,975,000	...1891
1892....	41,711,000	6,195,000	38,323,000	50,279,000	30,536,000	....	....	4,807,000	38,107,000	65,403,000	...1892
1893....	42,159,000	6,262,000	38,340,000	50,748,000	30,725,000	....	....	4,824,000	38,440,000	66 826,000	...1893
1894....	....	6,342,000	38,733,000	51,308,000	30,914,000	....	....	4,873,000	38,786,000	68,275,000	...1894
						PERSONS EMPLOYED IN AND ABOUT THE COAL MINES.					
1883....	*b*39,694	106,252	109,574	207,577	2,237	....	9,280	1,088	471,679	....	...1883
1884....	40,707	105,582	106,323	214,728	2,273	....	9,069	1,081	478,006	....	...1884
1885....	40,994	103,095	98,600	218,725	1,821	....	8,859	1,202	478,981	....	...1885
1886....	40,981	100,282	99,386	217,581	2,629	33,158	9,309	1,016	482,012	....	...1886
1887....	42,643	100,739	99,997	217,357	2,870	32,781	....	1,134	493,122	....	...1887
1888....	43,630	103,477	102,070	225,452	2,883	37,957	8,510	1,151	510,741	317,637	...1888
1889....	45,816	108,382	107,941	239,954	2,714	43,271	9,340	1,400	542,828	294,494	...1889
1890....	48,748	116,779	118,502	262,475	2,817	40,571	9,314	1,576	590,011	317,223	...1890
1891....	51,241	118,983	128,658	283,227	2,386	*c*42,225	12,100	1,566	626,568	349,577	...1891
1892....	51,691	118,578	130,116	289,415	2,295	....	12,583	1,523	647,409	366,667	...1892
1893....	52,459	116,861	129,669	290,632	2,105	*c*43,244	12,865	1,536	640,662	400,634	...1893
1894....	53,751	117,103	131,587	299,627	....	....	....	1,534	665,747	408,671	...1894
						TONS OF COAL PRODUCED PER PERSON EMPLOYED.					
1883....	*b*201	171	189	270	96	....	112	141	347	....	...1883
1884....	196	171	184	267	98	....	105	153	336	....	...1884
1885....	199	169	193	267	104	....	104	145	333	....	...1885
1886....	204	172	196	267	92	138	105	167	327	....	...1886
1887....	213	182	208	278	114	138	....	149	329	....	...1887
1888....	219	186	217	290	127	136	119	147	333	451	...1888
1889....	188	184	221	281	144	143	116	134	326	461	...1889
1890....	183	174	216	268	133	148	125	119	308	484	...1890
1891....	179	165	198	260	121	*c*148	104	126	296	477	...1891
1892....	179	165	197	247	129	*c*160	114	131	281	484	...1892
1893....	186	166	194	254	151	....	115	130	256	433	...1893
1894....	178	175	205	256	....	....	....	140	283	409	...1894
						TONS OF COAL CONSUMED PER HEAD OF POPULATION.					
1883....	0.25	2.45	0.81	1.06	0.09	....	0.13	0.26	3.85	1.82	...1883
1884....	0.26	2.39	0.78	1.08	0.10	....	0.13	0.27	3.71	1.81	...1884
1885....	0.26	2.31	0.75	1.09	0.11	0.06	....	0.28	3.63	1.81	...1885
1886....	0.26	2.22	0.74	1.09	0.11	0.06	....	0.27	3.56	1.80	...1886
1887....	0.27	2.33	0.78	1.13	0.13	....	0.14	0.28	3.62	2.02	...1887
1888....	0.29	2.45	0.81	1.21	0.14	....	....	0.31	3.73	2.20	...1888
1889....	0.30	2.47	0.83	1.28	0.15	....	....	0.35	3.82	2.03	...1889
1890....	0.31	2.68	0.91	1.30	0.16	0.07	....	0.36	3.87	2.25	...1890
1891....	0.32	2.51	0.92	1.37	0.14	0.07	....	0.38	3.90	2.38	...1891
1892....	0.32	2.48	0.92	1.30	0.14	....	....	0.38	3.80	2.48	...1892
1893....	0.33	2.35	0.90	1.33	0.13	....	....	0.38	3.35	2.37	...1893
1894....	....	2.56	0.96	1.36	....	....	....	0.45	3.81	2.22	...1894
						PRICE PER TON OF COAL AT THE MINES.					
1883....	$1.37	$1.97	$2.44	$1.27	$1.52	....	$2.15	....	$1.35	$1.54	...1883
1884....	1.36	1.84	2.39	1.27	1.48	....	2.20	....	1.30	1.34	...1884
1885....	1.34	1.71	2.28	1.26	1.53	....	1.70	....	1.24	1.58	...1885
1886....	1.33	1.60	2.17	1.26	1.43	....	1.62	....	1.16	1.51	...1886
1887....	1.29	1.56	2.07	1.25	1.48	....	1.60	....	1.16	1.55	...1887
1888....	1.27	1.63	2.00	1.26	1.41	....	1.58	....	1.22	1.42	...1888
1889....	1.35	1.71	2.02	1.38	1.42	....	1.69	....	1.53	1.23	...1889
1890....	1.45	2.55	2.32	1.85	1.49	*c*$1.60	1.58	....	1.98	1.23	...1890
1891....	1.51	2.44	2.58	1.94	1.47	*c*2.40	1.63	....	1.92	1.27	...1891
1892....	1.47	1.99	2.41	1.78	1.39	*c*2.27	1.48	....	1.75	1.31	...1892
1893....	1.48	1.81	2.22	1.63	1.32	....	1.47	....	1.63	1.25	...1893
1894....	....	1.80	2.17	1.59	....	....	1.47	....	1.60	1.20	...1894

(*a*) From *Coal Tables*, compiled by Mr. Robert Giffen, by order of the British House of Commons, in 1895. The statistics for the United States are taken from THE MINERAL INDUSTRY volumes and the State inspectors of mines' reports. (*b*) Austria only (exclusive of Hungary) under this heading. (*c*) *Mines and Minerals of the United Kingdom*, Foster, 1894. (*d*) Not including government mines.

Year.	British India.	Canada.	Cape of Good Hope.	Japan.	Natal.	New South Wales.	New Zealand	Queensland.	Tasmania.	Victoria	Year.
POPULATION.											
1883....	261,497,206	4,324,810	....	37,452,000	....	861,310	540,877	287,475	123,650	920,694	1883
1884....	264,238,218	....	....	37,869,000	....	904,980	564,304	309,913	127,054	944,564	1884
1885....	267,007,960	....	1,252,347	38,151,000	....	949,570	575,172	326,916	129,267	969,202	1885
1886....	272,606,801	....	....	38,507,000	....	989,340	589,386	342,614	131,616	1,000,510	1886
1887....	275,464,263	....	1,377,213	39,070,000	....	1,020,330	603,361	366,940	135,988	1,032,993	1887
1888....	278,377,501	....	1,428,729	39,607,000	....	1,051,080	607,380	387,463	138,346	1,076,966	1888
1889....	281,295,451	....	1,458,823	40,072,000	530,776	1,081,820	616,052	406,658	142,177	1,103,727	1889
1890....	284,243,988	....	....	40,453,000	543,913	1,121,860	625,508	422,776	145,290	1,133,226	1890
1891....	287,324,769	4,833,239	1,527,224	40,719,000	543,913	1,165,300	634,058	410,330	152,619	1,157,678	1891
1892....	290,366,507	....	1,609,974	41,090,000	555,831	1,197,650	650,433	421,297	153,144	1,167,373	1892
1893....	293,379,814	....	1,659,740	41,388,000	562,214	1,223,370	672,265	432,299	154,424	1,174,006	1893
1894....	296,455,021	....	1,711,487	....	571,620	1,251,450	686,128	445,155	157,456	1,179,103	1894
PERSONS EMPLOYED IN AND ABOUT THE COAL MINES.											
1883....	23,172	....	....	....	....	5,481	....	....	43	48	1883
1884....	24,541	....	....	....	....	6,227	....	....	48	6	1884
1885....	22,745	....	202	....	....	7,097	1,448	....	....	35	1885
1886....	24,794	....	180	....	....	7,847	....	....	127	40	1886
1887....	28,438	....	197	....	....	7,998	1,605	....	85	35	1887
1888....	29,301	....	95	....	....	9,301	1,499	....	104	55	1888
1889....	29,928	....	235	*d*21,440	451	10,277	1,717	....	134	254	1889
1890....	32,971	....	387	*d*21,017	583	10,469	1,846	....	191	209	1890
1891....	34,827	....	422	*d*35,629	588	10,820	1,693	....	197	260	1891
1892....	38,645	....	905	*d*28,104	882	10,514	1,681	....	170	103	1892
1893....	37,679	....	1,128	*d*30,345	689	10,028	1,888	*c*947	143	560	1893
1894....	43,197	9,654	1,601	....	898	9,131	1,899	....	128	748	1894
TONS OF COAL PRODUCED PER PERSON EMPLOYED.											
1883....	58	....	....	....	....	467	....	....	209	9	1883
1884....	58	....	....	....	....	448	....	....	152	556	1884
1885....	58	....	74	....	....	413	359	....	....	23	1885
1886....	57	....	106	....	....	367	....	....	83	2	1886
1887....	55	....	93	....	....	371	354	....	330	101	1887
1888....	59	....	313	....	....	350	417	....	406	158	1888
1889....	66	....	102	*d* 85	58	362	347	....	306	58	1889
1890....	67	....	77	*d*103	142	296	351	....	287	71	1890
1891....	68	....	60	*d* 74	152	379	401	....	235	89	1891
1892....	67	....	42	*d*114	164	366	407	....	213	231	1892
1893....	69	....	47	*d*110	192	332	372	*c*282	242	166	1893
1894....	66	365	40	....	160	408	385	....	246	233	1894
TONS OF COAL CONSUMED PER HEAD OF POPULATION.											
1883....	0.01	0.64	....	0.02	....	1.19	1.03	0.48	0.35	0.43	1883
1884....	0.01	0.74	....	0.02	....	1.19	1.14	0.47	0.37	0.45	1884
1885....	0.01	0.70	0.11	0.02	....	1.20	1.05	0.71	0.39	0.49	1885
1886....	0.01	0.75	....	0.02	....	1.12	1.05	0.66	0.36	0.54	1886
1887....	0.01	0.85	0.07	0.03	....	1.13	1.05	0.65	0.44	0.55	1887
1888....	0.01	....	0.09	0.03	....	1.24	1.09	0.72	0.48	0.60	1888
1889....	0.01	0.97	0.11	0.03	0.05	1.20	1.04	0.63	0.50	0.71	1889
1890....	0.01	1.07	....	0.04	0.15	1.15	1.09	0.72	0.55	0.64	1890
1891....	0.01	1.10	0.10	0.05	0.11	1.35	1.12	0.67	0.57	0 76	1891
1892....	0.01	1.03	0.13	0.05	0.15	1.35	1.12	0.67	0.53	0.66	1892
1893....	0.01	1.16	0.09	0.04	0.14	1.20	1.11	0.64	0.44	0.60	1893
1894....	0.01	1.09	0.10	....	0.12	1.26	1.12	0.63	0.45	0.61	1894
PRICE PER TON OF COAL AT THE MINES.											
1883....	....	....	....	$2.08	....	$2.23	....	$2.39	... ...	$6.68	1883
1884....	....	....	....	1.75	....	2.23	....	2.34	....	4.80	1884
1885....	....	....	....	1.72	....	2.20	....	1.97	....	....	1885
1886....	....	$1.87	....	1.56	....	2.18	....	1.97	.... .	5.95	1886
1887....	$1.08	1.91	....	1.36	....	2.18	$2.58	1.95	$2.98	6.02	1887
1888....	1.14	1.93	....	1.44	....	2.14	2.60	1.96	1.87	3.94	1888
1889....	1.09	1.99	....	1.67	$2.38	2.11	2.68	2.14	1.67	3.61	1889
1890....	1.13	2.03	....	1.90	2.85	1.97	2.62	2.18	2.14	4.55	1890
1891....	1.24	2.18	....	1.85	2.38	2.05	2.70	2.22	2.19	4.13	1891
1892 ...	1.09	2.02	....	1.36	1.63	1.83	2.68	2.20	2.40	4.11	1892
1893....	1.01	2.02	....	1.21	2.38	1.70	2.64	2.23	1.99	2.59	1893
1894....	.98	2.02	....	....	2.38	1.50	2.62	2.01	2.01	2.66	1894

Lignite is not included under "Coal" except in the cases of Italy, Russia, and the United States.

The coal production of the countries named in this table, as well as for subsequent and previous years, will be found under appropriate headings in the several volumes of THE MINERAL INDUSTRY.

PERSONS EMPLOYED AND NUMBER OF ACCIDENTS (*a*) IN AND ABOUT THE MINES OF THE UNITED KINGDOM.

Year.	Persons Employed in and About All Mines.			Number of Deaths from Accidents							Death-Rate per 1,000 Persons.						
				From Different Causes Underground.					Total Surface.	Gross Total.	Employed Underground.					Total Aboveground.	Total Above and Underground.
	Below-ground.	Above-ground.	Total.	(*b*) Explosions.	Falls of Ground.	In Shafts	Miscellaneous.	Total.			(*b*) Explosions.	Falls of Ground.	In Shafts	Miscellaneous.	All Causes.		
1851..	171,893	44,324	216,217	321	327	219	73	940	44	984	1.867	1.902	1.274	0.425	5.469	0.993	4 551
1852..	177,160	45,683	222,843	264	349	209	116	938	48	986	1.490	1.970	1.180	0.655	5.295	1.050	4.425
1853..	182,427	47,041	229,468	214	370	236	94	914	43	957	1.173	2.028	1.294	0.515	5.010	0.914	4.170
1854..	187,695	48,399	236,094	210	389	290	99	988	57	1,045	1.119	2.073	1.545	0.527	5.264	1.178	4.426
1855..	192,962	49.757	242,719	146	407	229	127	909	46	955	0.751	2.109	1.187	0.658	4.711	0.924	3.935
Av..	182,427	47,040	229,468	231	368	236	101	937	47	985	1.280	2.016	1.296	0.556	5.149	1.012	4.301
1856..	198,229	51,116	249,345	236	400	216	114	966	61	1,027	1.190	2.018	1.090	0.575	4.873	1.193	4.119
1857..	203,497	52,474	255,971	377	372	175	141	1,065	54	1.119	1.853	1.828	0.860	0.693	5.233	1.029	4.372
1858..	208,764	53,832	262,596	215	366	172	140	893	38	931	1.030	1.753	0.824	0.671	4.278	0.706	3.545
1859..	214,031	55,191	269,222	95	399	191	160	845	60	905	0.444	1.864	0.892	0.748	3.948	1.087	3.362
1860..	219,298	56,549	275,847	363	388	182	122	1,055	54	1,109	1.655	1.769	0.830	0.556	4.811	0.955	4.020
Av..	208,763	53,832	262,596	257	385	187	135	964	53	1,018	1.234	1.846	0.899	0.648	4.628	0.994	3.883
1861..	224,566	57,907	282,473	119	427	164	163	873	70	943	0.530	1.901	0.730	0.726	3.887	1.209	3.338
1862..	231,345	59,655	291,000	190	422	137	332	1,081	52	1,133	0.821	1.824	0.592	1.435	4.673	0.872	3.893
1863..	237,705	61,295	299,000	163	407	147	134	851	56	907	0.686	1.712	9.618	0.564	3.580	0.914	3.033
1864..	244,496	63,046	307,542	94	395	184	125	798	69	867	0.384	1.616	0.753	0.511	3.264	1.094	2.819
1865..	250,784	64,667	315,451	168	381	163	179	891	93	984	0.670	1.519	0.650	0.714	3.553	1.438	3.119
Av..	237,779	61,314	299,093	146	406	159	186	898	68	966	0.618	1.714	0.668	0.790	3.791	1.105	3.240
1866..	254,927	65,736	320,663	651	361	162	203	1,374	107	1,484	2.554	1.416	0.635	0.796	5.402	1.628	4.628
1867..	264,827	68,289	333,116	286	449	158	211	1,107	86	1,190	1.080	1.695	0.597	0.797	4.169	1.259	3.572
1868..	275,722	71,098	346,820	154	444	132	204	934	77	1,011	0.559	1.610	0.479	0.740	3.387	1.083	2.915
1869..	274,630	70,816	345,446	257	466	129	179	1,031	85	1,116	0.936	1.697	0.470	0.652	3.754	1.200	3.230
1870..	278.961	71,933	350,894	185	411	129	186	911	80	991	0.663	1.473	0.462	0.667	3.266	1.112	2.824
Av..	269,813	69,574	339,387	306	426	142	196	1,071	87	1,158	1.158	1.578	0.528	0.730	3.995	1.256	3.433
1871..	294,850	76,031	370,881	269	435	123	176	1,003	72	1,075	0.912	1.475	0.417	0.597	3.402	0.947	2.899
1872..	332,380	85,708	418,088	154	456	155	217	982	78	1,060	0.463	1.372	0.466	0.653	2.954	0.910	2.535
1873..	445,186	131,646	576,832	100	518	201	246	1,065	108	1,173	0.225	1.164	0.451	0.553	2.392	0.820	2.034
1874..	462,647	132,543	595,190	166	453	188	229	1,036	123	1,159	0.359	0.979	0.406	0.495	2.239	0.928	1.947
1875..	461,922	131,996	593,918	288	490	207	260	1,245	118	1,363	0.623	1.061	0.448	0.563	2.695	0.894	2.295
Av..	399,397	111,584	510,981	195	470	174	225	1,066	99	1,166	0.516	1.210	0.437	0.572	2.736	0.899	2.342
1876..	443,338	128,691	572,029	95	474	145	172	886	117	1.003	0.214	1.069	0.327	0.388	1.998	0.909	1.753
1877..	429,120	122,666	551,786	345	489	150	211	1,195	110	1,305	0.804	1.140	0.350	0.492	2.785	0.897	2,365
1878..	413,603	113,184	526,787	586	496	130	184	1,396	94	1,490	1.417	1.199	0.314	0.445	3.375	0.831	2.825
1879..	413,444	110,426	523,870	184	450	136	188	958	79	1,037	0.445	1.088	0.329	0.455	2.317	0.715	1.979
1880..	423,426	114,415	537,841	499	493	112	197	1,301	101	1,402	1.178	1.164	0.265	0.465	3.073	0.883	2.607
Av..	424,586	117,876	542,462	341	480	134	190	1.147	100	1,247	0.811	1.132	0.317	0.449	2.709	0.847	2.306
1881..	432,678	117,741	550,419	116	486	132	222	956	97	1,053	0.268	1.123	0.305	0.513	2.209	0.824	1.913
1882..	440,006	119,487	559.493	250	498	143	225	1,116	102	1,218	0.568	1.132	0.325	0.511	2.536	0.854	2.177
1883..	447,188	117,980	565,168	134	500	124	267	1,025	115	1,140	0.300	1.118	0.277	0.597	2.292	0.975	2.017
1884..	448,847	115,649	564,496	65	504	100	229	898	100	998	0.145	1.123	0.223	0.510	2.001	0.870	1.768
1885..	449,093	112,583	561,676	341	470	84	238	1,133	81	1,214	0.759	1.047	0.187	0.530	2.523	0.719	2.161
Av..	443,562	116,688	560,250	181	491	116	236	1,025	99	1,124	0.408	1.108	0.263	0.532	2.312	0.848	2.007
1886..	448,657	112,435	561,092	129	482	97	211	919	99	1,018	0.288	1.074	0.216	0.470	2.048	0.880	1.814
1887..	453,653	114,373	568,026	154	493	97	227	971	80	1,051	0.339	1.087	0.214	0.500	2.140	0.699	1.850
1888..	465,006	127,650	592,656	50	496	89	234	869	109	978	0.108	1.067	0.191	0.503	1.869	0.854	1.650
1889..	489,179	136,050	625,229	138	493	86	307	1,024	152	1,176	0.282	1.008	0.176	0.628	2.093	1.117	1.881
1890..	531,670	142,764	674,434	290	448	98	259	1.095	145	1.240	0.545	0.843	0.184	0.487	2.060	1.016	1.839
Av..	477,633	126,654	604,287	152	482	93	247	975	117	1,092	0.312	1.015	0.196	0.517	2.042	0.913	1.806
1891..	559,189	148,222	707,411	51	500	132	245	928	128	1,056	0.091	0.894	0.236	0.438	1.660	0.864	1.493
1892..	571,840	149,968	721,808	123	454	103	268	948	120	1,068	0.215	0.794	0.180	0.469	1.658	0.800	1.480
1893..	570,978	153,529	718,747	160	435	115	292	1,002	123	1,125	0.280	0.762	0.201	0.511	1.755	0.801	1.565
1894..	589,689	149,408	739,097	317	457	93	188	1,055	118	1,173	0.538	0.775	0.158	0.319	1.789	0.790	1.587
1895..	....	....	....	55	439	110	356	960	126	1,086	......	......	......	......	......	......	......
Av..	....	....	....	141	457	111	270	979	123	1,102	......	......	......	......	......	......	......

(*a*) From 1851 to 1860, coal mines only; from 1861 to 1872, coal and stratified ironstone mines only; from 1873 to 1894, all mines, whether producing coal, metallic ores, stone, or other minerals. (*b*) Explosions of fire damp or coal dust.

in which he has analyzed and divided the accidents from different causes and those which happened below ground and the others on the surface is very instructive. The table really sums up the conclusions to be deduced from the statistics. One interesting point to be determined was whether more accidents happened on Mondays than on other days, as is sometimes maintained. The results for 1894 in the United Kingdom in no way support this assertion. Mr. Foster states, however, that it is impossible to make any useful comparison between the days of the week with reference to the frequency of accidents without knowing also the precise days on which the work was done. The smaller percentage of accidents on Saturdays can be explained by the fact that in some districts all collieries are invariably idle on that day.

The causes of accidents are carefully and fully gone into, covering explosions of fire damp or coal dust, and quoting one notable example, viz., the Albion colliery explosion, which was finally determined to be due to the ignition of coal dust or a small accumulation of fire damp from a shot fired in the timber supports of a main roadway which was being straightened out. This careless action caused the loss of 290 lives. The extent of the colliery can be judged by the following figures: 1020 persons were employed below ground on the morning of the accident and 504 in the afternoon.

Falls of ground, as in all similar statistics, take the lead as causes of fatalities, notwithstanding the occasional disastrous explosions and fires. Shaft accidents form a very small percentage of the total number of fatalities, owing to good management and efficient inspection. The accidents on the surface are those to which any one employed about machinery or railroading are exposed, but this careful analysis is certainly of service. Another table (not here quoted) gives the number of cases of persons injured by accidents each of which caused an inability to work for more than one week. The comparison is made between the rules and regulations existing in Germany, Belgium, Austria, France, and Italy with regard to this class of accidents, but it is very difficult to make such a comparison correctly, as is pointed out by Mr. Foster, on account of the different requirements by law in the different countries. In France, for instance, the accident is not entered in the statistics unless the person is prevented from working for the space of 20 days. In Austria the rule is the same, while in Belgium 8 days is the limit, and notice must be given by the master to the proper inspector within 48 hours of his knowledge of the fact. In Germany the law is still more strict, and under the German accident insurance law it is necessary to give notice of inability to work for any period exceeding 3 days.

THE MINERAL STATISTICS BY COUNTRIES.

In the following tables we group in a condensed form the mineral production, imports, and exports of the different countries. Many of these production statistics are given in the preceding pages under the headings of the different substances, but we give the figures here also for convenience of reference, and because it is well to be able to see what the production of any given country is as a whole and to compare it with others. The following tables, therefore, present a summary of the mineral industry of each country in a condensed form, and also show how large a share that industry contributes to its foreign trade. For the details of the industry, the articles on the different metals and minerals should be consulted.

The statistics in the following pages are nearly all from official reports, and are made up to the latest date to which those reports have been compiled. We give the figures usually for a period of five years, and the statistics for the preceding years, with much detailed information concerning the mineral resources of the several countries, can bc found in the earlier volumes of The Mineral Industry. The object is to bring the history of mineral production up to the latest possible date, and at the same time to avoid unnecessary repetition. In the first and second volumes of this series the statistics were given from the earliest period from which they could be compiled, but in the later volumes it has been deemed unnecessary to repeat the earlier figures, since they were already upon record in this accessible form. A period of five years is sufficient for any ordinary comparison; and the searcher after the statistical history of the industry can refer to one of the volumes named. In all cases where new figures have been obtained which were not given in previous editions they are presented in full.

The different countries are arranged in alphabetical and not in geographical order, as that is considered the more convenient for reference.

We must again urge the importance of adopting some uniform system for the collection and arrangement of mineral statistics and for the valuation of mineral products. Something has been done in this direction, but very much remains to be accomplished. In calling attention to this point and in securing the coöperation of the authorities in different countries, The Mineral Industry has already, we believe, been of essential service; and its editor will continue to labor to that end without ceasing.

AUSTRALASIA.

THE banking and commercial crisis which exercised so depressing an effect on the seven colonies of Australasia during the latter part of 1893 and the whole of 1894 was still severely felt in 1895. While the gold production of nearly all the colonies increased, the production of coal and other useful minerals did not advance; there was little new work done and few new discoveries made—certainly none of importance—outside of the gold and silver mines.

None of the Australasian colonies is an iron producer, and the efforts made to establish the industry have not succeeded. The iron reported in one or two of them is made from scrap and similar material.

New South Wales.—The following tables show the mineral production, imports, and exports of New South Wales for the five years ending with 1894:

MINERAL PRODUCTION OF NEW SOUTH WALES. (*a*) (IN METRIC TONS; £1=$5.)

Year.	Alunite.		Antimony Ore.		Bismuth		Coal.		Coke.		Cobalt Ore.		Copper Ingots.		Copper Ore and Regulus	
1890....	223	$15,000	1,043	$101,200	2	$1,530	3,110,156	$6,395,445	31,598	$205,735	..	......	3,216	$817,685	590	$48,870
1891....	715	9,440	930	110,285	40	2,500	4,102,940	8,713,978	30,798	172,365	1	$2,350	3,922	959,390	676	66,075
1892....	834	16,420	740	73,400	14	5,400	3,841,842	7,311,942	8,026	44,260	77	5,550	3,592	802,365	1,320	136,165
1893....	834	16,420	1,803	125,460	..	......	3,331,764	5,858,610	18,146	101,165	26	1,525	2,068	284,359	1,032	70,955
1894....	862	16,781	1,250	91,227	..	......	3,672,076	5,624,174	34,458	161,628	2	49	2,137	357,632	.....	....

Year	Fire-clay.		Gold—Kilos.		Iron.		Iron Oxide.		Lead.		Limestone Flux.		Man-ganese.		Opal. Pounds.	
1890	....	.....	3,973.8	$2,301,434	3,413	$199,740	457	$4,420	128	$7,935	42,104	$209,945	102	$1,625	......	....
1891	....	.....	4,769.4	2,791,528	4,192	180,505	233	2,170	194	10,125	75,249	326,785	140	1,700	......	....
1892	....	.....	4,879.1	2,845,889	2,827	113,025	460	4,345	72	3,630	105,032	465,155	16	235	......	....
1893	21	$224	5,576.4	3,256,430	2,227	73,930	1,280	7,630	439	21,025	132,764	555,205	....	......	499	$59,937
1894	24	292	10,102.2	5,629,742	......	....	433	3,261	31	1,265	89,990	337,234	....	......	198	27,664

Year.	Shale Oil.		Silver—Kilos.		Silver-Lead.			Tin Ingots.		Tin Ore.		Zinc.		Sundry Minerals.
					Ore.	Metal	Value.							
1890	56,912	$520,517	15,445	$477,050	91,164	41,985	$18,335,720	3,464	$1.585,585	263	$63,620	214	$11,890	$114,260
1891	40,998	390,800	22,070	674,250	93,871	56,288	17,423,695	2,989	1.308,845	207	48,215	222	13,110	66,935
1892	75,392	680.395	10,907	284,420	88,114	46,588	12,108,760	3,305	1.507,705	243	62,865	452	25,275	35,870
1893	56,568	506,100	16,546	390,655	158,368	59,341	14.767,945	2,830	1,115,695	150	33,020	....	....	27,850
1894	21,171	155,116	26,899	470,750	137,813	42,513	10,976,695	2.802	911,087	....	....	....	....	4,944

(*a*) From the *Annual Report of the Department of Mines and Agriculture*, New South Wales.

MINERAL IMPORTS OF NEW SOUTH WALES. (*a*) (*b*) (IN METRIC TONS AND DOLLARS.)

Year.	Coal.		Coke.		Copper.		Copper Ore.		Hardware.	Iron and Steel.	Machinery.	Tin Ingots and Ore.
1890....	25,867	$320,490	38,174	$962,515	21	$7,525	14,557	$730,225	$3,107,750	$4,879,135	$2,553,655	$1,288,355
1891....	30,399	348,885	76,542	1,865,835	3	960	14,837	669,780	3,326,465	7,207,940	2,721,640	1,104,125
1892....	711	2,575	61,852	857,005	10	1,860	10,202	509,855	3,173,445	5,394,110	1,544,555	1,186,225
1893....	468	1,865	61,874	322,975	91	16,070	1,822	90,320	1,748,730	2,986,005	1,114,205	1,054,200
1894....	374	1,225	47,586	183,420	348	71,040	668	32,535	892,035	2,884,765	1,107,310	893,240

MINERAL EXPORTS OF NEW SOUTH WALES. (IN METRIC TONS.)

Year.	Coal and Coke.		Copper.				Hardware.	Tin Ingots.		Tin Ore.	
			Ingots.		Ore and Regulus.						
1890..........	1.863,065	$5,128.295	3,216	$817,685	589	$48,870	$309,050	4,628	$2,119,845	265	$63,795
1891..........	2,560.767	6,569,305	3,922	959,360	678	66,075	261,825	3,948	1,724,450	211	49,490
1892..........	2,226,772	5,141,975	3,592	802,365	1,320	136,165	263,490	3,306	1,507,705	242	62,865
1893..........	1,864,635	4,074,645	1,068	221,175	1,032	70,955	212,455	2,679	1,115,685	150	33,020
1894..........	2,136,796	4,077,175	1,932	373,195	580	62,235	178,490	2,611	897,225	190	38,760

(*a*) From *British Statistical Abstracts.* The total value of the mineral products of this colony to the end of 1892 was £98,842,779, the details of which are: Coal, £27,271.429; gold, £39,202,656; silver, silver-lead, and ore, £13,779,931; copper, exported, £6,211,137; tin, exported, £9,840,910; shale, £1,552,796; coke, £84,473; iron, £406,-171; antimony, exported, £130,478; pig lead, exported, £11,049; bismuth, exported, £37,722; zinc spelter, exported, £11,043; limestone flux, £200,378; opal, £17,600; alunite, exported, £8172; building stone, exported, £8043; oxide of iron and pig iron, exported, £3516; marble, exported, £2577; lime, exported, £1780; cobalt, exported, £1580; ballast stone, exported, £989; manganese ore, exported, £712; slates, exported, £351; grindstones, exported, £311; fireclay, exported, £135; sundry minerals, exported, £56,841.
(*b*) Inclusive of imports overland.

While the complete official returns have been published as yet only up to 1894, we have received an advance statement giving the values of the leading articles of production for the year 1895:

VALUE OF CHIEF MINERAL PRODUCTS OF NEW SOUTH WALES, 1895.

Articles.	Value.	Articles.	Value.	Articles.	Value.	Articles.	Value.
Antimony	$36,255	Coke	$123,415	Iron	$78,100	Shale (oil)............	$376,090
Chrome ore......	65,240	Copper..........	704,425	Limestone	340,800	Silver and silver-lead.	8,213,355
Coal..............	5,476,635	Gold	6,514,026	Opal	30,000	Tin....................	693,115

There were increases, as compared with 1894, in gold, copper, shale, and chrome ore; decreases in silver and silver-lead. The amount given in the table under the latter head includes ores shipped also, as well as the metals. Coal showed a decrease in value, though there was an increase of 66,500 tons in quantity. The total value of all the mineral products in 1895 was $22,760,090, a decrease of $2,520,590, or about 10%, from 1894.

New Zealand.—The following tables show the mineral exports and imports of this colony for the five years ending with 1894:

MINERAL EXPORTS OF NEW ZEALAND. (*a*) (IN METRIC TONS.)

Year.	Antimony Ore.		Coal.		Coke.		Copper Ore.		Gold—Kilos.		Hematite Ore.		Kauri Gum.	
1890.....	523	$55,605	70,735	$335,015	2,254	$16,670	....	......	6,009	$3,867,190	1½	$25	7.558	$1,892,815
1891.....	420	24,750	93,140	455,865	2,585	18,290	¼	$20	7,838	5,037,440	....	5	8,523	2,185,280
1892.....	370	24,500	80,181	401,125	4,375	28,455	....	......	7,405	4,773,720	....	......	8,845	3,588,390
1893. ...	336	17,355	70,249	363,495	51	265	....	......	7.054	4,565,690	....	......	8,452	2,553,875
1894.....	......	....	81,222	395,885	107	800	....	......	6,202	4,439,325	....	......	8,470	2,022,835

MINERAL EXPORTS—*Continued.*

Year.	Manganese Ore.		Mixed Ores.	Silver—Kilos.	
1890....	490	$5,020	$1,365	1,015	$30,810
1891....	1,172	13,170	30	872	25,755
1892....	529	6,195	3,155	686	19,980
1893....	324	4,115	3,250	1,961	48,715
1894....	......	....	....	......	....

MINERAL IMPORTS OF NEW ZEALAND. (*b*) (IN METRIC TONS.)

Year.	Coal.		Iron.	Machinery.	Railway Materials.	Tools and Implements.
1890	112,758	$510,380	$2,955,344	$1,094,990	$264,155	$262,660
1891	127,325	602,110	2,829,635	1,019,620	142,905	245,870
1892	127,460	582,765	3,605,650	1,025,485	120,050	253,390
1893	117,444	544,890	2,040,680	1,060,220	272,705	337,900
1894	113,768	525,955	1,897,710	889,980	213,985	339,685

(*a*) From *Mines Statement*, 1894, by the Hon. A. T. Cadman, Minister of Mines, Wellington. There is no statement of the production of minerals in New Zealand save that of coal (for the statistics of which see article on coal), but the exports practically represent the whole production. The total value of the mineral products of this colony to the end of 1893 was £61,072,410, some of the details of which are: Gold, £49,000,999; silver, £153,887; kauri gum, £6,860,196; coal, £3,842,408; manganese ore, £56,107; antimony ore, £37,367.
(*b*) From *British Statistical Abstracts.*

New Zealand has suffered less than any other of the seven colonies from the financial crisis. Its gold production is increasing rapidly, having been 8216 kgms., valued at $5,459,815, in 1895. The coal output is increasing also.

Queensland.—But little new is to be said of the mineral production of this colony, of which gold and coal form the chief items. The following tables show the production, imports, and exports for the five years ending with 1894:

MINERAL PRODUCTION OF QUEENSLAND. (*c*) (IN METRIC TONS; £1 = $5.)

Year.	Antimony Ore.		Bismuth Ore.		Building Stone.		Coal.		Copper Ore.		Gems.	Gold—Kilos. (*d*)		Opal.	Mundic Ore.	
1890.......	175	$24,080	..	....	......	....	343,791	$785,355	188	$15,000	......	18,992	$12,211,740	$15,000	..	.....
1891.......	220	18,125	..	....	......	....	275,949	640,990	100	4,325	....	17,920	11,528,780	50,000	..	.....
1892.......	26	1,390	..	....	......	....	269,354	616,540	82	12,305	$22,185	19,146	12,311,160	50,000	..	.....
1893.......	30	1,440	75	$51,960	27,510	$21,240	267,091	626,700	302	19,110	22,500	19,187	10,796.450	....	7	$44
1894.......	28	1,400	66	31,350	......	....	275,136	572,965	415	47,910	....	17,437	11,587,541	60,000	..	.....

Year.	PRODUCTION—*Continued.* Silver Ore.		Tin Ore.		IMPORTS. Hardware and Ironmongery.	Iron and Steel.	Machinery.	EXPORTS. (*e*) Copper Ore.		Copper, Smelted.		Tin Ore.		Tin, Smelted.	
1890...	1,944	$283,195	3,018	$774,815	$580,305	$1,402,030	$667,100	87	$12,025	18	$5,090	2,844	$731,350	537	$263,250
1891...	889	109,395	2,272	581,935	524,010	2,032,240	659,830	36	2,550	87	17,770	1,800	506,525	193	97,000
1992...	6,992	182,180	2,427	615,490	413,650	1,094,120	689,675	54	4,470	254	57,445	1,876	177,145	426	198.875
1893..	10,541	212,040	2,522	534,665	288,980	704,070	526,010	107	6,420	29	6,475	1,745	444,520	246	119,615
1894...	5,697	110,385	2,916	511,385	384,425	1,069,005	593,655	64	4,900	135	25,400	1,783	365,725	422	138,720

(*c*) From *Annual Report of the Under Secretary for Mines for 1894.* (*d*) For 1894 the production is in fine kgms., or pure gold. (*e*) From *British Statistical Abstracts.*

The gold production for 1895 decreased somewhat, the total being 15,987 kgms., valued at $10,623,863.

South Australia.—The mineral exports and imports for the four years ending with 1893 are given in the following tables:

MINERAL EXPORTS OF SOUTH AUSTRALIA. (*f*) (IN METRIC TONS; £1 = $5.)

Year.	Copper.		Copper Ore.		Gold—Kilos.		Lead Ore.		Silver-Lead Ore		Manganese Ore.		Regulus.	
1890..	3,009	$777,085	15,628	$357,875	....	$104,040	1,062	$84,520	..	......	2,808	$35,115	1,176	$104,935
1891..	3,609	910,710	13,245	265,875	....	136,900	130	8,935	..	......	861	8,625	41	2,500
1892..	2,769	660,200	10,674	217,425	....	....	......	....	..	......	......	....	.....	....
1893..	4,389	1,017,042	1,276	28,268	*g*1,031	685,335	......	....	35	$2,044	2,467	30,949	.....	....

Year.	Salt.		Slate, Roofing.		Spelter.		Tin Ore.		Various.		Totals.
1890........	5,689	$34,015	339,084	$19,540	17	$1,305	......	......	45	$1,850	$1,520,280
1891........	7,628	49,695	170,000	7,100	16	1,135	10	$340	....	h11,495	1,403,310
1892........	....	....	....	....	......	......	......	......	....	....	....
1893........	7,229	45,463	....	....	73	4,507	......	......	21	925	....

MINERAL IMPORTS OF SOUTH AUSTRALIA.

Year.	Coal, Coke, and Other Fuel.		Hardware.	Iron—Bar, Sheet, etc.		Iron—Galvanized, Plain, and Corrugated.		Implements Not Agricultural.	Machinery.
1890......	232,686	$1,253,645	$157,150	10,270	$426,445	4,634	$422,530	$446,110	$153,585
1891......	402,552	2,008,190	238,395	8,874	343,875	7,431	641,875	490,630	153,970
1892......	324,954	1,560,880	184,335	6,498	232,305	9,610	605,315	294,860	132,930
1893......	313,300	1,673.520	163,260	5,446	194,475	4,831	347,680	233,235	140,495
1894......	377,240	1,520,195	270,975	4,847	175,620	6,235	450,995	178,635	70,070

(*f*) From the mining records of South Australia, British blue books. and *Statistical Register for South Australia for 1893.* (*g*) Total product in fine metal. (*h*) Includes mica, value $6045, and precious stones, $1490.

The gold production increased in 1895 to 1363 kgms., valued at $905,181. The development of South Australia is slow, owing to its small population, the vast extent of its territory, its hot climate, and lack of water. The gold production, however, shows a rapid increase.

Tasmania.—The following tables show the production, imports, and exports for the five years ending with 1894:

MINERAL PRODUCTION OF TASMANIA. (*j*) (IN METRIC TONS; £1 = $5.)

Year.	Coal.		Gold—Kilos.		Limestone.		Silver Ore.		Stones, Building. Cubic Feet.		Tin Ore.		Tin.	
1890..	54,672	$269,060	729	$435,570	3,259	$14,050	2,086	$132,435	115,873	$18,970	4,790	$1,099,340	3,264	$1,483,805
1891..	46,252	227,620	1,219	749,080	5,132	9,245	4,887	261,420	93,838	22,595	4,392	1,309,575	3,329	1,465,850
1892..	36,240	178,345	1,403	870,350	2,253	5,750	9,476	227,510	89,050	21,120	4,737	1,280,415	3,246	1,453,970
1893..	34,587	170,210	1,158	729,375	1,546	3,965	14,530	993,050	37,470	3,965	4,781	1,032,055	3,179	1,301,095
1894..	30,499	121,995	1,602	1,064,650	......	....	27,700	1,635,760	....	....	......	....	3,195	1,348,000

MINERAL IMPORTS OF TASMANIA. (*i*) (IN METRIC TONS.)

Year.	Coal.		Ironmongery and Hardware.	Railway Material.	Copper and Lead.	Iron and Tin.	Earthen and Glass Ware.
1890................	32,462	$163,615	$672,745	$295,190	$7,875	$211,645	$107,765
1891................	40,688	200,710	809,110	177,685	9,730	185,260	111,440
1892................	43,852	227,940	599,765	31,055	8,875	128,875	93,355
1893................	32,252	121,395	320,690	57,000	8,205	121,100	51,175
1894................	40,832	59,760	291,840	26,745	....	....	....

MINERAL EXPORTS OF TASMANIA. (*i*) (IN METRIC TONS.)

Year.	Gold—Kilos.		Tin and Tin Ore.		Silver and Silver Ore.		Copper and Copper Ore.	
1890..........	843	$435,425	3,265	$1,483,805	562	$84,360	4	$280
1891..........	1,064	665,065	3,344	1,465,850	2,524	310,990	....	....
1892..........	1,164	728,685	3,254	1,453,970	4,440	396,765	....	....
1893..........	939	655,520	3,318	1,330,795	13,200	769,260	184	229,830

(*j*) From the *Report of the Secretary for Mines* and Appendix A to *Statistics of Tasmania for 1893 and 1894.*

The gold production decreased in 1895 to 1521 kgms. (fine gold), valued at $1,011,135. While the exact figures have not been received for other metals, it is understood that copper and tin both showed increases in 1895.

Victoria.—The production, imports, and exports for the five years ending with 1894 are given below:

MINERAL PRODUCTION OF VICTORIA. (*k*) (IN METRIC TONS; £1 = $5.)

Year.	Antimony Ore.		Calcite and Silicate of Aluminum.		Coal.		Lignite.		Copper Ore		Gold—Kilos.		Lead Ore.	
1890........	132	$15,600	610	$1,500	14,836	$69,495	10,016	$12,500	254	$500	18,307	$11,771,200	51	$250
1891........	67	5,940	102	25	23,202	98,655	6,424	8,365	61	1,080	17,928	11,527,980	9	45
1892........	299	11,390	......	....	23,739	100,220	6,706	18,625	......	......	20,356	13,089,120	......	......
1893........	93	2,155	......	....	93,221	245,835	4,573	11,035	489	73,810	20,874	13,414,000	765	......
1894........	35	875	......	....	......	....	3,566	10,040	......	......	*l*19,697	13,089,464	......	......

MINERAL PRODUCTION OF VICTORIA—*Cont.* / MINERAL IMPORTS OF VICTORIA. (*m*) (IN METRIC TONS.)

Year.	Silver—Kilos.		Slate and Flagging.		Tin Ore.		Coal.		Iron and Steel.		Iron-mongery.	Rails.	Machin-ery.
1890	1,309	$46,290	3,568	$6,060	924	$19,180	708,121	$3,727,945	100,050	$4,932,570	$742,530	$812,740	$1,749,635
1891	......	1,050	2,311	2,675	1,807	25,460	861,826	4,189,050	88,106	5,233.515	785,250	52,945	1,283,970
1892	16	400	626	900	414	5,195	751,538	3,375,235	61,827	3,687,405	581,065	20,960	776,846
1893	1,234	29,915	171	225	54	10,850	611,826	2,092,420	23,141	1,753,310	340.575	....	625,000
1894	......	....	315	425	61	11,430	550,709	977,075	22,795	1,073,520	404,505	....	472,330

(*k*) From the blue books of the Mines Department of the colony. (*l*) Fine kgms., or pure gold. (*m*) From *British Statistical Abstracts.*

Victoria is the leading gold producer among the seven colonies, and its total increased in 1895 to 21,638 kgms., or $14,379,726.

Western Australia.—The small population and unfavorable climate have, as in South Australia, limited settlement and production very much. During the past two years, however, this colony has attracted more attention than any of the others, owing to the extraordinary gold discoveries reported in the Coolgardie and other districts. Men and money poured into the colony, but the results so far have been disappointing.

MINERAL IMPORTS OF WESTERN AUSTRALIA. (*n*) (IN METRIC TONS.)

Year.	Copper	Coal.		Iron, Pig and Sheet.		Iron Manufactures.	Lead.		Tin.	Zinc.	Soda Compounds.
1891........	....	......	$60,390	....	....	....	....	....	....	....	....
1892.......	$1,625	25,607	69,200	2,189	$125.190	$19,453	78	$5,820	$9,160	$2,240	$5.170
1893........	1,215	19,424	76,010	3,068	145,255	20,854	67	4,875	6,340	3,445	3,890

(*n*) From the *Blue Book* of Western Australia, 1894.

MINERAL EXPORTS OF WESTERN AUSTRALIA. (*o*) (IN METRIC TONS; £1 = $5.)

Year.	Copper Ore.		Gold—Kilos.		Lead.	Lead Ore.		Pearls.	Tin Ore.	
1890............	*p*8	$680	709.36	$433,320	....	217	$10,675	$200,000	68	$27,025
1891............	*p*266	22,310	942.79	575,910	....	25	1,250	200,000	207	51,000
1892............	576	43,480	1,852.18	1,131,420	....	29	750	200,000	270	69.215
1893............	51	3,030	3,449.00	2,106,925	....	......	....	150,000	230	55,670

(o) From British blue books and *Western Australian Year-Book for 1892–93.* The exports represent the production, as practically all ores are exported. (*p*) Estimated.

The gold production in 1894 was 5251 kgms., or $3,489,345; in 1895 it increased to 5869 kgms., or $3,900,078. The gold mines have absorbed attention and little has been done in other lines.

AUSTRIA-HUNGARY.

THE mineral production of Austria is of a varied character and is also of considerable importance. Mineral fuel is the largest single item, the total production in 1894 having been 26,905,490 metric tons, of which, however, nearly two-thirds (17,332,538 tons) was brown coal, or lignite. A large quantity of this lignite is exported to adjoining provinces of Germany, Austria taking some coal in return.

The petroleum production, which is chiefly from the oil wells of Galicia, has grown rapidly in quantity and importance during the past two or three years. An account of the Galician oil fields will be found on another page.

The production of silver is considerable in amount. It is controlled by the government, which has since 1894 somewhat restricted the output.

The following tables show the mineral production of Austria for the five years ending with 1894:

MINERAL PRODUCTION OF AUSTRIA. (*a*) (IN METRIC TONS AND FLORINS.)

(1 florin = 48 cents.)

Year.	Alum and Alum Slate.		Antimony Ore.		Arsenic Ore.		Asphalt.		Bismuth Ore.		Coal.		Lignite.	
1890..	58,838	35,998	770	51,880	....	....	181	2,960	792	19,032	8,931,064	30,401,070	15,329,056	27,639,114
1891..	34,394	20,750	333	42,574	4	300	180	2,808	1,083	25,476	9,192,885	32,684,692	16,183,076	30,769,056
1892..	20,480	12,863	97	11,765	....	....	78	1,407	856	22,308	9,241,126	31,680,036	16,190,273	30,096,891
1893 .	13,370	10,862	441	50,708	....	....	88	1,301	797	21,818	9,732,651	33,549,863	16,815,955	34,048,957
1894..	10,854	13,495	696	68,632	2	100	116	1,907	570	15,194	9,572,952	33,182,691	17,332,538	32,290,005

Year.	Copper Ore.		Gold Ore.		Graphite.		Iron Ore.		Iron Pyrites.		Lead Ore.		Mang. Ore.	
1890..	7,503	343,422	1,547	18,168	23,728	726,036	1,361,548	3,105,764	3,717	66,596	11,237	969,622	8,007	102,624
1891..	9,316	354,574	440	14,440	21,346	693,326	1,231,244	2,854,888	2,831	48,522	13,361	1,068,512	5,279	70,742
1892..	8,636	329,824	164	14,886	20,978	637,012	993,290	2,325,088	1,210	25,292	13,265	922,260	4,558	54,830
1893..	8,576	316,232	477	43,787	23,807	637,870	1,109,111	2,482,191	1,221	25,199	10,696	849,869	5,411	58,556
1894..	7,235	278,849	86	9,907	24,121	881,980	1,214,763	2,676,114	....	....	12,060	836,744	5,055	55,417

Year.	Nickel and Cobalt Ore.		Petroleum.		Quicksilver Ore		Salt.		Silver Ore.		Sulphur Ore.		Tin Ore.	
1890..	0.4	318	122,500	490,000	70,730	891,616	304,084	23,044,927	14,494	3,167,178	5,422	64,624	569	5,168
1891..	.....	....	122,006	492,150	70,633	1,035,560	301,422	22,639,125	14,538	3,180,882	3,088	37,204	720	3,600
1892 .	0.3	....	120,000	482,000	79,447	1,007,829	288,424	20,796,030	14,171	2,672,606	1,804	20,987	33	2,900
1893..	.....	....	*b*122,000	488,000	76,215	735,493	305,586	20,440,426	18,018	3,415,704	1,950	20,485	26	2,741
1894..	0.55	....	....	....	84,127	988,754	....	....	18,338	3,000,171	2,435	34,484	24	2,465

Year.	Uranium Ore.		Wolfram Ore.		Zinc Ore.		METALLURGICAL PRODUCTION. (a) Alum.		Antimony.		Bismuth.		Copper.		Copperas.	
1890......	25	41,674	37	12,336	32,642	558,812	1,464	101,632	200	84,584	0.1	1,914	992	602,162	1,296	38,982
1891......	22	19,314	57	21,380	28,878	575,557	1,127	74,340	115	45,118	0.68	5,606	1,033	584,720	1,184	30,158
1892......	18	24,889	72	19,806	33,944	580,365	1,096	69.902	114	44,489	0.55	4,765	837	502,593	1,085	31,698
1893......	21	28,647	43	10.066	30,531	465.230	837	54,344	175	74,090	0.58	5,327	944	568,221	1,220	25,199
1894......	26	59,404	40	10,908	28,491	439,780	1,150	73,656	279	107,341	0.02	2,023	1,341	744,772	1,480	27,800

Year.	Copper Sulphate.		Gold. Kilos.		Iron, Pig.		Lead.		Litharge.		Nickel and Cobalt Products.		Mineral Paint.	
1890......	438	108,804	21	29,092	666,273	27,360,616	8,297	1,399,494	1,913	296,554	.....	......	778	22,136
1891......	198	42,286	14	19,272	617,145	24,881,094	7,583	1,206,104	2,267	253,058	1.5	450	838	25,350
1892......	133	24,587	13	17,580	630,790	24,417,266	7,252	1,125,493	2,520	393,356	0.15	196	2,022	57,429
1893......	177	35,275	35	52.506	663.345	24,186,083	7,212	1,103,840	2,411	352,648	0 12	163	3,020	75,329
1894......	140	28,832	61	96,779	742,372	26,750,603	7,570	1,113,088	2,057	301,514	0 1	156	3,002	76,379

Year.	Quicksilver.		Silver—Kilos.		Sulphur.		Sulphuric Acid.		Uranium Salt.		Tin.		Zinc.	
1890......	542	1,596,562	35,862	3,197,584	37	2,642	11,334	441,946	4	64,212	50	59,438	5,449	1,467,840
1891......	570	1,383,682	36,037	3,219,048	45	3,416	12,268	374,576	4	45,244	56	63,718	5,006	1,375,076
1892......	542	1,148,320	36,658	3,293,746	53	4.338	11,038	315,433	2	28,298	72	85,184	5,237	1,264,587
1893......	512	1,068,515	37.344	3,330,265	44	3,613	10.248	336,509	5	74,267	66	76,717	5,870	1,212,709
1894......	519	1,056,718	38,246	3,031,631	76	536	9,938	264,280	5	69,742	80	80,860	6,810	1,268,940

(a) From *Oesterreichische Zeitschrift für Berg- und Hüttenwesen.* Austria also produced in 1893 1129 metric tons sulphate of iron, valued at 29,934 florins. (b) Estimated.

HUNGARY.

Hungary is an old mining country, some of its deposits of silver, lead, and other ores having been worked at a very early date. Its fuel production is smaller than that of Austria, but is still of much importance. The gold production is considerable in amount, but varies very little from year to year, no new discoveries having been reported for a long time. It was 2687 kgms. in 1894, showing a gain over previous years, and in 1895 it was 2691 kgms. As in Austria, the silver mines are controlled by the government, and in recent years their output has been restricted on account of the low prices of the metal.

Hungary has deposits of iron ore of value, but is not a large maker of iron. The production is increasing, however. In recent years Hungary has been prosperous, and is gradually growing to depend less entirely upon her agricultural and pastoral resources.

The following tables show the mineral production of Hungary for the five years ending with 1894:

MINERAL PRODUCTION OF HUNGARY. (a) (IN METRIC TONS AND FLORINS.)

(1 florin = 48 cents.)

Year.	Antimony Ore. (b)		Asphaltum and Asphalt Oil.		Alum Ore.		Coal.		Lignite.		Briquettes.		Coke.	
1890..	224	40,590	......	....	525	772	994,812	4,831,308	2,249,098	6,835,016	25,184	198,877	......	....
1891..	.....	......	7,649	9,518	1,407	2.060	1,019,352	4,990,356	2.427,126	7,713,443	35,446	275,086	17,124	167,298
1892..	853	72,788	......	200,000	1,069	1,560	1,052,214	5,174,772	2,741,391	8,085,417	34,882	232,663	2,129	18,951
1893..	881	67,000	......	....	......	....	982,798	5,161,900	2.917,899	9,394,300	34,190	269,800	3,188	29,300
1894..	1,265	68,733	44,432	223,791	634	1,141	1,037,322	5,447,201	3,181,071	10,301,700	30,057	233,247	10,250	88,767

Year.	Galena.		Iron Pyrites.		Manganese Ore.		Mineral Wax.		Nickel and Cobalt Ore.		Petroleum.		Realgar.		Salt.	
1890..	207	35,266	56,746	294,446	1,445	6,955	1,200	48,000	57	23,270	990	26,407	....	......	159,912	13,943,165
1891..	....	......	57,715	250,349	128	2,357	1,656	94,767	.....	....	.....	....	....	......	162,788	13,862,083
1892..	....	......	56,050	236,097	1,304	8,340	......	......	340	29,240	20	690	0.2	......	163,514	14,119,613
1893..	213	40,500	68,189	277,900	......	......	......	......	202	18,700	14	690	1.0	......	157,209	14,605,000
1894..	....	......	74,619	320,970	......	......	......	......	25	8,106	.....	....	....	......	....	....

Year.	Zinc Blende (b)		Sulphuric Acid.		Antimony. Crude. (c)	Antimony. Regulus.	Copper.		Copper Sulphate.		Gold—Kilos.	
1890............	77	2,378	1,559	21,956	352	137,184	275	156,836	197.0	36,864	2,131.35	2,973,041
1891............	127	2,650	2,230	60,387	1,370	268,745	247	156,552	.....	....	2,183.92	3,046,440
1892............	116	2,825	3,340	54,983	343	138,003	317	165,215	5.0	1,871	2,246.77	3,134,437
1893............	77	1,050	2,337	36,700	361	144,700	343	174,400	2.0	300	2,000.00	2,790,200
1894............	......	......	4,018	57,046	....	....	271	135,367	1.4	350	2,687.07	4,497,627

Year.	Iron, Pig.		Iron Sulphate.		Lead.		Litharge.		Nickel & Cobalt Products.	
1890............	299,109	11,338,308	87	1,931	1,266	181,945	197	36,864	59	23,449
1891............	304,701	11,525,357	540	10,212	2,173	350,230	351	60,988	58	29,240
1892............	309,494	11,690,952	595	10,233	2,335	412,558	507	93,884	58	20,272
1893............	319,362	12,103,200	762	12,300	2,514	348,600	227	39,600	202	18,700
1894............	312,148	11,216,865	795	7,950	2,113	295,015	689	117,512	....	....

Year.	Mineral Paints.		Quicksilver—Kilos.		Silver—Kilos.		Sulphur.		Sulphuret of Carbon.	
1890............	237	6,487	8,102	20,253	17,049.8	1,597,907	63	887	266	30,561
1891............	221	8,820	8,631	19,385	16,736.6	1,506,294	40	3,392	174	31,329
1892............	263	10,508	7,853	15,641	18,423.8	1,658,143	42	3,773	116	20,208
1893............	321	8,600	2,500	4,800	23,631.0	2,120,000	70	5,900	249	44,800
1894............	608	13,853	1,837	4,699	20,155.0	1,217,186	93	7,809	248	44,568

(a) For 1890, from *Magyar Statistikai Evkonyv;* for 1891 and 1892, from *Ungarische Montan Industrie Zeitung;* for 1894, from *Oest. Zeitschrift für Berg- und Hüttenwesen.* The figures for 1893 furnished by the Hungarian Royal Statistical Office.

(b) This does not include the ore produced in Hungary from which the metallurgical products given in the table were derived. It gives only the amount of ore which was sold, and presumably was not smelted in the country.

(c) Pure sulphide of antimony prepared by smelting.

EXPORTS AND IMPORTS.

The exports and imports of Austria and Hungary are reported together by the joint customs administration for the two monarchies. The following tables show the foreign trade, both imports and exports, in mineral products for the five years ending with 1894:

MINERAL IMPORTS AND EXPORTS OF AUSTRIA-HUNGARY. (*a*) (IN METRIC TONS.)

IMPORTS.

Year.	Aluminum, Alloys, and Manufactures	Antimony Regulus.	Asbestos. Crude	Asbestos. M'f'd.	Asphalt. Raw.	Asphalt. Refined.	Barytes.	Borax.	Brass Manufactures.	Coal.	Coke.	Charcoal.	Lignite.	Chrome Ore.	Clays. Crude	Clays. M'f'd.
1891	42.8	0.4	101	37	1,082	2,022	3,585	1,535	2,269	3,670,196	248,193	1,150	15.174	10	24,115	97,539
1892	49.3	2.1	15	96	1,822	1,442	4,584	852	1,731	3,352,129	254,000	1,023	18,338	10	27.776	121,632
1893	41.2	......	97	99	2,144	1,012	4,413	1,451	......	3,840,874	309,861	853	20,111	570	25,149	....
1894	....	......	....	....	......	......	......	......	......	4,098,266	437,259	......	16,700	....	......	....

EXPORTS.

1891	6.3	276.4	15	27	51	35	192	27	1,138	713,069	73,453	20,238	900,255	157	28,447	47,974
1892	22.9	305.9	9	69	287	......	33	30	1,234	653,667	87,745	16,181	6,748,844	293	30,882	39,448
1893	28.1	......	47	187	223	22	35	68	......	642,424	108,576	14,838	6,763,186	327	31,307	......
1894	....	......	....	...	......	......	......	......	......	624,670	110,559	......	6,902,393	....	.....	......

IMPORTS.

Year.	Cobalt and Nickel Ore.	Copper.		Packfong and Manufactures.	Tomback & Manufac'es	Cryolite		Fluorspar.		Glass and Glassware.	Gold.			Graphite.		Gypsum, Crude.	Hydrochloric Acid.	Iron Manufactures.
		Mf'es	Ore			Crude	M'f'd.	Crude	M'f'd		Coin.	Metal	Ore	Crude	Refined.			
1891	249	9,951	909	349	1	79	52	3,900	444	4,147	23.6	20.7	0.5	691	181	1,657	499	47,623
1892	459	8,337	909	321	5	128	73	2,837	275	3,652	29.2	30.8	....	638	93	1,441	460	49,237
1893	971	11,822	638	292	41	131	99	2,782	228	3,599	46.9	62.1	....	782	......	862	438	......
1894	1,393	......	25	......	....	....	....	......	......	....	......	......	....	......	......	......	......	......

EXPORTS.

1891	233	590	10	488	24	10	2	35,524	15	42,788	5.3	65.5	0.3	6,490	4,887	855	1,540	36,502
1892	194	619	19	435	26	14	....	35,187	22	44,093	8.5	41.1	66.4	7,074	4,911	970	1,876	31,782
1893	305	683	14	448	4	2	1	159	63	45,087	9.4	45.5	73.2	7,253	4,284	838	1,841	......
1894	129	......	15	......	....	....	....	......	......	....	......	......	....	......	......	......	......	......

IMPORTS.

Year.	Iron.				Iron Pyrites.	Iron Sulphate	Kaolin.		Lead.			Lime.		Chloride of Lime.	Manganese Ore.	Marble.
	Ore.	Pig.	Rails.	Spiegel.			Crude.	M'f'd.	Lead, Alloys, M'f'es.	Litharge.	Ore.	Crude	Hydraulic.			
1891	68,121	40,743	705	104	30,770	745	2,827	1,221	4,561	250	283	7,536	16,744	867	425	1,494
1892	71,679	45,843	333	920	32,261	1,424	2,154	1,622	7,348	316	355	8,558	18,931	1,016	519	1,939
1893	73,248	57,733	927	697	45,530	800	2,273	1,874	6,286	316	299	9,115	17,098	1,559	354	1,816
1894	88,212	105,799	100	511	59,685	866	....	....	....	......	290	......	......	......	2,445	......

EXPORTS.

1891	88,059	8,394	253	294	8,539	747	5,811	34,881	255	1,007	3,658	19,924	58,750	311	8,364	3,041
1892	108,120	7,932	161	1,153	6,833	417	16,988	30,185	202	1,334	3,784	14,432	59,784	38	3,768	2,389
1893	106,259	9,274	20	371	3,042	476	23,624	26,192	270	1,311	1,608	28,019	66,543	216	3,697	2,638
1894	144,309	9,017	16	82	5,972	871	....	....	....	......	1,232	......	......	......	2,099	......

IMPORTS.

Year.	Oil, Mineral.		Paint, Mineral.		Nickel and Manuf'ct'es.	Peat.	Phosp. & Phos. Ac.	Platinum and Other Prec. Metals	Potassium.	Chloride of Potassium.	Nitrate of Potassium.	Quicksilver.	Salt.	Silver.			Slag.
	Crude	Ref or Partly Refined	Crude	Ref.										Coin.	Metal	Ore.	
1891	122,790	16,735	1,718	2,409	52	2,485	217	0.05	767	1,917	27,199	17	26,801	49	79	22.0	426
1892	135,823	14,479	1,295	2,165	46	2,935	200	2.1	164	1,945	28.071	2	27,836	60	88	0.5	3,621
1893	139,168	16,764	1,680	3,147	51	2,228	238	....	......	1,869	37,626	3	26,609	59	58	0.1	1,659

EXPORTS.

1891	443	2,188	1,138	1,605	83	2,712	1	0.7	5,157	315	44	488	4,861	31	120	10	84,484
1892	576	1,873	1,169	1,232	237	5,101	1	3.3	6,001	925	11	465	10,088	79	127	23	49,647
1893	613	3,767	922	1,409	79	5,441	6	1.2	......	1,118	15	414	7,678	87	131	14	45,478

IMPORTS.

Year.	Soda.			Glauber Salt.	Stone Quartz, etc.	Stoneware.	Stucco.	Sulphur.	Sulphuric Acid.	Tin and Manufactures.	Various Minerals.		Various Non-Prec. Metals and M'f'es.	Various Ores.	Zinc.	
	Calcin.	Caustic.	Crude & Crys.								Crude	Gr'd or Tre'd			Ore.	Spelt, Mf'es
1891	1,391	690	911	5,484	115,893	42,711	7,544	14,939	2,689	2,378	49,704	38,840	1,484	327	104	11,715
1892	807	1,316	197	5,389	117,773	55,477	7,925	13,900	1,909	2,406	46,506	40,266	1,417	432	3,481	14,724
1893	953	......	....	6,688	155,571	70,394	.....	13,090	2,090	2,921	50,722	455,478	....	401	3,739	15.529

EXPORTS.

1891	1,063	626	806	78	315,857	37,731	1,814	352	3,953	125	25,773	34,085	3,380	1,283	7,766	1,184
1892	1,048	202	271	77	260,946	36,943	1,766	474	2,855	144	21,598	35,405	3,400	905	12,578	1,442
1893	608	......	323	570	272,239	36,743	.....	1,508	3,906	150	118,665	33,642	....	619	7,578	1,939

(a) From *Statistische Uebersichten betreffend den auswärtigen Handel des oesterreichisch-ungarischen Zollgebiets*, Wien.

BOSNIA.

The mineral industry of Bosnia, which is of considerable importance, had fallen into a very low condition previous to the Austrian occupation of the country in 1878. Since then it has received a somewhat larger development. The production for five years is shown in the following table:

MINERAL PRODUCTION OF BOSNIA. (a) (IN METRIC TONS AND FLORINS.)

Year.	Chrome Ore.		Lead-Silver Ore.		Lignite.		Manganese Ore.		Salt.		Zinc Ore.		Antimony, Crude.		Copper.		Pig Iron.		Quicksilver.	
1890..	1,000	10,800	92	800	59,906	49,080	5,500	36,801	5,000	140,000	61	248	36	5,480	134	28,400	230	3,640	5.3	6,360
1891..	918	10,030	109	2,280	77,266	66,160	8,847	58,000	5,970	167,660	47	188	27	2,720	160	32,000	987	11,200	5.2	5,560
1892..	1,296	14,411	41	1,680	85,449	76,049	7,944	51,203	8,006	224,000	16	64	91	6,240	140	26,602	3,173	41,360	0.3	281
1893..	965	19,996	...	....	118,263	113,434	7,403	44,265	8,517	238,476	..	...	3	198	101	19,796	2,816	36,613	0.2	600
1894..	1,808	30,890	...	....	160,800	414,100	6,588	104,085	10,250	779,000	..	...	..	.....	270	135,197	3,287	107,477	...	.....

(a) These figures were kindly furnished by C. von Ernst, of Vienna. There has also been produced: Antimony ore, in 1891, 108 tons; 1892, 276 tons; quicksilver ore, in 1891, 88 tons; 1892, 3.5 tons. Also from *Montau Zeitung für Oesterreich Ungarn*. Produced in 1893: Quicksilver ore, 0.886; copper ore, 2365; iron ore, 6874; antimony ore, 0.089; fahl ore, 0.318; iron pyrites, 0.700; coal, 122,396; iron (pig), 45.16; and salt, 85.51 tons.

At present the more important items are chrome ore, manganese ore, copper, and salt. The iron industry is small as yet, but there are opportunities for much larger growth, and the Austrian authorities are taking steps to encourage the development of the mining industries.

BELGIUM.

No other country of the size of Belgium has so large a mineral production and so active an industry. The deposits of coal and iron which are found in its territory have been very thoroughly exploited, as have also the zinc and lead ores, and the metallurgical establishments use large quantities of imported ores, as well as the native products. As might be expected in a country where the mineral industry is of so much importance, the statistics are unusually complete and the system of mine inspection is a very thorough one.

The following tables show the production of ores or minerals, the metallurgical production, and the output of coal for the five years ending with 1894:

MINERAL PRODUCTION OF BELGIUM. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Blende.		Calamine.		Iron Ore.		Iron Pyrites		Lead Ore.		Total Zinc Ore.		Totals.
1890	10,370	$174,400	5,040	$65,600	186,546	$251,800	2,980	$5,600	150	$3,200	15,410	$240,000	$500,600
1891	10,200	163,280	4,080	47,410	*b*202,204	234,540	1,990	3,820	70	1,620	14,280	210,690	501,540
1892	8,250	126,880	4,010	49,440	*b*209,943	218,620	2,570	5,480	60	1,640	12,260	176,320	463,720
1893	7,300	83,720	4,010	43,440	284,465	295,580	6,301	9,800	67	1,520	11,310	127,160	561,220
1894	7,570	76,000	4,015	39,700	311,222	316,440	3,050	5,980	160	3,380	11,585	115,700	557,200

COAL PRODUCTION OF BELGIUM.

Year.	Metric Tons.	Value.	Per Ton.	Profit per Ton.	Number of Workmen.	Annual Wages.
1890	20,365,960	$53,700,600	$2.64	$0.58	116,779	$223
1891	19,675,664	49,490,800	2.52	.36	118,983	217
1892	19,583,173	40,257,600	2.06	.12	118,578	191
1893	19,410,519	36,281,180	1.87	.07	116,861	177
1894	20,534,501	38,258,420	1.86	....	117,103	188

METALLURGICAL PRODUCTION OF BELGIUM. (*a*) (IN METRIC TONS AND PRICE PER TON.)

Year.	Forge Pig.		Foundry Pig		Manganiferous Pig.		Bessemer Pig		Thomas Pig		Castings.		Total Pig.	
1890	526,644	$11.64	69,183	$13.51	1,786	$17.03	164,943	$15.60	24,210	$13.18	1,070	$25.42	787,836	$12.71
1891	445,436	10.18	56,241	11.78	......	......	147,913	14.01	34,536	11.40	....	....	684,126	11.20
1892	442,009	9.15	67,236	9.62	......	......	190,599	13.09	53,424	10.39	....	....	753,268	10.28
1893	428,480	9.00	74,630	9.54	......	......	165,077	11.59	77,077	9.47	....	....	754,264	9.66
1894	408,086	9.00	80,110	.....			322,744				....	....	810,940	....

Year.	Wrought Iron.		Cast Steel.		Rolled Steel.		Lead.		Silver—Kilos.		Zinc.	
1890	514,311	$32.27	245,566	$22.97	201,817	$30.99	9,617	$65.28	33,083	$35.10	82,710	$111.76
1891	497,380	29.20	243,913	19.63	206,305	28.22	12,698	61.35	33,950	32.76	85,999	112.26
1892	479,008	27.09	260,037	17.90	208,281	26.50	10,146	53.03	30,267	28.94	91,546	101.74
1893	485,021	25.51	273,113	16.79	224,922	25.67	12,006	51.23	26,717	25.79	95,565	82.79
1894	453,391	....	396,914	....	344,776	....	14,120	49.90	28,961	20.91	97,041	74.58

(a) From *Statistiques des Mines, Minières, Carrières, et Usines Métallurgiques.* Figures for 1894 estimated by Mr. Emil Harzé.
(b) Does not include ferro-manganese, which amounted to 18,498 tons and 16,775 tons ($50,092 and $41,660) respectively in 1891 and 1892.

Information received in advance of the publication of the complete statistics gives the production of coal from the Belgium mines for 1895 at 20,414,849 tons. A considerable part of this coal is exported, chiefly to France, but on the other hand some coal is imported from Germany.

The production of pig iron from the Belgian blast furnaces in 1895 is also given as follows: Foundry iron, 85,450 tons; forge iron, 329,651 tons; Bessemer and Thomas pig, 414,034 tons; total, 829,135 tons. In addition to this supply some pig iron is imported, most of which comes from the Luxemburg furnaces.

The production of wrought iron in bars, plates, and other forms in 1895 reached a total of 453,380 tons. The total quantity of steel ingots produced was 455,550 tons, while the quantity of steel turned out in finished forms—rails, plates, bars, etc.—was 392,332 tons.

Belgium is a large exporter of iron and steel products, and its works not only compete for contracts all over Europe, but have secured a large trade with India and other Eastern countries. The establishment best known abroad is the John Cockerill Company, which has extensive works at Seraing and shipyards at Hoboken; but there are several other large concerns.

Outside of the iron trade the most important metallurgical concern is the Vieille Montagne Zinc Company, whose extensive works use a large part of the native ores produced and also import large quantities from abroad.

The following table shows the quarry production for five years:

QUARRY PRODUCTION IN BELGIUM. (c) (VALUES IN DOLLARS; 5 fr. = $1.)

Year.	Building Stones.		Chalk, Marl.		Dolomite.		Flagstones.		Limestone for Flux.	
	Cubic Meters.	Value.	Cubic Meters.	Value.	Tons.	Value.	Square Meters.	Value.	Cubic Meters.	Value.
1890	1,874,340	$3,798,200	114,400	$48,800	2,650	$1,200	129,848	$82,600	140,720	$48,600
1891	1,737,951	3,502,800	38,075	28,600	1,500	600	123,875	76,200	197,365	61,600
1892	2,502,692	3,980,800	32,610	26,600	3,100	1,800	105,793	67,400	140,800	55,800
1893	2,645,622	4,285,000	46,295	28,400	3,500	1,400	90,780	52,800	166,425	70,200
1894	2,721,399	4,345,250	33,700	24,248	77,000	43,383	96,109	50,945	77,900	43,383

Year.	Marble.		Paving Stones.		Phosphate of Lime.		Plastic Clay.		Quartz Gravel.	
	Cubic Meters.	Value.	Pieces.	Value.	Tons.	Value.	Tons.	Value.	Cubic Meters.	Value.
1890	12,122	$427,400	72,913,700	$1,421,800	301,210	$1,093,800	215,592	$343,600	632,430	$259,600
1891	11,350	441,800	86,158,700	1,517,200	291,080	1,006,000	222,760	279,200	465,380	228,000
1892	11,750	455,400	88,048,700	1,497,800	268,210	756,000	276,855	341,800	18,100	10,400
1893	13,147	506,800	96,041,650	1,714,000	331,230	881,000	192,262	287,200	7,280	3,800
1894	11,849	383,760	84,309,000	1,390,481	371,776	848,085	172,010	241,160	6,640	3,067

Year.	Sand.		Silica for Pottery		Slate.			Sulphate of Baryta.		Whetstones.	
	Cubic Meters.	Value.	Cubic Meters.	Value.	Pieces.	Cubic Meters	Value.	Tons.	Value.	Pieces.	Value.
1890........	316,419	$107,600	25,900	$45,800	30,951,500	140	$166,200	9,800	$10,800	....	....
1891........	328,731	126,000	34,300	65,400	31,569,000	220	189,400	20,000	16,000	*e*130,000	$24,400
1892........	383,545	163,600	*d*38,370	48,800	33,903,000	415	224,400	42,000	56,800	*e*153,000	38,000
1893........	389,970	130,800	32,850	40,400	32,508,500	615	212,800	41,500	58,200	100,000	9,200
1894........	374,705	136,611	28,620	34,400	32,011,000	475	210,512	40,000	60,000	87,000	7,099

(*c*) From *Statistiques des Mines, Minières, Carrières, et Usines Métallurgiques.* Belgium also produced, in 1893, 880 tons of ochery earth, worth $1400, and 1800 tons of feldspar, worth $3200.
(*d*) Excluding kaolin produced in 1892, 750 cu. meters, $1600.
(*e*) Excluding grindstones produced in 1891, 90 cu. meters, $400; in 1892, 17,100 cu. meters, $3400.

Among the more important of these products classed as quarry products—that is, minerals taken from open workings and not from subterranean mines—is the phosphate of lime, which is produced in large quantity. The production is increasing, which is contrary to the experience of France and other European nations, where the cheaper phosphates of America and Africa have largely replaced the native mineral.

The imports of minerals are chiefly of fuel and raw materials for manufacture. The coal and coke are chiefly from adjoining districts of Germany; the iron ore is from Luxemburg, with a small quantity from France.

The following tables show the mineral imports and exports of Belgium for a period of six years:

MINERAL IMPORTS OF BELGIUM. (*a*) (IN METRIC TONS.)

Year.	Coal.		Briquettes.		Coke.		Lime.		Iron Ores, Iron and Steel Filings.		Sulphur.		Various.
1889....	1,004,624	$2,893,370	1,345	$4,008	18,545	$74,922	35,313	$77,600	1,805,250	$4,332,800	51,771	$2,070,800	$7,649,200
1890....	1,719,534	6,018,369	1,704	6,986	65,339	341,854	36,311	79,800	1,164,548	3,947,600	42,309	1,692,400	9,563,200
1891....	1,621,065	5,608,885	3,686	15,112	140,576	598,854	25,378	55,800	1,534,609	3,071,400	33,020	1,320,800	10,282,400
1892....	1,486,212	4,607,257	5,542	17,734	191,054	668,689	25,884	57,000	1,679,485	3,191,200	24,973	899,000	9,979,800
1893....	1,288,640	3,865,920	5,545	17,467	287,560	983,455	29,460	58,920	1,684,679	3,200,997	17,838	642,156	8,480,880
1894....	1,377,099	....	4,317	......	326,188	....	......	....	....	....	......	....	....

Year.	Various Other Metals.	Stone.		Chemical Products.	Glass and Glassware. (*b*)	Salt, Coarse.		Salt, Refined.	
1889........	$1,800,400	....	....	$15,093,200	$332,600	78,117	$468,400	32,320	$323,200
1890........	1,498,000	54,433	$762,000	11,928,200	409,800	64,031	384,200	39,100	391,000
1891........	2,159,800	59,042	826,600	13,780,400	409,800	79,422	476,600	39,586	395,800
1892........	2,002,600	76,491	1,242,600	14,845,800	416,000	86,330	518,000	34,162	341,600
1893........	1,622,947	49,648	747,918	16,520,549	487,560	84,524	507,145	39,561	395,612

IMPORTS OF METALLURGICAL PRODUCTS INTO BELGIUM. (IN METRIC TONS.)

Year.	Steel.		Copper and Nickel.		Iron, Pig and Scrap.		Iron, Wrought.		Gold, Silver, and Platinum Jewelry.	Lead.		Zinc.	
1889..	12,376	$738,800	7,550	$2,635,600	263,357	$3,027,000	24,070	$967,200	$662,800	30,312	$2,425,000	5,113	$429,400
1890..	13,517	665,600	7,386	2,580,800	264,275	3,435,600	23,136	985,200	755,200	35,985	2,878,800	5,242	440,400
1891..	13,174	599,000	8,269	2,199,800	205,482	2,401,000	25,286	987,200	678,200	34,093	2,044,600	6,972	794,800
1892..	18,647	838,000	8,222	2,056,400	174,177	1,970,600	24,321	885,200	764,200	31,054	1,614,800	5,936	617,400
1893..	29,818	1,190,643	8,025	1,968,962	186,198	2,107,443	30,817	1,169,399	874,566	38,028	1,901,420	5,833	501,632

(*a*) From *Annuaire Statistiques de la Belgique.* The figures for 1893 furnished by Mr. E. Harzé, *Ingénieur Principal au Ministére de l'Intérieur.*
(*b*) The quantities of crushed glass imported were 820 tons in 1890, 841 tons in 1891, and 1178 tons in 1892.

MINERAL EXPORTS OF BELGIUM. (IN METRIC TONS.)

Year.	Coal.		Briquettes.		Coke.		Lime.		Iron Ores. Iron and Steel Filings.		Sulphur.		Various Other Articles
1889	4,219,700	$12,325,536	317,164	$945,129	1,219,958	$4,928.634	328,024	$721,600	157,908	$270,600	4,528	$181,200	3,563,200
1890	4,533,785	15,868.247	317,628	1,302,275	1,064,759	5,570,819	357,474	786,400	174,231	295,200	4,232	169,200	2,288,800
1891	4,750,232	16,435,803	358,691	1,470,633	933,668	3,977,426	373,671	822,000	194,933	370,200	4,071	164,800	5,958,600
1892	4,539,485	14,072,403	351,570	1,125,024	991,018	3,468,598	385,399	847,800	228,804	454,000	3,868	139,200	5,446,600
1893	4,849,887	14,549,661	489,225	1,541,059	941,663	3,220,487	404,039	808,078	172,967	339,902	4,609	165,918	6,125,735

Year.	Steel.		Copper and Nickel.		Iron, Pig and Scrap.		Iron, Wrought.		Gold, Silver, and Platinum Jewelry.	Zinc.	
1889.........	118,217	$6,288,400	3,751	$1,390.800	22,573	$288.800	412,453	$14,707,400	$30,200	67,489	$6,344,000
1890.........	109,604	5,811,200	4,671	1,692,800	23,165	301,200	356,109	13,585,000	21,600	67,026	6,300,400
1891.........	87,431	4,524,800	4,674	1,318,200	23,963	317,600	359,740	12,182,200	17,000	68,026	7,755.000
1892.........	98,867	5,189,000	4,659	1,186,800	27,748	355,000	337,999	10,752,000	29,600	76,823	7,989,600
1893.........	114.530	7,633,447	5,480	1,447,589	28,017	464,702	318,197	9,276,604	......	76,296	6,614,164

Year.	Lead.		Various Metals.	Stone.		Chemical Products.	Glass and Glassware.	Salt, Coarse.		Salt, Refined.	
1889....	20,070	$1,605,600	$584,200	829,615	$11,614,600	$7,039,600	$9,268,000	248	$5,400	216	$2,200
1890....	27,370	2,189,600	493,200	911,258	4,556,200	7,035,800	9,026,800	341	2,000	106	1,000
1891....	24,073	1,414,400	521,800	872,937	4,364,600	7,011,200	9,054,800	1,216	7,200	152	1,600
1892....	24,709	1,284,800	622,200	927,767	5,504,000	8,019,800	8,887,600	1,118	6,800	228	2,200
1893....	29,947	1,497,358	544,178	1,112,273	5,419,974	8,683,269	9,902,816	556	3,339	148	1,484

The part taken by the iron industry in the exports is shown by the figures. The extent and value of the chemical industry are shown by the value of the exports of that class. Outside of coal and coke, the articles sent abroad are generally in finished form, including machinery and similar manufactured products.

CANADA.

THE mineral production of Canada in 1895 reached a total value of $21,412,-703, of which $6,370,146 was furnished by the metallic products, $10,736,729 by the non-metallic, and $4,305,828 by the quarry and clay products. The largest single item was of coal, the estimated value of which was $7,774,178, or 36% of the total. This shows a decrease of $673,159 in value, as compared with 1894, and of 309,857 tons in quantity. The production of gold and silver showed a very remarkable increase in 1895.

The following tables show the production of Canada for the five years ending with 1895:

MINERAL PRODUCTION OF THE DOMINION OF CANADA. (*a*) (IN METRIC TONS.)

Year.	Antimony Ore.		Arsenic.		Asbestos.		Baryta.		Bricks. Thousands. (*b*)		Building Material. Stone—Cu. Yds. (*b*)		Building Material. Flagstones. Sq. Ft.	
1891....	9	$60	18.0	$1,000	8,167	$999,878	......	......	176,533	$1,061,536	187,685	$708,736	*d*24,766	$2,721
1892....	....	....	....	......	5,518	390,462	286	$1,260	202,147	1,251,934	219,747	609,827	13,700	1,869
1893....	....	....	....	......	5,743	310,156	......	......	290,000	1,800,000	*c*219,747	609,827	40,500	3,487
1894....	....	....	6.4	420	6,935	420,825	......	......	....	*c*1,800,000	....	1,100,000	152,700	5,298
1895....	....	....	....	......	7,943	368,175	8	168	....	1,800,000	....	1,200,000	80,005	6,867

Year.	Building Material—*Continued.* Granite.		Building Material—*Continued.* Marble.		Cement. Barrels.		Fireclay.		Pottery	Tiles and Sewer Pipes. (*b*)	Coal.		Coke.	
1891....	9,977	$70,056	217	$1,752	93,473	$108,561	227	$750	$258,844	$368,699	3,085,734	$8,144,247	51,800	$175,592
1892....	22,047	89,326	308	3,600	117,408	147,663	....	9,567	265,811	558.517	2,986,999	7,184,510	*f*50,926	160,249
1893....	20,431	94,393	535	5,100	158,597	194,015	490	700	213,186	550,000	3,481,383	8,423,759	*f*55,409	161,790
1894....	14,901	109,936	....	....	107,327	140,659	229	515	113,874	450,325	3,495,599	8,447,329	52,404	147,861
1895....	1,741	90,199	181	2,000	134,644	181,162	1,206	3,492	125,600	457,045	3,186,542	7,774,178	48,404	143,047

Year.	Copper, Fine. (*g*)		Feldspar and Quartz.		Glass and Glass-ware.	Gold—Kilos. (*i*)		Graphite.		Grindstones.		Gypsum (Exports).	
1891....	4,324	$1,160,760	622	3,425	....	1,595	$930,614	236	$1,560	4,064	$42,587	184,705	$206,251
1892....	3,215	826,849	159	525	....	1,566	907.601	151	3,763	4,793	51,187	218,679	241,127
1893....	3,679	875.865	*h*612	5,025	....	1,692	976,603	20	....	4,173	38,379	195,668	196,150
1894....	3,847	805,760	......	......	....	1,436	954,451	350	....	3,408	32,717	203,300	202,031
1895....	3,987	949,229	......	......	....	2,876	1,910,921	199	6,150	3,555	31,532	205,188	202,608

Year.	Iron Ore.		Chrome Iron Ore.		Pyrites.		Iron, Pig. (j)		Iron Manufactures.	Lead (in Ore).	
1891....	62,594	$142,005	....	....	59,312	$203,193	21,674	$368,901	$21,680	267	$25,607
1892....	93,667	263,866	....	....	54,223	179,310	38,504	637,421	....	k802	72,505
1893...	j113,128	298,018	....	....	53,108	175,626	50,754	790,283	....	k968	78,996
1894....	j99,782	226,611	2,009	$36,946	36,765	121,581	45,327	646,447	....	k2,628	158,262
1895....	93,157	238,070	2,728	41,301	31,024	102,594	....	....	....	10,467	749,966

Year.	Lime—Bushels. (b)		Limestone for Flux.		Manganese Ore.		Mica—Kilos.		Nickel—Kilos.		Mineral Paint. (n)	
1891....	1,829,894	$251,215	10,323	$11,547	213	$6,694	....	$71,510	2,103,012	$2,775,976	816	$17,750
1892....	2,260,640	411,270	20,836	21,492	104	10,250	....	l104,745	m1,094,837	1,399,956	354	5,800
1893....	6,750,000	900,000	25,217	27,519	193	14,578	....	l69,622	m1,806,669	2,071,151	971	17,710
1894....	....	c900,000	31,843	34,347	67	4,180	....	l50,000	2,225,976	2,061,120	1,048	11,120
1895....	....	900,000	31,370	32,906	113	8,464	....	65,000	1,763,836	1,360,984	.....	....

Year.	Crude Petroleum. Barrels. (o)		Phosphate.		Platinum.	Precious Stones.	Roofing Cement.		Sand and Gravel (Exports).		Molding Sand.	
1891....	755,298	$1,004,546	21,405	$241,603	$10,000	$1,000	817	$4,810	221,165	$59,501	209	$1,000
1892....	779,753	982,489	10,825	157,424	3,500	1,000	726	12,000	270,235	85,329	313	1,380
1893....	798,406	834,334	7,437	70,942	1,800	1,500	863	5,441	298,569	121,795	c4,291	9,460
1894....	829,104	835,322	6,613	43,940	1,000	1,500	513	1,978	294,523	86,940	c2,789	6,148
1895....	802,573	1,201,184	1,653	9,565	....	1,650	......	3,153	251,441	118,359	6,137	13,530

Year.	Salt.		Silver—Kilos. (p)		Slate.		Soapstone.		Terra Cotta.	Various Products.	Whiting.	
1891....	40,854	$161,179	9,713	$406,233	....	....	522	$863	$113,103	$694,441	.....	....
1892....	41,267	162,041	9,661	269,489	4,699	$69,070	......	....	97,239	r752,610	.....	....
1893....	56,539	195,926	13,000	321,423	6,452	90,825	640	1,920	q55,704	382,144	.....	....
1894....	51,890	170,687	20,202	409,239	....	75,550	831	1,640	q65,600	345,372	500	$750
1895....	54,449	180,417	49,630	1,158,633	....	58,900	431	2,138	195,123	254,657	.....	....

(a) From reports compiled by the Geological Survey of Canada, kindly furnished by Mr. Elfric Drew Ingall.
(b) Incomplete. (c) Estimated. (d) Metric tons.
(e) Contains in 1893, 16,000 M., value $191,000; sewer pipe, value $194,462; in 1894, tiles, value $200,000; sewer pipe, $250,325; tiles estimated in 1893 and 1894.
(f) The entire production of Nova Scotia.
(g) Copper contents of ore, matte, etc., values per lb.: 1891, 13c.; 1892, 11⅝c.; 1893, 10⅛c.; 1894, 9½c.
(h) Includes quartz, 91 metric tons, value $500.
(i) Nova Scotia and Ontario gold is computed at $19.50 per oz., except 1891 Ontario gold at $20. British Columbia gold and that of the Northwestern Territories, including the Yukon district, at $17; Quebec gold at $18, except in 1891 at $20 per oz. For 1894 and 1895 the quantity given is in fine metal.
(j) Native iron ore converted into pig iron in 1891, 55,278 metric tons, value $130,955; in 1892, 87,950 metric tons, value $250,966; in 1893, 112,539 metric tons; in 1894, 98,766 metric tons.
(k) Lead contents of ores in 1891 at 4.35c. per lb., in 1892 at 4.1c. per lb., in 1893 at 3.7c. per lb., and in 1894 at 3¼c. per lb.
(l) Exports, plus quantity sold to Canadian electrical and stove manufacturers.
(m) In 1892, exports of fine nickel in matte, ore, etc., valued at 58c. per lb. (In matte at Sudbury the values of the metals would be nearer 6c. for copper and 18¾c. for nickel.) Total value at Sudbury of the matte shipped during 1892, $450,560. In 1893 at 52c. and in 1894 at 42c. per lb., which represent the final market value of the nickel. In matte its value at the mine would be about 13c.
(n) Comprises ocher; in 1891 and 1892, ocher alone.
(o) Calculated from the inspection returns at 100 gals. crude to 38 gals. refined oil. The value of the crude was in 1891, $1.33 per bbl. of 35 imperial gals.; in 1892, $1.26; in 1893, $1.04½; in 1894, $1.00¾ per bbl. 1 barrel refined = 42 imperial gallons.
(p) Silver contents of ore; values for production and exports: 1891, $0.98; 1892, $0.86⅝; 1893, $0.76 7/16; 1894, $0.63.
(q) In 1893 includes porous fireproof terra cotta; in 1894 includes porous fireproof terra cotta and other structural and ornamental forms.
(r) 1892 not including natural gas, value $150,000; 1893 includes 50,335 metric tons, value $470 (zinc contents of ore at 4c. per lb.); natural gas, $376,233; and 863 tons roofing cement, worth $5441, and 512 tons roofing cement, valued at $1978; 1894 includes 163 metric tons lithographic stone, value $30,000; also natural gas, value $313,754, being the gross amount received through sale.

The precious metals are obtained in Nova Scotia, at the extreme east of the Dominion, in Western Ontario, and in British Columbia, the far-western province. The Nova Scotia and Ontario production does not increase, or increases very slowly; but British Columbia is now passing through a period of rapid development. Much attention has been attracted to the mines, and a large amount of capital will probably be invested there during the next year or two. These mines have been largely owned and worked by Americans, who were the pioneer prospectors of the country. The lead production is chiefly obtained from the silver mines of this province.

The iron industry does not grow rapidly. Nearly all the iron ore now mined is in Nova Scotia, where also most of the pig iron is made. The bog iron ores of Quebec have been worked only to a limited extent, and no progress has been made in treating the great deposits of titaniferous iron ores of that province. Some work is done in the iron mines of Northern Ontario, but very little compared with their extent.

The nickel mines of the Sudbury district, in Ontario, continue to be actively worked, and now furnish all the world's supply of that metal, except the comparatively small quantity which comes from New Caledonia. All of the nickel from the Sudbury mines is exported in the form of ores or matte to be refined in the United States or Europe—principally in the former.

Of the non-metallic products the asbestos from the Quebec mines, which is mainly exported to the United States, is of considerable importance. It has no competitor except the Italian mineral. The phosphate production has declined very much, and the Quebec apatite no longer competes with the South Carolina or Florida phosphates.

The coal is produced chiefly in Nova Scotia and British Columbia, the coal fields of the Northwestern Territory being very little worked as yet. The Nova Scotia coal finds its market in the maritime provinces and along the St. Lawrence River mostly, but little of it going beyond the limit of easy water transportation in the Dominion. A small quantity goes to New England and some also to the West Indies, but the exports are not important.

The greater part of the British Columbia coal, on the other hand, is exported. The report of the Minister of Mines of that province for 1895 states that out of a total of 939,654 tons mined 756,334 tons were exported. Nearly all of this went to California, though some cargoes were also shipped to the Hawaiian Islands and Mexico.

The same report gives the production of coal from the time it first became of commercial importance up to the present time as follows:

COAL PRODUCTION OF BRITISH COLUMBIA.

Year.	Tons.	Year.	Tons.	Year.	Tons.	Year.	Tons.	Year.	Tons.	Year.	Tons.
1874....	81,000	1878.....	171,000	1882.....	282,000	1886.....	326,636	1890....	678,140	1894...	1,012,953
1875....	110,000	1879.....	241,000	1883.....	213,000	1887.....	413,360	1891....	1,029,097	1895 ..	939,654
1876....	139,000	1880.....	268,000	1884.....	239,070	1888.....	489,300	1892....	826,335		
1877....	154,000	1881.....	228,000	1885.....	365,000	1889.....	579,830	1893....	978,294		

In the three years 1888–91, inclusive, there was a remarkable development, but since 1891 the production has fluctuated without increasing. The development of the gold and silver mines will probably enlarge the home demand.

CHINA.

BUT little is actually known of the mineral industry of this extensive country. The only positive information to be had is found in the customs returns of imports and exports, which are given below for a period of five years. China is known to produce coal, iron, lead, silver, and some gold, but very few mines are worked, largely because of the superstitions of the people. A beginning has been made at coal mining, and this will probably be extended as the demand increases; and railroad construction is to be undertaken soon according to the latest accounts, having been forced on the government by the results of the late war with Japan.

MINERAL IMPORTS OF CHINA. (*a*) (IN METRIC TONS.)

Year.	Coal.	Copper, Sheet.	Copper, Old.	Gypsum.	Iron, Bar, Hoop.	Iron, Nail-Rod.	Iron, Manufactured.	Iron, Pig.	Iron, Old.	Iron, Wire.
1889......	18,008	906	1,068	10,367	3,928	13,524	3,695	240	11,860	502
1890......	6,165	574	970	11,000	4,147	16,080	4,180	588	17,979	1,022
1891......	6,267	750	926	7,658	5,041	18,120	5,290	408	22,656	1,110
1892......	15,373	822	834	9,326	4,431	17,316	4,400	316	19,660	1,308
1893......	11,430	610	540	9,858	3,855	15,270	3,867	396	16,316	1,325

Year.	Kerosene. 1000 Gals.	Lead, Pig.	Lead, White.	Lead, Yellow.	Quicksilver.	Salt.	Steel.	Tin.	Tin, Slabs.	Tin, Plates.	Yellow Metal.
1889..............	8,835	8,076	....	....	60	2,628	1,278	....	1,991	165	455
1890..............	15,384	7,719	8	7	58	3,729	1,189	....	2,366	154	537
1891..............	23,644	8,334	9	11	98	9,570	1,660	29	2,209	113	606
1892..............	23,286	8,604	13	12	154	8,976	1,557	73	2,100	187	602
1893..............	34,764	8,520	8	9	107	12,798	2,015	17	2,616	258	940

MINERAL EXPORTS OF CHINA. (*a*) (IN METRIC TONS.)

Year.	Alum, White.	Coal.	Copper, Cash. Strings.	Copper, Tribute.	Gypsum.	Ironware.	Steel.	Tin.
1889..........	3,426	61,235	16,194	....	8,200	2,100	....	60
1890..........	3,199	111,016	2,440	....	8,046	2,836	305	65
1891..........	4,005	105,440	26,800	927	6,894	2,841	240	126
1892..........	4,760	140,967	6,091	618	8,670	2,469	207	73
1893..........	5,511	131,773	464	618	8,956	2,812	164	16

IMPORTS AND EXPORTS OF GOLD AND SILVER OF CHINA. (*a*)
(1 half-tael = $1.)

IMPORTS.			EXPORTS.		
Year.	Gold.	Silver.	Year.	Gold.	Silver.
1893......	$5,142,814	$49,515,467	1893.....	$12,643,783	$37,612,051

(*a*) From statistical series, 1893, *Imperial Maritime Customs*, China

EXPORTS OF GOLD FROM KOREA.
(1 half-tael = $1.)

EXPORTS.			
Year.	Gold.	Year.	Gold.
1892.....	$852,751	1893.....	$918,659

The following tables show the imports and exports of two of the leading ports open to foreign trade:

MINERAL IMPORTS, EXPORTS, AND RE-EXPORTS OF AMOY. (*a*) (IN METRIC TONS.)

	IMPORTS.						EXPORTS.			RE-EXPORTS.	
Year.	Iron, Bar, Nail-Rod.	Iron, Old.	Kerosene. Gallons.	Lead, Pig.	Quicksilver.	Tin, Slabs.	Bricks and Tiles, Pieces.	Chinaware.	Iron, Pans, Ironware.	Lead, Pig.	Tin, Slabs.
1886....	108	614	148,592	172	19	426	665,114	1,396	600	290	162
1887....	133	565	199,180	310	17	403	4,105,510	1,664	724	231	252
1888....	91	474	156,360	156	18	616	4,335,807	1,506	740	183	206
1889....	126	600	324,300	288	17	485	3,615,517	1,252	562	130	313
1890....	55	395	906,900	174	22	393	5,434,172	906	448	168	270
1891....	78	546	1,181,920	174	21	395	3,131,719	1,120	499	118	240
1892....	55	512	1,895,030	266	18	462	2,855,712	1,243	529	180	174
1893....	54	778	1,533,290	200	13	435	4,357,208	1,070	639	150	156

(*a*) From special tables, statistical series, *Imperial Maritime Customs*, China.

MINERAL IMPORTS OF SHANGHAI. (*a*) (IN METRIC TONS.)

Year.	Coal. (*b*)	Copper	Iron.	Lead.		Kerosene. (*c*)	Quicksilver.	Steel.	Tin.		Yellow Metal and Nails.	Zinc in Sheets.
				Pig.	Sheets.				Slabs.	Plates.		
	Tons.	Tons.	Tons.	Tons.	Tons.	Cases.	Kilos.	Tons.	Tons.	Tons.	Tons.	Tons.
1889....	....	1,747	49,627	6,660	147	1,506,532	58,834	1,058	2,124	480	216	106
1890....	....	604	40,960	6,167	67	1,820,449	62,315	1,669	2,237	520	326	287
1891....	....	1,631	73,688	4,516	51	2,921,169	52,090	1,740	2,198	614	260	179
1892....	....	1,571	59,468	5,366	52	2,092,567	90,024	1,265	2,440	725	53	283
1893....	396,947	1,577	48,386	4,799	49	2,559,500	31,460	929	2,170	479	263	267
1894....	420,556	....	....	....	....	3,403,923	....	....	....	....	....	....

(*a*) From Alex. Bielfeld's reports, Shanghai. Tons converted from piculs (1 picul = 0.6 metric ton). (*b*) From Wheelock & Co.'s report, Shanghai. (*c*) 1 case holds 10 gallons.

The imports of coal were formerly from England and Australia, but Japanese coal has now largely displaced the Australian and to some extent also the English. Russian oil now forms a considerable part of the imports, in 1894 about one-third; the rest is furnished by the United States.

KOREA.

Even less is actually known of the mineral industry of Korea than of China itself. The country is known to produce some gold from alluvial washings and to abound in iron ores. The Koreans are skillful iron workers after a primitive fashion, and make iron of excellent quality in small furnaces and in forges. We have included the tables of imports and exports here, though the country has now ceased to be a dependency of China, and will, very probably, pass in time under Russian rule.

MINERAL IMPORTS OF KOREA. (*a*) (IN METRIC TONS.)

Year.	Brass Metal, etc.	Coal.	Copper, Pigs and Slabs.	Copper, Nails, Wire.	Copper Ore.	Iron, Nail-Rod.	Iron, Bar, Hoop.	Iron, Old.	Iron, Nails.	Kero-sene. Gallons.
1886......	....	....	46	3	....	20	6	91	10	70,932
1887......	....	147	137	13	....	75	41	117	11	160,824
1888......	5	48	344	5	....	18	60	276	25	204,075
1889......	198	646	1,177	16	....	3	46	213	30	398,430
1890......	54	401	346	18	....	72	176	387	65	415,325
1891......	55	1,291	1,148	37	....	9	221	296	42	540,390
1892......	115	1,373	653	18	198	31	192	260	92	724,563
1893......	199	791	1,064	13	215	62	284	451	90	936,000

Year.	Lead.	Metals, Manufac-tured.	Nickel.	Quick-silver.	Salt.	Spelter, Zinc.	Steel.	Tin, Slabs.	Tin Com-pounds.	Tin, Plates.	White Metal.
1886............	....	12	....	1.08	1,033	18	....	30	....	1	6
1887............	....	34	....	2.70	5,393	13	....	27	9	17	12
1888............	45	43	....	3.78	280	200	....	19	10	15	23
1889............	170	63	....	2.28	479	842	8	24	9	24	15
1890............	....	180	....	4.32	146	27	89	63	32	38	28
1891............	240	360	....	3.62	1,305	828	86	49	28	31	28
1892............	46	210	0.96	2.46	1,625	475	45	67	31	17	16
1893............	142	150	1.14	3.6	2,652	1,116	71	75	17	48	24

COLOMBIA.

LITTLE that is new can be reported of the mineral industry in Colombia during 1895. The condition of affairs remains very much as in previous years, and development is restricted by the difficulties of transportation and the impossibility of placing machinery where it is needed. The mountainous nature of the greater part of the country emphasizes the lack of railroads and of good roads of any kind; and until this is overcome there is little prospect of any important advance.

The production of gold in Colombia which was estimated at 4353 kilos in 1894 was very nearly the same in 1895, though no exact figures can be obtained. The silver output remained at about 52,500 kilos, showing, like the gold, no material change.

Colombia possesses an important advantage over nearly all other South American countries in the existence of coal fields, which the investigations so far made have shown to be extensive and, in many places, of excellent quality. There is little doubt that the coal beds near the Gulf of Uraba and at other points when developed and provided with transportation can supply the wants of the country itself and furnish a surplus for export. Chile is the only country which can approach Colombia in this respect, and it is believed that the Colombian coal fields exceed those of Chile in extent and in possibilities of development.

Petroleum is found near the Gulf of Uraba, and arrangements are being made to prospect the field.

The advantages of a cheap and abundant supply of fuel will be realized hereafter, when the mineral development of the country reaches a more advanced stage. At any rate, the growth of the industry will not be hampered nor delayed by the difficulty of obtaining fuel, as in Peru, where the high cost of imported coal and coke has been a serious drawback in mining and has almost prevented the extension of metallurgical operations.

Altogether the existence of four extensive coal fields has been determined. The only mining operations so far carried on have been near La Pradera, in the Department of Cundinamarca. The coal from this mine is largely used in the iron works also owned by La Pradera Company. A company has been organized to work coal mines near Uraba, and it is said that operations will be begun there in a short time.

Iron ores are found near Cali and in several other localities. The Cali ore beds are not far from coal of good quality, and will be accessible when the Canca Railway is completed.

The Mineral Resources of the Republic of Colombia.

By Robert B. White.

It is not my intention to write a statistical article, but rather to present practical information. The publications of Humboldt, Captain Cochrane, Chevalier, and Vicento Restrepo give reliable data (which are also found in The Mineral Industry, Vols. I., II., and III.) as to produce since the Spaniards conquered the country. Such data are only instructive when accompanied by explanations as to the extent and nature of the means employed to attain the results noted. We find that Colombia has produced since the Spanish Conquest about $700,000,000 in gold and some $40,000,000 in silver, but to appreciate the meaning of these figures we must remember that up to the first quarter of the present century no machinery was used in the treatment of minerals, and that only a few thousand slaves—perhaps not more than 10,000 all told—were engaged in the mines. These were all of alluvial gold with the exception of a few rich silver mines in which the ore was treated by the "Patio" process, a mulish business entirely.

Since 1830 gold-quartz lodes have been worked on a small scale, with antiquated machinery more or less similar to that used in Cornwall, England, for treating tin ore. It is only since 1870 that hydraulic methods have been employed in a few alluvial mines with good results. Taking these facts into account, we do not need much figuring to see that the mines must be rich. Had this country been favored by such a flood of labor, intelligence, and capital as was spread over California and the Western States, it would probably have outstripped them in productiveness.

Colombia has always suffered from one great drawback—the want of roads. The mining regions are generally mountainous, and transportation is both difficult and costly. Steamboats may now run up some of the rivers into a few of the alluvial districts, but generally speaking the country is no better off in means of communication than it was three centuries ago. Many ventures backed with plenty of capital have broken down because they did not take these circumstances into account. Where attempts have been made to work on too big a scale a break-down has always followed. A case in point is that of the English Frontino & Bolivia Company. This company had spent on its mines in Remedios, Department of Antioquia, previous to 1873 over $550,000 in capital and more than twice as much in produce laid out. The idea was to have a big steam engine, big stamp mills, and everything on a large scale, and the result was bankruptcy. The company was saved by its Colombian bankers, who gave me the direction of the concern in 1873, and by adopting a system of working adapted to the resources of the country the mines were made productive, all debts were paid off in 1875, regular dividends were paid from that time forward, and when I relinquished the superintendence in 1885 I handed over a steady-paying enterprise which has remained in that condition ever since. I could present a long list of such failures. The Purima Mine, near Abejonal, in Antioquia, was bought and worked by an English company about the year 1860. They spent all their capital, could not make the mine pay, and wound up. The mine was bought up by Colombians, and since that time three, if not four, big fortunes have been made out of it and it is still worked at a profit.

It seems to me that when people come to a country like this to look for mines they should not look at second-rate ventures which may be good enough in countries where good machinery and processes of extraction may be employed. What one must consider is, How much gold can be got out by the simple methods which can be put in practice here? If one goes into processes to get out the balance of the gold the result is failure. Some day, perhaps, the country will be opened up, and mines may then be worked which are now shelved as unprofitable.

I have made these introductory remarks so that it may be understood that when I speak of promising mines I do so with a fair appreciation of the difficulties of the country. I have been engaged here in mining for 25 years, and have not seen a single mine turn out badly where due consideration has been given to the circumstances. In many cases failure has been caused by ignorance. In one or two cases good alluvial mines have failed to pay when worked on hydraulic methods, and yet have paid well when worked by simple ground sluicing. The reason was that the stuff was not properly treated. More clean water, under-currents, and more sluicing are required to procure the settlement of the gold. In other cases practical miners, with an experience limited to California, for instance, have failed to see how different are the alluvials here. Worse blunders have been made in silver mining through trying to work on lines which the country will not admit. The success of the English Tolima Mining Company is due to the fact that it did not attempt to reduce its ore in the country. The selected ore and concentrates are sent to Swansea. Theoretically the company ought to do better, but it is quite right in accepting a possibly smaller but much surer profit.

Antioquia, Cauca, and Tolima are the departments where gold and silver are most abundantly found. At the present time the produce of Antioquia in gold is about $300,000 per month. Perhaps no section of country in the world presents so many and so varied formations of gold-bearing quartz. Reefs are met with of all ages and in all kinds of rocks. Granite, syenitic granite, diorite, and porphyry have their distinctive lodes and minerals. The Silurian rocks, the Jurassic, Cretaceous, and Tertiary beds have special reefs and ores characterizing them. One may match in Antioquia all the celebrated mining districts in the world. California, Utah, Nevada, Transylvania, Hungary, Mysore, Sandhurst, are all counterfeited. The great Zanando Mine represents the Freiberg district and the ore is treated by smelting as in Freiberg. This mine, which I had the honor of putting in good condition in 1871—up to which time it had not produced more than $30,000 profit in any year—has in later years distributed as much as $60,000 monthly to its shareholders. The Cristales Mine, in Remedios, with a working capital of $3700, paid its shareholders in six years $170,000 in dividends. Sucre, in the same district, was started with a capital of $1600 and returned in eight years $288,000 to its owners.

As a rule, all the well-constituted lodes are persistent in depth and many are richer at the lower levels. The old Frontino Mine, which has been worked since 1850, has a continuous run of ore over a length of 1800 ft. and the bottom levels are richer than the upper. Another mine, also in Antioquia, the Constancia, in

Anori, is richer in the deep workings than it was at surface. The reef is over 2 miles long and in places is 30 ft. thick, with good mill ore from wall to wall. The Clara Mine, in the Amalfi district, is located upon a reef which has been worked in various claims over a length of 3 to 4 miles, and over the whole of this distance it has the same bearing and dip to a degree—a very remarkable thing. This reef is the exact counterpart, in wall rock, quartz, and metalliferous contents, of the champion lode of the Sandhurst district in Australia. The yield in gold increases in depth.

All the quartz reefs in Antioquia are worked upon what I may call the Cornish tin system. The ore is stamped, very coarse; the gold is caught on blankets and worked out by hand. Californian stamps have been tried in one or two mines, but I am not aware that results have been obtained proportioned to the outlay which such machinery and the use of mercury involves in this country. Practically no progress has been made in mining in Antioquia for the last 50 years.

Most of the alluvial gold in Antioquia is obtained from modern placers and the beds of streams and rivers. In the north there are vast areas covered by post-Tertiary deposits of conglomerates, sands, gravels, and clays which are rich in gold. These deposits are too big for the people of the country to understand, and where they have been worked by ground sluicing only a casual pay streak or bed of gravel has been followed. One or two very badly directed attempts have been made to work these deposits by hydraulic methods, but no mine has been so far worked on a big scale. In places these alluvials are from 300 to 500 ft. in thickness, and I can safely say that they cover over 3000 sq. m. of country. The immense riches found in Sinci by the Spanish adventurer Heredia were no doubt obtained by the Indians from these alluvials. I may state my belief that diamonds will be found in the blue gravels of these deposits, which are in all respects similar to those of the Transvaal, only richer in gold.

In the Department of Cauca gold has been obtained principally from alluvial mines. Previous to the abolition of slavery in 1857 the mines were very productive, and most of the wealthy people in the country had derived their fortunes from mining. But with the freedom of the slaves came a complete suspension of all organized work, and it may be said that since that time no alluvial mines have been worked. Here as in Antioquia we have what I call primary and secondary alluvials. The first are mostly glacial drift formations, and gold is found both in the irregular deposits of bowlder clay, etc., as well as in the stratified gravels. These latter beds are of immense extent. They may be said to cover the whole Pacific coast line, like a fringe some 30 miles wide, over a length of more than 600 miles. Cement beds, conglomerates, clays, sands, and gravels occur in varying order and constitute deposits which are often from 300 to 500 ft. in thickness. The gravel is nearly all gold bearing, and in places the cement beds are very rich. I have crushed cement and panned out gold and platinum in the proportion of 1 oz. of each metal to the ton. The secondary alluvials are the modern gravels of the rivers, streams, and gulches, and from these most of the gold extracted has been obtained. Nearly every river and stream contains gold. Probably some of the river channels are very rich, but I am not aware that any have been prospected. In Antioquia this is a great branch of mining, and I have seen many cases in which old river channels have yielded gold at the rate of 8 ozs. to the sq. yd. In one instance an ancient channel on the Pacific Coast in the Cáuca produced 10,800 ozs. of gold from 200 sq. yds., but the channel was probably of the Glacial age.

I have mentioned "gulches." These are ancient water-ways, probably formed by the flood waters produced by the melting of the old glaciers. They are mostly dry, and both in the Cauca and Tolima have turned out very rich in gold. This is easily explained, since they are neither more nor less than natural sluices, in which millions of tons of glacial detritus have been washed and concentrated. Frequently they are full of bowlders, which makes them heavy to work, but are a pretty sure sign of richness.

In the interior, at the northeastern extremity of the department, there is a district covering some 800 or 1000 sq. m. in which all the ground is composed of glacial drift of one sort or another. One small mine has been worked with a monitor with good results, in a sort of bowlder clay. The gravels and cement beds have not been worked, but I have prospected them and found them rich. On the Pacific Coast the miners have two drawbacks. The first is the unhealthiness of the climate. This is, however, only temporary, for as soon as a clearing for a square mile or so is made the salubrity of the place is insured. The second defect is the scarcity of provisions. Plantains, maize, beans, and other products must be cultivated in order to obtain a wholesome and varied supply of food. This is also, therefore, a passing drawback, but both defects must be foreseen and provided against to avoid disappointment. If men are well lodged and fed they will stand the climate quite well.

In the matter of gold and silver bearing lodes little can be said about the Cauca. Such lodes exist from end to end of the territory, but so little work has been done on them that I can only refer to them as promising fields for prospectors. The Canton Supia belongs to the Cauca, and there one meets with one of the most remarkable networks of lodes to be found in the world. They are mostly owned by private individuals and companies, and the best of them have been worked for long periods. I do not consider the Supia mines to be exceptionally rich. There are perhaps a few mines—the Esperanza, for instance, near Supia—which have been badly worked or not appreciated by the owners and now offer some prospect of success if taken in hand by good miners. But there are exceptions.

In the Salento district, which I have already mentioned, good gold-bearing reefs may be discovered. In the Almaguer district, south of Popayan, the auriferous lodes may repay the prospector.

The mines of the Department of Tolima will come to the fore when better means of transportation are provided. The alluvial deposits of Tolima and its gold-bearing lodes are not rich, but they are reliable. Its silver-bearing lodes, with the exception of Frias, Cristo, and Bocareme, all near Honda, are not workable at the present price of silver.

From this brief sketch it will be seen that gold mining in Colombia may be profitable if one goes to work in the right way. Difficulties must not be underrated. The inconveniences of the country must be foreseen and provided against. Only rich mines can be made to pay, and rich mines undoubtedly exist. The mining laws of Colombia are more liberal than those of any country in the world. A clear title to a reef over an area 5300 ft. in length by 780 ft. in width costs about $150 in gold, and an alluvial claim of 6 sq. m. costs about the same. A yearly impost of $2, gold, is paid for a reef claim and $1.75 for an alluvial.

The ores of iron, zinc, antimony, arsenic, and copper cannot be worked to advantage in Colombia until means of transportation be provided. In the Atrato Valley there are copper lodes which might be valuable if a road were to be opened to the locality, which would not be a heavy undertaking.

Quicksilver is the only metal which might be profitably sought after. It is easy to extract and valuable enough to stand cost of carriage.

In Antioquia, near the town of Retiro, there is a good prospect of cinnabar in a mica slate rock. In 1871 I prospected this place for a company and had just struck a very promising lead of paying ore, when a disagreement between the partners put a stop to the work. Mines of quicksilver belong to the owners of the soil, and the proprietors of the land in Retiro had ceded their rights in perpetuity to the company, so that no one has ever renewed the explorations.

In the Quindiu Mountains, between Ibagué on the east and Cartago on the west, there is a powerful development of quicksilver ore. A Colombian syndicate started to prospect on the east side of the mountain range and bought up the land from the government. Foolishly, however, they tried to float a company in London before they had a mine to show. A good expert was sent out and he reported a good prospect and nothing more. This report, together with certain false statements in the prospectus, condemned the venture. I have, however, discovered that the lodes cross the mountains and crop out again on the west or Quindiu side, where they could be more easily worked and the mercury put in the market at less cost. The prospecting of these formations I think would be a good venture. The lodes in the Quindiu are in mica slate and are well formed and well defined. The only gangue is carbonate of lime and a little quartz. I am of opinion that eruptive dykes of felsite gave origin to these lodes, but their proximity to the volcanoes of the Quindiu may also account for them. In the Almaden district in Spain, besides the great mine, which is a sort of big chimney of ore, there are many true lodes which resemble in every way the Quindiu lodes as regards both their components and the inclosing rock.

Platinum is not expressly mined, but it is obtained with the alluvial gold in many of the rivers in the Choco. I believe that some of the cement beds would pay well to work by crushing for the extraction of gold and platinum.

As a matter of curiosity, I may mention that I found iridium in the Silencio Mine, Remedios district, in Antioquia. The ore is a rich gold-bearing quartz, and where the iridium occurred it was heavily charged with pyrites and galena. In 1882 I communicated this to the British Association, and I still preserve a sample of the iridium.

Some day perhaps we shall see in Colombia a mining company which will not begin business by assigning half its capital for the purchase of a property probably costing a few hundred dollars. If such a company goes to work in a practical manner and thinks more of getting dividends out of its mine than of speculating in its stock, we may see mining in Colombia attracting the world's attention and meriting a better description than the above modest sketch.

FRANCE.

THE mineral industry of France is of great extent and importance. Especially is this the case with the coal and iron production. Some of the iron and steel plants, such as the great works of the Schneider Company at Creusot and the forges of the Rive-de-Gier, are known all over the world.

While coal and iron are the leading branches, there are mines of lead and manganese of importance. There are also many metallurgical works.

In Vol. III. of THE MINERAL INDUSTRY the statistics of the French production for a series of years were given from official sources. In the following tables are given the figures for the five years ending with 1894:

MINERAL PRODUCTION OF FRANCE. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Alunite.		Antimony Ore.		Bauxite.		Bituminous Substances. (*b*)		Copper Ore.		Manganese Ore	
1890	.....	......	4,962	$161,259	18,670	$178,200	233,344	$311,847	15	541	15,984	$89,517
1891	.....	....	5,316	133,518	22,260	190,750	260,626	338,889	16	1,625	15,343	90,316
1892	.....	....	5,100	135,200	23,298	196,524	224,311	335,600	251	6,078	32,406	205,074
1893	253	$2,530	7,200	130,000	33,923	261,248	222,000	322,400	......	....	38,080	290,073
1894 (*d*)	354	3,540	6,144	81,231	....	....	230,603	351,561	......	....	32,751	200,277

Year.	Iron Ore.		Iron Pyrites.		Mineral Fuel.					
					Coal.		Lignite.		Peat.	
1890	3,471,718	$2,477,079	229,661	$655,922	25,591,545	$61,365,211	491,573	$917,290	157,701	$342,317
1891	3,579,286	2,557,084	246,827	682,412	25,676,463	63,560,000	523,282	950,000	168,365	387,454
1892	3,706,748	2,516,168	230,480	572,256	25,697,223	64,038,800	481,468	896,600	165,445	394,251
1893	3,517,433	2,339,169	231,025	561,284	25,172,792	58,105,400	478,189	852,800	174,290	460,174
1894 (*d*)	3,672,101	2,455,449	283,439	684,908	26,964,000	58,537,920	453,000	987,540	131,717	356,606

Year.	Lead-Silver Ore.		Salt.		Sulphur Ore. (*c*)		Tin Ore.	
1890	25,787	1,057,679	842,529	3.483,264	4,285	13,535	47,540	950,619
1891	25,897	946,324	810,675	2,827,777	6,749	20,072	56,338	1,285,504
1892	21,656	673,164	973,752	3,353,390	7,231	20,972	69,236	1,134,400
1893	24,599	530,742	1,103,287	3,317,471	3,733	13,022	77,466	1,061,166
1894 (*d*)	29,055	473,920	890,607	2,787,624	851	2,747	....	....

Also produced in 1894, 80,065 metric tons zinc ore, valued at $825,867.

(*a*) From *Annales du Commerce Extérieur* and *Statistiques de l'Industrie Minérale.*

(*b*) Includes pure bitumen, bituminous schist, bituminous sand, and asphalt limestone; see details in special tables below.

(*c*) Sulphur and limestone impregnated with sulphur.

(*d*) From the advance report of the *Ministère des Travaux Publics.*

PRODUCTION OF MINERAL OIL AND ASPHALT IN FRANCE. (*e*) (IN METRIC TONS.)

Year.	Mineral Oil.		Asphalt.	
1890	7,906	182,513	11,199	97,527
1891	9,926	239,460	15,070	132,407
1892	8,008	191,160	14,690	138,702
1893	8,710	189,580	13,608	103,165
1894	8,762	192,600	14,000	105,700
1895	....	....	....	....

(*e*) From *Statistiques de l'Industrie Minérale.*

METALLURGICAL PRODUCTION OF FRANCE. (*f*) (IN METRIC TONS AND DOLLARS.)

Year.	Aluminum.		Antimony.		Copper.		Iron, Pig.		Iron, Wrought.		Steel.	
1890	37.0	$136,000	843	$212,880	2,306	$721,280	1,962,196	$27,523,973	825,369	$29,593,160	581,998	$30,152,391
1891	36.0	85,520	880	177,153	2,125	635,471	1,897,387	24,827,169	833,409	29,546,616	638,530	33,497,528
1892	75.0	125,600	754	148,362	2,163	567,000	2,057,300	24,973,800	828,519	29,533,200	682,500	36,823,600
1893	137.0	194,900	868	157,300	6,587	1,507,700	2,003,100	23,347,000	808,171	23,347,400	789,852	33,367,000
1894	270.0	274,400	1,012	136,000	6,415	1,353,600	2,069,700	23,600,000	786,000	25,800,000	790,773	....

Year.	Lead. (*g*)		Litharge.		Nickel.		Precious Metals.				Zinc.	
							Gold—Kilos.		Silver—Kilos.			
1890	4,544	$307,731	43	$2,838	330	$333,000	200	$128,000	71,117	$2,275,774	19,372	$1,977,211
1891	6,680	417,116	63	3,906	330	336,400	220	140,800	71,303	2,281,696	20,596	2,070,333
1892	8,776	510,478	49	2.619	1,244	1,236,400	210	144,075	103,207	2,994,163	20,609	1,993,956
1893	8,119	404,187	33	1,617	2,045	1,237,560	300	192,000	98,077	2,550,020	22,419	1,843,649
1894	8,758	365,800	......	....	1,545	1,237,600	376	240,600	96,955	2,133,000	23,387	1,815,400

(*f*) From *Statistiques de l'Industrie Minérale* and from *Annales du Commerce Extérieur.*
(*g*) Lead produced from native ore only; does not include the metal produced from foreign mineral imported into France to be desilverized.

In addition to the figures above, we have obtained some advance statements of the production for 1895. The output of coal for that year was 27,801,246 metric tons and of lignite 434,763 tons, making a total of 28,236,039 tons.

The total production of pig iron in 1895 was 2,005,889 metric tons, of which 489,721 tons were foundry iron and 1,516,168 tons were forge iron or Bessemer pig. The production of wrought iron included 354,645 tons of bars, 88,599 tons of plates, and 427 tons of rails. The output of steel ingots was 716,931 tons, of which 693,290 tons were Bessemer and open-hearth steels and 23,641 tons were crucible, blister, and other special steels. The production of steel from these ingots in finished forms was as follows: Bars, shapes, etc., 386,168 tons; plates, 170,346 tons; rails, 160,417 tons; total, 716,931 tons. There was an increase in steel production and a nearly equal decrease in wrought iron.

The mineral imports and exports of France for the five years ending with 1894 are given below:

MINERAL AND METALLURGICAL IMPORTS OF FRANCE. (*h*) (IN METRIC TONS AND DOLLARS.)

Year	Bituminous Substances. (*i*)		Coal.		Copper.		Gold.	Silver.	Iron & Steel.		Castings.	
1890	389,400	$9,564,400	10,375,000	$49,553,200	31,571	$8,575,400	$23,440,000	$37,840,000	58,160	$1,298,600	20,620	$243,400
1891	273,000	8,743,600	10,542,000	37,954,200	30,074	8,694,000	72,500,000	35,280,000	45,856	1,228,600	56,756	681,000
1892	312,000	10,509,600	10,357,000	36,921,000	24,384	6,796,600	77,520,000	24,000,000	57,790	1,902,200	84,520	1,835,600
1893	860,000	11,689,600	11,401,000	36,464,800	29,880	7,276,200	61,094,356	31,743,279	82,529	2,000,600	93,616	2,262,800
1894	60,000	....	11,644,000	....	30,419	....	92,308,712	17,719,346	135,305	....	121,965	....

Year.	Lead.		Nickel.		Nitrate of Soda.	Stone.	Sulphur.		Tin.		Zinc.	
1890......	69,881	$4,480,200	601	$750,800	$8,219,600	$3,036,800	84,394	$1,744,000	6,063	$2,863,000	28,304	$3,202,200
1891......	74,502	4,506,600	801	1,031,400	7,519,400	3,972,800	88,678	2,416,000	6,204	2,847,000	30,449	3,447,000
1892......	72,721	5,166,200	2,703	1,456,400	9,013,600	4,456,000	98,721	2,329,200	7,085	3,382,600	29,884	3,305,400
1893......	77,679	5,262,800	1,866	1,046,200	60,234,400	4,925,800	98,750	2,329,200	8,890	3,683,000	35,200	3,781,200
1894......	84,674	....	623	....	....	....	112,152	....	8,236	....	35,368	....

(*h*) From *Statistiques de l'Industrie Minérale* and from *Annales du Commerce Extérieur.*
(*i*) Includes bitumen, bituminous schist and sand and asphaltic limestone.

MINERAL IMPORTS OF FRANCE. (IN METRIC TONS.)

Year.	Lead Ore.	Copper Ore	Antimony Ore.	Gold Ore. Kilos.	Iron Ore	Iron Pyrites Ore.	Manganese Ore.	Nickel Ore.	Silver Ore. Kilos	Tin Ore.	Zinc Ore.
1890..	2,126	5,080	196	....	1,610,000	39,553	54,601	416	946,000	444	39,473
1891..	3,893	10,024	208	7.176	1,438,000	45,457	44,919	6,165	1,245,000	628	36,437
1892..	7,281	16,850	123	13,277	1,684,000	47,502	43,888	11,927	3,539	523	41,931
1893..	5,261	20,527	175	2,606	1,630,000	56,505	35,531	18,236	4,092,000	78	34,221
1894..	5,825	10,191	153	(*j*)24,824	1,638,000	56,672	43,345	14,941	3,159,514	123	34,955

(*j*) Gold ore 1894 includes platinum ore imported.

MINERAL AND METALLURGICAL EXPORTS OF FRANCE. (*k*) (IN METRIC TONS.)

Year.	Aluminum Metal.	Antimony.		Copper.		Gold.		Iron.					Lead.	
		Ore.	Metal	Ore.	Metal	Ore.	Metal	Ore.	Pyrites	Pig.	Casting	Steel.	Ore.	Metal
1890....	....	1,666	140	12,083	5,060	......	5,953	285,000	15,908	219,122	233,980	69,344	12,879	9,895
1891....	....	1,153	78	11.802	6,528	......	6,045	299,000	12,120	196,271	145,412	54,019	13.280	10,657
1892....	42	1,333	90	12,387	8,526	......	4,222	305,000	22,455	161,173	159,453	30,323	10,823	10,057
1893...	43	492	165	10,198	7,601	5,211	4,222	302,000	38,060	130,028	143,652	28,426	14,032	9,243
1894....	31	1,173	140	4,536	6,634	966	4,448	247,627	48,627	140,718	156,638	37,361	11,866	8,133

Year.	Manganese Ore.	Mercury, Metallic.	Nickel.		Silver—Kilos.		Tin.		Zinc.	
			Ore.	Metal.	Ore.	Metal.	Ore.	Metal.	Ore.	Metal.
1890.........	595	10	48	90	7,908	24,085	61	921	24,050	5,156
1891..........	1,494	6	26	210	103,222	17,800	88	1,014	31,662	5,177
1892..........	8,541	5	455	319	195	18,950	222	918	32,023	7,034
1893..........	12,123	5	701	191	61,219	21,642	....	973	47,426	8,819
1894..........	157	25	241	882	51,272	26,703	4	819	58,281	7,282

(*k*) From *Statistiques de l'Industrie Minérale.*

Notwithstanding its own large production, France still imports a considerable quantity of coal; also a large amount of iron ore, some of which comes from Belgium, but a larger part from the minette ore deposits of Alsace.

THE FRENCH COLONIES.

We give below such statements of the mineral production of the French colonies as can be obtained. The African colonies of Algeria and Tunis are increasing in importance, producing iron ore, lead and zinc ores, and phosphates:

MINERAL EXPORTS OF ALGERIA. (IN METRIC TONS.)

Year.	Lead and Copper Ore.	Zinc Ore.	Year.	Lead and Copper Ore.	Zinc Ore.
1891........................	13,928	9,748	1893......................	6,762	27,844
1892........................	12,959	21,436	1894......................	2,673	28,788

Algeria reported also in 1894 71 tons of antimony ore.

MINERAL PRODUCTION OF ALGERIA. (*l*) (IN METRIC TONS; 5f. = $1.)

Year.	Antimony Ore.		Copper Ore.		Iron Ore.		Iron, Cast.		Lead-Silver Ore.		Quicksilver Ore.		Zinc Ore.		Copper Matte.		Salt, Sea.	
1892	48	$2,470	21,907	$281,022	452,603	$807,140	445	.....	349	$7,463	178	$1,323	21,907	$281,022	448	......	24,784	$10,408
1893	79	4,740	24,390	197,866	393,921	702,388	...	.....	212	4,181	757	9,806	24,390	197,866	....	......	19,008	93,420
1894	175	5,200	......	....	343,830	527,783	...	.....	276	4,045	866	11,602	29,703	163,392	....	......	17,830	74,763

(*l*) From *Statistiques des Richesses Minérales*, 1894, and *Statistiques de l'Industrie Minérale*, 1893.

VALUE OF IMPORTS AND EXPORTS OF TUNIS. (*m*) (£1 = $5.)

	IMPORTS.							EXPORTS.
Year.	Building Materials.	Coal.	Iron, Steel, Including Rails.	Marble.	Machinery.	Metal Goods.	Mineral Oils.	Zinc.
1891..........	$65,380	$121,550	....	....	$109,660	....	$43,110	$935
1892..........	159,850	121,180	$88,075	$23,385	88,675	$704,500	67,755	49,030
1893..........	....	92,810	219,485	....	116,350	485,225	61,935	121,390
1894..........	....	122,510	176,570	....	157,600	399,945	75,731	226,000

(*m*) From *British Diplomatic and Consular Reports*, Annual Series, No. 1293, August, 1893.

MINERAL PRODUCTION AND EXPORTS OF THE FRENCH COLONIES. (IN METRIC TONS.)

Tunis produced during 1894 28,000 tons of calamine and 7000 tons of salt.

New Caledonia.—Production of nickel ore amounted in 1892 to 83,000; 1893, 69,130; 1894, 61,243 tons. The exports in 1893, 45,613; 1894, 40,089 tons. Average value, $14 per ton. Cobalt production 1893, 2220 tons, exported 520 tons; 1894, 4112 tons, exported 4156 tons. Also exported in 1894 6 tons matte valued at $700 per ton. Value of cobalt averaged $14 per ton. No chrome ore was produced in 1893, but exports amounted to 242 tons. Production in 1894 reached 2927 tons, with exports during that year aggregating to 1042 tons, average value $12 per ton.

Indo-China and Tonkin.—The production of coal in 1893 was 250,000 tons; of 1894, the exports and consumption are known only; exports 1894 amounting to 100,000 tons, valued at $198,400, and the consumption 12,753 tons.

Annam.—Exported during 1894 1651 tons of coal, valued at $4800.

Cochin-China.—6200 kilos jet was produced there in 1894, valued at $2400.

Guiana.—Besides producing gold, phosphate has been mined since 1888, and produced the following amounts: 1888, 2207; 1889, 2559; 1890, 4187; 1891, none; 1892, 3938; 1893, 2561; 1894, 6605. All these phosphates are shipped to Nantes, France, at a freight rate of $5.40 per ton.

Of the Eastern colonies the nickel of New Caledonia is the best-known product; but Tonkin has coal fields of considerable importance, and is reported to have other mineral resources which may be developed as the new railroad into the interior is opened.

GERMANY.

THE mineral industry of Germany continues to show a steady and healthy growth, its progress being freer from fluctuations than that of any other important country. Many of its branches are fully referred to elsewhere in this volume, and the allied chemical industry is fully described in its place.

The following tables show the mineral production for five years:

MINERAL PRODUCTION OF GERMANY AND LUXEMBURG. (*a*) (IN METRIC TONS; 4 marks = $1.)

Year.	Antimony Ore.		Arsenic Ore		Asphaltum.		Boracite.		Coal.		Cobalt, Nickel & Bismuth Ore.		Copper Ore.	
1891...	1	$41	3,124	$32,563	49,150	$93,928	177	$12,660	73,715,653	$147,379,551	1,074	$159,328	587,626	$5,216,192
1892...	....	......	2,146	19,491	53,279	104,713	179	13,614	71,372,193	131,744,794	3,185	198,208	567,738	5,128,386
1893...	16	100	2,756	25,363	47,238	89,245	162	11,662	73,908,990	124,616,605	4,490	189,410	584,875	4,530,683
1894...	....	......	2,906	30,006	55,981	112,762	222	11,589	76,772,659	127,294,092	4,525	194,588	588,195	4,060,039
1895...	2	218	3,497	34,900	59,563	113,606	150	8,756	79,163,615	134,730,889	5,208	121,702	633,302	3,844,475

Year.	Epsomite.		Graphite.		Iron Ore.		Iron Pyrites.		Other Vitriol and Alum Ores.		Kainit.	
1891...	7,454	$16,314	3,824	$73,540	10,657,521	$9,852,076	128,288	$239,468	2,406	$1,517	472,256	$1,701,640
1892...	10,202	22,331	4,036	63,240	11,539,033	10,319,938	115,243	215,887	2,973	2,016	549,445	1,955,717
1893...	8,818	17,057	3,140	52,010	11,457,491	9,950,140	121,334	219,427	791	1,199	664,986	2,397,774
1894...	8,252	17,999	3,133	45,757	12,392,065	10,544,385	134,787	244,865	464	920	727,234	2,574,805
1895...	7,525	15,295	3,751	50,612	12,349,595	10,268,935	123,848	234,378	351	525	661,479	2,327,067

Year.	Other Potash Salts.		Lead Ore.		Lignite.		Manganese Ore.		Petroleum.	
1891........	898,993	$2,771,494	159,215	$4,163,988	20,536,625	$13,541,457	40,335	$202,445	15,315	$298,659
1892........	802,630	2,532,169	163,372	3,671,881	21,171,857	14,626,475	32,861	126,924	14,527	219,941
1893...	861,162	2,762,060	168,414	3,536,042	21,567,218	13,750,754	40,788	122,987	13,974	195,733
1894........	916,339	2,988,403	162,675	3,025,884	22,103,446	13,287,699	43,702	116,412	17,232	243,112
1895........	860,305	2,818,878	158,268	3,062,295	24,713,198	14,561,653	41,327	124,534	17,051	240,614

Year.	Rock Salt.		Silver and Gold Ore.		Tin Ore.		Uranium and Wolfram Ore.		Zinc Ore.	
1891........	666,793	$744,754	22,569	$1,151,723	75	$22,839	47	$10,564	793,544	$6,238,384
1892........	662,577	708,046	17,536	910,501	63	23,001	48	11,707	800,237	5,305,324
1893........	669,042	736,029	18,778	773,931	69	18,888	44	10,778	788,394	3,574,162
1894........	735,490	789,267	19,080	629,672	211	16,309	40	6,194	728,616	2,569,514
1895........	686,940	776,049	17,674	611,379	154	13,074	29	4,922	706,334	2,644,009

METALLURGICAL PRODUCTION OF GERMANY.

Year.	Antimony and Alloys.		Arsenical Products.		Cadmium—Kilos.		Copper, Matte and Black.		Copper, Pig.		Gold—Kilos.	
1890........	b139	$31,732	2,167	$147,241	4,157	$3,788	793	$66,026	24,427	$7,220,606	1,855	$1,290,417
1891........	198	43,175	1,988	138,626	2,797	2,468	596	46.139	24,092	6,952,884	3,077	2,141,998
1892........	b249	44,931	1,667	109,127	3,200	2,850	625	24,630	24,781	6,189,532	3,859	5,683,944
1893........	407	64.485	1,794	119,588	5,000	5,461	842	63,735	2,400	5.858,500	3,079	2,138,250
1894........	424	65,244	2,389	166,798	6,520	6,886	676	26,928	25,722	5,467,554	4,133	2,880,673

Year.	Iron.		Lead, Pig.		Litharge.		Mineral Paints.		Nickel Products. (c)		Silver—Kilos.		Sulphur.	
1890	4,658,451	$66,894,961	101,781	$6,407,359	3,972	$264,071	2,112	$56,653	934	$1,372,069	402,945	$14,037,716	1,915	$44,810
1891	4,631,218	58,107,003	95,615	5,816,587	3,124	197,317	2,332	61,820	1,062	1,606,200	444,852	14,749,420	2,020	51,050
1892	4,937,461	57,324,072	97,742	5,136,861	3,468	201,765	2,629	68,313	1,238	1,713,556	489,350	14,307,172	5,155	54,460
1893	4,986,030	54,986,500	94,659	4,519,250	3,551	183,181	2,993	84.008	1,402	1,703,286	449,383	11,766,155	2,151	51,308
1894	5,310,885	57,094,968	100,753	4,762,451	3,646	192,043	2,834	72,800	997	1,154,757	444,213	9,653,769	2,168	50,209

Year.	Sulphuric Acid.		Sulphate. Copper.		Sulphate. Iron.		Sulphate. Zinc & Nickel.		Sulphate. Mixed.		Tin.		Zinc.	
1890	464,044	$3,820,918	5,854	$624,757	8,351	$57,401	3,769	$60,683	344	$11,023	64	$30,887	139,266	$15,598,177
1891	467,633	4,018,746	3,502	288,938	......	....	4,117	103,453	298	10,038	287	131,131	139,353	15,639,337
1892	488,047	3,716,014	4,024	281,234	9,393	53,854	4,479	92,372	217	7,684	684	309,973	139,938	13,765,510
1893	517,790	3,887,500	4,773	353,351	8,457	41,763	4,648	84.305	233	8,535	951	348,135	142,956	11,821,500
1894	503,621	3,592,416	4,809	363,034	8,899	39,488	4,357	88,214	202	7,436	896	271,804	143,577	10,453,272

FINISHED PRODUCTS OF GERMAN SALT WORKS.

Year.	Alum.		Aluminum Sulphate.		Common Salt.		Glauber Salt.		Magnesium Chloride	
1891.....	5,619	$137,590	28,710	$541,805	503,386	$3,355,586	....	....	15,619	$39,528
1892.....	4,270	117,465	29,588	570,735	504,687	3,460,869	73,988	$502,750	14,386	50,828
1893.....	4,102	115,075	27,012	505,165	545,973	3,404,250	75,965	486,250	12,764	44,493
1894.....	3,914	107,092	26,804	480,176	517,536	3,544,440	66,309	392,640	17,422	50,913
1895.....	3,358	87,372	28,699	507,306	521,948	3,560,112	67,663	387,765	17,039	52,850

Year.	Magnesium Sulphate.		Potassium Chloride.		Potassium Sulphate.		Double Sulphate of Potassium Magnesium.	
1891..........	23,126	$71,126	129.512	$4,282,290	....	....	10,508	$199,155
1892..........	23,879	84,000	123,962	4,106,579	22,968	$931,750	11,593	228,172
1893..........	27,548	79,250	137,216	4,326,250	22,555	956,500	14,129	288,750
1894..........	28,628	88,814	149,775	4,722,049	23,281	958,736	14,156	274,694
1895..........	26,028	107,183	154,174	4,912,941	14,691	614,666	9,877	193,939

(a) From *Vierteljahrs und Monatshefte zur Statistik des Deutschen Reichs;* 1894–95 are taken from *Deutsche Kohlen-Zeitung.* (b) Includes manganese. (c) The nickel products include bismuth, cobalt, and uranium salt.

Imports and Exports.—The imports and exports of Germany are an important element in its industry. The exports are increasing, and both the government and the merchants are making systematic efforts to extend the foreign trade of the country. So far a considerable degree of success has been secured, and Germany is becoming a formidable rival to Great Britain in South America and the far East.

The following tables give the imports and exports for the five years ending with 1894, to which have been added, from advance information, those of the principal articles for 1895:

MINERAL IMPORTS OF GERMANY. (*a*) (IN METRIC TONS; unit of value, $1000.)

Year.	Alabaster and Marble.		Alum.		Ammonia, Sulphate of		Brass, Copper, Aluminum, and Nickel Ware.		Coal.		Coke.		Lignite.		Cobalt and Nickel Metal, Crude.	
1890..	20,213	$1,011	272	$9	33,873	$2,033	3,273	$2,150	4,164,538	$15,883	351,258	$1,967	6,506,404	$6,507	646	$888
1891..	19,003	950	157	5	31,110	1,867	2,126	1,498	5,032,826	19,219	318,798	1,731	6,805,586	6,806	784	1,078
1892..	21,298	959	....	....	34,207	1,881	*b*1,474	*b*1,125	4,436,983	14,870	465,726	2,147	6,701,309	6,366	1,356	1,611
1893..	21,520	650	....	....	42,596	2,550	*b*1,467	*b*1,050	4,664,048	14,925	439,182	1,725	6,705,672	6,375	1,006	950
1894..	......	......	....	....	36,634	......	....	....	4,805,971	....	404,178	......	6,868,161	......	1,236	.....
1895..	......	......	251	....	2,920	......	....	....	5,117,356	....	461,778	......	7,181,050	......	.....	.....

Year.	Copper Bars, Sheets, and Wire.		Copper, Pig.		Gold and Silver, Articles of.		Gold, Coined.		Gold, Crude and Bars.		Gold and Silver, Platinum Ores.		Iodine.		Iron Ore.	
1890..	906	$339	31,432	$9,272	27	$1,330	33	$20,369	7	$5,093	13,756	$3,783	138	$916	1,522,501	$5,297
1891..	1,104	369	34,182	9,400	28	2,378	58	36,350	27	18,893	18,962	5,215	156	1,035	1,408,025	4,862
1892..	912	300	32,498	7,962	30	1,242	45	28,045	24	16,572	19,308	5,551	169	1,119	1,655,843	5,589
1893..	448	175	38,455	8,850	32	1,300	26	16,050	37	18,975	20,516	5,125	324	2,150	1,573,202	5,250
1894..	495	....	37,031	......	....	....	....	....	....	....	13,935	....	242	.....	2,093,070	......
1895..	424	....	44,364	......	....	....	....	....	....	....	6,134	....	....	.....	2,017,136	......

Year.	Iron, Pig.		Iron, Wire.		Iron, Wrought.		Iron, Various Manufactures of.		Kaolin, Feldspar, Fireclay.		Lead, Pig.		Lead and Copper Ores.		Lead, Tin, and Zinc—Fine Manufact's of.	
1890..	385,328	$5,591	5,732	$526	28,942	$1,339	40,674	$9,224	157,311	$1,573	12,766	$862	54,572	$7,504	223	$183
1891..	244,852	3,264	5,692	478	22,364	929	44,346	5,794	153,750	1,538	17,625	1,091	49,040	6,130	189	144
1892..	209,306	2,519	4,675	375	21,085	831	31,885	3,225	151,398	1,514	17,501	941	43,893	3,292	....	....
1893..	218,998	2,475	4,888	400	17,054	625	32,494	3,000	141,096	1,325	23,857	1,200	43,490	2,925	....	....
1894..	203,974	......	......	......	19,966	......	......	......	....	......	24,208	.....	51,304	......	....	....
1895..	188,217	......	......	......	19,777	......	......	......	....	......	28,449	.....	65,270	......	....	....

Year.	Lime, Chloride of.		Limestone and Mortar.		Lubricating Oil, Mineral.		Machinery.		Petroleum.		Phosphate of Lime.		Super-phosphate.	
1889..	4,716	$189	190,204	$1,094	44,565	$1,894	45,799	$8,013	625,668	$20,334	86,268	$1,618	124,962	$3,062
1890..	6,647	216	173,612	998	52,311	2,289	56,942	10,485	646,804	18,272	115,524	2,166	148,440	4,056
1891..	3,431	120	164,029	820	60,666	2,578	42,713	7,776	675,528	16,348	92,411	1,733	114,011	3,135
1892..	......	......	174,483	873	63,150	2,684	......	......	743,433	15,185	169,798	2,972	86,851	1,954
1893..	......	......	200,165	1,000	70,576	4,400	......	......	765,100	9,575	226,923	2,825	110,876	1,800
1894..	......	......	....	....	......	......	......	......	785,100	....	....	....	124,373	....
1895..	7,671	......	....	....	......	......	......	......	811,058	....	....	....	96,099	....

Year.	Precious Stones.		Pyrites.		Salt.		Silver. Coined.		Silver. Crude and Bars.		Silver and Gold, Refuse.		Slags.		Slate.		Soda, Crude and Crystals.	
1890..	136	$2,797	210,725	$1,054	20,961	$105	23	$741	43	$1,494	28	$3,405	423,532	$1,112	68,695	$1,183	82	$1
1891..	139	2,730	238,644	1,193	20,751	311	28	845	69	2,297	34	4,162	361,457	949	66,587	1,147	90	1
1892..	95	1,762	218,272	982	24,533	218	30	783	64	1,871	35	4,230	410,631	1,283	62,566	1,095	293	5
1893..	73	500	274,766	1,305	23,645	93	24	475	78	2,025	41	4,905	477,182	1,670	61,543	1,075	242	4
1894..	....	......	315,115	......	19,631	.....	....	.....	190	......	66	......	....	......	......	......	328	......
1895..	....	......	....	......	19,347	.....	....	.....	....	......	....	......	....	......	......	......	......	......

Year.	Soda and Bicarbonate of Soda, Calcined.		Soda, Caustic.		Soda. Nitrate of.		Stone, Rough or Hewn.		Tin. Pig.		Tin. Plate.		Zinc. Ore.		Zinc. Pig.	
1890..	847	$24	710	$39	344,209	$13,768	696,638	$6,252	9,013	$4,281	4,296	$376	38,099	$953	8,625	$895
1891..	569	17	350	21	395,653	17,309	691,720	6,179	9,081	4,200	1,199	102	37,762	944	7,969	847
1892..	467	14	148	5	379,899	16,146	685,591	5,142	8,765	4,163	1,234	104	41,558	883	13,021	1,399
1893..	763	23	419	13	384,710	16,350	697,448	4,800	10,538	4,478	1,227	98	23,883	418	12,211	1,189
1894..	758	....	467	.....	....	....	....	......	10,774	.....	......	.....	14,712	......	17,988	......
1895..	682	....	.....	.....	....	....	....	......	10,581	.....	......	.....	25,817	......	17,542	......

(*a*) From *Statistisches Jahrbuch für das Deutsche Reich;* 1895 from *Chemiker Zeitung.* (*b*) Not including brass.

MINERAL EXPORTS OF GERMANY. (*a*) (IN METRIC TONS; unit of value, $1000.)

Year.	Aluminum and Nickel Ware.		Cement.		Coal.		Coke.		Copper, Bars and Sheet.		Copper, Manufactured.		Copper, Pig.	
1890..	1,379	$2,241	396,046	$4,320	9,145,187	$28,896	1,074,755	$6,227	2,906	$1,054	8,417	$5,451	8,429	$2,571
1891..	1,417	2,125	388.457	3,816	9,536,374	29,961	1,354,298	7,138	4,145	1,430	9,675	5,992	6,244	1,779
1892..	1,317	1.647	432,153	2,776	8,971,055	24,974	1.717.893	7,295	4,507	1,352	10,076	5,832	6,598	1,666
1893..	1,463	1,475	423,892	2,450	9,677,305	26,150	1,902,424	7,325	4,890	1,350	12,646	7,450	7,497	1,775
1894..	......	....	406,369	....	9,739,075	....	2,261,961	....	5,008	......	......	....	6,608	....
1895..	......	....	471,123	....	10,360,838	....	2,293,328	....	4,700	......	......	....	6,329	....

Year.	Gold, Bars and Crude.		Gold, Coined.		Iron Ore.		Iron, Pig.		Iron, Wrought		Iron, Various Kinds of.		Iron and Steel Rails.	
1890..	3	$1,890	14	$8,518	2,208,480	$1,800	116,922	$1,917	142,811	$4,999	116,848	$3,281	130,837	$3,762
1891..	7	4,781	41	25,608	1,984,428	1,501	111,154	1,808	193,253	5,725	176,185	4,230	142,846	3,571
1992..	10.6	7,421	48	30,036	2,276.155	1,711	113,391	1,568	199,064	5,340	185,616	4,046	113,712	2,559
1893..	5.3	3,650	35	21,725	2,353,398	1,750	108,675	1,475	231,297	5,900	(*b*) 225,902	4,600	87,360	1,850
1894..	3.5	......	....	......	2,558,729	......	154,647	......	300,598	......	....	....	119,410	....
1895..	....	......	....	......	2,480,135	......	185,289	......	277,909	......	....	....	....	....

Year.	Wire Nails.		Iron, Various Manuf's of.		Kaolin, Feldspar, Fireclay.		Lead.		Leads, Crayons, and Pastels.		Lead, White; Zinc, White; Zinc, Gray.		Lead, Tin, and Zinc, Manuf's of.		Machinery.	
1890..	41,040	$1,898	*c*390,233	$41,875	59,785	$598	32,124	$2,128	978	$807	21,212	$2,090	5,357	$2,261	88,112	$16.551
1891..	49,709	2,051	472,682	45,025	75,396	754	24,971	1,514	943	743	22,128	2,066	5,738	2,261	91,110	17,139
1892..	50,323	1,887	450,336	36,975	82,983	829	25,647	1,363	948	711	24,306	2,016	4,271	4,369	916,631	14.418
1893..	54,849	2,050	483,484	39,650	79,570	800	23,945	1,175	1,090	817	25,754	19,765	11,825	4,354	96,105	16,076
1894..	56,414	......	....	....	......	....	24,354	......	.....	......	....	......	......	......	....	....

Year.	Phosphate, Super.		Potash.		Potassium Salts.		Precious Metal Ware.		Salt.		Saltpeter.		Silver, Bars and Crude.	
1890..	56,253	$1,677	10,628	$1,011	67,658	$2,375	95	$9,040	199,467	$889	10,135	$1,014	....	....
1891..	43,318	1,299	11,094	1,137	76,987	2,700	89	7,825	254,370	985	9,663	1,015	....	....
1892..	56,075	1,402	12,233	1,254	63,242	2,250	85	6,375	197,371	765	8,874	932	352,756	$10,345
1893..	62,800	1,175	10,865	1,125	85,858	3,050	87	5,975	196,095	825	9,652	925	450,596	11,800
1894..	60,668	......	....	......	93,913	......	......	....	273,058	......	....	....	419,970	....

Year.	Silver, Coined.		Stone, Rough and Hewn.		Ultramarine.		Zinc. Sheets.		Zinc. Spelter.	
1890	.....	.....	540,908	$2,951	5,258	$763	16,178	$1,982	57,427	$6,389
1891	......	.....	505,574	2,748	4.404	639	15,370	1,979	57,852	6,581
1892	37,613	$992	537,220	2,675	4,353	631	16.304	1,875	53,287	5,529
1893	29,434	694	483,103	2,416	4,142	601	17,459	1,669	62,592	5,455
1894	......	.....	....	......	......	....	16,038	......	61,799	......

(*a*) From *Statistisches Jahrbuch für das Deutsche Reich*, 1892, 1893, and 1894. The classification in the issues of 1892 and 1893 differ. Also from *Vierteljahrshefte zur Statistik des Deutschen Reichs*, Part II., 1893, and Part II., 1894. (4 marks = $1.) (*b*) Including scrap iron, structural iron, blooms, ingots, etc. (*c*) Including manufactures.

The most important article of export in its crude form is coal, a considerable quantity of which is sent abroad, though Germany also imports coal; these imports are chiefly from Austria and Belgium. The aim of the German merchants has always been to send abroad finished products rather than crude ores or other unmanufactured material.

In addition to the general statistics of the empire, we have received special official reports from several of the constituent States, the figures from which are given below.

Baden.—The production is not extensive, but includes a variety of substances. There is a considerable chemical industry also, as shown in the tables.

MINERAL PRODUCTION OF BADEN. (*a*) (IN METRIC TONS; 4 marks = $1.)

Year.	Coal.		Clay, Fire.		Gypsum.		Iron, Cast, Second Fusion.		Iron Ing's (Steel).		Iron, Wrought.		Lead Ore		Limestone etc.	
1890..	5,167	$17,693	2,491	$3,155	24,835	$19,993	24,965	$1,174,722	53	$4,100	3,117	$168,974	1	$105	5,480	$1,470
1891..	5,616	16,744	2,485	3,140	22,086	15,326	25,215	1,160,640	58	4,063	2,833	126,093	13	1,507	5,700	1,290
1892..	4,500	13,000	8,139	7,760	22,129	14,729	24,910	1,138,148	80	1,062	2,733	123,202	6	454	4,441	1,181
1893..	3,200	9,200	8,475	6,647	28,904	16,217	24,940	1,167,990	188	23,562	644	38,351	5	415	4,170	1,122

Year.	Manganese Ore.		Quartz-sand.		Salt.		Sand-stone.		Sulphate of Alumina.		Sulph. Acid.		Tripoli.		Zinc Ore.		Totals.
1890..	..	......	2,036	$1,647	27,819	$202,454	10	$45	2,000	$33,750	9,872	$86,380	12	$1,447	1,282	$7,692	$1,723,627
1891..	30	$232	1,714	1,612	29,493	196,663	87	415	1,768	39,776	10,633	106,327	12	1,447	97	728	1,676,003
1892..	6	15	3,027	1,609	29,463	208,984	5	125	3,476	82,564	12,331	123,315	10	1,005	1,530	6,120	1,723,237
1893..	5	12	1,924	1,048	28,472	211,486	8	200	1,498	33,705	12,572	94,296	8	763	484	1,451	1,606,465

(*a*) Statistics for Baden 1890–93 were compiled for THE MINERAL INDUSTRY by the *Domanendirection*, Carlsruhe. The production of iron ore in 1892 was 10.5 tons, valued at $116.

Bavaria.—While the production of coal and iron ore is not large, there are some interesting products in other directions. Bavarian lithographic stone is used all over the world where lithographs are made. The ochers are considered the best in Germany and the gypsum is also in demand. The following tables show the production for five years:

MINERAL PRODUCTION OF BAVARIA. (*a*) (IN METRIC TONS; 4 marks = $1.)

Year.	Antimony Ore.		Barytes.		Building Stones.		Cement.		Coal.		Lignite.	
1890..	1.00	$75	5,114	$13,023	575,016	$891,265	76,135	$73,839	740,753	$1,992,507	8,117	$10,187
1891..	0.59	40	5,124	9,962	612.657	998,182	71,648	68,104	756,148	2,012,768	10,044	11,762
1892..	......	......	4,765	9,543	582,784	883,062	87,571	78,798	713,052	1,815,415	13,367	15,662
1893..	......	......	....	....	568,410	836,689	79,779	80,386	802,537	2,000,357	17,167	14,518
1894..	......	......	4,550	5,425	547,115	869,769	81,723	83,426	806,389	1,972,941	20,687	17,079

Year.	Copper Ore.		Emery.		Feldspar.		Fireclay.		Flagstones.		Fluorspar.		Graphite.	
1890..	50	$125	275	$2,484	999	$3,596	91,009	$182,452	19,597	$49,392	4,223	$4,076	4,355	$73,921
1891..	......	....	184	1,511	1,445	2,890	103,287	206,674	20,772	69,005	7,847	8,420	3,824	73,540
1892..	1,831	7,706	170	1,710	1,200	2,400	108,312	237,056	19,538	79,930	4,594	5,907	4,036	63,240
1893..	650	2,762	172	1,498	1,200	2,400	110,970	217,859	26,873	110,493	3,988	4,473	3,140	52,010
1894..	......	....	148	1,584	1,720	3,540	121,950	219,154	18,083	77,932	3,616	6,015	3,133	45,732

Year.	Gypsum.		Iron Ore.		Iron Pyrites.		Kaolin.		Limestone.		Lithographic Stone.		Manganese Ore.	
1890..	32,631	$9,562	153,768	$155,867	1,741	$4,138	18,635	$22,773	182,616	$50,393	11,485	$401,975	187	$562
1891..	30,197	10,407	149,653	150,720	1,933	4,833	18,320	19,284	224,185	61,431	8,775	219,375	260	650
1892..	24,517	12,764	146,392	149,004	1,945	4,862	18,085	17,232	233,417	64.716	8,650	216,262	137	275
1893..	25,540	14,275	149,270	139,610	2,107	5,269	17,835	22,117	283,488	76,376	8,885	234,640	180	445
1894..	25,267	13,219	138,976	140,944	1,928	4,748	15,944	22,122	229,784	60,443	9,286	185,730	80	270

Year.	Ocher and Mineral Paints.		Quartzsand.		Salt, Rock.		Sandstone.		Slate.		Soapstone.		Whetstone.	
1890..	6,855	$27,116	27,936	$7,735	665	$4,236	237,030	$312,679	1,127	$9,742	1,351	$26,075	88	$2,188
1891..	5,710	14,750	32,974	11,271	1,042	6,638	221,575	307,117	1,433	12,127	1,145	22,930	109	2,075
1892..	8,877	20,773	32,381	10,963	955	6,115	246,193	319,562	1,463	13,005	1,271	20,343	147	2,802
1893..	10,317	31,168	15,325	5,531	1,214	7,654	238,405	314,290	1,485	12,886	1,911	29,320	57	1,300
1894..	9,195	23,971	29,775	9,632	630	4,122	221,642	291,924	1,145	13,062	1,900	22,913	66	1,456

Year.	Zinc and Lead Ore.		Iron, Pig.		Iron, Cast, 1st Fusion.		Iron, Cast, 2d Fusion.		Iron, Bar.		Iron, Sheet.		Iron, Wire.	
1890..	1,127	$22,548	66,517	$863,565	187	$7,459	53,567	$2,671,410	68,684	$2,567,147	3,511	$161,161	4,983	$165,573
1891..	......	....	76,552	883,823	213	7,999	52,257	2,523,427	64,742	2,187,057	282	12,519	1,644	46,080
1892..	......	....	77,598	898,302	334	12,521	48,212	2,249,683	64,646	2,020,865	592	22,349	1,008	28,035
1893..	......	....	75,209	856,182	206	6,959	49,614	2,307,051	49,908	1,483,411	1,482	57,766	307	8,211
1894..	......	....	75,669	865,543	196	6,606	53,342	2,490,670	46,860	1,351,169	268	10,087	279	7,426

Year.	Steel.		Lead.		Salt.		Sulphate of Soda.		Other Sulphates and Alum.		Sulphuric Acid.	
1890..	47,917	$1,438,886	1,989	$125,533	40,718	$444,977	404	$3,521	833	$43,044	7,914	$79,226
1891..	67,088	1,834,077	......	....	40,629	439,614	466	3,800	662	29,198	7,520	70,500
1892..	70,790	1,887,673	......	....	41,352	444,192	516	4,617	612	29,597	6,566	62,192
1893..	60,824	1,645,074	......	....	42,153	459,596	1,229	3,750	628	27,873	7,355	64,692
1894..	86,594	2,022,324	......	....	42,183	484,146	568	3,250	668	34,526	6,979	59,693

(*a*) From the *Uebersicht der Production des Bergwerks-Huetten und Salinen Betriebes in dem Bayerischen Staate.* In 1890 there was also produced 260.4 kgms. silver, valued at $8450.

In addition to the figures given above, we have received advance statements for 1895, from which we obtain the following figures for the leading products: Coal, 903,340 tons; lignite, 26,532 tons; iron ore, 145,191 tons; iron pyrites, 1955 tons. The production of fireclay was 106,925 tons, of kaolin 13,250 tons, and of ocher 8579 tons. The report for the metallurgical production shows a total of 77,115 tons of pig iron and 96,828 tons of steel. In the chemical production 6515 tons of sulphuric acid were made.

Prussia.—This State is the largest producer of coal, iron ore, and many other mineral products in the empire. It is especially important as a coal producer, furnishing about 90% of the total output of the empire. The production for the five years ending with 1894 is shown in the tables below:

MINERAL PRODUCTION OF PRUSSIA. (*a*) (IN METRIC TONS; 4 marks = $1.)

Year.	Alum Shale		Antimony Ore.		Arsenic Ore		Asphalt.		Boracite.		Coal.		Lignite. (*b*)	
1890..	911	$648	....	......	2,183	$27,728	14,533	$50,079	176	$13,260	64,373,816	$119,880,961	15,468,434	$9,697,812
1891..	2,163	963	....	......	2,169	25,864	11,217	36,021	150	11,073	67,528,015	131,806,263	16,739,984	10,892,089
1892..	2,460	1,087	....	......	1,202	12,229	12,665	35,956	168	12,953	65,442,558	117,677,458	17,219,033	11,913,033
1893..	302	418	15	$75	1,634	16,384	11,290	34,730	139	13,037	67,657,844	110,084,144	17,566,137	11,184,614
1894..	126	189	....	......	2,222	22,220	14,108	44,537	164	10,490	70,643,979	113,518,107	17,791,062	10,512,840

Year.	Cobalt Ore.		Copper Ore.		Epsom Salt.		Graphite.		Iron Ore.		Iron Pyrites.		Kainit.	
1890..	651	$10,739	587,722	$4,978,543	6,688	$14,311	....	......	4,243,399	$7,899,970	111,291	$216,961	308,660	$1,095,891
1891..	576	9,209	578,256	5,149,521	6,421	13,896	....	......	3,903,811	6,207,238	119,100	213,457	399,007	1,421,727
1892..	534	14,550	557,172	5,073,704	8,518	18,423	....	......	4,081,306	6,388,537	104,346	184,851	448,095	1,562,839
1893..	203	8,491	573,721	4,471,014	7,721	14,656	....	......	4,007,898	6,036,567	110,072	192,937	531,560	1,904,822
1894..	203	5,741	579,132	4,012,585	7,734	16,833	....	......	4,012,446	6,141,224	123,149	215,597	529,169	1,814,585

Year.	Other Potash Salts.		Lead Ore.		Manganese Ore		Nickel Ore.		Petroleum.		Quicksilver Ore.		Rock Salt.	
1890..	708,467	$1,937,579	148,615	$4,349,864	40,131	$181,696	33	$409	2,449	$84,545	.....	......	250,351	$303,086
1891..	617,638	1,712,988	140,123	4,000,998	36,860	181,899	185	1,452	2,498	76,050	.....	......	283,924	321,893
1892..	501,748	1,439,801	141,660	3,462,955	31,388	106,087	529	4,500	1,585	41,925	.....	......	245,550	253,628
1893..	596,062	1,769,353	148,441	3,364,366	39,132	97,830	652	8,090	1,365	36,592	1.2	$25	260,727	280,259
1894..	625,662	1,897,079	144,724	2,900,092	42,526	98,950	1,341	13,413	1,600	39,790	.....	......	305,810	329,341

Year.	Silver and Gold Ore.		Zinc Ore.		Antimony and Alloys.		Arsenic Products.		Bismuth.		Cadmium. Kilos.		Cobalt Products.	
1890..	152	$13,594	757,862	$5,843,854	115	$16,899	817	$41,108	......	......	4,187	$3,789	40	$197,440
1891..	131	20,610	792,351	6,230,590	165	23,750	812	41,379	......	......	2,797	2,468	44	198,740
1892..	4	11,498	797,698	5,294,549	210	23,106	592	22,739	......	......	3,200	2,850	54	239,909
1893..	12	18,665	787,048	3,507,104	362	39,898	709	31,939	0.648	$174	5,284	5,461	44	190,315
1894..	6	9,281	727,645	2,567,053	376	40,034	1,147	57,377	3.002	7,117	6,052	6,335	46	142,675

Year.	Copper.		Copper, Pig.		Gold—Kilos.		Iron, Pig.		Lead, Pig.		Litharge.	
1890..	793	$66,026	21,779	$6,430,001	127.67	$89,795	3,288,369	$49,127,521	91,133	$5,712,706	2,907	$190,453
1891..	547	43,150	21,236	6,102,910	100.31	69,790	3,288,441	43,832,358	87,372	5,286,817	2,246	142,510
1892..	625	24,630	21,559	5,383,722	115.82	81,067	3,439,081	42,515,551	87,983	4,607,369	2,634	153,143
1893..	831	65,666	20,707	5,045,292	738.75	513,707	3,539,701	41,118,869	85,866	4,166,992	2,548	139,304
1894..	670	26,223	21,966	4,670,025	687.88	479,215	3,744,116	43,048,291	92,379	4,357,035	2,647	141,079

Year.	Manganese and Alloys.		Nickel and Alloys.		Paint, Mineral.		Salt, Common.		Silver—Kilos.		Sulphur.		Sulphuric Acid.	
1890..	24	$14,833	434	$466,783	1,659	$33,885	271,615	$1,721,098	260,824	$9,046,996	1,603	$40,098	340,512	$2,746,565
1891..	33	19,425	594	689,405	1,813	35,863	265,549	1,675,428	277,546	9,254,830	1,721	46,528	343,826	2,938,186
1892..	39	21,825	747	747,312	2,082	40,320	264,896	1,695,904	301,374	8,786,415	1,850	49,828	360,156	2,722,789
1893..	44	24,590	896	900,339	2,415	55,171	266,478	1,707,265	276,645	7,276,755	1,871	77,659	387,306	2,977,760
1894..	48	25,210	522	480,675	2,250	39,325	280,511	1,777,592	279,781	6,102,001	1,888	42,912	420,965	3,098,586

Year.	Sulphates.										Tin.		Zinc.	
	Copper.		Iron.		Nickel.		Zinc.		Mixed.					
1890..	2,182	$217,051	6,384	$39,905	26	$8,250	1,944	$28,458	281	$8,302	....	....	139,056	$15,574,109
1891..	1,285	109,032	7,682	51,344	45	14,000	2,405	36,723	223	6,723	238	$107,778	139,147	15,616,909
1892..	1,338	95,056	7,778	41,692	44	14,000	2,748	40,886	167	5,506	644	290,720	139,725	13,743,287
1893..	1,872	135,231	7,134	30,765	44	11,237	2,704	37,111	187	6,298	909	329,790	142,773	11,806,066
1894..	1,858	137,956	7,600	27,788	46	13,795	2,746	38,914	148	4,813	842	252,600	143,354	10,435,118

(a) From *Zeitschrift für das Berg-, Hütten-, und Salinenwesen.*

Saxony.—Mining in Saxony is centered chiefly in the Freiberg district, which is an exceedingly interesting one, owing to the great diversity of its ores and metallic products, the early date at which mining was begun, the perfection to which the processes of extraction have been carried, and the fact that among its mines grew up the first *Bergakademie,* or mining school, in the world. It is not many years since the Freiberg school was the only one in existence where a student could obtain a thorough and systematic training as a mining engineer. Freiberg graduates were found all over the world, and the reputation of the school extended everywhere. The foundation and successful growth of mining schools elsewhere, especially in our own country, has produced a great change, but students from many different countries are still found in the little Saxon town.

Some particulars of the work done at the Freiberg mines have been given in previous volumes of THE MINERAL INDUSTRY, and on another page is presented a full account of the treatment of the arsenical ores and residues at the works in Schneeberg and elsewhere.

The following tables show the general output of the mines of Saxony for a period of five years, and also the products of the Freiberg mines and metallurgical works:

MINERAL PRODUCTION OF SAXONY. (*a*) (IN METRIC TONS; 4 marks = $1.)

Year.	Arsenopyrites.		Bismuth, Cobalt, and Nickel Ores.		Coal.		Lignite.		Iron Ore.		Manganese Ore.		Pitch Blende.		Tin Ore.	
1890	1	$27	187	$153,403	4,150,842	$10,289,151	848,053	$634,739	10,808	$28,079	792	$3,008	5	$3,552	60	$29,267
1891	...	.....	291	148,379	4,366,819	10,957,819	864,376	657,733	14,159	36,912	2,046	4,717	....	......	50	22,758
1892	...	.....	2,113	183,261	4,212,875	9,939,670	927,860	674,682	12,895	23,945	1,638	3,699	....	......	49	18,945
1893	...	.....	3,634	174,917	4,274,064	10,128,936	940,988	663,831	1,650	2,972	......	......	....	......	49	18,908
1894	..	.....	2,980	175,513	4,123,227	9,435,935	918,589	611,836	1,043	1,833	......	......	734	2,653	211	23,697

MINERAL PRODUCTION OF SAXONY—*Continued.*

Year.	Wolfram Ore.		Mixed Ores. (*b*)		Other Minerals. (*c*)		Totals.
1890	37	$5,722	31,498	$1,163,737	2,250	$18,249	$12,329,147
1891	42	8,212	31,909	1,164,205	3,136	16,891	13,017,626
1892	37	8,108	30,231	1,025,078	3,212	15,256	11,892,644
1893	42	7,866	31,565	1,000,077	2,425	4,547	12,002,554
1894	39	5,747	33,411	713,975	607	7,393	11,008,582

METAL CONTENTS OF THE MIXED ORES TREATED AT THE ROYAL SMELTING WORKS AT FREIBERG. (*a*) (IN METRIC TONS.)

Year.	Total of Mixed Ores.		Arsenic.	Copper.	Gold. Kilos.	Lead	Nk'l and Cobalt.	Silver. Kilos.	Sulphur	Zinc.
1890	31,498	$1,163,737	528	16	0.184	3,583	2.97	34,151	4,935	151
1891	31,528	1,159,029	462	18	0.286	4,253	0.97	34,499	4,619	318
1892	30,015	1,023,215	415	13	0.0496	4,163	0.55	34,908	4,208	338
1893	31,335	869,041	406	20	......	4,361	0.65	33,253	4,841	188
1894	31,099	709,397	424	20	......	4,619	0.558	31,635	5,354	134

PRODUCTS SOLD BY THE ROYAL SMELTING WORKS AT FREIBERG AND THE BLUE-COLOR WORKS AT SCHNEEBERG. (*a*) (IN METRIC TONS.)

Year.	Arsenic Products. (*d*)	Bismuth	Cobalt (*e*) Products.	Copper Sulph	Gold. Kilos.	Lead Products. (*f*)	Lead, Sheet	Lead, Shot.	Lead, other Mf'es of. (*g*)	Nickel Speiss.	Silver. Kilos.	Sulphuric Acid (*h*)	Other Chemicals.	Zinc and Zinc Gray.
1890.......	1,342	1.9	453	2,404	778	4,393	1,330	248	612	35	84,201	16,653	1,082	210
1891.......	1,170	2.5	416	1,750	950	4,159	1,200	193	179	56	83,513	13,832	726	207
1892.......	1,075	2.0	407	1,975	778	6.054	565	187	356	49	94,830	10,860	932	212
1893.......	1,084	2.1	445	2,024	954	5,456	642	194	454	54	95,102	14,409	690	182
1894.......	1,229	2.4	404	2,140	957	4,603	1,160	161	198	75	81,322	12.679	699	221

(*a*) From *Jahrbücher für das Berg- und Hüttenwesen im Königreiche Sachsen.* (*b*) See the appended table of Metal Contents of Mixed Ores Treated at the Royal Smelting Works at Freiberg. (*c*) Fluorspar, barytes, mineral paint, etc. (*d*) Including arsenious acid, red, yellow, and white glass, and metallic arsenic. (*e*) Product of the blue-color works at Schneeberg. (*f*) Including soft lead, antimonial lead, litharge, etc. (*g*) Lead pipe, etc. (*h*) Including sulphuric acid of various sorts.

GREECE.

The mineral production of Greece, though at present confined to a few localities, is of considerable interest and importance. The ancient mines of Laurium still continue to furnish somewhat large quantities of lead, zinc, and silver ores. The iron mines of Seriphos supply iron ores of high grade. In 1895 some cargoes from these mines reached the United States, the first which had been sent to our ports since 1892. The magnesite of the island of Eubœa is worked extensively, the products being made into tiles and refractory bricks. The Naxos emery is well known wherever that mineral is used.

The mineral industry of Greece was described in detail in Vol. II. of The Mineral Industry by Mr. E. Grohmann, of Seriphos. To the same gentleman we are indebted for the figures given in the table below, which show the production for five years ending with 1895:

MINERAL PRODUCTION OF GREECE. (*a*) (IN METRIC TONS; 1 drachma = 20 cents.)

Year.	Blende.		Calamine, Calcined.		Chrome Ore.		Emery.		Gypsum.		Iron Ore.		Iron Ore, Manganiferous.	
1891..	2,870	$102,440	25,800	$811,200	200	$2,400	936	$18,720	100	$1,800	76,350	$96,200	108,733	$262,486
1892..	2,800	75,160	24,769	624,160	1,470	17,934	1,479	19,227	110	1,800	142,445	185,178	157,756	371,190
1893..	2,727	47,480	19,862	385,300	1,820	20,800	2,449	31,837	133	2,180	67,670	81,200	121,352	281,540
1894..	1,030	16,700	19,800	348,480	1,477	18,400	3,570	46,410	85	1,540	121,570	142,100	159,080	314,120
1895..	2,710	45,230	21,321	395,250	2,740	34,120	3,055	45,825	113	2,030	150,210	179,250	152,123	342,670

Year.	Soft Lead.		Lead Ore, Argentiferous.		Lead, Argentiferous.		Lead Dust.		Lignite.		Magnesite.		Manganese Ore	
1891..	......	....	3,946	$154,683	14,528	$1,462,970	1,900	$19,000	10,700	$21,400	5,223	$15,669	13,453	$86,099
1892..	......	....	2,380	74,720	15,958	1,410,780	1,129	9,800	11,500	23,000	10,100	28,400	11,716	84,120
1893..	......	....	4,625	97,122	14,534	1,156,900	1,913	17,800	12,134	24,268	8,815	24,680	5,250	36,760
1894..	479	$24,910	6,250	147,500	13,955	1,073,500	1,680	13,700	14,320	28,640	13,262	59,340	9,319	52,190
1895..	7	490	1,580	47,400	19,838	1,656,500	1,406	12,020	17,748	55,500	11,096	33,288	7,250	42,750

Year.	Millstones. Number.		Puzzolan.		Sea Salt. (*b*)		Sulphur.	
1891..	......	$5,200	34,727	$31,248	19,772	$316,352	1,498	$46,120
1892..	......	5,200	30,800	27,720	21,600	345,600	1,664	46,592
1893..	......	8,000	32,348	29,100	18,329	293,264	2,400	67,380
1894..	11,448	5,535	28,550	25,700	21,310	332,436	1,528	35,755
1895..	......	10,020	29,810	26,830	22,238	335,800	1,480	31,970

(*a*) The figures for 1891–95, inclusive, furnished by Mr. E. Grohmann, of Seriphos. The figures for gypsum, lignite, millstones, puzzolan, salt, and sulphur are the sale returns. The figures for all the other substances are the quantities exported. Of substances not included in the above there were sold: Silver, 1890, 200 kgms., $6000; soft lead, 1890, 27 tons, $1700; 1892, 76 tons, $4370. Exported: Copper ore, 1890, 150 tons, $5250; magnesia bricks, 1893, 1275 tons, $25,500. (*b*) Government monopoly.

ITALY

The mineral production of Italy is of large extent and variety and in some directions of very considerable importance. This production was treated at some length in Vol. II. of The Mineral Industry, and several of its branches are referred to elsewhere in this volume. Since that time the principal changes to be noted in recent years have been in the direction of improvements in machinery and of the use of better methods of mining.

Italy has only a small production of mineral fuel, and to this fact it is due that the metallurgical industries are on a comparatively limited scale, a considerable part of the more valuable minerals mined being exported in the form of ore. This is especially the case with the ores of zinc and lead.

Italy supplies the greater part of the sulphur used in Europe and the United States, and this is one of the more important articles of its commerce. The sulphur mines have suffered for several years from the effects of low prices and the lack of system in mining and preparing the sulphur for market. Several attempts have been made to combine the producers and to introduce improvements; so far without success, though the effort has not been abandoned.

The following tables show the mineral production of Italy for the five years ending with 1894:

MINERAL PRODUCTION OF ITALY. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Alum.		Alunite.		Antimony Ore.		Asphaltum.		Boracic Acid.		Copper Ore.		Gold Ore.		Graphite.	
1890	1,290	$26,276	5,000	$5,500	891	$65,742	45,125	$240,778	2,824	$301,424	50,378	$371,541	8,296	$104,320	1,735	$4,656
1891	1,029	20,080	4,000	3,840	891	65,742	28,180	135,780	3,831	444,780	53,059	565,867	7,729	93,276	2,415	6,593
1892	1,695	36,050	4,000	3,840	621	45,672	34,580	168,184	2,560	321,910	102,427	552,288	6,612	94,696	1,650	3,778
1893	.....	....	4,200	4,031	1,193	40,402	25,980	113,160	2,847	313,170	96,299	509,509	7,393	132,746	1,465	3,080
1894	.....	....	6,000	4,800	1,504	45,059	60,493	280,678	2,746	236,156	92,886	445,629	7,748	132,782	1,575	2,520

Year.	Iron Ore.		Iron Pyrites.		Lead Ore.		Lignite.		Manganese Ore.		Manganiferous Iron Ore.		Mercury.	
1890	220,702	$483,203	14,755	$37,719	32,187	$1,301,539	376,326	$581,254	2,147	$10,414	....	....	449	$583,994
1891	216,486	553,437	19,868	54,118	30,233	1,196,846	289,286	441,170	2,429	12,919	....	....	330	356,400
1892	214,487	554,431	27,670	71,987	33,310	1,139,098	295,713	426,073	1,243	8,359	4,622	$8,320	325	305,500
1893	191,305	356,539	29,460	72,227	29,004	813,107	317,249	454,300	810	6,548	8,805	14,960	273	264,737
1894	187,728	417,831	22,638	59,269	29,882	758,422	271,295	378,792	760	4,700	5,810	9,296	....	....

Year.	Petroleum.		Salt, Rock.		Salt, Saline.		Silver Ore.		Sulphur.		Zinc Ore.	
1890............	417	$24,121	17,099	$51,660	9,879	$67,799	1,750	$420,195	369,239	$5,653,058	110,926	$2,450,529
1891............	1,131	68,420	31,285	75,890	9,258	53.390	2,006	394,697	395,528	8,905,091	120,685	2,544,121
1892............	2,548	150,900	15,504	49,619	8,217	38,455	1,680	345,898	418,535	7,844,333	129,731	2,722,099
1893............	2,652	159,010	16,790	56,910	8,602	39,810	1,236	235,594	417,671	5,923,335	132,767	2,093,415
1894............	2,853	169,452	19,467	56,974	11,326	57,861	1,103	169,445	405,781	5,053,591	131,777	1,839,791

METALLURGICAL AND REFINED PRODUCTS OF ITALY. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Antimony.		Asphaltum.		Boracic Acid.		Borax.		Briquettes.		Copper.	
1890....	182	$54,716	10,302	$80,594	1,874	$187,400	950	$114,000	579,050	$3,664,740	6,406	$2,504,365
1891....	218	37,714	9,375	66,020	1,775	177,500	2,056	267,280	644,005	4,099,570	5,977	2,243,229
1892....	315	53,822	9.270	78,570	1,089	130,680	1,471	191.230	612,069	3,883,650	6,039	2,159,469
1893....	376	59,560	8,905	65,711	2,847	313,170	1,099	104,287	540,790	3,273,730	6,911	2,386,247
1894....	251	57,626	7,820	49,826	2,746	236,156	1,141	136,872	433,309	2,901,012	7,048	2,466,927

Year.	Gold—Kilos.		Iron, Pig.		Iron, Wrought.		Lead.		Petroleum, Benzine, etc., Refined.	
1890....	206	$108,836	14,346	$425,784	176,374	$9,769,728	17,768	$1,137,152	350	$42,000
1891....	284	166,839	11,930	315,209	152,668	7,996,459	18,500	1,139,600	813	74,448
1892....	330	202,579	12,729	411,258	124,273	6,278,691	22,000	1,144,000	1,573	154,495
1893....	362	224,203	8,038	230,921	138,046	6,826,843	19,898	994,300	2,613	258,676
1894....	349	252,057	10,329	301,339	141,729	6,643,615	19,605	968,446	1,640	193,520

Year.	Salt, Sea.		Silver—Kilos.		Steel.		Sulphate of Alumina.		Sulphur, Refined.	
1890....	442,010	$899,851	32,248	$1,164,432	107,676	$5,821.481	2,553	$58,430	105,660	$2,213,171
1891....	347,274	613,555	37,600	1,203,200	75,925	3,948,766	859	17,108	154,611	4,393,278
1892....	395,269	800.831	43,000	1,281,400	56,543	2,756,499	1,890	40,450	182,630	4,595,280
1893....	397,506	929,522	40,095	1,130,679	71,380	3,397,426	2,050	43,878	34,750	641,902
1894....	402,515	830,382	58,626	1,289,772	54,614	3,353,852	2,480	45,960	71,295	1,152,576

Imports and Exports.—The following table shows the mineral imports and exports for the five years ending with 1894:

	MINERAL IMPORTS OF ITALY. (*a*) (IN METRIC TONS.)								MINERAL EXPORTS OF ITALY. (*b*) (IN METRIC TONS.)							
Year.	Coal. (*c*)	Iron, Pig.	Iron and Steel. (*d*)	Machinery.	Marble, Alab'ster R'gh.	Marble, W'kd	Ores, Various.	Sulphur	Coal. (*b*)	Iron, Scrap	Iron and Steel. (*d*)	Machinery.	Marble and Alab'ster	Marble M'f's.	Ores, Various.	Sulphur.
1890	4,354,847	168 043	101,284	31,651	476	277	6,607	28	7,098	59	889	1,189	68,820	58,313	286,889	328,708
1891	3,916,685	137,233	80,488	23,077	296	266	7,346	20	13,322	143	576	1,104	69,474	53.958	327,326	269,377
1892	3.877,571	145,723	80,889	22,392	216	379	16,497	50	12,919	256	683	1,076	77,816	57,917	272,278	291,081
1893	3,724,401	176,978	86,190	21,403	550	245	49,267	25	12,655	198	1,501	1,429	72,887	56,447	307,685	310,867
1894	4,696,258	157,153	83,367	......	250	......	15,406	267	13,692	67	645	......	72,812	......	308,555	299,090

(*a*) From the *Revista del Servicio Minerario*, and the metallurgical production for 1893 from *Zeitschrift für Berg- und Hüttenwesen*, 1894, p. 509. (*b*) The zinc ore exports were in 1890, 80,759; 1891, 104,656; 1892, 119,286; 1893, 113,218 tons. The iron ore exports were in 1890, 186,676; 1891, 202,309; 1892, 124,755; 1893, 156,273 tons. The lead ore exports were in 1890, 8266; 1891, 7328; 1892, 6695; 1893, 5561 tons. The copper ore exports were in 1890, 9894; 1891, 10,116; 1892, 12,719; 1893, 12,811 tons. (*c*) All kinds of fuel. (*d*) Wrought iron and steel.

It will be seen that coal and iron were the most important articles of importation, ores (mainly zinc and lead) and sulphur holding the chief places among the exports.

JAPAN.

THE mineral industry of Japan, which dates from an early period, has now passed through the transition stage, which was marked by the abandonment of the older methods which Japanese miners and engineers had worked out for themselves and by the adoption of improved machinery and processes. The country possesses mines of copper, lead, silver, antimony, and manganese, deposits of coal which are now extensively worked, sulphur, which is also worked on a large scale, and petroleum. Among the less important products are gold, silver, quicksilver, and tin.

The most noted metal mines are those of copper. The Ashio Mine has been worked for many years and is one of the great copper producers of the world. Its production has varied somewhat from year to year, but upon the whole is increasing.

The tables below give from the official statements the production of the mines owned by the government for a period of five fiscal years (ending May 31), and also that of the private mines for two calendar years. The output of the private mines is the larger and more important part of the total:

PRODUCTION OF GOVERNMENT MINES IN JAPAN. (*a*) (IN METRIC TONS.)

Products.	Number of Mines.	1889-90.	1890-91.	1891-92.	1892-93.	1893-94.
Gold, kilograms	2	238	260	218	273	306
Silver, kilograms	2	6,166	7,026	5,980	8,584	10,523
Copper, metric tons	2	36	24	17	275	148
Pig iron, metric tons	1	1,933	2,179	1,966	1,415	1,184
Lead, metric tons	2	....	....	....	69	162
Copper sulphate, metric tons	1	....	346	353	63	....
Coal, metric tons	2	187,036	6,687	14,900	20,907	20,088

(*a*) Fiscal years ending May 31.

PRODUCTION OF JAPANESE MINES WORKED BY PRIVATE OWNERS. (IN METRIC TONS.)

Year.	Antimony.	Antimony Sulphide.	Arsenic.	Coal.	Copper.	Copperas.	Gold. Kilos.	Graphite.
1892	42	1,341	3	3.180,347	20,485	....	406	600
1893	122	1,524	1	3,323,552	17,843	265	445	26

Year.	Iron.	Lead.	Manganese.	Petroleum	Quicksilver.	Red Ocher.	Silver. Kilos.	Sulphur.	Tin.
1892..........	17,453	818	5,018	2,015	15	....	51,308	20,486	41
1893..........	15,824	939	14,144	1,641	2	2	68,936	23,889	38

The coal production already exceeds the home requirements and a large part of it is exported, finding a market in the Chinese and other Eastern ports, where it has largely replaced English and Australian coal. The coal best known in these foreign markets is from the Takasima, the Miike, and the Namazuta mines.

Regular explorations have been carried on for some time in the petroleum fields, but without any marked results as yet. The sulphur mines continue to produce largely and the workings are being extended.

The following table shows the production of salt for six years. The returns do not specify what portion of the output is rock salt and what is obtained from sea water by evaporation:

SALT PRODUCTION IN JAPAN. (*a*) (IN METRIC TONS.)

Year.	Tons.	Year.	Tons.	Year.	Tons.
1888........	655,311	1890........	632,672	1892........	735,140
1889........	529,913	1891........	725,978	1893........	865,319

(*a*) Fiscal years ending May 31.

The recent war with China interfered slightly with mining operations in some directions, but stimulated them in others. The war has also given into the possession of Japan the great island of Formosa, which is known to have very valuable deposits of coal and petroleum. These it is proposed to develop systematically under the new administration of the country.

The iron industry has not been very largely developed in Japan as yet, chiefly because of the absence of a sufficient supply of ores. Great interest has been taken in it, the object being to make the country independent of foreign supplies so far as possible. The government has established steel works, machine shops, and shipyards, which are equipped with the best machinery, but the raw material for these works is nearly all imported. A sufficient supply of fuel exists and other conditions are very favorable for the industry.

From early times the Japanese have been noted for their very skillful and artistic work in metals, principally copper and its various alloys. Japanese bronzes and bronze work are known everywhere and form a valuable part of the trade of the country. In the preparation of the alloys as well as in working the metals great skill has been shown.

The manganese ore mined is for the most part exported, some of it coming to this country. A part of the antimony produced also comes to the United States, usually in the form of regulus.

Imports and Exports.—The following tables show the mineral imports and exports of Japan for a period of four years:

MINERAL IMPORTS AND EXPORTS OF JAPAN. (IN METRIC TONS.)

IMPORTS. (*a*)

Year.	Brass.		Coal.		Iron.		Kerosene.	Lead.		Nickel.		Quicksilver.	
1890........	6	$2,947	11,587	$110,497	10,512	$185,948	$4,950,256	971	$85,425	85	$118,423	64	$102,833
1891........	9	48,238	15,110	142,918	12,287	199,209	4,535,720	1,221	104,028	9	9,651	70	105,660
1892........	243	204,405	......	....	*b* 62,313	3,740,219	....	*c*7,077	759,033	......	....	66	95,546
1893........	163	67,471	7,517	81,707	98,944	4,301,400	4,401,401	3,547	331,868	42	60,761	76	115,082

Year.	IMPORTS—*Continued.* Tin.		Zinc.		EXPORTS. (*d*) Antimony.		Coal.		Copper.		Sulphur.	
1890....	127	$69,281	546	$69,716	1,716	$349,961	1,234,127	$4,796,090	19,567	$5,352,314	18,801	$263,283
1891....	128	71,721	336	42,762	1,859	232,499	1,259,782	4,749,734	17,464	4,877,090	19,149	284,831
1892....	104	62,984	......	....	1,229	163,309	1,300,068	4,577,106	18,013	4,870,501	....	....
1893....	142	90,578	3,065	462,690	1,316	183,854	1,519,888	4,817,913	15,364	4,574,709	10,441	238,833

(*a*) In 1893 were imported: Coke, 5105 tons, $29,325; copper, 3 tons, $1478; German silver, 46 tons, $38,290; graphite, 2 tons, $232; iron manufactures, $1,090,122; various metal manufactures, $255,679.
(*b*) Includes manufactures of iron and steel. (*c*) Includes sheet and pipe.
(*d*) Exported in 1892 and not on table: Minerals, 61,288 kgms., $110,131; lead, 48 tons, $419; brass and brass wire, 49.96 tons, $73,013; copper, sheet and wire, 9.47 tons, $31,680; iron manufactures, $44,806; bronze manufactures, $213,522; sundry manufactures, $43,007. In 1893 also exported: Bronze, 416 tons, $91,115; Coke, 1143 tons, $7219; various metal manufactures, $162,324; miscellaneous minerals, $217,086.

The chief items of the imports were iron and oil. The coal was the largest item in the exports, copper coming next with only a slightly lower value. Sulphur is also an article of importance in the list.

MEXICO.

THE production of Mexico is referred to in several of the articles in the preceding pages, but there are some features to which attention may be called.

Mexico has long been noted as a silver-mining country, but in 1895 she assumed the first rank as a silver producer, the output of 1,582,901 kgms. reported for the year exceeding that of any other country in the world. The continual opening up of new mines, the more active exploitation of old ones, and the large production are evidences that the mining of the white metal still leaves a margin of profit, in spite of the low prices which have prevailed. As in previous years, a large part of the silver mined in Mexico is coined at the National Mint and exported in that form, the Mexican dollar having a currency in the far East which gives it always a selling price slightly above its bullion value.

Another very considerable part of the silver produced in Mexico is sent from the smelters in that country to the United States in the form of base bullion and is refined here. In the article on "Gold and Silver" reference is made to the economic conditions which have built up a large and flourishing smelting industry in Mexico, so that the most of the silver-lead ores which were formerly exported before treatment are now smelted at home.

Few changes of importance in metallurgy can be reported, and the old processes are still largely used in the mines everywhere. Some progress has been made in the introduction of pumping and hoisting machinery and in the use of water power with electric transmission.

A feature in the Mexican mining industry not to be disregarded is the rapid increase in gold production. A few years ago gold mining was almost entirely neglected, but the active search for the yellow metal has had its effect in Mexico as well as elsewhere, and the production rose from 6771 kgms. fine gold in 1894 to 8427 kgms. in 1895, with every prospect for a further gain.

In copper the Boleo mines in Lower California continue to be the chief producer, though some copper is won elsewhere in connection with silver. The operations of the Boleo Company are increasing in extent and importance.

Lead is produced in Mexico only in connection with silver, and there are no mines of soft or non-argentiferous lead. The greater part of the lead made is exported, chiefly, as noted above, in the form of base bullion to be refined.

Quicksilver mining is on the increase, and the Huitzuco, the Guadalcazar, and the Nueva Potosi mines are all actively at work. Some new discoveries of cinnabar have been reported, but none of them are actually worked as yet.

The great need of the mining industry in Mexico is a supply of fuel at a reasonable price. The probability seems to be that this question will be solved by the gradual but steady extension of railroads. These will before long open up some of the coal deposits which are known to exist, but which have not been worked because their product could not be transported at a reasonable cost. It is important to note that by an amendment to the constitution of Mexico internal taxes on commerce between the States will cease after July 1, 1896.

Imports and Exports.—The following table shows the mineral imports and exports of Mexico for the five years ending with 1895:

MINERAL IMPORTS OF MEXICO. (*a*) (IN METRIC TONS.)

Year. (*b*)	Coal.		Coke.		Copper.		Iron and Steel.		Lime and Cement.		Marble.	
1891*c*...	....	....	......	....	......	....	......	....	......	....	......	....
1892*c*...	....	....	......	....	......	....	......	....	......	....	......	....
1893....	254,610	$1,356,666	62,386	$315,327	688	$529,175	57,233	$3,071,824	9,662	$140,251	245	$8,862
1894....	162,613	626,070	71,619	378,522	659	462,985	43,128	2,496,000	4,466	28,664	152	8,099
1895....	230,595	701,913	67,853	287,075	939	600,916	33,765	2,429,136	9,877	79,162	198	4,390

Year. (*b*)	Petroleum.		Quicksilver.		Soda, Caustic.		Sulphur.		Sulphate of Copper.	
1891*c*...	....	....	......	....	......	....	......	....	....	....
1892*c*...	....	....	......	....	......	....	......	....	....	....
1893....	22,404	$370,674	727	$603,525	834	$52,085	898	$18,996	1,442	$82,500
1894....	16,061	242,027	711	506,643	1,982	113,137	234	8,878	1,511	113,496
1895....	14,865	250,292	819	541,664	3,716	167,487	321	12,037	1,819	123,948

(*a*) From the *Boletin Semestral de la Direccion General de Estadistica* and the *Estadistica Fiscal.*
(*b*) Fiscal years ending June 30.
(*c*) No official figures have been published for the fiscal years 1890-91 and 1891-92, as we are informed by the Secretaria de Fomento.

MINERAL EXPORTS OF MEXICO. (*a*) (IN KILOGRAMS.)

Year. (*b*)	Gold and Silver.	Copper, Metallic.		Copper Ore.		Lead.		Tin.	
1891............	$36,256,372	5,364,871	$940,920	33,600	$850	8,138,194	$1,125,468	....	....
1892............	49,137,304	4,348,702	860,378	123,901	8,937	10,676,548	2,363,521	....	....
1893............	56,504,305	12,820,282	2,265,881	435,685	11,512	1,418,976	345,646	2,862	$1,420
1894............	46,484,360	11,516,382	1,979,728	2,877,321	65,441	1,146	100	58,416	13,231
1895............	52,535,854	13,339,788	2,148,184	2,707,585	64,261	39,931,656	1,807,402	29,563	16,879

Year. (*b*)	Coal.		Marble.		Guano.	
1891..........................	39,482,132	$160,702	1,111,612	$87,556	1,492,047	$29,000
1892..........................	55,969,921	221,154	1,400,355	169,654	....	....
1893..........................	8,279,968	33,960	3,367,591	349,233	559,936	12,021
1894..........................	49,729,184	205,605	1,039,841	108,512	....	....
1895..........................	53,192,661	232,919	1,518,827	167,136	....	....

(*a*) From the *Annuario de la Estadistica*, 1894. (*b*) Fiscal years ending June 30.

Iron, coal, and coke are the more important articles of import, while the precious metals, silver ore, copper, and lead were the chief exports.

RUSSIA.

If we consider the vast extent of the Russian empire, its great resources and its present production, we may say that its mineral industry is as yet only in its infancy, and presents greater possibilities of future development than that of any other country in the world. This development has been fairly begun and in some directions is being actively pushed, its progress depending chiefly upon the extension of the railroad system of the country, transportation being a most important element.

Russia is the fourth gold producer in the world, and in 1895 showed a considerable advance. The total production of gold in that year is estimated at 51,161 kgms., valued at $33,990,000, against 40,572 kgms., valued at $26,942,893, in 1894. The Ural region and Siberia are the main sources of this production, though a small amount is found in Finland. Nearly all the gold is obtained from placer workings, and vein mining has hardly been begun. A great increase is to be expected in the future from the adoption of improved methods and the use of machinery in the Siberian mines to which capital and labor are being attracted as they are made more accessible by the progress of the Siberian Railroad. To this may be added something from the new discoveries in Russian Turkestan, and in time also from the rich placers now known to exist on the Chinese side of the Amoor Valley, the working of which is now prohibited by the Chinese government, but which are pretty sure to pass under Russian control in a few years.

The silver production of Russia is not large; it was 10,272 kgms. in 1895 and 10,117 kgms. in 1894, nearly all coming from the Siberian mines.

The world is chiefly dependent on Russia for its supply of platinum. This rare metal is obtained in connection with gold in the Ural region; the total output is reported at 318 poods, or 5209 kgms., in 1894, which compares with 5094 kgms. in the preceding year.

In the production of petroleum Russia is second only to the United States, and not only supplies her own wants, but also exports a great quantity, competing with our own producers in Eastern Europe and in all the Asiatic markets. It is somewhat difficult to obtain exact statistics, but official figures furnished us by our correspondent in St. Petersburg put the production at 315,898,696 poods, or 5,174,421 metric tons, in 1894, while that for 1895 is estimated at 5,300,000 metric tons. At present nearly all of this oil comes from the Apsheron Peninsula, on the western shore of the Caspian Sea, Baku being the center of the producing district. Petroleum is known to exist also in Northern Russia, in the Caucasus, and in the island of Sakhalin on the eastern coast of Siberia; but these fields have been hardly touched as yet.

The coal and iron production is growing steadily, and the iron industry especially is encouraged by the government. For these products we have official figures for 1893 and 1894 and advance statements for 1895, which are given in the following table:

COAL AND IRON PRODUCTION OF RUSSIA. (IN METRIC TONS.)

Year.	Coal.	Pig Iron.	Wrought Iron.	Steel.
1893	7,551,180	1,160,737	436,000	390,000
1894	8,648,640	1,312,760	459,206	492,878
1895	9,725,000	1,454,298	464,810	574,112

The chief coal-producing districts at present are those of Poland and the Donetz Basin. A large production is expected from the Siberian coal fields when they become accessible.

Iron is made in Poland, in Finland, in South Russia, in the Ural, and in Siberia. The iron of the Ural district is of exceptionally good quality, and castings of extraordinary fineness are made there.

Of the pig iron reported in 1895 92.4% was made in private works and the remaining 7.6% in the government plants in Finland, Poland, the Ural, and Siberia. During the year there were 180 private plants at work, of which 88 were in the Ural, 48 in the Moscow district, 32 in Poland, 6 in North, 6 in South Russia, and 5 in the Southeastern district. The production and imports of pig iron for three years are given below:

PRODUCTION AND CONSUMPTION OF PIG IRON IN RUSSIA.
(IN METRIC TONS.)

Year.	Production.	Imports.	Consumption.
1893	1,160,737	162,145	1,322,882
1894	1,312,760	154,644	1,467,404
1895	1,454,298	132,776	1,587,074

It will be a long time before Russia is able to export iron, but she is evidently making progress toward supplying fully her own needs.

The following table shows the production of some other minerals in 1893 and 1894:

PRODUCTION OF CERTAIN MINERALS IN RUSSIA. (IN METRIC TONS.)

Year.	Asphalt	Chrome Ore.	Cobalt Ore.	Copper	Glauber Salts.	Iron Pyrites	Lead.	Manganese Ore.	Quicksilver Ore.	Salt.	Sulphur	Zinc.
1893	3,250	1,392	19	5,141	1,393	7,069	380	141,526	190	1,357,902	388	4,522
1894	3,651	1,500	21	5,133	1,403	7,500	359	157,241	196	1,336,608	400	5,014

The most important articles of export are petroleum and manganese ore. Of the latter a considerable quantity comes to the United States. Petroleum is sent chiefly to the East, and a large trade has been built up which is carried on by steamer from Batoum, on the Black Sea, by way of the Suez Canal. A number of tank steamers built for the purpose are engaged in this trade. Batoum is the shipping port for the oil district, being connected with Baku by railroad.

The Mineral Wealth of the Caucasus.

By F. Theis.

While it has long been known that the Caucasus is one of the richest mineral territories of Russia, its advance in production has been very slow, principally because of the mountainous and difficult nature of the country and the lack of roads. What can be done by proper enterprise has already been shown by the success which has attended the development of the petroleum industry by the Nobels and by the flourishing condition of the Siemens enterprises. In the following statement a short description is given of the occurrence and output of the useful minerals in the Caucasus.

Antimony.—Antimony ore is found on both slopes of the central chain of mountains in volcanic and metamorphosed strata. It is chiefly found in thin veins with occasional outcrops, but has not been mined on a commercial scale.

Arsenic.—Arsenic is found in connection with cobalt, nickel, and some of the rarer metals in small quantities in the Daschkessan mines of Siemens Brothers in the province of Telisavetpol.

Coal.—The production of coal is still small. Coal beds are known to exist at several points, but most of these are so difficult of access that it would be impossible to market the fuel. Moreover, unless it could be furnished at a very low price it could not compete in the neighboring markets with the petroleum residues, which in this part of Russia are commonly used on account of their cheapness. The most important deposit so far found is on the Ekwibul River, in the Okriv territory, at the foot of the Makeral Mountains to the northeast of Kutais. Coal outcrops on the mountain side, which rises sharply from the valley, the seams alternating with sandstone and clay. Their position shows that they occupy the upper part of the carboniferous formation. While this is true coal, a large bed of lignite, or brown coal, exists and has been worked to a small extent near the town of Vladikavkas, on the southern slopes of the Katsch-Duk Mountains. This lignite occurs in the Tertiary formation and the veins are generally thick and easy to work, but for the reasons above given only a small amount is taken out, for local use entirely. Several other lignite beds have been found in the Kuban territory and in the province of Tersch, but none has been worked except to a small extent for local consumption.

Copper.—Copper ores have been found in the foothills on the southern slope of the central mountain chain in the provinces of Telisavetpol, Erivan, and Kutais. So far as explored, the ores are found in veins and in masses and streaks, but seldom in the sedimentary formation. Sulphide ores are the most abundant, but copper oxide is found also, as well as native copper in masses. Owing to the difficulty of transportation only the richest deposits are worked at present. There are several small smelters in operation besides the large works of Siemens Brothers at Kedabschk. Here the latest improvements have been introduced, and it is understood that the results are profitable. The output of the works is between 1900 and 2000 tons of fine copper yearly. At first nearly all the smelting was done with charcoal, the firm having acquired an extensive tract of forest land to insure a regular supply. Recently, however, petroleum residues have been successfully used in the smelters. The ores are all smelted on the spot, the export of copper ore being prohibited by the Russian government.

Gold.—The existence of gold is known in the Caucasus in the primary formations as well as in the secondary strata. On the southern slope of the central mountain chain gold has been found in the primary formation, but nowhere in important quantities. In the mountain regions in the provinces of Telisavetpol, Erivan, Kutais, and Tiflis quartz veins are found carrying gold mixed with copper and iron pyrites. On the banks of the river Gous, in the province of Kutais, outcroppings of quartz carrying free gold have been found. At this point one prospector found a large nugget which is preserved in the museum at Tiflis. Placer workings have been carried on in the beds of the Rion, the Ingur, the Koder, and several of the small streams of both slopes of the central mountain chain. Most of these workings have been abandoned on account of the poor returns obtained. No gold has so far been found in the volcanic rocks of the Caucasus mountain regions, but it is quite possible that further explorations may show deposits of value.

Iron.—Extensive deposits of iron ore are known to exist in the Caucasus, but none has yet been developed. The difficulties of transportation are too great to permit shipments of ore, and no fuel of suitable quality is available.

Lead.—Lead ores are found on the northern slope of the central chain south of Tiflis and north of the Elborus. So far as explorations have extended, the ores occur usually in the forms of masses somewhat irregularly distributed in the sedimentary formation, no regular veins having been so far developed. A company known as the Elborus Company has recently been formed to work the deposits of Kortschai, which are believed to be rich and extensive.

Manganese.—One of the principal products at present furnished from the Caucasus is manganese ore. This is found on the southern slope of the central chain, and the largest deposit is in the province of Kapuia, near Sharopansk. Here the ore is found in extensive beds in the basin of the Quirilla, a small branch of the Rion River. In several other places it is found in wide veins and masses in the Tertiary rocks. The mineral most common is wad, but pyrolusite, manganite, and psilomelane are also found. The contents of the ore taken out in the Sharopansk district run as high as 83% of peroxide of manganese, and the exports have reached a considerable figure. The principal workings are near the village of Tschiatur.

Silver.—A small quantity of silver has been obtained from the copper and lead ores of the Caucasus. No silver is known to exist there except in connection with those metals.

Quicksilver.—Cinnabar has recently been discovered near Hapza, on the left bank of the Isamur River, in the province of Daghestan, and so far as explored it appears to exist over a large area. A number of prospectors have examined this deposit and 44 requests for concessions have been made to the authorities, so that it is probable that a good deal of development work will be done.

Sodium Sulphate.—A large bed of sulphate of soda exists about 25 miles from Tiflis which in some places is from 6 to 7 meters thick. This bed has been worked to some extent, the mineral being used for the manufacture of soda by the Le Blanc process. In the Baku oil fields there is a large demand for the substances used in the purification of oil, such as caustic soda, but heretofore these, with the sulphuric acid required, have been imported from England.

Sulphur.—The occurrence of sulphur has been known for a long time at several points in the Caucasus. The most important localities are in Daghestan, in Terghana, in Kudan, in the Baku and the Nachitshewan districts in the province of Grigan, and in the Euscher district of the province of Tiflis. The principal production is from the Tschirkat mines, in the Tchiut Mountains, which are owned by a French firm, the product being chiefly exported. A large demand for sulphur is found in the oil district of Baku, but this is mainly supplied by imports.

Zinc.—The principal occurrences of zinc ore are as sulphides found in connection with lead and copper ores, although some small deposits have been found that are not associated with lead. The entire production at present is from the government mines at Alagir, which produce from 2000 to 3000 tons yearly. No other mines are worked.

SPAIN.

In some important particulars the mineral production of Spain is notable. The mines best known produce copper ores, lead, iron ores, iron pyrites, quicksilver, and sulphur; copper and lead are most important.

The following tables show the production for a period of five years:

MINERAL PRODUCTION OF SPAIN. (*a*) (IN METRIC TONS AND DOLLARS; $1 = 5 pesetas.)

Year.	Alum Ore.		Antimony Ore.		Asphalt Rock.		Clay.		Coal.		Cobalt Ore.		Fluorspar.	
1890	......	......	820	$25,348	43	$98	5,397	$5,577	1,212,089	$2,424,177	111	$4,368	5	$97
1891	340	$1,700	693	20,805	248	523	180	360	1,262,510	2,525,020	60	1,804	3	54
1892	550	2,750	395	12,467	503	1,051	132	264	*b*1,611,761	3,835,676	......	......	2	36
1893	650	3,250	88	2,784	820	1,280	60	30	1,484,794	2,280,720	18	194	56	272
1894	310	1,549	35	700	985	2,010	.....	......	1,776,000	2,535,303	52	624	18	230

Year.	Copper Ore.						Graphite.		Iron Ore.		Iron Pyrites.		Kaolin.	
	Argentiferous.		Iron, Copper Pyrites.		Copper and Cobalt.									
1890	334	$2,576	3,011,779	$11,058,323	5,077	$121,848	95	$1,064	6,546,495	$7,855,794	163,825	$532,760	1,938	$22,065
1891	......	......	3,495,761	13.285,892	3,444	61,361	63	706	5,601,558	6,721,868	283,721	922,662	1,262	13,882
1892	......	......	2,731,593	13,111,649	2,086	50,064	34	249	5,236,275	6,283,531	232,162	754,993	500	5,000
1893	15,219	27,901	2,144,908	2,151,603	1,116	26,784	....	....	5.419,071	4,056,546	220,000	110,000	1,502	5,397
1894	11,879	21,744	2,432	2,383,820	906	21,746	10	30	5,397,419	4,031,884	120,000	60,000	247	1,896

Year	Lead Ore.		Lead Ore, Argentiferous.		Lignite.		Manganese Ore.		Mercury Ore.		Phosphates.		Salt.	
1890	161,875	$4,532,995	332.739	$10,146,545	26,307	$42,090	9,872	$98,722	34,580	$1,492,960	48	$96	615,727	$1,813,932
1891	160,418	4,491,712	264,625	8,071,065	27,188	103,500	6,993	6,973	35,169	1,749,583	1,542	3,084	582,833	1,748,498
1892	215,906	5,613,558	192,517	5,852,518	*c*32,870	41,127	16,910	136,171	35,025	1,755,538	2,150	3,152	682,634	2,596,741
1893	169,707	3,263,648	179,458	4,139,695	35,315	41,967	1,460	7,666	34,309	1,628,188	211	415	151,464	85,052
1894	152,879	2,357,494	173,004	5,367,991	45,368	63,267	430	612	31,537	1,230,455	40	80	206,565	88,898

Year	Silver Ore.		Steatite.		Sulphate of Barium.		Sulphate of Soda.		Sulphur Ore.		Tin Ore.		Topaz of Hinojosa—Kil		Zinc Ore.	
1890	3,574	$26,029	3,106	$9,693	335	$2,680	332	$1,494	29,639	$76,670	61	$9,255	337	$2,423	81,398	$651,184
1891	15,085	62,189	2,510	10.564	671	5,360	911	4,012	30.577	79,513	69	12,456	1,900	27,654	78,216	651,180
1892	656	113,543	1,341	6.576	665	4,658	350	1,540	26,330	68,458	244	42,347	280	3,173	74,265	530,555
1893	4,825	257,041	4.010	18,705	643	2,943	180	270	24,793	59,830	34	3,611	81	1,874	62,616	387,101
1894	7,411	237,995	3,181	13,728	......	...	312	468	21,414	55,677	26	2,678	.....	1,495	58,964	398,646

(*a*) From the official *Reports of the Comision Ejecutiva de Estadistica Minera*, Madrid, 1894. The figures for 1894 were kindly furnished by Señor Don Roman Oriol as published in the *Revista Minera*.
(*b*) Including lignite. (*c*) Fiscal year 1891–92.

Notwithstanding the large production of ores, the metallurgical output is small, a great part of the ores mined being exported. This is partially due to the absence of mineral fuel, a large portion of that now used being imported.

The following tables show the metallurgical production of Spain for five years:

METALLURGICAL PRODUCTION OF SPAIN. (*a*) (IN METRIC TONS AND DOLLARS.)

Year.	Alum.		Arsenic Sulphide.		Refined Asphalt.		Hydraulic Cement.		Coke. (*b*)		Copper. (*c*)		Iron, Pig.	
1890....	...	....	60	$7,541	23	$188	135,988	$388.109	191,235	$772,975	64,373	$9,542,469	170,782	$2,732,634
1891....	...	....	58	4,753	192	2,531	150,721	423.355	304,030	1,257,407	58.067	8,345,389	159,250	2,002.075
1892....	...	....	72	4,165	845	10,985	114,428	296,598	354,644	1,493,284	81,343	11,240,821	*d*259,575	7,260,461
1893....	650	$3,250	129	8,262	580	7,540	140,314	356,071	390,110	1,443,544	45,409	4,893,719	134,563	1,878,728

Year.	Iron, Wrought.		Steel.		Lead. (*j*)		Lead, Argentiferous.		Mercury.		Silver—Kilos.	
1890......	61,445	$2,949,355	75,255	$3,100,491	91,628	$5,611,855	86.325	$8,977,779	1,813	$2,239,547	52,000	$1,770,496
1891.....	64.799	3,110,347	69,902	2,804,468	82,463	5,050,034	76,622	8,427,776	1,790	1,840,108	50,051	1,704,187
1892......	(*e*)	......	(*e*)	....	125,550	6,981,048	93,710	7,297,619	1,657	1,607,579	72,000	2,339,817
1893......	58,923	2,441,290	76,583	3,048,669	77,486	3,886,695	91,832	7,138,834	1,666	1,394,630	63,605	1,774,671
1894......	......	....	70,000	....	152,620	8,175,000	......	....	.....	....	85,000	....

Year.	Sulphate of Soda.		Sulphur.		Zinc.					
					Pig.		Sheet.		Calamine, Calcined.	
1890......	128	$1,536	9,855	$221,737	3,103	$406,780	2,816	$495,040	35,348	$416,441
1891......	538	6,456	9,900	222,750	2,803	367,154	2,789	490,899	31,379	363,996
1892......	206	2,204	7,822	132,982	*f*5,908	....	(*g*)	....	28,118	*i*1,211,304
1893......	247	3,681	4,686	82.600	3,290	405,612	2,462	433,418	*h*21,548	13,963

(*a*) From the official *Reports of the Comision Ejecutiva de Estadistica Minera*, Madrid, 1894. The figures for 1894 were kindly furnished by Señor Don Roman Oriol.

(*b*) Including briquettes, which were in 1890, 174,524 tons, value $698,096; 1891, 258,254 tons, value $1,036.192; 1893, 273,118 tons, value $1,117,672.

(*c*) Including precipitate and matte. The precipitate amounted in 1890 to 40,012 tons, value $7,402,140; in 1891, 33,401 tons, value $6.168,502; in 1893, 26,404 tons, value $3,696,628. The matte in 1890 amounted to 24,303 tons, value $2,124,673; in 1891 to 24,444 tons, value $2,116,784; in 1893 to 18,899 tons, value $1,175,956.

(*d*) Including pig iron, wrought iron, and steel.

(*e*) Included under iron, pig, 1892.

(*f*) Including ingot and sheet.

(*g*) Included under ingots, 1892.

(*h*) Estimated for the second half.

(*i*) Total value for ingots, sheet, and ore.

(*j*) In 1892 contains 99 tons antimonious lead, value $5963.

Additional substances, 1894: Cast iron, 260,000 tons; soft iron, 120,000 tons; mercury, 47,900 flasks; copper precipitate (*cascare de cobre*, 75% copper), 28,000 tons; copper matte (45% copper), 17,000 tons; zinc, 5700 tons.

In the preceding articles in this volume the lead and copper mines of Spain are referred to in detail, while notes will also be found on the treatment of quicksilver ores at the Spanish mines. Advance statements put the total lead production for 1895 at 176,000 tons, an increase of 13,380 tons over the preceding year. An increase in copper production is also indicated by the reports of the Rio Tinto, the Tharsis, and other copper-mining companies for the year.

Exports and Imports.—The copper produced from the Spanish mines is chiefly exported either in the form of ore or as matte or precipitate. The lead ores are also in large part exported, though there is a considerable production of metallic lead. Iron ores constitute a very important item of export, the Spanish ores being esteemed for their high grade and freedom from phosphorus. England and Germany are the chief purchasers of these ores. In 1895 some shipments were made to the United States.

The following tables show the mineral imports and exports for a period of five years:

MINERAL IMPORTS OF SPAIN. (*a*) (IN METRIC TONS AND DOLLARS; $1 = 5 pesetas.)

Year	Asphalt and Pitch.		Carbonates, Alkaline.		Chemical Products.	Coal. Tons.	Coke. Tons.	Coal. Value.	Coke. Value.	Gold Bars. Kilos.		Gold Coin.
1891	36,430	$728,621	23,159	$1,019,037	$2,855,200	1,634,400	228,926	$8,825,006	$1,236,002	1,922	$1,191,640	$4,766
1892	25,682	513,635	23,213	1,109,393	....	1,688,637	175,872	9,020,169	940,983	7,738	4,797,560	3,936
1893	33,608	672,164	25,649	1,128,571	....	1,497,699	267,288	8,014,112	1,410,045	2,203	1,365,860	1,008
1894	29,639	592,799	26,902	1,143,708	....	1,612,147	225,900	9,028,019	1,265,046	......	....	634,394
1895	33,766	675,316	27,501	1,219,755	....	1,515,506	255,043	8,190,270	1,377,230	......	....	119,929

Year.	Iron, Pig.		Iron, Bar.		Machinery. (*b*)		Petroleum, Crude.		Silver Bars. Kilos.		Silver Coin.	Soda Nitrate.	
1891..	34,609	$484,533	18,013	$776,996	30,611	$7,760,400	54,821	$2,192,863	544,901	$21,796,040	$487,916	15,816	$949,007
1892..	30,022	420,312	10,177	478,206	6,297	1,609,381	44,656	1,786,241	97,468	3,898,720	1,000,719	18,335	1,099,917
1893..	23,484	328,784	7,139	343,303	2,795	649,686	54,942	1,977,925	394	14,184	3,827,308	18,998	1,139,923
1894..	26,561	373,885	9,616	417,342	3,134	698,102	44,052	1,263,514	1,935	61,920	4,339,319	23,984	1,439,060
1895..	12,385	173,889	7,768	354,289	3,597	863,220	46,592	1,211,397	4,286	120,008	4,776,925	26,385	1,583,129

Year.	Steel.		Sulphur.		Tin Plate.		Tin Ingots.	
1891..................	45,002	$1,876,979	7,125	....	2,659	$265,929	625	$312,867
1892..................	31,637	1,214,953	8,568	$222,759	2,433	293,341	813	406,580
1893..................	15,143	717,841	6,330	162,186	2,986	268,794	1,004	395,362
1894.............. ...	23,121	973,998	5,674	124,840	3,212	254,567	936	459,244
1895..................	18,123	753,266	6,813	121,976	1,241	104,223	825	379,625

MINERAL EXPORTS OF SPAIN. (*a*) (IN METRIC TONS AND DOLLARS; $1 = 5 pesetas.)

Year.	Antimony Ore.		Copper Ore.		Iron Ore.		Iron Pyrites.		Lead-Silver Ore.		Manganese Ore.		Phosphates.	
1891..	551	$33,039	661,762	$5,029,398	4,343,887	$8,687,768	283,721	$567,443	19,405	$730,016	3,885	$36,520	1,935	$3,870
1892..	395	12,467	511,015	3,884,478	4,799,647	8,639,266	443,026	886,052	10,613	890,315	10,410	97,854	1,740	3,480
1893..	87	16,515	574,590	4,391,500	4,646,877	8,564,379	399,880	800,560	12,048	1,016,821	9,480	96,993	......	......
1894..	45	2,127	539,290	4,877,801	4,988,222	8,977,400	520,128	1,040,260	12,162	1,020,766	7,319	68,779	......	......
1895..	9	582	504,408	4,539,668	5,179,761	9,323,569	488,099	977,398	9,203	764,180	29,997	281,987	......	......

Year.	Zinc Ore.		Copper Matte and Precipitate.		Iron, Pig—Soft Iron and Steel.		Lead. (*d*)		Quicksilver.		Zinc, Bar and Sheet. (*e*)	
1891....	39,583	$238,391	32,270	$4,195,221	70,967	$1,456,889	146,029	$12,386,060	1,886	$2,112,159	2,044	$212,644
1892....	39,574	261,191	36,862	4,768,135	51,975	1,152,324	154,969	10,519,924	1,644	1,840,938	2,161	216,185
1893....	32,358	203,372	18,658	3,496,283	31,230	499,693	158,737	10,756,053	1,560	1,746,845	2,486	248,638
1894....	34,238	225,200	36,752	*c*4,213,024	48,749	682,112	158,735	11,091,540	870	974,340	2,680	267,999
1895....	29,356	293,177	59,507	4,385,213	22,669	315,930	151,129	8,451,967	1,327	1,486,647	1,367	126,669

(*a*) From the *Revista Minera de España* and figures kindly furnished by Señor Roman Oriol, excepting the mineral exports for 1890–92, which are from the *Report of the Comision Ejecutiva de Estadistica Minera*, Madrid, 1894.

(*b*) Engines and boilers only.

(*c*) Includes 35,096 tons matte, $350,970. Other exports: Coal in 1891, 11,460 tons, $61,880; in 1892, 14,300 tons, $77,706; in 1893, 8387 tons, $45,290; copper matte in 1891, 24,487 tons, $284,055; in 1892, 30,222 tons, $350,591; in 1893, 28,130 tons, $286,302; gold bullion and coin in 1891, $114,576; in 1892, $95,536; in 1893, $114,298; silver bullion and coin in 1890, 25,000 kgms., $1,010,456; in 1891, 101,509 kgms., $4,060,380; in 1892, 2,237,458, $8,349,832; in 1893, 705,703, $254,051; salt in 1892, $232,234 tons, $700,702; in 1893, 200,924 tons, $602,772.

(*d*) Includes argentiferous lead. (*e*) Includes calamine, calcined.

SWEDEN.

Sweden has been for many years noted for the high grade of its iron, and that branch of its mineral industry has always been the most important. In recent years the introduction of the Bessemer and other steel processes in other countries has supplied a metal which for many purposes could be substituted for Swedish iron, and the demand has fallen off. The iron makers of the country have recognized the conditions of the trade, and at an early date took up the Bessemer process, which they have used very successfully, introducing also certain improvements to adapt the process to their special purposes. Steel production, therefore, has taken an important place, though Swedish iron still continues to be made and exported.

Sweden also produces copper, the chief output being from the mines of the Stora Kopparbarget, which have been worked for over 800 years. A history of this ancient mine was given in Vol. I. of The Mineral Industry. Other products are lead ore, zinc ore, silver, cobalt, and a small quantity of gold.

The following table gives the mineral production of Sweden for a period of five years:

MINERAL PRODUCTION OF SWEDEN. (*a*) (IN METRIC TONS.)

Year.	Alum.	Cement Value.	Coal.	Cobalt Ore	Copper Ore.	Fire-clay.	Gold Ore.	Iron Ore.	Iron Bog Ore.	Iron Pyrites	Manganese Ore.	Nickel Ore.	Plumbago.	Pyrolusite (Powder'd)	Red Ocher	Silver and Lead Ore.	Zinc Ore.
1890	981	$477,729	187,512	145	20,670	126,003	1,457	940,429	812	1,134	10.698	616	14	45	1,534	14,986	61,843
1891	542	487,858	198,033	244	21,823	134,909	2,680	985,255	2,150	1,659	9,079	483	17	192	1,468	15,044	61,591
1892	346	581,188	199,380	53	24,069	123,096	3,463	1,291,933	1,650	1,249	7,832	....	15	172	1,090	19,803	54,981
1893	357	507,668	199,933	101	22,033	138,469	2,441	1,481,487	2,275	480	7,061	....	49	......	1,370	21,043	46,623
1894	261	....	213,634	....	25,710	129,617	.....	1,926,523	689	656	3,359	....	106	......	1,564	14,825	47,029

Year.	Brass.	Cobalt Oxi. Kilos	Copper.	Copperas.	Copper, Hammer'd	Copper, Sulphate	Gold. Kilos.	Iron. Pig.	Iron. Bloom.	Iron. Bar.	Steel. Bessemer.	Steel. Siemens-Martin	Steel. Other	M'f's of Iron and Steel.	Lead.	Silver. Kilos.	Sulphur.	Sulphuric Acid.
1890	275	7,020	617	500	363	636	87.664	456,103	225,632	281,833	94,247	72,985	2,055	78,998	310	4,555	42	16,714
1891	293	6,260	543	419	308	612	109.580	490,913	224,651	280,430	92,985	78,197	1,592	72,438	299	3,658	23	18,172
1892	302	7,138	745	476	314	580	87.626	485,664	235,426	273,510	82,422	76,556	1,494	......	799	5,211	46	28,147
1893	497	3,298	543	454	389	659	93.376	453,421	225,533	266,727	84,389	81,889	1,222	81,549	461	4,464	75	27,324
1894	...	1,580	350	362	.....	722	93.6	462,809	204,517	267,049	83,322	84,003	510	88,942	330	2,870	36	......

(*a*) From *Bidrog till Sveriges Officiela Statistik, Bergshandteringen* and *Tullkomitens Betänkande*, II., Bilaga 1, Stockholm, 1891. There were also produced of allanite 20 and 14 tons in 1890 and 1891; of litharge, 66 tons in 1890-92; of nickel matte, etc., 586 tons in 1889-91. In 1892 there was also an output of 16 tons of cement copper.

The mineral imports of Sweden are chiefly coal and coke, the country furnishing very little mineral fuel. The chief exports are iron and iron ore. The latter are increasing very rapidly, as the ores from the Gellivara mines have been introduced in Great Britain and large quantities are now taken by the British blast furnaces. The Gellivara ores are also sent to Germany.

Norway.

Iron is an important product of Norway, as well as of Sweden, although the Norwegian industry is less extensive. Norway charcoal blooms and bars at one time were a standard of excellence in the iron trade.

Gold is found in the river beds in Northern Norway, but is not mined. There is a small silver production, from the Köngsberg Works, which in 1895 yielded 4859 kgms. of silver, the balance sheet showing a loss of 9900 kroner, or $2750. The expenses, however, comprised over $15,000 applied to extensions, besides the expenses of an ordinary nature. The output for 1896 is estimated at some 400 kgms. more than during the previous year. Electric boring has been introduced experimentally with two machines from Messrs. Siemens & Halske, and this is expected to reduce the ore-breaking expenses 20% in future.

According to Professor Reusch, of the Norwegian Geological Survey, feldspar is mined on the southern coast of Norway, as well as quartz and mica. Most of the feldspar is exported to Germany, most of the mica to the United States.

In 1892 Norway exported 45,589 tons of building stone. The most remarkable of the Norwegian granite is the augite-syenite from the Laurvik country. The chief constituent of the rock is feldspar (Lodium orthoclase; called by Brogger "Krypto-perthit"); other constituents are augite, brown hornblende, and olivine. Professor Reusch says this rock is a quite distinct type of augite-syenite, which has not been found yet anywhere else, and which can be immediately recognized wherever it is used as ornamental stone. The Norwegian stone cutters call it "Labrador."

Professor Reusch also says that Norway has imported up to date all the marble it needed from other countries. In all probability, however, it will become a marble-exporting country. There are inexhaustible deposits of pure white, yellowish-white, grayish-black, and of a very beautiful red breccia marble in the district of Nordland near the polar circle. This beautiful rose-colored rock occurs in the granite gneiss of Hinderheim in the neighborhood of Trondhjem. It consists chiefly of piemontite and thulite (varieties of epidote and zoisite containing Mn_2O_3). It is used on a small scale chiefly in Paris as ornamental stone.

UNITED KINGDOM.

DURING 1895, as in the preceding year, the mineral industry of the United Kingdom suffered very little from strikes and labor troubles; it was generally in an improving condition, as better demand and higher prices were felt.

The following tables show the mineral production for five years:

MINERAL PRODUCTION OF THE UNITED KINGDOM OF GREAT BRITAIN AND IRELAND. (*a*)
(IN METRIC TONS.)

Year.	Alum Shale.		Arsenic.		Arsenical Pyrites.		Barytes.		Bauxite.		Clays.	
1890..	6,525	$4,010	7,395	$303,635	5,198	$22,070	25.769	$148,420	11,716	$28,815	3,362,447	$4,495,830
1891..	5.564	3,410	6,147	292,965	5,179	21,850	27,317	160,600	10,939	16,140	3,274,855	4,719,480
1892..	2,969	1,825	5,196	218,430	4,569	24,940	24,637	146,415	7,440	9,300	3,153,824	4,446,875
1893..	2,184	1,320	6,170	288,470	3,134	14,740	2,306	126,815	9,022	20,750	3,114,251	4,087,095
1894..	4,035	....	4,877	243,070	3,340	19,115	20,985	107,050	8,097	28,090	3,315,988	4,118,505

Year.	Coal.		Cobalt and Nickel Ore.		Copper Ore.		Copper Precipitate.		Fluorspar.		Gold Ore.		Gypsum.	
1890....	184,594,850	$374,769,985	85.37	$1,300	12,333	$139,005	351	$23,350	272	$1,260	584	$2,070	142,592	$289.955
1891....	188,519,767	370,499,080	Nil.	......	8,981	101,070	327	21,775	143	935	14,348	62,000	154,195	300,190
1892....	184,713,640	330,252,255	......	......	6,092	57,965	274	15,560	174	940	10,151	45,840	149,915	291,135
1893....	169,659,680	279,049,040	......	......	5,535	64,805	....	12,050	238	805	4,634	38,285	148,143	296,845
1894....	191,289,965	313,650,895	......	......	5,844	69,545	445	11,565	128	345	6,708	67,865	155,905	331,775

Year.	Iron Ore.		Iron Pyrites.		Lead Ore.		Manganese Ore.		Ocher and Umber.		Oil Shale.	
1890............	14,066,681	$19,632,225	16,281	$35,330	46,399	$2,030,820	12,646	$33,665	19,381	$87,375	2,248,516	$3,041.845
1891............	12,987,159	16,779,300	15,716	40,010	44,578	1,783,915	9,632	31,065	13,825	100.515	2,399.826	3,535,885
1892............	11,494,809	14,853,160	14,142	34,785	40,668	1,482,420	6,176	22,170	12,326	83,910	2.123,585	2,612.420
1893............	11,567,132	14,139,735	16,351	36,460	40,664	1,402.695	1,380	3,810	10,876	69.400	2,020,027	2,445,650
1894............	12,565,288	15,953,235	15,771	40.212	41,250	1,334,975	1,837	3,700	8,652	70,200	2,018,167	2,482,980

Year	Phosphate of Lime.		Salt.		Slates and Slabs.		Sulphate of Strontia.		Tin Ore (Black Tin).		Wolfram.		Zinc Ore.	
1890.	18,295	$147,500	2,182,045	$5,500,070	441,473	$5,136,175	10,444	$25,690	15,155	$3.912.460	106	$8,340	22,402	$549,450
1891.	10,164	100,000	2,077,072	4,884,120	421,829	4,835,000	8,193	20,150	14,726	3.676.200	140	16,705	22,580	567,225
1892.	12.396	111,250	1,988,024	4,307,005	424,975	5,129,610	5.147	6.330	14,588	3,672.825	127	15,000	24,264	520,080
1893.	3.386	28,853	2,015,027	3,676,110	453,242	5,538,138	6.000	11,625	14,132	3,185.265	22	2,100	24,524	406,350
1894.	711	6,385	2,271,686	3,818,145	469,060	5,856,830	6,932	9,810	13,116	2,437,615	...	....	22,170	336,555

(*a*) Production figures for 1894 are from mines under the jurisdiction of the mine inspectors, whose reports are published in the *Summaries of Statistics* report.

The following table shows the output of certain metals for a period of five years:

PRODUCTION OF CERTAIN METALS IN THE UNITED KINGDOM. (IN METRIC TONS.)

Year.	Fine Copper.	Metallic Lead.	Tin.	Zinc.	Silver from Lead--Kilos.
1890	941	34,140	9,752	8,692	9,043
1891	731	32,733	9,503	9.037	8,673
1892	503	30,014	9,419	9,500	8,436
1893	439	30,173	9,124	9,585	8,663
1894	447	29,681	8,327	8,130	8,575

The production of copper is rapidly declining, owing to the exhaustion of the mines and the great cost of producing as compared with the foreign mines. Tin mining is also a vanishing industry, as the Cornish mines can no longer compete with the cheaper supplies from the far East. The Dolcoath Mine, in Cornwall, has recently been reorganized, and the stockholders will try the effect of introducing improved machinery and methods. Should these fail to make the mine pay, it will probably mark the end of Cornish tin mining.

In addition to the figures given above we have received the preliminary statements of the mine inspectors' reports for 1895. These show that the production of coal for the year was 189,661,362 long tons, an increase of 1,383,837 tons over 1894 and the largest output ever reported in a year. The production of iron ore was 7,231,835 long tons. The quantity of oil shale mined was 2,246,865 long tons and that of fireclay 2,314,983 tons.

The total production of pig iron in 1895 was 7,895,675 long tons, an increase of 7.2% over 1894. The steel production was 3,259,962 long tons, of which 1,535,225 tons were Bessemer and 1,724,737 tons open-hearth steel.

During 1895 the total number of persons employed in and about the mines of the United Kingdom was 733,657, of whom 584,298, or about 80%, worked underground and 149,359, or about 20%, on the surface. Of the surface workers 5636 were women. In addition to the number reported in the mines, there were 104,625 employed in the quarries and open workings.

Exports and Imports.—Great Britain continues to be the great coal-exporting country, and from 16 to 20% of its yearly production is sent abroad. It is also a very large exporter of iron and steel in all forms, as is shown by the following tables, which give the exports and imports for the five years ending with 1895:

MINERAL IMPORTS OF THE UNITED KINGDOM. (IN METRIC TONS; £1 = $5.)

Year.	Alkali.		Brimstone.		Copper Ore.		Copper Regulus and Precipitate.		Copper, Unwrought and Part Wrought.		Chemical Products.
1891....	4.428	$252,020	21,766	$647,485	90,423	$3,664,550	125,223	$16,507,525	44,958	$11,819,550	$6,845,365
1892....	2,857	207,580	26,499	738,905	93,399	2,926,865	136,328	16,450,530	35,626	8,279,710	7,511,470
1893....	4.456	395,520	26.171	624,985	82,099	2,430,110	120,621	14,164,700	42,694	9.571,585	6,778,230
1894....	7,908	519,120	24,281	513,140	84,138	2,468,125	80,114	8,844,835	57,970	11,821,590	6,876,435
1895....	9.355	572,930	25,319	496,835	101,353	2,873,015	92,732	11,164,775	43,219	9,159,030	7,449,615

Year.	Glass of All Sorts.		Guano.		Iron Ore.		Iron, Bar, Angle, Bolt, and Rod.		Iron, Girders, Beams & Pillars		Iron Manufactures.	
1891..	76,659	$9,045,205	24,003	$693,210	3,231,750	$12,267,035	78,674	$3,757,935	75,227	$2,549,400	157,540	$13,823,605
1892..	81,111	9,351,095	28,323	947,165	3,841,369	13,584,100	77.137	3,461,295	75,781	2,512,870	146,093	12,660,590
1893..	134,665	12,216,295	18,600	473,605	4,131,323	13,960,140	66,810	2,965,165	73,480	2,096,915	153,139	12,728,195
1894..	106,478	11,346,775	28,661	720,555	4,485,880	14,917,985	64,265	2,777,790	70,537	2,141,150	157,387	12,164,025
1895..	101,391	10.564.945	49,849	1,961,975	4,521,516	14,889,760	68,933	2,747,610	70,307	2,181,920	166,063	14,204,230

Year	Steel, Unwrought.		Lead, Pig & Sheet.		Nitrate of Soda.		Paraffine.		Petroleum. Liters.		Phosphate of Lime and Rock.	
1891	8,572	$437,840	172,456	$10,688,370	123,998	$5,249,090	28,418	$4,025,170	494,378,537	$13,426,840	260,906	$3,141,975
1892	6,587	312,430	185,725	9,882,180	121,486	5,100,960	28.074	3,748,520	492,754,491	12,234,530	319,187	3,328,544
1893	9,079	452,530	194,252	9,276.075	88,169	4,030,985	39,025	4,069,685	577,151,861	12.733,800	328,461	2,972,335
1894	8,726	384,294	163,970	5,259,275	127,697	5,845,765	31,835	3,165,295	616,963,562	12,424,880	386,102	3,614,675
1895	11,036	475,015	165,531	8,370,215	124,649	4,994,485	36,619	3,778,950	583,285,093	16,844,520	365,414	3,171,070

Year.	Pyrites, Iron, Copper, or Sulphur.		Quicksilver.		Saltpeter.		Silver Ore.	Tin in Blocks, Ingots, Bars, or Slabs.		Zinc, Crude, in Cakes.		Zinc Manufactures.	
1891	626,148	$5,631,235	2,135	$2,537,515	14,163	$1,255,105	$18,831,695	28,661	$12,825,370	59,455	$6,647,525	20,483	$2,571,980
1892	614,142	5,317,530	1,939	1,980,920	15,666	1,339,655	15,160,845	29,942	13,719,070	53,643	5,512,955	19,263	2,315,400
1893	622,634	5,327,025	1.767	1,705,930	12,323	1,069,370	15,354,655	34,093	14,460,535	57,842	5,036,985	18,739	1,991,765
1894	625,968	5,258,510	1,952	1,516,810	14,694	1,327,795	12,199,775	39,777	13,592,495	54,768	4,098,745	18,844	1,775,110
1895	591,782	4,935,825	1,685	1,672,790	11,607	1,068,265	8,732,220	42,269	13,155,190	63,523	4,669,455	19,674	1,875,855

MINERAL EXPORTS OF THE UNITED KINGDOM. (*a*) (IN METRIC TONS.)

EXPORTS OF DOMESTIC PRODUCE.

Year.	Alkali.		Brass and Manufactures.		Cement.		Coal, Coke, Cinders, and Fuel.		(*b*) Coal, etc., for Ste'm'rs	Coal Products. (*c*)	Copper, Unwrought, in Ingots.	
1891	316,383	$11,676,405	5,793	$2,583,030	585,242	$5,703,485	31,584,570	$94,475,390	8,673,933	$7,849,570	35,928	$9,823,740
1892	299,018	10,597,200	5,498	2,272,685	500,546	4,514,550	30,944,282	84,053,790	8,738,591	6,661,865	42,972	10,307,220
1893	296,481	9,289,640	5,877	2,291,165	444,898	3.722,120	29,512,740	71,877,380	8,257,207	6,375,310	28,802	6,836,460
1894	303,786	8,148,895	6,527	2,023,575	432,782	3,519,755	33,600,000	86,879,035	9,444,000	6,319,215	19,770	4,255,585
1895	318,023	7,800,700	5,439	2,094,490	401,727	3,209,590	33,641,447	77,213,520	9,558,314	7,863,515	30,108	6,744,500

Year.	Copper, Wrought or Manufactured.		Mixed or Yellow Metal.		Earthenware.	Glass of All Sorts	Hardware and Cutlery.	Implements, Tools and Parts.	Iron, Pig.		Iron, Bar, Angle, Bolt, and Rod.	
1891	16,425	$5,384,245	66,650	$19,140,560	$9,791,720	$5,067,085	$12,637,875	$6,557,865	853,580	$11,027,835	220,617	$7,314,500
1892	16,478	4,864,985	74,619	18,817,645	9,523,560	4,426,525	10,973,630	6,310,245	779,402	9,873,725	176,206	5,738,410
1893	17,277	4,861,505	66,889	3,410,870	9,117,405	3,829,700	10,233,030	6,130,725	853,391	9.857,590	151,329	4,647,760
1894	15,664	4,146,425	16.213	3,435,155	8,038,700	3,582,385	9,190,630	5,922,985	843,815	9,561,750	121,269	4,112,785
1895	15,918	4,217,380	15,205	3,165,550	9,197,705	3,945,270	9,314,790	6,238,540	880,446	10,377,745	146,348	4,445,250

Year.	Iron, Railroad, of All Sorts.		Iron and Steel Wire and M'f's Excpt Tel. Wire		Iron Hoops, Sheet, Boiler, Armor. (*d*)		Iron, Galvanized Sheets.		Tin, Plates and Sheets.		Iron, Cast and Unwrought, and Manufactures.	
1891	713,553	$19,263,820	68,603	$5,715,635	160,000	$6,252,705	166,541	$11.550,540	455,598	$35,833,275	370,778	$24,032,005
1892	475,538	11,236,110	48,112	3,969,575	142,373	6,318,035	159,649	10,385,340	401,866	26,651,080	325.059	21,811,445
1893	567,823	12,555,070	37,735	3,237,305	141,845	6,096,035	169,407	10,228,750	385,480	24,956,500	285,095	18,825,125
1894	430,416	9,427,840	35,380	3,107,110	131,803	5,237,555	172,536	9,760,330	359,782	21,751,085	270,589	17,190,325
1895	465,359	9,509,010	42,932	3,555,350	104,722	3,822,800	207,469	11,245,465	371,838	21,223,975	294,682	18,704,435

Year.	Old Iron for Remanufacture.		Steel, Unwrought.		M'f's of Steel or Steel and Iron Combined.		Total of Iron and Steel.		Lead, Pig, Sheet, Piping, and Manuf'res.		Locomotives.	Mining-Machinery.
1891	112,856	$1,771,845	152,874	$8,660,365	17,311	$2,962,475	3,292,312	$134,385,000	49,010	$3,412,395	$8,086,270	....
1892	108,202	1,638,080	151,532	8,703,270	15,491	2.503,770	2,783,381	108,828,840	59,098	3,542,550	4,918,760	....
1893	120,461	1,671,370	170,407	8,509.170	18,826	2.378,110	2,903,753	102,962.885	49,723	2,763,005	2,313,300	$2,047,525
1894	87,387	1,134,365	215,428	9,881,090	19,158	2,490,465	2,699,345	93,655,700	47,905	2,594,340	3,750,195	1,933,555
1895	97,186	1,243,365	213,462	9,743,495	24,082	3,109,915	2,883,559	98,476,910	42,353	2,472,670	3,997,985	3,604,275

Year.	Salt, Rock, White.		Telegraph Wire and Apparatus.	Tin, Unwrought.		Zinc or Spelter, Unwrought & Wrought.	
1891................	682,078	$2,982.040	$7,170,100	5,249	$2,457,460	7,798	$808,665
1892................	664,668	2,696.310	4,549,585	5,738	2,720.335	9,974	894,880
1893................	646,389	2,522.500	5,314,435	6,848	3,031,995	9,895	793,155
1894................	771,398	3.020.675	7,087,230	5,944	2,160,950	9,372	635,645
1895................	753,338	2,732,925	3.949,050	5,748	1,915,145	10,023	650,675

EXPORTS OF FOREIGN PRODUCE.

Year.	Chemical Manufactures and Products.	Copper, Unwrought and Part Wrought.		Glass of All Sorts.		Guano.		Iron, Bar, Angle, Bolt, and Rod.	
1891...........	$808,890	11,874	$3,290,605	5,229	$504,765	1,073	$52,290	57,034	$2,282,105
1892...........	1,083,545	11,261	2,797,665	4,516	460,360	1,961	60,000	47,225	1,914,320
1893...........	984,285	13,050	3,066,395	4,702	431,860	1,472	63,670	28,533	1,199,960
1894...........	1,081,660	6,597	1,394,975	4,735	372,505	1,549	53,785	18,663	700,685
1895...........	1,050,435	8,093	1,788,920	4,334	380,285	2,001	63,085	23,185	874,945

Year	Steel, Unwrought.		Iron and Steel Manufactures.		Petroleum. Liters.		Quicksilver.		Saltpeter.		Tin, in Blocks, Ingots, Slabs, or Bars.	
1891........	4,291	$230,795	29,750	$2,367,790	4,370,092	$267,855	1,928	$2,222,845	1,219	$111,715	14,856	$6,694,470
1892........	3,004	147,390	38,761	2,638,255	9,010,298	527,005	1,713	1,662,885	1,574	131,335	16,627	7,665,500
1393........	4,983	246,440	47,860	2,925,770	5,988,157	339,155	1,298	1,200,240	1,396	110,255	19,377	8,441,810
1894........	3,789	146,520	35,521	2,117,910	7,497,161	288,525	1,482	1,296,890	2,716	237,195	21,887	7,615,235
1895........	5,289	234,030	36,687	2,564,485	6,665,467	268,690	1,253	1,234,620	1,459	130,020	21,043	6,597,305

(*a*) From *Accounts Relating to Trade and Navigation of the United Kingdom.*
(*b*) Coal, etc., 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 returns.
(*c*) Including naphtha, paraffine, paraffine oil, and petroleum.
(*d*) Prior to 1895 iron black plates for tinning were included under this heading.

These tables show to how great an extent the United Kingdom is an importer of raw materials and an exporter of finished products.

OTHER COUNTRIES.

We give below such particulars as are attainable with regard to other foreign countries. In most of these the mineral industries are of small importance.

Bulgaria.—Mining is still in a rudimentary stage in Bulgaria, and attention is now directed to the development of only coal, mineral waters, and quarries. The coals found in the country are of two classes, lignites and anthracites. The lignites occur at many points in the Balkans, and the more important centers of production are Pernik, Bobowdol, in Northern Bulgaria, and Mirichien, in Southern Bulgaria. There are beds of anthracite at Trevna, Toudin, and Svoghia, which furnish the better class of coal of the country. The Pernik Mine has now a yearly output of 150,000 tons. The Bobowdol Mine has been worked under unfavorable conditions, with badly planned openings, but furnishes at least 2000 tons yearly to the works at Daubnitza and Kustendil; difficulty of transportation, which has to be by pack-horse, retards the development and working of this deposit. The Trevna Mine, formerly worked by the Turks, supplied the works at Tirnova and Gabrovo. The recent explorations seem to show that there is not a continuous coal bed, but rather a series of deposits, thus rendering the working difficult and expensive. The same conditions affect the coal beds of Svoghia and the other coal districts.

Iron ore has been found and was formerly mined, and there are many remains of Catalan forges; but the iron industry has been completely abandoned. Lead ores have been found near Kustendil, but the tenor in lead and silver is not determined.

Some of the rivers carry auriferous sands, which the Macedonians have for years come to wash, but the gold industry has not much importance.

Notwithstanding active search, petroleum deposits have not been found. Apparently the oil-bearing strata which exist throughout the Balkan Peninsula do not extend into Bulgaria.

The quarries of building stone furnish some excellent varieties and have been worked in the neighborhood of the larger towns to a considerable extent.

Portugal.—This country produces coal, copper ore, antimony, and some minerals of minor importance. The copper ore is nearly all from the Mason & Barry mines and is exported for treatment. Iron ores are found, but are not worked to any extent.

A recent authority says that there are three distinct coal deposits in Portugal. In the north, near Oporto, anthracite coal of good quality occurs, but it is often so mixed with shale as to render the working difficult. The principal mines are Sao Pedro da Cora, Passal da Baioco, Covello, and Midors Pegas. The large coal extracted from these mines is used in Oporto in cooking ranges and stoves, and the small coal is made into briquettes for the same purpose. Near Busaco, at Santa Catherina, there are seams of a semi-bituminous coal, but they are not now being worked. Near the town of Batalha, which is situated 60 miles north of Lisbon and 12 miles south of the Oporto & Lisbon Railway at Leiria, there is a coal field extending to 1200 acres, where the outcrops of several seams of coal have been located and a few drifts made to prove them toward the dip. The Batalha coal is lignite rather than true coal. A similar deposit is found 6 miles distant at Porto de Moz, but is not now worked.

Switzerland.—This country produces only a little coal and some iron ore. A small quantity of placer gold has been obtained in some of the Alpine streams, but these placers are not now worked. The mineral imports and exports for five years are given below:

MINERAL IMPORTS OF SWITZERLAND. (*a*) (IN METRIC TONS; 5f. = $1.)

Year.	Chemical Products	Coal and Coke.		Iron and Steel, Wrought, Pig, & Manufactures.		Iron and Steel, Pig & Wrought.		Iron Manufactures.		Mineral Oil, Crude and Refined.		Machinery and Locomotives.
1890..	$4,407,000	993,612	$6,092,800	154,632	$8,576,600	135,363	$5,253,200	19,268	$3,323,400	40,569	$1,763,800	$3,017,200
1891..	3,982,600	1,060,624	6,616,400	166,870	8,654,800	145,367	5,254,800	21,503	3,400,000	43,756	1,611,400	3,212,000
1892..	4,052,200	985,340	5,827,400	165,771	8,385,000	144,705	4,919,200	21,066	3,465,800	47,956	1,263,200	2,913,000
1893..	4,263,228	1,251,851	7,225,824	160,437	....	160,436	4,819,556	20,662	3,161,570	......	....	....
1894..	....	1,289,660	....	185,861	....	185,861	....	28,702	....	......	....	....

MINERAL EXPORTS OF SWITZERLAND. (*a*) (IN METRIC TONS.)

Year.	Chemical Products. (*b*)		Dyes, Coal Tar.		Iron Manufactures.		Machinery and Locomotives.
1890..........	7,591	$548,000	1,338	$1,785,000	3,317	$1,047,200	$4,461,400
1891..........	8,289	553,600	1,541	1,958,200	1,957	855,600	4,063,200
1892..........	9,078	638,900	1,756	2,276,600	2,203	800,600	4,015,600
1893..........	9,848	1,199,057	1,986	2,498,200	2,748	839,639	....
1894..........	11,500	1,399,000	2,136	2,629,300	2,821	798,160	....

(*a*) From *British Statistical Abstracts* and from figures furnished by the *Direction Générale des Douanes Fédérales*, Berne.
(*b*) Including spirits for technical use; 1893, 3704 tons, $290,772; 1894, 4146 tons.

Turkey.—No reliable statistics of the mineral industry of this country can be obtained, and what little is known about it is from foreign sources. The chief products exported are chrome ore, manganese ore, and emery, all from Asiatic Turkey. During 1895 about 4000 tons of chrome ore were shipped from Salonica and nearly 30,000 tons of manganese ore from Stratoni. A number of mining concessions—mainly for chrome ore, coal and iron ores—were granted during 1895, but it is impossible to say whether work has been begun under any of them.

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.			Antimony, Crude and Regulus.			Antimony Ore.			
	Lbs.	Kilos.	Value.	Lbs.	Metric Tons.	Value.	Lbs.	Metric Tons.	Value.	Total Value.
1891	3,921	1,779	*b*$7,635	3,258,701	1,498	$388,850	1,433.531	650	$36,232	$425,082
1892	43	19	51	3,950,864	1,792	392,761	192,344	87	7,338	400,099
1893	7,816	3,546	4,683	....	....	....	116,495	53	4,753	....
1894	5,303	2,406	2,524	1,205,752	547	79,265	375,468	170	18,068	97,333
1895	25,294	11,473	7,814	4,051,022	1,817	230,946	....	....	....	....

Year.	Asbestos.			Asphaltum.			Barium Sulphate.					
	Unmanufactured.	Manufact'ed.	Total.	Short Tons.	Metric Tons.	Value.	Man'f'c'd Lbs.	Metric Tons.	Value.	Unm'f'd. Lbs.	Metric Tons.	Value.
1891	$353,589	$4,872	$358,461	14,725	13,358	$229,350	3,813,760	1,729	$22,041	11,043,200	5,009	$4,505
1892	262,433	7,209	269,642	98,581	89,433	336,868	3,111,360	1,411	15,419	6,247,260	2,834	7,418
1893	175,602	9,397	184,999	76,996	69.854	196,314	2,265,121	1,028	11,179	6,681,920	3,031	7,612
1894	....	....	240,029	106,014	96,202	313,685	1,672,000	759	10,556	3,768,000	1,709	5,270
1895	225,147	19,731	....	79,294	71,935	212,407	....	....	....	....	....	....

Year.	Barytes.		Bauxite.			Brass and Manufactures of. Value.	Cement.		
	Metric Tons.	Value.	Lbs.	Metric Tons.	Value.		Barrels.	Metric Tons.	Value.
1891	7,412	$26,546	17,936,504	8,135	$46,252	$277,533	*c*2,991,236	542,820	$4,411,330
1892	4,667	22,837	12,804,253	5,808	57,948	235,782	*c*2,440,705	442,801	3,378,331
1893	4,450	18,791	11,431,678	5,185	28,217	215,650	*c*2,674,149	485,326	3,470,169
1894	2.720	15,826	2,305,783	1,046	6,661	134.356	*c*2,638,107	478,785	3,396,729
1895	4,680	24,673	12,985,525	5,890	29,194	157,639	*c*2,975,082	543,844	3,873,123

Year.	Nitrate of Soda.			Bicarbonate Soda.			Caustic Soda.		
	Lbs.	Metric Tons.	Value.	Lbs.	Metric Tons.	Value.	Lbs.	Metric Tons.	Value.
1891	219,712,640	99,663	$2,579,930	1,500,663	661	$26,936	68,154,226	30,918	$1,700,532
1892	213,456,320	96,815	2,933,174	1,466,595	665	25,874	54,384,120	24,670	1,339,500
1893	257,626,880	116,890	3,673,537	1,380,426	526	23,136	52,116,492	23,641	1,171,878
1894	219,824,640	99,739	3,185,356	4,479,524	2,028	63,625	44,772,512	20,309	911,942
1895	265,388,480	120,380	3,778,360	8,682,028	3,937	123,425	72,019,114	32,668	1,211,090

Year.	Sal and Ash Soda.			Other Soda Salts.			Nitrate of Potash.			Muriate of Potash.		
	Lbs.	Met. Tons.	Value.	Lbs.	Met. Tons.	Value.	Lbs.	Met. Tons.	Value.	Lbs.	Met. Tons.	Value.
1891	347,822,902	157,800	$4,509,611	16.226.334	7,360	$114,955	15,292,057	6,937	$469,591	78,144,810	35,450	$1,220,119
1892	361,648,637	164.073	4,698,379	40,954,822	18,580	284,853	13,012,087	5,900	382,771	70,227,971	31,900	1,098,267
1893	348,994,906	158.346	3,983,039	29,850,109	13,544	205.523	13,374,016	6,066	369,274	74,663,116	38,407	1,192,516
1894	319,517.064	144,971	2,658,581	17,667,314	8,016	132,385	9.375,950	4,254	249,842	101,597,074	46,097	1,540,081
1895	307,026,104	139,266	2,321,612	9,943,015	4,510	155,006	11,419,090	5,180	305,207	81,732,736	37,074	1,296,184

Year.	Chromate and Bichromate of Potash.			Chloride of Lime.			Chrome Ore.			Chromic Acid.			Clays or Earths, including Kaolin.		
	Lbs.	Met. Tons	Value.	Lbs.	Met. Tons.	Value.	Long Tons.	Met. Tons	Value.	Lbs.	Kil's	Value	Long Tons.	Met. Tons.	Value.
1891	755,254	343	$53,897	108,880,831	49,389	$1,632,127	4,560	4,633	$108,764	634	287	$203	62,598	63,606	$471,785
1892	1,193,972	541	94,708	109,888,561	49,846	1,962,084	4,930	5,009	55,589	772	347	204	75,283	76,495	605,022
1893	979,706	444	78,981	98,618,147	44,735	1,843,410	6,354	6,456	58,629	3,708	1,682	641	73,387	74,586	564,547
1894	1,483,762	673	125,796	96,256,251	43,673	1,697,038	3,470	3,525	38,364	6,680	3,030	1,045	78,698	79,983	616,506
1895	2,045,910	928	181,242	103,317,968	46,865	1,628,877	5,230	5,314	82,845	2,083	945	414	98,862	100,450	716,590

Year.	Coal.					Coke.			Cobalt Oxide.		
	Anthra. Short Tons.	Bitumin. Short Tons.	Total Short Tons.	Total Metric Tons.	Total Value.	Short Tons.	Metric Tons.	Value.	Lbs.	Kilos.	Value.
1891..	16,676	1,525,972	1,542,648	1,399,490	....	50,753	46,043	$223,184	35,483	16,094	$60,630
1892..	....	1,144,499	1,144,499	1,038,290	$3,747,140	24,482	22,210	86,350	32,833	14,775	60,067
1893..	....	1,108,538	1,108,538	1,005,933	3,620,368	33,165	30,080	99,683	28,164	12,775	41,105
1894..	....	1,244,330	1,244,330	1,128,156	3,829,807	29,137	26,427	70,358	24,020	10,900	29,857
1895..	....	1,226,386	1,226,386	1,112,570	3,637,085	29,622	26,867	71,366	36,155	16,400	39,839

Year.	Fine Copper in Ore.			Copper Ingots, Old, etc.			Manufactur'r's Value.	Total Value.	Cryolite.		
	Lbs.	Metric Tons.	Value.	Lbs.	Metric Tons.	Value.			Long Tons.	Met. Tons.	Value.
1891....	11,690,312	5,303	$875,855	3,154,557	1,431	$276,263	$513,611	$1,655,729	8,296	8,430	$76,350
1892....	8,107,582	3,677	499,574	1,724,772	782	131,608	96,627	727,809	7,241	7,357	96,932
1893....	7,723,387	3,504	467,988	5,536,690	2,510	488,710	83,752	1,040,450	9,574	9,728	126,688
1894....	3,870,769	1,756	297,118	2,289,324	1,039	170,368	65,256	533,742	10,684	10,855	142,494
1895....	....	....	....	9,381,800	4,255	839,603	60,342	899,945	9,500	9,652	127,165

Year.	Earthen, Stone, and China Ware	Emery, Grains.			Emery, Rock.			Other M'f'res.	Total Value.	Guano.		
		Lbs.	Met. Tons.	Value.	Long Tons.	Metric Tons.	Value.			Long Tons.	Met. Tons.	Value.
1891....	$8,752,163	90,658	41	$3,729	2,530	2,571	$67,573	....	$71,302	11,937	12,129	$199,044
1892....	8,987,111	566,448	257	22,586	5,280	5,365	95,625	2,412	120,623	3,073	3,122	46,014
1893....	8,769,778	516,953	234	20,073	5,066	5,147	103,875	3,819	127,767	5,951	6,045	97,890
1894....	6,978,148	597,713	271	18,645	1,642	1,668	51,487	1,830	133,038	5,246	5,332	102,423
1895....	10,524,608	678,761	308	25,066	6,803	6,912	80,386	27,586	71,962	4,066	4,131	48,917

Year.	Iron Ore.			Iron, Pig, Scrap, Spiegel, and Ferromanganese.			Bar Iron.			Castings, Boiler, Hoop, Sheet, Taggers.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Met. Tons.	Value.
1891	912,864	927,561	$2,456,546	67,179	68,260	$1,432,455	18,099	18,390	$770,858	d12,752	12,958	d $781,557
1892	806,585	819,571	1,795,644	99,348	100,947	2,023,428	19,728	19,594	776,927	71,756	72,909	3,195,684
1893	526,951	535,435	906,687	60,667	61,644	1,321,899	14,896	15,138	603,985	76,647	77,878	3,276,537
1894	167,307	169,281	267,241	17,962	18,250	451,348	9,228	9,378	377,397	....	......	....
1895	524,153	532,571	786,207	59,298	60,250	1,441,501	20,049	20,371	772,822	....	......	....

Year.	Steel Ingots, Billets, Blooms, Slabs, Sheets, etc.			Tin and Terne Plates.			Rails.			Total.	Lead, Ore, and Dross.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Met. Tons.	Value.	Long Tons	Met. Tons.	Value	Value.	Lbs.	Met. Tons.	Value.
1891	34,685	35,243	$1,673,214	327,868	333,147	$25,900,305	253	257	$8,405	$41,983,626	105,898	48	$6,721
1892	30,586	31,081	1,591,092	268,472	272,793	17,102,487	347	352	10,607	33,882,447	127,873	58	9,932
1893	26,868	27,300	1,293,834	253,485	257,564	15,559,423	2,888	2,922	57,584	29,667,364	(c)	......	....
1894	9,494	9,649	809,184	215,067	218,581	12,053,167	300	304	4,292	....	....	......	....
1895	26,255	26,677	1,610,889	219,545	223,071	11,482,380	1,447	1,470	27,076	....	45,052,674	20,436	687,222

Year.	Lead, Pig, Bars, and Scrap.			Sheets, Pipe, and Shot.			Manufacturer's N. E. S.	Total Values. (f)
	Lbs.	Metric Tons.	Value.	Lbs.	Metric Tons.	Value.		
1891	3,392,562	1,539	$104,184	334,179	151	$12,406	2,744,122	$2,867,633
1892	1,549,771	749	110,593	90,153	40	6,207	....	4,569,176
1893	3,621,525	1,643	141,405	56,678	26	2,914	....	6,608,639
1894	139,961,911	63,486	4,228,706	44,080	20	2,050	....	4,228,796
1895	200,996,955	91,172	2,909,647	128,008	58	5,030	....	2,909,647

Year.	Manganese. Ore.			Manganese. Manufactured.			Marble, Stone, & M'f's of.	Metals, Comp's & M'f's of.	Mica. (r)	Mineral Subst's N. E. S.	Nickel.	Oil, Mineral.		
	Long Tons.	Met. Tons.	Value.	L'ng Tons	Met. Tons	Value	Value.	Value.	Value.	Value.	Value.	Gallons.	Liters.	Value.
1891	28,624	29,087	$371,594	201	204	$9,024	$1,312,856	$7,445,640	$110,442	$183,175	$321,163	1,362,288	5,156,259	$62,222
1892	58,364	......	830,046	208	....	10,305	1,525,271	6,470,918	100,846	275,615	426,817	909,885	3,443,913	49,487
1893	67,717	68,807	860,832	(g)	....	......	1,637,165	6,325,307	120,864	261,646	384,628	523,800	1,842,583	31,801
1894	44,655	45,384	432,561	....	....	......	1,197,987	3,768,116	126,184	139,688	45,927	152,870	578,659	27,266
1895	86,111	87,489	747,910	....	....	......	1,275,855	4,701,496	174,886	....	56,890	1,917,823	7,259,804	54,963

Year.	Ozokerite.			Paints and Colors.	Palladium, Manufactured		Platin'm Man'factured.		Platinum, Ore, Sponge, Plate.		Platinum, Vases, Retorts, etc.		Precious Stones.	
	Lbs.	Met. Tons	Value.	Value.	Weight. Grams.	Value	Kil.	Val.	Kilos.	Value.	Kilos.	Value.	Rough & Uncut	Cut.
1891	1,869,241	847	$149,539	$1,378,970	....	......	.012	$49	2,204.35	$972,989	66.59	$26,228	$975,772	$11,769,663
1892	1,250,000	567	150,000	1,366,844	....	......	....	.....	1,774.96	505,852	170.63	53,763	1,032,869	13,427,774
1893	1,744,905	792	133,111	1,294,857	....	......	....	1,412	1,993.20	538,478	......	69,823	802,075	10,022,371
1894	(f)	....	....	1,045,251	....	$5	....	.....	1,670.90	485,272	......	88,195	839,806	6,710,472
1895	....	....	....	1,364,657	....	......	....	171	2,320.13	690,584	......	27,354	111,033	6,623,669

Year.	Pyrites.			Salt.			Sulphur, Crude.			Flowers, Sulphur.		
	Long Tons.	Metric Tons.	Av. Sulph. % Contents.	Lbs.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Met. Tons.	Value.
1891	130,000	132,093	44	463,455,263	210,220	$793,115	116,971	118,854	$2,675,192	206	209	$6,762
1892	210,000	213,381	43	456,613,733	207,213	768,415	100,721	102,342	2,189,307	158	160	5,439
1893	194,934	198,072	(h)	332,939,120	151,515	569,626	107,601	109,333	1,903,191	241	245	5,746
1894	163,546	166,163	25	421,225,027	191,118	643,167	124,467	126,500	1,734,643	165	168	4,145
1895	190,436	193,483	....	566,869,055	257,130	760,811	125,959	127,974	1,593,148	581	590	12,888

Year.	Refined Sulphur.			Block Tin.			Zinc. (i) Sheet, Block, Pig, and Old.			Zinc. (i) Man'f's Net Value.	Zinc. (i) Total Value.
	Long Tons.	Metric Tons.	Value.	Lbs.	Metric Tons.	Value.	Lbs.	Metric Tons.	Value.		
1891.	10	10	$1,997	41,146,123	18,663	$8,091,363	814,218	369	$41,369	$18,424	$59,793
1892.	26	27	4,106	46,821,958	21,238	9,415,889	x410,896	186	23,307	22,709	46,016
1893.	43	44	1,017	40,184,556	18,228	8,007,292	x425,998	193	22,931	20,756	43,687
1894.	41	42	1,207	22,745,958	10,320	5,944,065	x512,932	233	17,271	12,342	29,613
1895.	229	233	4,378	54,252,045	24,609	7,405,619	864,113	392	29,352	12,183	41,535

(a) From *Summary Statements of the Imports and Exports of the United States* and *Mineral Resources of the United States*, and several figures for 1893 and 1894 kindly furnished by Mr. J. V. Whitney, acting Chief of Bureau of Statistics. When not otherwise expressed, all years are calendar. All fiscal years end June 30. The following substances, not given in the above table, were imported in 1893: Bromine, 780 lbs., $234; plaster of paris, unground, 164,300 long tons, $180,263; ground, 1368 long tons, $22,643; calcined, 2565 long tons, $18,316; ocher and ochery earths, dry, 6,126,006 lbs., $53,943; ground in oil, 51,804 lbs., $3321; spiegeleisen and ferro-manganese, 37,457 long tons, $879,731; quicksilver, 30,191 lbs., $12,507; talc, 2,720,528 lbs., $12,825. Further imports in 1894: Bromine, 20 lbs., $11; ocher and ochery earths, dry, 4,937,738 lbs., $45,276; ground in oil, 22,387 lbs., $2100; plaster of paris, unground, 162,500 short tons, $179,237; ground, 340 short tons, $5966; calcined, 1687 short tons, $10,857; quicksilver, 7 lbs., $6; talc, 1,242,171 lbs., $6815; borax, 1,029,786 lbs., $39,256.

(b) In 1891, manufactured only; in 1893, 3286 lbs., $2168, crude and alloys of any kind in which aluminum is the component material of chief value; in 1892, $2244, and in 1893, $3301, manufactures not specially provided for. (c) Custom-house returns for these years are given in pounds, which are reduced to barrels of 400 lbs. for convenience of comparison. (d) Six months.

(e) Amount of lead contained in silver ore was 58,069,401 lbs., $985,324; that contained in other ores and dross, 13,686 lbs., $354. In 1893 were imported: Litharge, 42,582 lbs., $1310; red lead, 832,152 lbs., $26,885; white lead and white paint containing lead, 682,912 lbs., $33,973; in 1894, lead ore and dross, 33,020,250 lbs., $437,999.

(f) Value of lead in ores from Mexico included, which amounted to 18,124 tons in 1890, 23,867 tons in 1891, 39,608 tons in 1892, and 29,370 tons in 1893. (g) Not enumerated. (h) Containing above 25% of sulphur.

(i) The imports of zinc oxide were, in 1890, dry, 2,631,458 lbs.; in oil, 102,298 lbs.; in 1891, dry, 2,839,351 lbs.; in oil, 128,140 lbs.; in 1894, dry, 3,371,292 lbs.; in oil, 59,291 lbs.

MINERAL EXPORTS OF DOMESTIC PRODUCE OF THE UNITED STATES. (*a*) (IN TONS OF 2240 LBS.)

Year.	Asbestos. Value	Brass and Man'f's Value.	Cement. Bbls	Cement. Value.	Chemicals Drugs, Medicines. Value.	Coal, Anthracite. Short Tons.	Coal, Bituminous. Short Tons.	Total Short Tons.	Total Metric Tons.	Copper Ore. (c) Lbs.	Copper Ore. (c) Metric Tons.	Copper Ore. (c) Value.
1891	$17,847	....	$83,607	$130,371	....	967.181	1,807,202	2,774,383	2,516,920	86,477,440	39,225	$6,565,620
1892	4.800	$438,486	79,179	137,167	$6,618,827	851,639	1,645,686	2,497.325	2,265,573	113,113,616	51,308	6,479,758
1893	17,134	741,317	93,485	154,461	7,002,879	1,334,287	2,324,591	3,658,878	3,320,216	93,527,950	42,424	4,257,128
1894	5,762	779,875	*b* 108,000	165,809	7,722,532	1,440,625	2,195,716	3,636,341	3,299,765	9,748,480	4,422	440,129
1895	....	730,424	83,632	117,646	8,749,090	1,470,710	2,211,983	3,682,693	3,340,917	30,965,760	14,046	1,631,251

Year.	Copper, Pig, Sheet, Old. Lbs.	Copper, Pig, Sheet, Old. Met. Tons.	Copper, Pig, Sheet, Old. Value.	Manufacturer's Value.	Total Value.	Earthen, Chinaw're Value.	Glassware. Value.	Gold and Silver in Coin and Bullion. (*d*) Gold.	Gold and Silver in Coin and Bullion. (*d*) Silver.	Gold and Silver in Ores. (*e*) Gold.	Gold and Silver in Ores. (*e*) Silver.
1891	*f* 69,279,024	31,425	$8,844,304	$293,619	$15,703,543	....	....	$79,086,581	$27,692,879	$100,918	$1,090,511
1892	*f* 30,515,736	13,742	3,438,048	245,064	10,162,870	$245,731	$938,154	76,532.056	35,975,834	9,262	1,592,934
1893	*f* 138,984,128	63,043	14,213,378	464,991	18,935,497	151,308	971,503	79,775.820	46,288,721	190,849	190,846
1894	162,393,000	73,681	15,324,925	378,040	16,143,094	138,289	917,519	101,819,924	47,044,205	149,501	149,501
1895	121,328,390	55,034	12,222,769	1,084,289	13,307,058	139,297	1,002,328	104,605,623	53,833,153	....	....

Year.	Iron, Pig. Long Tons.	Iron, Pig. Metric Tons.	Iron, Pig. Value.	Iron, Bar. Long Tons.	Iron, Bar. Metric Tons.	Iron, Bar. Value.	Iron, Boiler, Band, Hoop Scroll, and Sheet. Long Tons.	Iron, Boiler, Band, Hoop Scroll, and Sheet. Metric Tons.	Iron, Boiler, Band, Hoop Scroll, and Sheet. Value.	Iron, Steel Ingots, Bars, Sheets, and Wire. Long Tons.	Iron, Steel Ingots, Bars, Sheets, and Wire. Metric Tons	Iron, Steel Ingots, Bars, Sheets, and Wire. Value.
1891..	14.945	15,186	258,000	1,341	1,363	$85,382	506	514	$34,019	12,516	12,718	$940,375
1892..	15,427	15,675	282,290	963	979	60,463	31	31	1,762	15,291	15,537	1,027,541
1893..	24,587	24,989	379,437	1,842	1,872	94,239	255	259	10,467	17,079	17,354	1,033,757
1894..	24,480	24,872	309,222	3,195	3,248	130,374	99	101	5,380	27,716	28,159	1,355,705
1895..	26,164	26,584	371,297	3,329	3,383	147,798	198	201	8,169	32,822	33,349	1,492,545

Year.	Iron—*Continued.* Rails. Long Tons.	Rails. Met. Tons.	Rails. Value.	Total Value.	Lead, Man'f's Value.	Marble, Stone, & Man'f's Value.	Mica. Value	Nickel. (*a*) Value.	Petroleum (1=1000 in quantities and value) Crude. Gals.	Crude. Value	Naphtha. Gals.	Naphtha. Value	Illuminating. Gals.	Illuminating. Value.
1891	11,239	11,420	$363,488	$30,736,442	$173,887	....	......	$184,782	96,723	$5,366	11,424	$868	531,445	$34,880
1892	7,982	8,110	256,325	27,900,862	154,375	$765,165	$250	197,763	104.397	4,696	16,393	1,038	589,418	31,827
1893	19,876	20,194	595,988	30,159,363	508,090	964,616	480	378,577	115,091	3,966	16.344	1,004	711,828	31,796
1894	13,556	13,773	356,186	29,943,729	497,993	1,009,704	659	495,218	114,958	4,673	14,915	912	733,924	30,287
1895	15,599	15,849	362,131	35,071,535	214,856	959,871	......	239,897	116,108	6,285	12,922	999	686,006	43,540

Year.	Petroleum—*Continued.* Lubricating. Gals.	Lubricating. Value	Res. & All Oth's Gals.	Res. & All Oth's Value.	Paraffine. Lbs.	Paraffine. Value.	Platinum. Manufactures. Kilos.	Manufactures. Value.	Scrap. Kilos.	Scrap. Value.	Quicksilver. Lbs.	Quicksilver. Metric Tons.	Quicksilver. Value.
1891	32,210	$5.000	1,003	$61	65.076	$3,979	....	....	43.59	$12,900	....	....	....
1892	34.027	5,131	403	38	69,876	4,160	....	$9,000	....	....	269,104	122	$133,626
1893	35,645	5,069	543	35	99.061	4,553	....	23,953	....	....	1,272,271	577	542,410
1894	39,946	5,368	119	10	85,125	3,277	....	6,992	....	....	1,102.187	500	379,528
1895	47,875	6,289	170	14	114,236	4,505	....	....	....	....	1,188,955	504	482,085

Year.	Salt. Lbs.	Salt. Metric Tons.	Salt. Value.	Tin, Man'f's Value.	Zinc Ore and Oxide. Lbs.	Zinc Ore and Oxide. Metric Tons.	Zinc Ore and Oxide. Value.	Zinc Sheets, Pigs, Bars. Lbs.	Zinc Sheets, Pigs, Bars. Metric Tons.	Zinc Sheets, Pigs, Bars. Value.	Manufacturer's Value.	Total Value.
1891	5,242,280	2,378	$29,519	....	13,071,840	5,935	$149,435	4,294,656	1,948	$278,182	38,921	$466,538
1892	....	....	....	$204,429	2,058,560	....	41,186	12,494,335	5,667	669,549	166,794	877,529
1893	....	....	....	258,449	109,760	50	1,271	7,446,934	3,379	413,673	224,787	638,460
1894	....	....	....	301,503	....	....	5	3,607,050	1,610	144,074	99,406	243,480
1895	3,116,505	1,414	6,500	252,223	53,760	24	1,008	3,060,805	1,388	153,175	50,051	203,226

MINERAL EXPORTS OF FOREIGN PRODUCE FROM THE UNITED STATES. (*a*)

Year.	Asphaltum or Bitumen (Crude).			Brass and M'f's.	Cement.			Chemicals.								
								Salts of Potash. (*b*)			Chloride of Lime			Nitrate of Soda.		
	Long Tons.	Met. Tons.	Value	Value	Lbs.	Met. Tons	Value.	Lbs.	Kilos.	Value	Lbs.	Kilos	Val.	Long Tons.	Metric Tons.	Value.
1891	398	404	$4,530	$5,097	4,055,002	1,839	$17,297	......	......	......	......	......	...	104	106	$2,984
1892	84	85	2,513	8,702	8,614,537	3,907	32,371	......	......	......	......	......	...	214	217	8,355
1893	378	384	4,838	3,430	5,710,675	2,590	20,202	109,778	49,794	$4,922	2,566	1,164	$231	2,428	2,467	105,624
1894	502	510	9,211	6,979	3,889,928	1,765	15,072	719,861	326,529	14,436	10,943	9,046	540	549	558	19,819
1895	72	73	1,906	8,711	3,578,230	1,623	......	379,767	172,260	12,555	10,600	4,808	305	1,084	1,101	44,847

Year.	Chemicals—*Continued.*									Clays or Earths of All Kinds, including China Clay.			Coal, Bituminous.		
	Caustic Soda.			Sal Soda and Soda Ash			All Other Salts of Soda								
	Lbs.	Met. Tons	Value.	Lbs.	Kilos.	Value.	Lbs.	Kilos.	Value.	Long Tons.	Met. Tons.	Value	Long Tons.	Met. Tons.	Value.
1891	2,693,103	1,222	$72,382	84,152	37,944	$1,150	76,640	34,557	$1,162	52	53	$578	1,239	1,259	$12,005
1892	1,408,986	639	37,872	46,876	21,266	725	63.591	28,844	942	60	61	514	127	127	1,310
1893	1,760,856	799	45,724	193,556	87,795	2,519	68.759	31,189	1,135	175	178	1,531	9	9	126
1894	2,929,473	1,329	66,017	101,886	46,214	1,305	131,118	59,474	5,648	92	93	616	877	891	4,934
1895	1,592,150	722	31,691	269,765	122,363	2,423	68.127	30,902	1,174	89	90	740	3,440	3,495	7,699

Year.	Copper.							Earthen, Stone, and China Ware.	Fertilizers.						
	Copper Ore. Fine Copper Therein.			Pigs, Bars, Ingots, Old, & Other Unm'f'd			Manufacturer's Value.		Guano.			Phosphates, Crude or Native.			Other Fert'z's
	Lbs.	Met. Tons	Value.	Lbs.	Met. Tons	Value.			Tons.	Met. Tons.	Val.	Long Tons.	Met. Tons.	Value	Value.
1891	2,082,708	945	$78,514	534,949	243	$43,637	$15,185	$19.144	......	......	.....	115	117	$1.150	$52,190
1892	707,739	321	38.088	1,274,410	780	97,364	6,711	11,458	1	1	$44	......	......	......	....
1893	1,012,267	459	81,187	1.007,554	470	80,236	20,546	15,657	6	6	295	......	......	......	222
1894	235,140	107	20,008	1,150,169	022	78,544	13,056	19,541	106	108	1,620	......	......	......	8
1895	....	.....	....	475,588	216	43,193	11,626	25,482	......	......	.....	743	755	12,775	2,154

Year.	Glass and Glassware.	Gold-bearing Ores, N. E. S.	Gold and Silver, Manufactures of.	Graphite.			Iron Ore.			Iron and Steel, and Tin Plate, etc.					
										Pig Iron.			Scrap Iron and Steel, fit only to be remanufact'd.		
	Value.	Value.	Value.	Long Tons.	Met. Tons	Value	Long Tons.	Met. Tons	Value	Long Tons.	Met. Tons.	Value	Long Tons.	Metric Tons.	Value.
1891	$6,814	$6,484	$39,927	36	37	$2,500	......	...	......	226	230	$2,980	370	376	$3,539
1892	12,761	13,272	69,314	......	.....	......	31	31.5	$211	133	135	1,544	340	345	6,164
1893	11,366	17,057	17,308	164	166	5,615	......	....	.....	35	36	350	117	119	1,800
1894	26,509	....	55,065	43	44	4,371	......	....	.....	78	79	922	1,52[illegible]	1,550	18,422
1895	15,303	362,379	....	5	5	305	......	....	.....	210	213	2,536	92	93	1,024

Year.	Iron and Steel, and Tin Plate—*Continued.*											
	Bar Iron, Rolled or Hammered.			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.			Steel Plate and Taggers, Wire Rods, Wire and Wire Rope, and Structural Iron or Steel.		
	Lbs.	Metric Tons.	Value	Long Tons.	Metric Tons.	Value.	Lbs.	Metric Tons.	Value.	Lbs.	Metric Tons.	Value.
1891	76,896	35	$1,151	19	19	$462	5,516	2	$485	412,620	187	$12,306
1892	93,883	43	1,268	100	102	2,433	39,794	18	1,938	296,023	132	9,525
1893	7,067	3	148	1,243	1,263	24,297	181,111	82	10,232	336,682	153	8,503
1894	72,160	32	1,606	546	555	10,449	64,650	29	8,094	211,032	96	4.870
1895	8,207	4	288	204	207	3,755	43,143	11	2,499	242,238	110	8,861

Year.	Tin Plates, Terne Plates, and Taggers Tin.			Manufacturer's Value.	Lead and Manufactures of.	Marble and Stone, and Manufactures of.	Metal Compositions and Manufactures.	Mineral Substances.	Oil, Minerals			Paints and Colors
	Lbs.	Metric Tons.	Value.		Value.	Value.	Value.	Value.	Gals.	Liters.	Value	Value.
1891	1,164,742	528	$41,637	$110,324	$1,743,739	$6.436	$96.737	$1,114	40	151	$17	$5,626
1892	548,134	349	16,433	83,260	3,348,124	1,892	105,904	16	310	1,173	247	3.4[illegible]2
1893	1,256,393	560	36,542	164,721	5,478,182	10,736	91,624	2,572	4,776	18,077	1,045	10.271
1894	920,426	418	29,402	175.727	3,316,481	18,832	270,557	7,196	40,350	152,725	12,291	9,1[illegible]0
1895	666,458	302	18,446	126,576	704.708	6,998	66,389	....	23	7	43	24.147

Year.	Platinum, Unmanufactured			Precious Stones.	Salt.			Silver-bearing Ores.	Sulphur or Brimstone (Crude).			Tin in Bars, Blocks, Pigs, or Grain, or Granulated.			Zinc or Spelter, M'f'res.
	Lbs	Kilos.	Value	Value.	Lbs.	Met. Tons.	Value	Value.	Long Tons.	Met. Tons.	Value	Lbs.	Met. Tons.	Value.	Value.
1891	....	......	......	$33,433	1,096,400	497	$1,270	$212,624	50	51	$1,545	44,900	20	$2,000	$778
1892	1	½	$83	5,956	3,542,113	1,607	4,687	305,640	......	......	3	55,532	25	11,212	44
1893	1	½	35	311,660	1.155,217	524	2.897	69,027	65	66	1,360	310,266	141	63,580	570
1894	....	......	......	7,071	4,693,678	2,095	5,618	62,584	......	......	......	168,484	76	26,537	216
1895	....	......	......	22,967	3,116,505	1,414	6,500	377,933	......	......	......	395,456	179	63,584	2,875

(*a*) From July 1, 1891, nickel oxide and matte are included.
(*b*) Includes lime.
(*c*) Ore, so called, is mostly matte, and during 1891 and 1892 matte exports averaged about 55% fine copper.
(*d*) Total exports of coin and bullion; that is, includes both domestic and foreign not elsewhere specified.
(*e*) 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. In the above table the value of silver in copper matte so far as could be ascertained from the Director of the Mint has been added to the value of silver ores, the values being calculated at the commercial rate each year. The gold in copper matte exported is not included in the exports of gold given in the above table.
(*f* Sheets are not included these years, but are reported with manufactures.

THE MINING-STOCK MARKETS IN 1895.

One of the marked features of the year 1895 was the development of a largely increased interest in mining stocks. In the foreign markets the South African and West Australian gold mining shares attracted general attention and absorbed enormous amounts of capital. Nothing like the universal attention bestowed on these stocks was known in this country, but there was a marked change from the neglect with which mining stocks had been treated for several years past. The details of this movement and the points to which special attention has been attracted will be found in the reports from the different exchanges which are given below.

The Baltimore Mining-Stock Market.

Mining stocks in Baltimore during 1895 were entirely neglected, with no prospect of any revival in activity. Many of the North Carolina shares, which in former years were so actively dealt in on the exchange, have been stricken from the list and no new ones appear to take their places. The legitimate coal stocks have held their own as regards prices, but transactions have been very infrequent. Taken all in all, there cannot be said to have been any market for mining stocks in Baltimore for the year 1895.

FLUCTUATIONS IN PRICES OF MINING STOCKS AT BALTIMORE. (*a*)

Company.	Par Value.	Opening.		Highest and Lowest During the Year.				Closing.	
				Bid.		Asked.			
		Bid.	Asked.	Highest	Lowest	Highest	Lowest	Bid.	Asked.
Atlantic Coal	10	50	....	50	....	....	....	....	....
Baltimore Mining and Smelting	5	....	2	....	....	2	....	....	....
Baltimore & North Carolina	5	....	2	....	....	2	....	....	....
Conrad Hill	10	....	4	....	....	10	2	....	....
Consolidated Coal	10	30	31½	33	30	36	31½	31	....
Consolidated Gold and Copper	5	....	2	....	....	4	2	....	....
Diamond Tunnel	10	33	35	33	32½	35	....	....	....
George's Creek	100	108	115	110	102	120	104	108½	115
Great Republic	5	....	2	....	....	2	....	....	....
Howard Coal and Coke	5	110	120	110	....	120	....	....	....
Lake Chrome	5	....	10	....	....	10	....	....	....
Newburg Orrel	25	....	10	....	....	10	....	....	....
Ore Knob	10	....	5	....	....	50	5	....	....
Silver Valley	5	....	20	....	....	20	....	....	20
Vernon Mining	....	....	20	....	....	20	....	....	....

(*a*) Quotations given are in percentages of the par value.

The Boston Mining-Stock Market.

The year 1895 will be memorable for its active speculation in mining stocks. The gold mines of the Old World, as well as those recently discovered in our own country, have laid the foundations of large fortunes, while the copper mines of Lake Superior and Montana, which have been for many years almost exclusively a Boston specialty, afforded large opportunities for money making during the year. A few of the Lake Superior companies pay regular dividends; some are in process of development and will soon be paying mines, while others are purely speculative in character and have a record to make, but all offer to the active operator great inducements for trading. In the early months of the year the market was dormant, but in the summer months the advance in prices of copper started a boom in the market for the shares of the several companies and led to the highest prices which have been known for many years. At times the excitement was intense and prices were carried up beyond all reason; this, however, soon worked its own cure, and the decline was as rapid as the advance had been. In the depression of December the prices of some of the stocks were down below the lowest figures touched previously during the year.

The leader of the market in point of activity in advance was the Boston & Montana Mining Company of Montana, a company comparatively new, but a large producer and chiefly owned and managed by Boston people. Early in the year its stock was selling at \$33⅝ per share, and for several months did not advance above \$40. When the active movement was started in June the stock advanced rapidly, until on July 30 it reached its maximum at \$99½. Later it had wide fluctuations, selling in November at \$60½, on December 16 at \$78⅝, and on December 21 it declined to \$57, recovering on December 24 to \$69. The company paid two dividends, one of \$2 in May and one of \$4 regular, and \$1 extra in November—\$7 in all; and it expects to pay regular quarterly dividends hereafter.

Butte & Boston is under the same management as the Boston & Montana and is in process of development. Like the Montana, its stock is largely held in Boston and sold in February at \$8¾. It participated in the summer rally and sold up to \$26 per share, declined to \$13¾ in November, and in December sold at \$8½, with recovery later to \$13.

Of the Lake Superior stocks the Calumet & Hecla, the old reliable for investors, paid last year four dividends of \$5 each, and its market price ranged from \$280 in April to \$330 per share in July. In the December decline it touched \$290.

The Tamarack, also a favorite investment stock, paid two dividends of \$4 each. The market price at the opening of the year was \$158, followed by a decline to \$125 in April. In the summer rise it reached \$173, in December it sold at \$115, with later sales at \$121.

Quincy is another valuable property, held by both New York and Boston parties. The company paid two regular dividends and one extra, of \$4 each, for the year, and its stock, after selling at \$99 in January, advanced to \$170 in July and on the decline touched \$110. Latest sales were at \$120.

Osceola sold in January at \$25, in March at \$20, and reached the top price,

$41½, August 9. Owing to the accident at the mine in the early fall and the general decline in the market it dropped to $25 and has since sold at $33. In the depression it went off to $20, recovering to $24. It has paid $3½ in dividends in 1895, and its future is considered favorable.

Franklin continues to produce fairly well for a mine which a few years since was considered about exhausted. The work on the Franklin, Jr., is pushed with vigor and its outlook is very promising. The Franklin did not pay any dividend during the year, all its surplus fund being used for the development of the new property. Its market price ranged from $15 at the opening of the year to $11 in April, followed by an advance in July to $24. It has gradually declined, touching $9 recently and recovering to $11. The stock is well held and large amounts are seldom offered for sale.

Kearsarge ruled fairly active during the year and paid one dividend of $1 per share. Its lowest price, $7½ in April, was followed on the general advance in July to $26. On the down track it receded to $12¾ in November, and on December 21 it sold at $7, with recovery to $11¾ the following day.

Atlantic is not a very active stock in this market, being largely held in New York. The stock sold at $9 in April and on the upward wave in July advanced to $29, and gradually settled with the rest of the market to $11 and recovered later to $15.

One of the promising mines of the Lake region is the Tamarack, Jr. The work of developing the property was pushed with a good degree of energy the past year and with satisfactory results. Its market price ranged from $9½ in May to $30 in July, and it sold at $11 recently, with recovery to $15.

The work of development was resumed on the Tecumseh Mine. There was nothing doing in the stock during the first six months of the year, but the advance induced some speculation in it, and after selling at $3 it advanced to $4¾ when the boom was at its height; later sales were at $3.

Centennial has practically "played out" and the mine is to be sold under foreclosure. An effort was made to redeem the property and the stockholders were asked to contribute $2 per share toward that object, but there was not a very generous response. This stock sold as high as $2 and as low as 15c. It sold some years ago at $47½ per share and was then thought to be one of the best properties in its class.

Wolverine is considered by many as having a fair show to become a paying mine some day. Its market value the year ranged from $3 early in the year to $10¼ when highest in July. In the reaction which followed it sold down to $5, recovering to $6.

The Arnold was in evidence during the excitement of the summer and sold up from $1 in May to $6 in July, declining later to the lowest price of the year. There was very little done in Copper Falls. A sale at $7 was recorded in May and in August it sold at $6½ and $10, since which there have been no transactions. There were rumors of a consolidation with the Arnold, both mines being under one management, but it was authoritatively denied.

The low-priced mines which in former years have been more or less active in this market did not make much showing in the boom, and only a few of them were quoted at all. We note sales of Allouez from 25c. to $2¾ and later at $1.

Bonanza Development sold from 20 to 75c. and more recently at 30c.; Humboldt, 25 to 35c.; Pontiac at 25c.; Mesnard at $1; National at $1 up to $3 and later at $1½.

The Anaconda and the Old Dominion Copper companies were added to the exchange list late in the year, but the transactions in both were limited. Anaconda was quoted at $35 and Old Dominion at $14@$17.

The silver mining stocks were neglected during the year, the interest largely centering, outside of the copper stocks, in the gold-mining industry. Sales were made of Breece Mining at 25c. and Catalpa at 8c.

Napa Quicksilver continued to pay regular and extra dividends during the year, amounting in the aggregate to 70c. per share. The lowest recorded market price for the stock was in May, $5¼, and the highest, $8, in August. Later quotations were at $7.

Several gold mining stocks were placed on the exchange during the year, but they were not very largely dealt in, although they offer great inducements to traders. The Merced Mining Company was started at $45 per share and sold even higher than that previously on the street; later sales were as low as $18. Its par value is $15 per share, with $10 paid in. Santa Ysabel was started at $8½, sold up to $16¾, but later declined to $7. Santa Rosa was placed by subscription at $1¼ per share, par $5, but sold on the exchange at $1. The above are all California mines. Another California mine, the Pioneer, was placed on the market, but was not listed on the exchange. The subscription price was $5, and sales were as high as $9½ per share. It was quoted at about $4 at the close of the year.

The Boston & Cripple Creek Mining Company of Colorado was listed on the exchange and sold at $1.35, but the attempt to market too much stock resulted in a decline to 20c. per share; later it sold at 50c. and closed at about 35c. The Gold Coin Mines, another Colorado company, sold at $1.35 and declined to $1.05. A dividend of 1½c. per share was paid in November and the stock sold ex-dividend at 97½c., with later sales at $1.05.

The year closed with a somewhat better feeling than that prevailing during the December flurry in the general stock market.

The Cleveland Mining-Stock Market.

Trading in the stocks of all the companies mining iron ore in the Lake Superior region for 1895 was inactive. Shares in the old companies at the opening of the year seemed undesirable properties to outsiders on account of the dismal prospects for a paying output, the unprofitable prices at which ores were selling, and the attention which the new Mesabi range was attracting. The apathy in the market thus existing at the outstart continued through most of the year. The returns to the ore-mining companies were not commensurate with the unexpected boom in the product, for the reason that the bulk of ore was sold in the spring at prices little more than a shade above last year's low range of values. Another check to financial returns was the advance in lake carrying charges during the latter portion of the season of navigation. These increased freights had to be paid by the ore companies in some instances, for those companies had

FLUCTUATIONS OF MINING STOCKS AT BOSTON DURING 1895.

Name and Location of Company.	Par Val.	January.		February.		March.		April.		May.		June.	
Allouez, Mich	$25	. . .	. . .	35	25	. . .	. . .	. . .	. . .	1 25	50	1 00	75
Arnold, Mich	25	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	3 50	1 00	3 00	2 00
Atlantic, Mich	25	11 00	10 00	10 50	10 00	10 50	10 00	11 00	9 75	16 50	11 00	17 13	15 50
Bonanza, Mich	10	. . .	. . .	. . .	. . .	20	. . .	22 50	20	25	. . .	30	. . .
Boston & C. C., Col	1	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Boston & Mont. Mont	25	39 25	33 38	38 88	34 50	38 50	35 50	42 50	37 00	54 50	42 00	60 50	50 25
Butte & Boston, Mont	25	11 37	9 50	10 00	8 75	9 88	9 00	14 00	9 00	17 00	13 50	16 50	14 00
Breece, Col	25	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Cal. & H'cla, Mich	25	290 10	. . .	295 00	290 00	290 00	280 00	285 00	280 00	590 00	282 00	298 00	292 00
Catalpa, Col	10	08	. . .	08	. . .	08	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Centennial, Mich	25	90	50	60	50	50	. . .	50	. . .	2 00	50	1 00	. . .
Central, Mich	25	75	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Copper F'lls, Mich	25	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	7 00	. . .	. . .	. . .
Dom. Coal, N. S	100	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	16 75	14 50
Dom. Coal, pref	25	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	97 50	91 50
Franklin, Mich	25	15 00	14 50	14 00	12 50	12 00	11 00	15 50	11 00	17 63	14 75	17 00	15 00
Gold Coin, Col	1	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Humboldt, Mich.	25	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	35	25	. . .	. . .
Illinois Steel, Ill.	100	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Kearsarge, Mich.	25	9 25	7 50	9 50	8 00	8 75	7 50	10 00	8 25	15 25	9 75	15 00	13 25
LakeSup. Ir Mich	25	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	20 25	20 13	25 50	21 00
Minn. Iron, Minn	100	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	57 39	. . .	. . .	. . .
Merced, Cal	15	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Mesnard, Mich	25	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1 00	. . .	. . .	. . .
Napa, Cal	7	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	6 13	5 50	6 25	7 25
National, Mich	25	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	3 00	1 25	2 00	1 00
Old Dom., Ariz	25	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Osceola, Mich	25	25 00	20 50	22 50	21 25	21 25	20 00	24 25	21 00	30 00	24 00	29 00	26 00
Pontiac, Mich	25	25	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Quincy, Mich	25	107 00	99 00	102 50	98 75	103 00	100 00	108 00	101 50	125 00	106 00	119 50	115 50
Quincy Scrip	25	45 00	41 00	43 00	39 75	46 75	39 25	57 00	48 50	70 00	57 50	66 00	62 00
Santa Ysabel, Cal	5	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	9 00	8 50
Santa Rosa, Cal	10	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Tamarack, Mich	25	158 00	144 50	146 50	143 00	143 00	134 88	136 00	125 00	149 00	128 00	141 00	128 00
Tam. M. G. R'ts, M	25	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	5 00	4 75	5 25	3 00
Tam. scrip, Mich.		. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Tam, Jr., Mich	25	12 25	10 50	12 00	11 00	12 00	11 00	14 50	11 50	20 13	9 50	19 88	18 50
Tecumseh, Mich	25	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Wolverine, Mich	25	3 63	3 00	4 50	2 63	4 63	2 69	5 00	4 05	7 25	4 09	7 00	6 25
Westinghouse Pa	50	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
" pref. "	50	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .

Name and Location of Company.	Par Val.	July.		August.		September		October.		November.		December.		Sales
Allouez, Mich	$25	1 00	75	2 75	1 00	1 00	. . .	1 00	. . .	. . .	. . .	50	. . .	17,090
Arnold, Mich	25	6 00	2 88	5 38	2 50	3 50	1 75	2 88	1 38	1 50	1 00	2 00	1 06	86,705
Atlantic, Mich	25	29 00	16 00	28 50	21 50	25 00	18 75	22 50	16 00	18 00	15 00	17 00	13 00	41,462
Bonanza, Mich	10	75	30	60	50	50	. . .	55	35	30	05	. . .	. . .	19,200
Boston & C.C., Col	1	. . .	. . .	. . .	. . .	. . .	. . .	1 35	25	40	20	50	35	38,125
B'stn & M'nt M'nt	25	99 50	61 00	96 56	85 50	94 00	77 50	88 50	67 00	75 00	60 50	78 75	57 00	997,126
B'tte & B'stn M'nt	25	25 75	15 38	26 00	20 50	22 50	16 50	19 50	14 25	17 50	13 75	16 13	8 50	357,869
Breece, Col.	25	. . .	. . .	. . .	. . .	. . .	. . .	23	. . .	. . .	. . .	. . .	. . .	800
Cal. & H'cla, Mich.	25	330 00	293 00	315 00	300 00	325 00	315 00	318 00	305 00	310 00	295 00	307 00	290 00	5,800
Catalpa, Col.	10	08	. . .	. . .	13	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4,600
Centennial, Mich	25	1 50	95	2 38	1 25	2 00	25	1 25	15	16 50	15	. . .	. . .	35,451
Central, Mich.	25	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	215
Copper F'lls Mich	25	. . .	. . .	10 00	6 50	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	950
Dom. Coal, N. S.	100	15 75	14 38	17 38	15 63	17 00	15 75	16 00	13 75	14 50	12 25	14 75	8 50	52,427
Dom. Coal, pref.	25	93 00	92 00	101 00	97 00	99 00	98 00	98 00	94 00	93 50	92 50	95 00	85 00	2,825
Franklin, Mich.	25	24 00	15 50	24 00	19 75	21 56	16 50	19 75	14 50	15 00	11 00	12 50	9 00	29,687
Gold Coin, Col.	1	. . .	. . .	. . .	. . .	1 35	1 20	1 25	1 00	1 30	1 00	1 15	95	48,405
Humboldt, Mich	25	35	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	700
Illinois Steel, Ill.	100	. . .	. . .	. . .	. . .	. . .	. . .	82 00	77 00	79 00	76 00	76 00	59 00	5,756
Kearsarge, Mich.	25	26 00	14 38	25 51	18 51	22 00	17 00	21 36	14 25	17 50	12 75	16 25	7 00	153,792
LakeSup. Ir Mich	25	25 25	. . .	. . .	. . .	. . .	. . .	29 00	7 00	30 00	. . .	30 00	. . .	1,080
Minn. Iron, Minn	100	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	200
Merced, Cal.	15	45 00	39 25	. . .	. . .	. . .	. . .	38 00	29 00	36 00	18 00	34 00	24 00	8,948
Mesnard, Mich.	25	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	400
Napa, Cal.	7	. . .	8 00	. . .	. . .	. . .	. . .	8 00	7 00	7 50	7 00	7 50	7 00	1,614
National, Mich.	25	1 88	1 25	1 63	1 50	. . .	. . .	29 00	. . .	. . .	. . .	. . .	. . .	5,601
Old Dom., Ariz.	25	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	18 50	13 00	5,190
Osceola, Mich.	25	41 50	28 25	40 63	35 25	38 00	29 00	33 20	25 00	28 00	25 00	28 00	20 00	88,445
Pontiac, Mich.	25	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	100
Quincy, Mich.	25	170 00	116 00	154 00	140 00	160 00	136 50	143 00	125 00	126 00	115 00	125 00	110 00	22,533
Quincy, Scrip.	25	89 00	64 00	83 00	14 00	81 00	70 00	79 75	73 00	71 00	56 00	71 00	65 00	9,059
Santa Ysabel, Cal	5	16 75	5 00	14 25	13 25	13 50	11 50	12 00	9 00	9 50	7 00	11 00	7 00	30,070
Santa Rosa, Cal.	10	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1 00	. . .	1 10	. . .	1,775
Tamarack, Mich.	25	175 00	100 00	173 00	158 00	160 00	147 50	150 00	132 50	139 00	130 00	137 00	115 00	21,683
Tam. M. G. R'ts, M	25	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	17,767
Tam. scrip, Mich.		. . .	. . .	70 00	67 00	60 00	57 00	85 00	70 00	75 00	60 00	75 00	60 00	1,016
Tam, Jr., Mich.	25	30 00	19 00	29 00	22 00	28 25	19 50	22 50	15 00	18 00	12 50	15 50	11 50	34,809
Tecumseh. Mich.	25	3 00	. . .	3 94	3 00	4 50	3 00	4 00	2 00	. . .	. . .	3 50	3 00	11,068
Wolverine, Mich	25	10 25	6 13	10 30	7 50	8 75	6 25	8 00	6 00	7 00	5 85	7 13	5 00	137,362
Westinghouse Pa	50	. . .	. . .	. . .	. . .	. . .	. . .	35 50	34 00	35 13	32 00	34 50	30 00	3,255
" pref "	50	. . .	. . .	. . .	. . .	. . .	. . .	55 50	54 00	55 00	54 00	55 00	51 00	1,725

not always covered by season charters their product sold in the spring, and the added cost of freightage thus reduced profits below the estimates made last spring. That was the dark side of the picture. There were other ore transactions made at the advancing prices which yielded considerable revenues to the companies. Taken all in all it was an unsatisfactory year, though better than its predecessor. The net financial results were not proportionate to the immense output. Dividends were paid by some of the companies, but in one instance at least they were not earned.

During the year there was quite a decided improvement in the value of stocks, even though the market remained dull. Republic Iron shares advanced from $5 to $12; Lake Superior from $22 to $32; Chandler from $30 in January to $38; Cleveland Cliffs, quoted at about $40 at the close of the year, showed an advance. Minnesota Iron Company shares jumped from $40 to $70. Pittsburg & Lake Angeline remained steady at $75 for $25 shares. Jackson also maintained its value of about $75. Aurora, quoted at $6 in January, in December was held at $8. This improvement in values was so gradual as to be almost unnoticed and was unattended by any activity.

The Mining-Stock Exchanges of Colorado.

The year 1895 in Colorado was one of gold-mining development and mining-stock speculation. Gold has been mined in Colorado for more than three decades, and people there have speculated in mining securities for years past, but not to the extent that is now going on. This is the result of the fall in the price of silver, stimulating the search for gold, resulting first in the discovery of the Little Johnny gold mine at Leadville and in the special attention drawn to Cripple Creek.

The history of the year's trading in mining stocks is practically the history of the exchanges, and Colorado Springs being the most important speculative center demands first mention. The old stand, therefore, perhaps the best known of all the exchanges located in the famous health resort, is the Colorado Springs Mining Stock Association. A number of prominent men resolved to further Cripple Creek's progress by legitimate trading in the stocks of the mining companies operating in the new district, as well as of companies in other camps of the State. The result was that the association was incorporated in May, 1894, and opened for business on September 4, 1894, with 31 members, each of whom paid $180 for his seat. With the undoubted reputation of the members and the able officers of the exchange, in addition to the favorable developments in the mines of Cripple Creek, the institution could not but prosper. The business of the association increased so rapidly and seats were in such active demand at $1000 that the Governing Committee deemed it wise to increase the membership to 50 at $500 each, which would mean 19 new members. The books were opened on October 31, 1895, and nearly 50 applications were immediately received, of which 35 were considered desirable, and consequently the total membership was raised to 66. Since the books were closed seats have sold as high as $750 and were held at $900.

Not the least reason why the Colorado Springs Mining Stock Association was for a time the only really prosperous mining-stock exchange in the United States was the precaution observed in listing stocks. The business reputation of the members was established, and the association as a body also soon made a reputation for itself by its actions in sifting carefully the merits or at least fair chances of the stocks to be listed. Its rule is that a company must have produced at least $5000 net within the preceding year, in addition to passing a rigid examination before the Listing Committee and the exchange attorneys, before it can be listed as a mine, thereby securing title and legal issuance of stock. Prospects may also be listed, but they must make sworn statements and pass the same examination as mines. The exchange recently appointed a building committee and has purchased a property on which an exchange is being erected which will be a credit alike to the members and to the city.

Just a year after the incorporation of the Mining Stock Association, and in consequence of the increasing demand for mining stocks, the Colorado Springs Board of Trade Mining Exchange was organized with 100 members and a membership fee of $100. The total number of seats was at once subscribed and there have been no vacancies. It had the advantage of active and enterprising officers and a large list of stocks to select from, and so prosperous has been its career that seats rose to $500, though few holders are willing to sell even at that price. This exchange is also careful about listing stocks. In the fall of 1895, so great was the volume of business of the two exchanges that a third was launched in the shape of the Consolidated Exchange. It did a respectable business. Since the close of 1895 the Board of Trade and Consolidated exchanges have united.

It is difficult to overestimate the growth of the popular demand for the low-priced mining stocks dealt in at Colorado Springs. All sorts and conditions of men, and women too, bought and sold mining stocks as an investment and as a speculation. The Mining Stock Association, or rather its members, received orders from towns and cities all over the country, in addition to a heavy local trade. Its total sales for the year from May 15 were 18,721,122 shares of listed stocks, having a cash value of $3,653,150, and also 36,257,997 shares of unlisted stocks, a total of 54,979,119 shares. The Board of Trade sold from May 15, when it opened for business, to December 15, or just 7 months, 75,991,072 shares of stock, representing a cash value of $3,402,126. In a single day 1,768,765 shares changed hands, and there were days in which the cash value of the stock sold was over $250,000. The Consolidated, being but a few months old and not so well known as the association or the Board of Trade, showed more moderate dealings.

Though but a few miles away from Colorado Springs, Cripple Creek also felt the need of an exchange, and the Gold Mining Stock Exchange of Cripple Creek was organized in the fall by some well-known residents of the camp. In the two months of its life in 1895 this exchange reported transactions aggregating several million shares. The speculative movement spread so that an exchange was also started at Pueblo, the local demand apparently justifying such a course.

Of the existing exchanges of the State the oldest is the Colorado Mining Stock Exchange of Denver. It was organized and commenced business in July, 1889. It prospered for a time and then came the decline in the price of silver and the general business depression, owing to which the business of the exchange fell off to a very small volume, most of the stocks listed being of silver-mining com-

FLUCTUATIONS OF PRICES AT COLORADO SPRINGS.

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.
Alamo	$1.00	.01¾	.01½	.01½	.....	.01¾	.01⅝	.02⅝	.01⅜	.03⅛	.02⅛	.03⅛	.02⅞
Anaconda	5.00	.46½	.20½	.42	.35	.37½	.30	.40	.32	.41½	.36	.40	.38
Anchoria-L	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Aola	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Argentum-J	2.00	1.01	.82	.88½	.61	1.14½	.83	1.15	1.00	1.05	.90	1.02	.97
Bankers	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ben Hur	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Blue Bell	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Bob Lee	1.00	.0055	.005	.005	.004½	.006	.003½	.006½	.005	.006	.005	.02¼	.006
Buckhorn	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Calumet	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Champagne	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
C. K. & H.	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Colorado C. & M.	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Columbine	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Copper Mt.	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
C. O. D.	1.00	.03¼	.....	.....	.....	.02¼	.....	.....	.....	.....	.....	.....	.....
C. C. Con.	1.00	.01¾	.01⅜	.01¾	.01⅝	.02⅜	.01½	.03⅛	.01½	.07	.02⅞	.02⅛	.01¾
Creede & C. C.	1.00	.01⅞	.01⅜	.01⅞	.01½	.02⅜	.01⅜	.01⅞	.01½	.01¾	.01½	.....	.....
Cripple Creek Ex.	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Defender	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Des Moines	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Enterprise	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Eureka	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Fanny B.	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Fanny R.	1.00	.07⅜	.04⅞	.06¾	.05	.05¼	.05⅛	.06	.03⅞	.09	.05¼	.06	.05½
Favorite	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Franklin	1.00	.01	.007½	.008	.....	.005½	.004	.006	.005½	.005⅛	.005	.007½	.005½
Free Coinage	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Garfield Gr.	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Gold & Gl.	1.00	.08¼	.05½	.13½	.04¾	.06½	.04⅞	.07¾	.05¼	.07⅝	.06	.08	.07½
Golden Age	1.00	.06½	.006	.07	.006½	.....	.....	.....	.....	.....	.....	.....	.....
Golden Eagle	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.11	.....
Gold King	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Gold Standard	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Goldstone	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.004¾	.004¼
Good Hope	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Granite Hill	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.008	.007½
Gould	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.03¾	.03¼
Gold Reserve	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Henrietta	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ida May	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Isabella	1.00	.15¾	.11¾	.16¾	.13½	.19½	.14¾	.22½	.18	.19¾	.16	22½	.16¼
" Stamped	1 00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Jack Pot	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.02⅜	.02
Jefferson	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Keystone	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.01⅞	.01¾
Ladessa	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Lottie Gibson	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Matoa	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Maggie R.	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Magna Charta	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Mollie Gibson	5.00	1.67½	.99	1.07½	.85	1.15	.82	1.26	.94	1.15	.95	1.02½	.88
Mt. Rosa	1.00	.03¾	.02½	.03	.02⅜	.03½	.02½	.04	.03½	.04⅝	.03¾	,06½	.04¾
Mutual	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Nugget	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.09	.....
Ontario	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ophir	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.06½	.....
Orphan Bell	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oro Grande	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oriole	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pappoose	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pharmacist	1.00	.05⅛	.04	.05⅛	.05	.05¼	.04⅞	.07	.04⅞	.05⅞	.03⅞	.06¼	.05½
Portland	4.00	.65	.39	.58	.47	.60	.52	.74¼	.54¾	.71½	.66	.73	.67
Princess Eulalia	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Red Bird	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Reno	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Sacramento	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Santa Fé	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Specimen	1.00	.04	.02½	.03¾	.02½	.03½	.03	.03	.02¾	.03⅜	.02⅞	.03⅝	.03
St. L. & C. C.	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Security	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Silver State	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.009	.....
Star of West	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Summit	1.00	.10¼	.07¾	.11⅛	.10¾	.10	.07¾	.07¼	.06	.05	.05½	.06½	.06
Temonj	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Union	1.00	.11	.07	.11⅞	.07⅞	.13⅛	.10¼	.15⅝	.12¼	.15	.13	.14⅝	.13⅞
Union Leasing	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Virginia M.	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Wheel of Fortune	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Work	1.00	.03⅛	.02⅝	.02⅝	.02½	.02⅞	.02½	.02¾	.02½	.02¾	.02⅝	.03	.02¾
World	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.01⅝	.01½

FLUCTUATIONS OF PRICES AT COLORADO SPRINGS—*Continued.*

Name and Location of Company.	July.		August.		September.		October.		November.		December.		Sales.
	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	
Alamo	.03⅞	.02¾	.05	.03⅜	.05	.03¾	.05	.04⅜	.12	.04⅜	.10	.07	767,329
Anaconda	.42	.38½	.41½	.40	.73	.59	.70	.57½	.71	.55½	.71	.54	505,310
Anchoria-L	.55	.36	1.50	.41	2.00	1.00	2.00	1.00	2.50	1.50	3.00	2.00	56,450
Aola	......	......	.018¾	.0011	.02¾	.01¾	.02⅝	.02	.03⅞	.02¾	.04⅝	.03¼	777,683
Argentum-J	1.09½	.87	.95	.68	.82	.65	.70	.49	.63½	.40	.49	.38	962,573
Bankers	......	......	......	......	.10	.08¼	.12	.08¼	.21½	.11½	.24½	.17½	569,633
Ben Hur	.04	.01⅜	.08	.04	.07½	.06⅛	.06⅝	.05¾	.10¾	.06⅜	.12⅜	.08	649,394
Blue Bell	.02½	.01¾	.05	.03	.10	.04⅝	.08	.05⅛	.10⅜	.06⅛	.14	.07⅞	230,510
Bob Lee	.055	.005	.014½	.005½	.01⅞	.01	.01⅞	.01	.02¾	.01⅜	.24⅜	.02¼	2,129,476
Buckhorn	.02⅝	.02⅜	.04	.03	.05⅝	.03¼	.04½	.03¼	.05⅜	.03¾	.07⅞	.06⅛	905,325
Calumet	......	......	......	......	.011¼	.01	.11	.01	.01	.009¼	......	......	130,368
Champagne	......	......	......	......	......	......	......	......	.011¼	.006	.012	.008	750,000
C. K. & H.	......	......	......	......	.013¼	.01	.009¾	.007	.02⅛	.009	.02	.01½	1,621,600
Colorado C. & M.	.01½	.01	.02⅝	.01½	.03	.02½	.04⅛	.02⅜	.06½	.03¾	.08⅜	.07	2,100,750
Columbine	.01½	.01	.03	.01½	.03⅛	.02⅜	.03½	.01¾	.04¾	.02⅜	.06¾	.04	243,139
Copper Mt.	.009½	.006	.02⅜	.01	.03¼	.02⅜	.02¾	.01¾	.03	.01⅝	.03	.02½	1,244,009
C. O. D.	.04	......	......	......	.05	......	.06½	.04	.06¼	.03	.07½	......	41,500
C. C. Con	.08⅛	.05⅜	.19½	.06¼	.18	.14	.16¼	.11½	.26¾	.14¾	.25¾	.17	3,093,870
Creede & C. C.	......	......	.03⅞	.02	.04¾	.03	.13⅜	.03¼	.08½	.03⅜	.08⅛	.05¾	1,548,250
Cripple Creek Ex	......	......	......	......	......	......	.20	.02	.17½	.16¼	.17½	.16½	229,429
Defender	......	......	......	......	......	......	......	......	.014	.005¾	.015	.014½	994,000
Des Moines	......	......	......	......	.03	.02½	.03	.006	.06	.02¾	.07⅞	.06½	352,025
Enterprise	.05⅝	.04¾	.10	.05½	.12	.09¾	.15	.09	.22	.13	.31	.19	248,950
Eureka	......	......	.01⅛	.06	.01	.008	.008½	.007	.01⅞	.001	.02¼	.01⅞	521,500
Fanny B	......	......	......	......	......	......	.12¼	.003	.008	.005¾	......	......	31,000
Fanny R	.10	.05½	.007¾	.007	.13¼	.07¼	......	......	.20	.12⅛	.19½	.06⅛	1,108,597
Favorite	......	......	......	......	.07	.05¼	.10¼	.06	.14½	.09	.15	.11	232,674
Franklin	.008	.006	.006¾	.006	.011¾	.01	.01⅜	.01	.02¾	.012	.03⅛	.01½	808,000
Free Coinage	......	......	......	......	.05½	.03½	.07⅛	.01	......	......	......	......	2,000
Garfield Gr	......	......	......	......	.04⅛	.03	.03⅞	.03	.06⅞	.03½	.07	.05½	973,375
Gold & Gl	.10½	.07⅝	.14⅝	.10	.15½	.14	.21	.13⅝	.25	.18½	.28	.06¼	749,485
Golden Age	.007¼	.006	.012¼	.01	.02¼	.01¼	.02½	.01¼	.05	.02¼	.05	.03½	481,000
Golden Eagle	.11½	.01	.011¼	.01	.014¾	.013	.01⅝	.012	.03⅛	.0014	.03¼	.02⅞	495,075
Gold King	.25	.19	.42	.30	.60	.40	.70	.52	.75	.60	.68	.50	20,400
Gold Standard	......	......	.07	.02¾	......	......	.11⅝	.08⅛	.13¾	.09½	.13	.10½	1,134,300
Goldstone	.006¾	.004	.010½	.007	......	......	.009¾	.001	.02½	.00115	.02½	.02¼	1,856,950
Good Hope	......	......	......	......	......	......	.02½	.01¾	.03	.01⅞	.02⅝	.02½	46,500
Granite Hill	.017¾	.007⅞	.02⅜	.01⅜	.03½	.02¼	.07¾	.01⅛	.02⅞	.01¾	.02½	.02	1,197,000
Gould	......	......	.06¾	.04⅛	.09½	.07⅛	......	......	.18	.09¼	.25	.17	608,375
Gold Reserve	......	......	......	......	.004¾	.003	......	......	......	......	.009½	.004¼	79,160
Henrietta	......	......	......	......	......	......	......	......	.017½	.004¾	.015	.013	377,000
Ida May	......	......	......	......	......	......	.16	.14½	.15½	.13	.19	.14	8,000
Isabella	.21	.18½	.25	.20½	.30	.25	.27⅝	.23	.52	.26	.55	.39⅝	1,904,934
" Stamped	......	......	......	......	......	......	.26½	.22¼	......	......	.51	.42½	29,340
Jack Pot	.03⅛	.01½	.05⅝	.02½	.06	.04¼	.06¼	.04⅞	.15	.06⅜	.13⅞	.12	1,469,220
Jefferson	......	......	......	......	......	......	......	......	......	......	.20	.12	184,237
Keystone	.02	.01½	.05	.01⅞	.05⅞	.04¼	.05⅜	.04	.10⅜	.04¼	.10½	.08	481,900
Ladessa	......	......	......	......	.02⅛	.01⅜	.02	.01	.02¼	.01⅝	.02⅜	.02	596,570
Lottie Gibson	......	......	......	......	......	......	......	......	......	......	.03½	.03	3,000
Matoa	.04	.03⅛	.05½	.04	......	......	.13½	.10	.21	.10	......	......	657,000
Maggie R	......	......	......	......	.008¼	.008	.008¾	.006	.01¾	.001	.009½	.008	926,800
Magna Charta	.006¾	.006	.02⅝	.01¾	.02⅜	.01⅞	.02⅝	.02	.03¾	.02¼	.03½	.03	685,750
Mollie Gibson	.95	.80	.90	.57	.68½	.50	.61	.39	.49½	.38	.42	.30	419,502
Mt. Rosa	.06	.04⅛	.10⅛	.06	.12½	.09	.16¼	.09	.22	.11	.21	.16	1,256,305
Mutual	.05½	.04	.08	.04¼	.07	.04⅞	.05⅝	.04⅞	.09	.05⅜	.09	.07	391,451
Nugget	.10½	.09⅝	.12½	.09¾	.16⅝	.11⅛	.13	.10¼	.15½	.11	.16¼	.14¾	248,951
Ontario	......	......	......	......	......	......	......	......	.014½	.011½	.013	.011½	501,000
Ophir	.06½	.03	.07	.05½	.06½	.04	.06	.04¼	.11¼	.05½	.10⅝	.08	137,256
Orphan Bell	.07	.06	.10½	.05¾	.10	.09	.10	.08	.14	.08½	.14½	.05¾	263,733
Oro Grande	......	......	......	......	.002¾	.002	.002½	.001	.003½	.002¼	......	......	213,749
Oriole	......	......	......	......	......	......	......	......	......	......	.05⅜	.04½	196,600
Pappoose	......	......	......	......	......	......	......	......	......	......	.08¼	.05¾	617,000
Pharmacist	.05⅞	.04¼	.05¾	.04¼	.05¼	.04⅛	.09¼	.04	.19⅛	.09¼	.18	.17¼	2,688,641
Portland	1.12½	.71	2.25	1.11	1.95	1.67¼	2.00	1.68½	2.06	1.90	2.02	1.60	1,027,703
Princess Eulalia	......	......	......	......	.007¾	.004	.005¾	.004	.08¾	.005½	......	......	1,528,246
Red Bird	......	......	......	......	......	......	......	......	.02⅞	.02½	.03	.02½	186,350
Reno	......	......	......	......	......	......	.04¾	.03¾	......	......	.10	.06¾	192,980
Sacramento	......	......	.07⅛	.05¾	.06⅜	.04½	.06¼	.04	.09⅛	.05⅜	.10	.08½	1,461,000
Santa Fé	.006	.005½	.010¼	.006	.10¼	.006	.09¾	.006	.02⅛	.006	.01½	.01⅛	439,000
Specimen	.10	.03¾	.15	.07½	.17	.12	.17½	.15	.17	.14¼	.17½	.12⅛	661,250
St. L. & C. C.	......	......	......	......	......	......	......	......	.05⅛	.04	.04⅞	.04	97,600
Security	......	......	......	......	......	......	......	......	.012¼	.009	.011½	.009	13,000
Silver State	.009¾	.008	.02¼	.01	.02⅜	.02	.02⅛	.01¾	.02¼	.01⅞	.03¼	.02¼	712,070
Star of West	.007¾	.007	.008½	.007	.02⅛	.01	.02	.01	.02⅜	.01¾	.02¼	.02	1,129,930
Summit	.08	.06⅝	.12½	.07⅛	.27	.15½	.28½	.15	.27	.20	.27	.22	484,329
Temonj	.04⅝	.04¼	.04⅝	.04	......	......	.10½	.09⅝	.17½	.10⅛	.16½	.14½	108,740
Union	.27	.14⅝	.29½	.20½	.23	.20	.24	.19¾	.30	.23	.36	.29	2,775,346
Union Leasing	.66	.60	.60	.40	.57	.39	.41	.27	.40	.30	.35	.29	31,280
Virginia M.	.01⅜	.01	.02¼	.01⅜	.03½	.02¼	.03¾	.02¼	.04	.02	.03⅝	.03	824,227
Wheel of Fortune	......		......	......	.005⅔	.005	.006½	.006	.011¼	.005½	.010¾	.009½	1,232,800
Work	.03⅜	.03	.07	.04	.07	.05¾	.07	.02	.18	.16	.21½	.14¾	1,260,304
World	.01⅞	.01⅜	.03	.01⅝	.02⅞	.01⅞	.02¼	.01⅛	.02	.01¼	......	......	96,699

panies. After a depression lasting nearly three years the developments at Cripple Creek and in the Leadville gold belt revived popular interest in mining stocks. The Denver Exchange profited accordingly. Though the "boom" did not strike Denver until comparatively late in the year, the exchange did a much heavier business than in 1894, its total sales of listed stocks being 63,149,450 shares. It was also proposed to deal in mining securities at the Denver Real Estate Exchange and elsewhere in the city, but the old exchange did the greater part of the local business.

The shares of companies owning or operating mines in Colorado are dealt in in various cities of the world. On the London Stock Exchange Cripple Creek Exploration sold at £1@£1 5s., closing at 15s., New Guston at 10s.@13s. 9d., and Twin Lake at £1 5s.@£1 7s. 6d. In Paris Rebecca sold at 24@35f. In Shanghai Sheridan-Mendota sold at 1@4 taels, these being the highest and lowest figures respectively.

The Mining-Stock Market at Helena, Mont.

A brief summary of the condition of the mining-stock market in this locality for the year 1895 would be that aside from a few well-known dividend payers or mines of such promise and so well managed that they are expected to enter that class in the near future, very little business wss done. This has not been as peculative market since the object lessons of 1892 and 1893, when anything printed on paper representing a so-called mine on prospect found purchasers. Most of the paying mines are private properties and no stock is offered. Among the best stock corporations, like Helena & Frisco, Bald Butte, Combination, American Development, and Ontario, very little stock is ever offered, and that is readily

FLUCTUATIONS OF MONTANA MINING STOCKS DURING 1895.

Name of Company.	Par Value.	January.		February.		March.		April.		May.		June.	
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
American Dev. Co.	$1.00	3.00	......	3.00	......	3.00	......	2.75	......	3.50	......	2.75	2.50
Bald Butte	1.00	3.40	......	3.60	......	3.60	......	3.60	......	......	......	3.25	......
Combination	10.00	.75	......	.72½	......	.72½	......	.75	......	.72½	......	......	......
Helena & Frisco	5.00	......	......	......	......	.75	......	1.00	......	......	......	1.00	......
Helena & L. S. Co.	......	......	......	......	......	......	......	......	......	......	......	......	......
Iron Mountain	10.00	.55	.47½	.47½	......	.55	.52½	.60	.52½	.65	.60	.70	.65
Ontario	1.00	.90	......	1.00	......	1.00	......	1.00	......	1.00	.95	.95	......
Piegan	......	......	......	......	......	......	......	......	......	......	......	.10	......
Yellowstone	5.00	......	......	......	......	......	......	......	......	......	......	......	......

Name of Company.	July.		August.		September.		October.		November.		December.		Sales.
	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	
American Dev. Co.	......	......	......	......	......	......	......	......	......	......	......	......	2,500
Bald Butte	3.25	......	3.25	......	3.25	......	......	......	......	......	......	......	2,900
Combination	.60	......	.55	......	.50	......	......	......	......	......	......	......	3,000
Helena & Frisco	......	......	1.25	......	1.25	......	......	......	......	......	......	......	13,000
Helena & L. S. Co.	......	......	2.50	......	......	......	......	......	......	......	......	......	613
Iron Mountain	.72½	......	.70	.65	.55	.50	.55	.50	.55	.47½	.50	.47½	72,412
Ontario	......	......	.75	......	......	......	......	......	......	......	......	......	187,150
Piegan	.15	......	......	......	......	......	......	......	......	......	......	......	15,000
Yellowstone	......	......	......	......	5.00	4.75	5.25	......	......	......	......	......	35,000

absorbed; the exception being the Iron Mountain, and the anomaly is that a mine that within five years has paid in dividends over $1 per share on all the original stock sold, and within 12 months ten 2c. and two 1c. dividends, a total of $110,000, with a larger ore reserve than ever in its history—fully equipped and free from debt, with a safe conservative management—should find its stock fluctuating 50% in 90 days and falling from 75 to 50c. It can only be accounted for on the ground that large blocks of the stock have been held as collateral and forced on the market to raise quick money. It is not because the share-buying public are discriminating as to the real value of their investments in this line; if they were the mining-share business would be better for all concerned.

The accompanying table gives the local quotations. There are Montana stocks which are quoted in Butte, St. Louis, London, and other places, but which are not sold at home. Local transactions include the issue of 50,000 shares by the Merrill Gold Mining Company on organization; these shares were sold at 35c., payment to be made in installments. A controlling interest in the Royal Gold Mining Company was sold in October to Mr. W. A. Clark, of Butte, Mont.

Idaho Mining Exchange.

The year 1895, a very prosperous one for Idaho mines, left a permanent movement in the new Idaho Mining Exchange of Boisé City, the State capital. Some of the citizens of the State, feeling there was a strong inclination among themselves and neighbors toward investment of their savings in the development of its mining resources, held an informal meeting and elected the following committee to formulate a plan for facilitating this work: William Balderston, editor; David Falk, merchant; John B. Hastings, mining engineer; O. E. Jackson, mine owner; H. E. Neal, banker; Joseph Pinkham, ex-United States Marshal; Fremont Wood, lawyer. The committee decided upon the establishment of the exchange, to be conducted similarly to other stock exchanges, in addition to which it should furnish a bureau with cabinets and files, where samples of ores and descriptions of various mines and mining districts could be filed. It would also issue pamphlets descriptive of the mineral resources of the State and use every other effort to properly promulgate such information. It was felt that although there was no legal or moral law preventing residents of other States and countries from purchasing and working mining properties in Idaho, it was better for the welfare of its people that these holdings should be in the hands of actual residents. They claimed that the history of all the prominent mines shows that $10,000 properly expended in its prospect state would have accomplished all the results now attained—in other words, that with such a start the net earnings from the mine would have built the plant as required; that there was enough capital in Idaho to develop her mines, and all that was needed was segregation of holdings into small amounts within reach of every pocketbook, which was easily and best effected by formation of stock companies. As a result of its labors the committee presented the following subscription paper, which was signed by 300 of Idaho's leading citizens:

"We, the undersigned, hereby agree to associate ourselves together for the purpose of incorporating, establishing, and maintaining a mining exchange in

Boisé City, under the name of the Idaho Mining Exchange, the same to be managed and controlled by a board of 11 directors, to be elected by the members; the annual membership fee to be $20 for charter members; said fee for the first year to be payable one-half immediately following incorporation and election of officers, the other one-half subject to the call of the board of directors after 90 days from the date of the incorporation, the said exchange to be incorporated for the following purposes:

"For the development of the mining industry of the State.

"For the collection of information in relation to the mining resources of the State and for the advertising of the same.

"For the purpose of listing and affording facilities for the sale of such mining stocks as may be permitted by the board of directors under the rules and regulations hereafter adopted by the exchange.

"And for the purpose of carrying out the above objects we hereby agree to execute the necessary and proper articles of incorporation as charter members of the said Idaho Mining Exchange, and agree that the meeting of the members for the election of said directors shall be held in Boisé City on the 22d day of January, A. D. 1896."

The New York Mining-Stock Market.

For a number of years back public interest in New York in mining-stock trading had been declining. The chief reason for this is an unfortunate experience with "wildcats" years ago, which prejudiced many people against the purchase of mining stocks as a speculation or a form of investment proper. Promoters have grown accustomed to float their enterprises by subscriptions instead of by listing the stock of the companies on the exchange and selling "treasury stock" there.

In New York the principal selling and buying place for mining securities has long been the Consolidated Stock and Petroleum Exchange, which absorbed the old mining board. The New York Stock Exchange has a few mining stocks, such as Ontario, Daly, Homestake, Horn Silver, Phœnix, and Quicksilver, among its "unlisted securities," but it has rather discouraged such trading, and its governors have refused time and again to allow any more stocks to be added to the aforementioned.

The Consolidated has, therefore, been recognized as the Mining Exchange. Starting with a long list, it added to it steadily, if not always wisely, and for the past three years the absurdity of "calling" three or four score of mining companies, many of which had lost or practically abandoned their property or had been proven worthless, doubtless helped to increase the dullness.

The Consolidated Exchange late in 1895 had prepared a form of application for listing stock as follows: The president and secretary of the applicant company, under oath, are required to fill out a blank containing pertinent questions concerning the property. It is as follows: 1, Name of company; 2, purpose for which organized; 3, date of incorporation; 4, under what State or Territory law incorporated; 5, amount of authorized capital, $—, divided into — shares of the par value of $— each; 6, is the stock assessable; 7, is the stock issued "full paid" or is it subject to further installments; 8, if subject to further installments, state the conditions; 9, state the amount of capital stock issued, amount paid on each share, and in what manner paid; 10, number of shares originally set aside (or donated) for working capital; 11, number of shares now at the disposal of the treasury; 12, location of the principal office; 13, location of transfer office; 14, name of transfer agents; 15, are all certificates of stock registered and, if so, where; 16, names of officers; 17, names of directors (or board of trustees) who have accepted the position and own stock; 18, number of shareholders and names of holders of a majority of stock issued; 19, location of property; 20, mining claims, name, size, etc.; 21, metals produced; 22, has the mine heretofore been worked, and if so, by whom; 23, amount (in dollars) expended for mine development by present company and the amount so expended by former owners; 24, amount expended for milling machinery, buildings, etc., by present company and also by former owners; 25, capacity of milling machinery and of hoisting or mining machinery (tons per day); 26, average width of the vein or veins, formation, peculiarities, etc.; 27, depth of shafts, length of levels or tunnels; 28, number of men employed at present; 29, estimated value of ore in sight in levels or tunnels; 30, amount of ore now on the dump (tons) and estimated net value; 31, average value of ore per ton, ascertained (a) by reduction test and (b) by assay test; 32, cost of mining per ton and cost of reduction, including transportation, per ton; 33, distance to mill or smelter and cost of transportation per ton; 34, is the ore free milling or refractory; 35, by what process is the ore reduced or treated; 36, (a) number of tons mined by present company, (b) number of tons reduced, (c) gross value of bullion produced from same, and (d) net value; 37, number of dividends paid by present company and aggregate amount; 38, price at which the stock was sold in first subscription; 39, present "bid" and "asked" prices for the shares; 40, remarks to cover any point not specially asked above.

In addition to complete answers to the foregoing, the following papers must also be submitted to the committee: A report of the company's superintendent to date of application; a certified copy of charter of company; a certified copy of abstract of title, including United States patent, if any; date of patent; a certified copy of court records, if any; detailed statement of present financial condition of the company, showing debts and resources; maps, diagrams, etc., of the property; a receipt of the treasurer of the exchange showing payment of $50, to be retained whether the application is withdrawn before action or is rejected. The application blank concludes as follows:

"In making this application, it is hereby agreed, as a condition precedent to the listing of the stock, that the company shall furnish to the Committee on Mining Securities at any time, on demand, such reasonable information of its general condition as may be required, and that a failure to give such information shall subject the company to the penalty of having its stock stricken from the list. It is further agreed and understood that the company, having been duly notified (through its president and secretary or legal representative) of the listing of its stock, shall within 60 days thereafter send a written communication to the chairman of the exchange to have the stock regularly called for quotation purposes, and in default of such notification the Committee on Mining Securities reserves the right to have it called and quoted."

It will be seen from the above that the Consolidated Exchange really endeavors to protect its patrons, for with complete answers to all the requisite questions there can be little talk of false pretenses. One of the chief blunders of the exchange has been the keeping on the list a great number of companies which for some reason or other did not fulfill the expectations of the incorporators and practically went out of existence years ago. This has been partly remedied by the action noted below.

The course of the market itself in 1895 was uninteresting to a degree, though transactions were numerically greater than in 1894. It was very dull throughout

FLUCTUATIONS OF MINING STOCKS IN NEW YORK

Number.	Name and Location of Company.	Par Value.	Jan.		Feb.		March.		April.		May.		June.		July.	
			H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L
1	Adams, (s.l.) Col	$10														
2	Alice, (g.) Mont.	25	25						45	40	65	40			40	
3	American Flag, (s.) Col.	100							07	04	05		04	03	04	03
4	Argentum, Juniata, Col.	1									1 05				1 05	1 00
5	Atlantic, (c.) Mich.	25													17 75	
6	Belcher, (g. s.) Nev.	100			85						50					
7	Best. & Bel. (g. s.) Nev.	100	1 20	94			98		90		80	55	67	55	1 00	60
8	Bodie, (g.) Cal	100	75	70			1 25	1 15	1 20						30	
9	Bost. & Mont. (c.) Mont	25													83 75	75 25
10	Breece, Col.						25								20	
11	Brunswick, (g.) Cal	5			03	02	04	03	18	04	17	07	15	12	13	12
12	Butte & Bost., (c.) Mont	10													18 50	17 25
13	Bullion, (s. g.) Nev	100	20		15		19									
14	Bulwer, (g.) Cal	100	09	08			20		20							
15	Castle Creek, Idaho	10									03	02				
16	Chollar, (s. g.) Nev	100	58	47	62	43	67	54	50		49				18 50	75
17	Chrysolite, (s. l.) Col	50							20	15	20	17	20	17	19	
18	Comstock Tun., Nev	100	07	06	06	05			15		11		14	07	12	
19	Comst. Tun., B'ds, Nev.						06		15		15		12	11	12	
20	Comst. Tun., Scrip, Nev.								15		15				03	
21	Con. Cal. & Va., (s.g) Nev.	100	4 40	3 50	3 55	2 50	3 15	2 40	3 50	2 55	3 10	2 45	2 75	2 25	3 00	1 85
22	Cons. Imp., (g. s.) Nev.	100			05	04			08	07						
23	Creede & C. C., Col	1														
24	Crown Point, (g. s.) Nev	100	70	55	48	34	50		77	72					50	
25	Daly, (s. l.) Utah	20														
26	Deadw., Terra., (g.) S. D,	25	40				40								1 00	
27	El Cristo, Rep., Col.	2									10		50			
28	Enterprise, Col.	5							75	55						
29	Eureka Con., (s.l.g.) Nev	100					30	05			35					
30	Gold & Glohe, Col.	1														
31	Gould & Curry, (s.g.) Nev	100	52	45	49	40	62	55	60		30		35		47	38
32	Hale & Norcross, (g.s.) "	100	1 25	90	1 00	80	1 50	1 00	1 60	1 20	1 50	90	1 00	80	1 45	
33	Homestake, (g.) S. D.	100	28 00	20 00							22 00					
34	Horn Silver, (s. l.) Utah	25	2 50		2 50		2 30		2 75	2 30	2 80	2 70	2 70	2 50		
35	Iron Silver, (s. l.) Col,	20	15				30		32	21	33	32	37	35	50	40
36	Isabella, Col.	1							23	20			21	20	22	20
37	Kingston & Pemb., Ont.	10							20		30	25	50	25	30	25
38	La Crosse, Col.	10	10	07					10	07	10	09	14	09	13	10
39	Leadville, (g.) Col.	10	09	08			14	10	19	12	17	11	15	13	13	12
40	Little Chief, (s. l.) Col.	50	08		10		15	08	20	14	19				15	14
41	Mexican, (g. s.) Nev.	100	1 10	95	95	72	1 10	90	90		75		70	35	75	70
42	Mollie Gibson, (s.) Col.	5							1 30	1 05	1 05				90	87
43	Moulton, (s. g.) Mont.	5											20		30	21
44	Ontario, (s. l.) Utah.	100											9 00			
45	Ophir, (g. s.) Nev	100	2 15	1 80	1 60	1 40	2 25	1 60	1 75	1 65	1 70	1 50	1 50	1 25	1 60	1 45
46	Phœnix Con., (g.) Ariz.	100	11				10		10	08	10	08	05			
47	Plymouth Con., (g.) Cal	50	40	25					20							
48	Portland, (g.) Col.	1							80	60					99	98
49	Potosi, (s.) Nev	100	65	60	55		58		55		43	41				
50	Quicks., Cal. (com.)	100	2 25						4 00	3 13	4 13	3 88	3 88			
51	Quicks., Cal. (pref.)	100	13 50						20 00	18 00	19 50					
52	Quincy, (c.) Mich	25														
53	Savage, (s.) Nev.	100	66	55	1 50	40	45						40		55	51
54	Sierra Nev. (s. g.) Nev.	100	80	58	63	54	76	74	90	85	77	62	43		75	50
55	Small Hopes, (s.) Col.	2														
56	Standard Con., (g.s.) Cal	100	2 50	2 00	2 75		3 00	2 50	3 00	2 75	3 00	2 75	2 80	2 40	2 40	2 20
57	Tamarack, (c.) Mich	25													1 41	
58	Union Con., (g. s.) Nev.	100	60	53	2 65	40	2 75	50	60		80	37			50	27
59	Victor, (g.) Col	5	4 00													
60	Yellow Jacket, (g.) Nev	100	65	44	60	44	75	50	65	45	60	34	50	42	45	
	Total sales															

the year. The gradual decline of business may be seen from a comparison of the past eight years. This table shows the total number of shares sold in each year:

Year.	Shares Sold.	Year.	Shares Sold.
1895	678,925	1891	2,522,660
1894	302,372	1890	3,925,926
1893	624,617	1889	4,114,480
1892	1,527,371	1888	11,689,388

There was no particular activity in any one stock or group of stocks, and though there were several temporary "spurts" none seemed to be able to last a fortnight.

The Comstocks were lifeless. Prices fluctuated but little, and as there were no especially favorable developments on the Lode there was no marked advance and no attempt to "boom." Comstock Tunnel Company stock and bonds, owing to the new management and to the explorations on the Brunswick Lode, were in some demand and prices advanced from 5 and 6 to 15c. for the stock and the same for the bonds, though later they declined to 8 and 9c. Transactions in this stock were moderately heavy, though it is understood that many of the sales were "washed," as indeed is said to have been the case with the majority of the reported sales of the other Comstocks.

Of the California stocks the Bodie group underwent more or less desultory trading. Standard Consolidated is the foremost and reached the $3

DURING 1895.

Aug.		Sept.		Oct.		Nov.		Dec.		Sales	No.
H.	L.	H.	L.	H.	L.	H.	L.	H.	L.		
20	...	20	...	30	...	...	...	...	...	1,800	1
...	...	...	...	40	25	40	35	...	...	13,945	2
04	...	...	...	06	04	05	04	...	...	11,700	3
...	...	...	...	...	...	...	...	...	...	5,000	4
...	...	...	...	...	...	...	...	...	...	50	5
...	...	60	45	...	...	41	...	...	...	700	6
1 20	1 05	1 10	1 05	90	85	75	52	85	50	4,310	7
...	...	...	...	30	...	38	...	50	...	1,100	8
91 00	90 88	...	...	...	...	...	...	...	...	6,500	9
...	...	...	...	...	...	25	20	27	24	2,400	10
...	...	10	07	13	10	13	10	19	11	95,800	11
...	...	...	...	...	...	...	...	...	...	300	12
66½	15	15	...	...	...	...	...	...	...	600	13
05	...	...	...	...	...	...	...	...	...	1,200	14
...	...	...	...	03	02	02	...	...	...	2,200	15
22 63	65	65	...	55	...	35	...	...	...	8,250	16
...	...	12	...	31	08	25	24	27	24	25,500	17
10	...	08	...	08	...	09	08	08	06	138,425	18
11	...	...	...	...	...	10	...	07	...	39,300	19
09	...	...	...	...	...	...	...	...	...	1,015	20
3 00	2 65	2 85	2 60	2 75	2 55	2 60	2 25	2 30	1 95	21,446	21
06	...	08	...	03	02	05	04	05	...	12,900	22
...	...	...	...	...	...	...	...	08	...	...	23
...	...	60	...	...	...	...	...	...	...	1,250	24
7 38	2 55	7 38	7 00	...	...	...	...	6 63	6 50	590	25
...	...	...	...	...	...	...	...	80	...	1,800	26
...	...	...	...	10	05	09	07	...	...	400	27
...	...	...	...	50	...	65	50	...	...	9,015	28
...	...	...	...	...	...	...	...	20	...	950	29
...	...	...	...	18	17	...	...	...	...	900	30
60	45	63	59	...	...	35	25	47	...	5,300	31
2 30	1 60	1 50	...	1 45	...	1 40	40	1 15	89	6,000	32
...	...	...	...	31 50	...	25 00	...	30 50	27 00	825	33
2 40	...	2 20	...	2 40	2 00	2 30	2 05	2 40	2 25	7,970	34
48	40	30	25	30	24	27	20	25	23	15,050	35
...	...	26	25	30	...	...	...	50	49	11,220	36
30	...	25	21	35	25	25	...	25	...	4,106	37
20	13	16	10	16	08	13	10	14	...	42,300	38
14	11	15	11	15	12	15	12	15	12	60,800	39
15	13	...	...	22	13	25	12	25	20	17,900	40
75	60	83	67	68	...	61	40	60	43	6,400	41
...	...	65	...	60	50	...	...	...	...	16,800	42
...	...	...	...	35	30	...	...	...	...	700	43
10 00	9 00	10 00	...	9 75	...	9 63	...	9 25	8 75	395	44
1 60	1 50	1 80	1 70	1 65	1 50	1 25	1 00	1 50	...	5,060	45
05	...	...	...	...	...	13	04	11	07	9,200	46
...	...	...	...	...	...	20	...	...	...	1,650	47
1 30	1 25	1 75	1 65	2 00	1 75	...	...	...	...	16,800	48
...	...	70	...	62	55	65	...	...	...	2,920	49
3 88	...	...	...	3 00	...	2 75	2 50	...	...	4,000	50
...	...	...	...	18 00	15 00	...	...	...	...	1,413	51
139 75	139 50	...	...	...	...	...	...	...	...	...	52
75	15	43	...	51	38	40	...	35	...	2,250	53
...	...	...	...	1 00	90	90	70	75	55	10,160	54
...	...	...	...	80	...	95	80	1 00	90	3,250	55
2 30	2 25	2 35	1 75	2 60	2 25	2 20	1 50	1 80	1 45	9,090	56
...	...	...	...	...	...	...	...	...	...	260	57
40	...	75	21	80	23	70	50	60	...	4,760	58
...	...	...	...	...	...	5 25	...	...	...	500	59
50	35	66	55	...	...	38	29	37	...	2,500	60
...	...	...	...	...	...	...	...	...	...	678,925	

mark, though it declined later and closed under \$2, owing probably to the suspension of dividends. Bodie, for reasons yet unknown, rose to \$1¼ in March and April, but closed at about 30c. The other Bodies were in no demand.

Such stocks as Quicksilver never fluctuate much, and both the preferred and common stocks were steady at \$18 to \$20 and \$3 to \$4 respectively. Brunswick Consolidated opened at 2@3c., advanced to 15@18c. in April, and declined gradually to 10@13c. in December.

In point of numbers some of the old Colorado shares show the heaviest transactions of the year. Lacrosse, a Gilpin County gold property, owing to favorable developments in its neighborhood, advanced from 7c. in January to 20c. in August, but declined gradually, closing at 10@12c., with fairly heavy transactions. American Flag, another Gilpin County gold property, was also in some demand, and fluctuated from 4 to 6c., with a top price of 7c.

The Leadville group was among the most active. The developments in the Leadville gold belt and a number of pleasant rumors—unfortunately unconfirmed—helped the demand. Leadville Consolidated seemed to be the most active of all, the prices rising from 8c. in January to 19c. in April and declining to 11c. in the following month. During the remainder of the year it fluctuated between 11@14c. Little Chief, Iron Silver, and Chrysolite also advanced and declined during the year.

The Aspen group was exceedingly quiet throughout.

A number of Cripple Creek stocks are on the "temporary" list—that is, brokers are permitted to trade in them. A number of sales at the prices then ruling in Colorado Springs were made. They are nearly all good stocks, and people buy them chiefly for investment. Attempts are making to list more, to see if some of the Colorado Springs activity can be coaxed eastward. Victor, which is on the regular list, was very quiet, for the reason that holders have no desire to part with it. There were but two sales, one in January at \$4 and the other in November at \$5¼.

Of the Utah stocks Horn Silver was the favorite. Owing to the passing of two of the regular dividends the price declined from \$2⅝ to \$2—the highest and lowest of the year—but it ruled steady throughout at about \$2¼. Ontario and Daly are too high priced for much popular trading and are, moreover, closely held stocks.

Other shares were dealt in, and the table tells their story succinctly.

In view of the increasing interest in mining-stock speculation in the West, the Consolidated Stock and Petroleum Exchange made some efforts late in the fall to bring about a resumption of activity in this market. The Committee on Mining Securities considered various plans and suggestions. The first step was taken on December 5, when it was decided to strike off from the regular list of the exchange the stocks of the following mining companies, to take effect on and after February 1, 1896: Argenta, Bechtel, Bassick, Bradshaw, Consolidated Pacific, Carson River Dredging, Columbia, Del Monte, Diana, El Cristo, Excelsior, Elko, Emmet Water and Mining, Freeland, Found Treasure, Grand Prize, Gold Stripe, Iron Hill, Kossuth, Martin White, Monitor, Mutual Mining and Smelting, Mount Diablo, Navajo, North Belle Isle, Proustite, Rappahannock, Reward Mining and Smelting, Sutro Tunnel, Sutro Tunnel (first certificates), Surinam, San Sebastian, Sullivan, Scorpion, Tioga, United Copper, and Wall Street Mining and Milling Company. The following stocks were ordered placed

PRICES OF COAL AND INDUSTRIAL STOCKS AT NEW YORK DURING 1895.

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.
American Coal	$ 25	98 00	. . .	. . .	. . .	. . .	. . .	. . .	. . .	65 00	55 75	. . .	. . .
Baltimore & Ohio	100	65 50	58 50	64 00	55 88	. . .	. . .	59 25	55 00	102 25	94 50	64 00	61 25
Central of N. J.	100	93 75	84 88	89 13	81 50	98 75	83 25	. . .	. . .	. . .	. . .	102 00	97 13
Chesap'ke & Ohio	100	18 00	16 00	17 38	16 00	18 25	16 00	19 38	17 38	23 63	18 38	23 25	21 75
Col. Hoc. Val. & T.	100	17 88	16 00	20 13	18 88	27 00	19 00	27 88	25 00	27 50	25 25	27 00	25 13
" pref	100	60 00	57 50	61 00	. . .	69 75	60 50	67 00	66 00	67 00	65 00	64 50	62 50
Col. Coal & Ir. Dev	100	6 13	5 00	6 00	4 50	6 00	4 00	7 50	5 75	10 63	6 25	11 50	8 63
Col. Fuel & Ir	100	25 00	. . .	. . .	. . .	. . .	. . .	25 75	24 00	28 00	25 25	36 00	27 13
Col. Fuel & Ir. pref	100	. . .	. . .	. . .	. . .	. . .	. . .	64 00	60 00	70 00	60 00	72 00	64 00
C. & H. Coal & Iron	100	4 75	2 50	. . .	. . .	7 75	4 25	7 25	5 25	9 25	6 75	9 50	7 50
C. & H. C. & I., pref.	100	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Consol. Coal	100	33 50	33 00	31 25	30 00	. . .	. . .	30 00	28 25	29 00	. . .	32 00	. . .
D., L. & W	50	166 50	157 88	162 50	156 50	164 60	155 75	163 00	158 00	163 50	158 75	164 75	159 50
Dela. & Hudson	100	133 50	125 50	130 88	126 00	129 25	123 00	130 50	124 38	132 88	127 75	131 13	128 25
General Electric	100	34 88	28 75	30 25	28 25	37 88	25 88	36 13	32 63	35 88	32 00	37 88	34 88
Lake Erie & West	100	17 38	15 75	16 38	15 25	17 63	13 50	21 25	17 13	25 50	19 88	25 13	22 50
L. E. & W., pref	100	74 00	69 00	71 25	69 50	74 50	70 50	78 50	74 00	84 00	77 00	85 00	81 50
Md. Coal, pref	100	50 00	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Morris & Essex	50	163 00	160 00	160 00	156 00	. . .	. . .	162 50	161 00	162 50	162 00	163 00	162 75
National Lead	100	37 75	28 34	33 50	26 50	33 25	27 00	. . .	. . .	36 50	34 00	37 25	31 50
Nat. Lead, pref.	100	84 75	79 00	83 25	81 50	85 13	82 00	. . .	. . .	91 00	88 25	90 75	89 00
New Cent. Coal	100	6 00	. . .	. . .	. . .	. . .	. . .	. . .	. . .	8 50	8 00	9 00	8 00
N.Y., L. & W.	100	117 25	116 25	118 00	114 25	. . .	. . .	117 50	116 50	. . .	. . .	117 50	. . .
N.Y., L. E. & W.	100	10 88	9 50	10 75	8 34	10 38	7 25	12 63	9 50	15 38	10 13	11 38	9 50
" " pref	100	23 00	20 75	21 50	16 00	20 00	16 00	25 00	21 25	30 00	25 00	32 88	22 00
N.Y., Ont. & West.	100	17 00	15 38	16 38	15 75	16 88	15 75	17 63	16 25	19 25	17 13	18 63	17 63
N.Y., Sus. & West.	100	14 75	13 00	14 00	12 75	14 50	12 00	15 50	12 25	14 00	9 50	11 50	6 88
" " pref	100	43 00	38 50	40 75	34 00	40 25	35 50	37 63	34 88	38 00	. . .	32 00	. . .
Norfolk & West.	100	5 50	3 13	4 38	2 13	2 88	2 00	4 00	3 75	6 50	3 50	4 38	3 13
Phila. & Reading	50	13 75	8 34	10 13	9 63	14 13	7 50	16 88	12 50	21 63	15 88	19 38	15 38
Penn'a Coal	50	320 00	. . .	. . .	. . .	. . .	. . .	. . .	. . .	320 00	. . .	. . .	. . .
Tenn. Coal & Iron	100	16 88	13 25	15 00	13 63	16 13	13 50	22 13	15 50	29 88	20 75	40 13	27 75
" " pref	100	. . .	. . .	. . .	. . .	. . .	. . .	80 00	74 00	88 00	80 00	102 00	87 75

Name and Location of Company.	Par Value.	July.		August.		September		October.		November		December.		Sales.
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	
American Coal	$ 25	. . .	. . .	. . .	. . .	43 00	. . .	. . .	. . .	. . .	. . .	. . .	. . .	445
Baltimore & Ohio	100	65 00	62 38	65 50	63 38	66 75	63 00	64 50	60 00	60 50	54 00	55 88	23 00	129,863
Central of N. J.	100	104 75	100 25	111 88	101 75	116 50	107 00	114 75	108 00	109 50	105 00	110 38	93 00	784,025
Chesap'ke & Ohio	100	22 63	20 88	21 88	20 00	22 00	19 00	20 13	18 00	19 50	18 00	18 25	12 50	403,895
Col. Hoc. Val. & T.	100	26 00	24 75	25 63	24 50	25 75	23 50	24 38	20 38	21 75	16 75	19 00	14 38	128,828
" pref.	100	. . .	. . .	65 50	64 50	. . .	. . .	64 00	57 50	60 00	58 00	58 25	. .	2,221
Col. Coal & Ir. Dev	100	10 25	8 00	8 00	5 00	7 88	6 00	6 75	4 50	5 00	4 50	5 25	3 00	36,787
Col. Fuel & Ir.	100	41 38	33 00	38 50	36 00	41 50	36 00	41 00	32 25	35 00	30 00	39 25	30 50	185,244
Col. Fuel & Ir pref	100	94 00	75 00	94 00	. . .	100 00	. . .	100 00	98 50	. . .	. . .	. . .	. . .	2,058
C. & H. Coal & Iron	100	7 00	4 50	5 25	3 00	4 75	3 00	3 50	2 75	21 75	16 75	3 00	2 00	27,687
C. & H. C. & I., pref	100	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	60 00	58 00	. . .	. . .	4,403
Consol. Coal	100	32 50	32 13	. . .	. . .	. . .	. . .	35 00	. . .	33 13	. . .	. . .	. . .	2,090
D., L. & W.	50	163 50	161 50	164 00	161 00	170 00	169 50	174 00	165 00	169 50	165 00	168 00	154 00	151,055
Dela. & Hudson	100	131 88	129 25	132 25	130 00	134 88	129 13	134 00	130 00	131 00	127 00	130 00	118 00	176,259
General Electric	100	37 88	35 13	38 50	35 75	41 00	36 25	39 75	29 25	33 00	28 75	31 63	20 00	137,717
Lake Erie & West	100	28 00	23 75	27 75	23 00	27 00	23 50	25 50	22 00	24 50	22 00	32 50	15 50	190,302
L. E. & W., pref.	100	85 00	83 25	83 75	75 00	81 00	77 50	78 88	73 75	76 25	73 00	74 50	65 00	133,753
Md. Coal, pref.	100	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	50 00	. . .	. . .	. . .	135
Morris & Essex.	50	164 00	160 50	165 00	164 00	169 00	164 50	170 00	167 00	171 25	168 50	170 00	. . .	2,571
National Lead.	100	36 63	33 50	36 75	34 13	37 50	32 00	35 25	30 00	32 25	29 75	31 25	17 50	27,995
Nat. Lead, pref.	100	92 00	90 00	94 50	90 25	92 75	89 88	92 50	90 00	92 00	90 00	91 00	73 00	11,453
New Cent. Coal.	100	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	100
N. Y., L. & W.	100	115 75	115 50	. . .	. . .	116 75	. . .	. . .	. . .	. . .	. . .	. . .	. . .	696
N. Y., L. E. & W.	100	10 88	9 63	10 63	8 13	13 13	8 13	13 63	11 25	13 38	9 25	5 50	10 00	284,867
" " pref.	100	23 88	. . .	27 00	21 00	26 00	20 25	26 50	24 50	23 50	20 50	. . .	. . .	13,341
N.Y., Ont. & West	100	18 25	17 25	18 13	17 13	19 13	17 00	19 00	17 00	17 13	14 63	15 75	11 75	68,098
N. Y., Sus. & West	100	11 38	10 00	14 25	11 00	14 50	12 00	13 63	11 75	12 00	10 25	11 50	7 00	158,504
" " pref.	100	30 88	27 13	35 63	29 00	38 00	31 25	37 75	33 13	34 50	29 50	33 00	19 88	328,100
Norfolk & West.	100	3 88	3 25	4 50	3 50	4 50	3 50	3 88	3 88	3 75	3 00	3 50	1 50	21,403
Phila. & Reading	50	20 00	16 38	20 50	17 25	22 63	18 25	22 00	13 00	14 38	9 25	10 75	4 63	416,596
Penn'a Coal	50	340 00	320 00	325 00	320 00	. . .	. . .	340 00	326 00	. . .	. . .	. . .	. . .	359
Tenn. Coal & Iron	100	40 13	32 13	40 50	34 13	46 63	38 75	45 88	31 25	38 50	31 00	33 63	23 00	449,016
" " pref.	100	. . .	. . .	100 13	. . .	102 75	96 00	102 00	100 00	100 00	. . .	100 00	. . .	4,322

on the "suspended" list on and after February 1, 1896: Augusta Mining and Industrial (stock and bonds), Columbia & Beaver, Cleveland Tin, Colchis, Helena, Holyoke, Hector, Lee Basin, Monte Cristo, Oriental & Miller, Plutus, Robinson Consolidated, Ruby Silver (bonds), Stormont, Silver Queen, Santiago, Shoshone, Trio, and Tornado. Several applications by new mining companies for listing were made during the last fortnight of the year.

Following the example set by some of the Western cities the establishment of a new mining board was proposed. Papers for the incorporation of the New York Mining Exchange were sent to the Secretary of State at Albany on December 16. The incorporators are Henry A. Mott, Edwin A. Beers, James H. Kerr, and Edward H. Williams, all of New York. The object of the exchange, as stated in the application paper, is to establish an exchange and open a market for the sale of and dealing in shares of the capital stock of mining and other corporations and other securities created by such corporations, including bonds and the various classes of certificates representing interests in property; also mines of gold, silver, copper, quicksilver, coal, lead, marble, granite, tin, and all and every class of mineral properties. The capital stock of the new exchange is $10,000, divided into shares of $100 each. The directors for the first year are Isham B. Porter, James H. Kerr, Howard Scrymser, Stephen B. French, W. Leslie Scrymser, Henry A. Mott, Edwin A. Beers, W. C. Nicol, and Edward H. Williams. Since the close of 1895 the new exchange has completed its arrangements for business.

The course of the coal and industrial stocks, which are dealt in on the exchange, and which are held entirely apart from the mining stocks, is shown in the foregoing table.

A Quarter of a Century's Fluctuations in Mining Stocks.

The accompanying table, which has been compiled from the records furnished by the *Engineering and Mining Journal*, shows the fluctuations during the past quarter of a century in the selling prices of a number of prominent mining stocks. Only such stocks are included as may be considered to still have an actual existence and value. Had those been added which have since entirely disappeared the list might have been greatly increased.

In preparing this table the intention is not by any means to discourage investments in mining property, since mining when carried out on a business and commercial basis is as safe as and more profitable than any enterprise in a manufacturing or mercantile line. The object of the table is simply to show the enormous fluctuations that mining stocks are subject to in a period of inflation and speculation, and thereafter the absolutely certain reaction which takes place when the excitement has passed and the stocks are valued from a common-sense point of view according to the net returns they earn.

These eras of mining-stock speculation have come in waves, the first of which may be dated from 1870 and was confined to the mines of the Comstock Lode, reaching its culmination, for the time, in 1872, the advance in price in 13 of the leading mines on the Comstock Lode showing an increase of market value of no less than $80,594,000. A reaction took place after this advance in June, 1874; the same 13 mines showed a depreciation on the stock market of $43,835,800, the respective total values in 1870, 1872, and 1874 being $4,746,000, $85,340,000

(June, 1874), and $41,504,200. Later on there was a great renewal of speculation, and the market value of these same stocks in December, 1874, was $166,223,600, showing an increase in price from the quotations in 1870 of the astounding amount of $161,497,600. Up to this date December, 1874, the total assessments amounted to $6,666,000 and the total dividends to $26,156,000.

The foregoing shows the fluctuations between 1870 and 1875. After the latter date the Comstock stocks gradually fell in price, with an occasional reaction and a spurt which encouraged speculators to hope for a return to the old-time prices. As an instance of how rapidly prices changed, it is recorded that in 12 hours in February, 1872, the price of shares in the Savage Mine advanced $100 per share, and in 30 days California jumped from $85 to $585; and to show the reverse of the picture, Belcher, on May 8, 1872, fell $300 in 24 hours. The present quoted value of the above-mentioned 13 leading Comstock mines has dwindled from $166,263,600 in December, 1874, to $970,800 to-day.

The next real speculation in mining property and stocks was started by the discovery and rapid development of lead carbonate and high-grade silver ores at Leadville, Colo., which took place in 1878. One of the most attractive features for speculators, which no doubt caused much money to be seriously invested and still more to be wasted on mere paper speculation, was the result of H. A. W. Tabor's "grub stake" to George Hook and August Riche. Hook was a poor shoemaker and Riche was "dead broke." After sinking 26 ft. they struck carbonates on the Little Pittsburg, and within a few months Tabor & Riche bought out Hook's one-third interest in that and an adjoining claim called the Dives for $90,000, and within 4 months from the date of striking ore the net returns from ore sales were $105,000. By the end of the year the Little Pittsburg Consolidated, which included two other claims besides the two original ones, was turning out monthly ore of the value of $250,000.

The next period in the history of this mine (which carried along with it many minor ventures successfully in the stock market) was when it was placed on the Eastern market in October, 1879, with a capital of 200,000 shares, which sold at $30 per share, or $6,000,000 for the mine. Up to this date the published amount of dividends paid was $950,000. Early in 1880 the boom was over, and in one day Little Pittsburg dropped from $29 to $11 a share, and with it all Leadville stocks declined rapidly in sympathy. By June of the same year, although Little Pittsburg had paid in dividends $1,350,000, it was selling at $6 a share, or $1,200,000 for the mine, and at the same date Chrysolite, which had divided $1,100,000 in profits, was selling at $20 a share, or $4,000,000 for the mine.

To go outside the table and outside our own country, we may instance the boom of 1895 in South African mining stocks in London and Paris. At the end of September a list of the shares dealt in on the London exchange showed stocks having a par value of $250,786,800 selling at $1,076,900,000, or more than four times their face; and this enormous appreciation was in spite of the fact that the shares of actual dividend payers formed less than one-eighth of the total $32,775,000 par value. In the first week of November the selling prices of the same shares had decreased by $358,869,000, or 34%, and it is to be noted that the loss was almost as great on the actual dividend payers as in the purely speculative values.

A QUARTER OF A CENTURY'S FLUCTUATIONS IN MINING STOCKS.

1884 to 1895.

Company.	State.	Par Value.	1895.		1894.		1893.		1892.		1891.		1890.		1889.		1888.		1887.		1886.		1885.		1884.	
			H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
Alpha	Nev....	100	....	....	.25	.15	.20	...	.60	.50	1.45	.80	2.30	1.10	1.40	1.30	....	....		....	....	....	....	....	....	....
Belcher	"	100	.67	.41	1.00	.70	1.45	1.00	4.00	1 25	3.40	1.40	3.45	.24	5.00	2.35	8.88	4.10	12.25	6.13	....	....	....	....	....	....
Best & Belcher	"	100	1.25	.52	2.70	1.05	1.90	1.00	3.50	1.20	8.75	1.80	4.20	1.95	6.38	2.80	9.50	3.25	14.25	4.40	23.50	.60	3.65	1.00	3.00	.95
Bodie	Cal.....	100	1.25	.30	1.40	.05	.40	.20	.70	.15	2.25	:45	1.80	.40	2.00	.60	3.80	1.15	3.50	1.00	4.25	1.00	3.35	1.40	13.00	1.15
Breece	Colo...	25	.25	.20	....	....	.40	.15	.55	30	.47	.31	.70	.25	.31	.13	.55	.20	.72	.30	.60	.15	.28	.09	.40	.09
California	Nev. ..	100	...	....	...	....	....	....	....	....	....	..	....	....	...	....	....	...	....	....	....	....	....	....	....	....
Chollar	"	100	.67	.35	.86	.24	1.35	.35	1.85	.50	3.85	.90	4.90	2.00	3.40	1.35	7.50	1.95	11.25	4.40	11.00	.67	....	....	....	....
Chrysolite	Colo...	50	.30	.15	.20	....	.23	.20	.27	.15	.30	.18	.45	.14	.31	15	·55	.30	.67	.40	.90	.50	1.30	.65	1.25	.70
Comstock Tun	Nev....	100	.15	.05	.09	.03	.16	.06	.23	.08	.40	.14	.21	.10	.42	.15	...	....	....	...	...	....	....	....	....	....
Con. Virginia	"	100	....	....	....	...	....	....	....	....	....	...	....	....	....	....	....	....	....	...	...	....	....	....	.55	.02
Con. Cal. & Va.	"	100	4.40	2.25	8.25	2 10	3.00	1.00	6.00	1.10	9.00	2.50	5.90	2.30	10.00	4.30	24.00	7.00	27.13	13.00	65.00	1.15	3.75	.11	.45	.32
Con. Imperial	"	100	.08	.02	.24	.06	.12	.10	.16	.10	.33	.15	.60	.25	.90	.50	9.63	1.30	3.35	1.50	2.00	.08	....		..	....
Crown Point	"	100	.77	.34	1 00	.40	1.15	.55	1.70	.45	3 10	.85	3.30	1 15	6.13	1.75	11.25	3.45	18.00	5.87	12.00	5.50	1 60	1.25	....	....
Deadwood Terra.	S. Dak.	25	1.00	.40	.80	.50	1.75	.75	3.20	1.10	2.10	.75	1 60	1.25	2.00	1.25	2.05	1.50	3.70	1.70	3.40	1.70	....	....	...	....
El Cristo	R. of C	2	.10	.05	.10	.03	.60	.15	.75	.18	.60	.25	1 85	.55	1.90	.56	3.05	.58	9.63	1.75	...	....	....	....	....	....
Eureka Cons	Nev....	100	.35	.05	.90	.20	....	.	2.10	1.65	4.00	1.45	5.50	3.00	5.50	1 00	15.78	2.50	7.75	4.05	10.00	.75	9.25	1.00	4.76	1.50
Father De Smet	S. Dak.	100	.22	.15	.	..	.25	.15	1.24	.20	.49	.20	.42	.23	.65	.19	.61	.35	.85	.45	4.00	.50	6 00	3.00	4.50	2.60
Gould & Curry	Nev....	100	.63	.30	1.15	.45	1.80	.55	1.90	.17	3 80	1.15	2.85	1.30	3.30	1.40	5.63	2.55	6.50	3.75	9.00	.65	2.00	.50	2.25	.99
Hale & Norcross	"	100	1.75	.40	1.65	.45	1.45	.45	3.40	.75	3.50	1.05	3.15	1.90	5.33	2.45	13.37	4.16	9.25	3 35	10.00	.65	10.50	3.10	8.25	2.25
Holyoke	Idaho..	1			...	..	....	....	....	....	.06	.03	.06	.03	.07	.03	.08	.04	.31	.06	.		....	...	....	....
Homestake	Dak....	100	31.50	18.00	14.50	12.50	14 75	13.00	15.00	12.00	11.50	9.00	11.50	7.75	14.00	6.50	13.00	10.00	16.00	11.00	23.00	16.75	23.00	9.83	10.50	8.00
Horn Silver	Utah...	25	2.80	1.15	3.75	2.25	3.40	2.00	3.95	3.05	4.00	2.25	3.70	1.80	2.65	.76	1.50	.75	1.75	.75	4.00	1.65	3.15	1.70	7.50	3.40
Iron Silver	Colo. .	20	.50	.20	..	....	.50	...	.50	....	1.45	1.05	2.25	.55	3.50	1.80	4.15	3.00	3.10	2.50	3.90	1.70	1.60	.75	2.20	.65
Kentuck Cons	Nev...	100	....	....	....	...		....	...	....	....	....	...	...	....	....	....	....	. .	....	..	....	....	. .	...	...
La Crosse	Colo...	10	.20	.07	.09	.04	.07	.03	.07	.03	.07	.04	.11	.06	.12	.05	.14	.08	.17	.09	.28	.07	.13	.07	.16	.10
Leadville	"	10	.18	.10	.13	.07	.30	.10	.33	.13	.17	.06	.18	.10	.15	.07	.65	.10	.75	.25	.80	.22	.43	.30	.57	.31
Little Chief	"	50	.24	.08	.15	.08	.22	.16	.32	.22	.38	.20	.60	.20	.39	.17	.32	.10	.30	.25	.70	.19	.38	.20	65	.23
Little Pittsburg	"	10	....	....	..	....		..	....	....	...	....	....	....	.10	03	.39	.13	....	....	.90	.25	.50	.18	.60	.21
Mexican	Nev....	100	1.10	.35	2.35	.62	2.65	.60	2.90	1.05	5.12	1.70	4.30	2.25	7.50	2.40	6.38	2.25	....	....	12.00	.37	1.95	.25	2.35	.50
Ontario	Utah...	100	10.00	9.75	10 00	6.25	18.00	6.50	45.00	14.00	45.00	39.00	48.00	37.00	36.75	32.75	38.00	27.00	....	....	33.00	21.50	32.00	17.00	30.00	14.00
Ophir	Nev.. .	100	2.25	1.40	4.25	1.05	3 70	.40	3.75	1.60	9.25	2.75	5.75	2.75	8 63	3.15	12.50	4.70		....	15.00	.55	2.50	.35	3.80	.40
Phœnix	Ariz...	100	.13	.05	.30	.10	.60	.02	.81	.37	.70	.18	1.50	.40	.75	.11	.60	.25	5.00	2.38	....	....	....	....	....	....
Potosi	Nev ..	100	.78	.41	1.30	.38	2.90	.45	2.25	.50	7 00	1.45	8.00	1.65	2.85	1.05	7 50	2.90	....	....	9.00	.15	1.75	.20	....	....
Plymouth Cons	Cal.....	50	.40	.20	.35	.25	1.00	.50	3.25	.50	3.25	1.80	9.00	1.40	13.25	3.00	20.50	7.00	....		17.00	14.75	21.13	15.13	16.25	15.00
Savage	Nev....	100	1.50	.15	.70	.35	1.40	.44	2.50	.65	4 15	1.25	5.13	1.45	3.60	1.40	9.00	2.20	10.50	5.25	20.00	.65	6.50	1.00	1.05	.90
Sierra Nevada	" ...	100	1.15	.50	1.90	.35	2.70	.50	8.10	.80	4.35	1.20	3.85	1.20	4.10	1.15	6.25	2.50	8.38	2.70	14.00	.25	1.85	.24	4.25	.66
Standard Cons	Cal. ...	100	3.00	2.20	1.85	.85	1.55	.25	1.75	1.25	1.75	.90	1.85	.09	2.00	.40	3.90	1.00	2.50	.90	2.00	.79	1.50	.40	7.25	.20
Sutro Tunnel	Nev ...	100	.01	...	...	...	.02	.01	..	....	.10	.05	.13	.05	.12	.04	.23	.03	.46	.10	.27	.06	.26	.10	.25	.09
Union Con.	" ...	100	2.75	.21	1.90	.10	1.80	.30	2.25	.80	4.25	1.15	3.90	1.35	6.30	2.00	5.13	2.70	5.50	2.50	10.00	.09	1.55	.30	3.50	.50
Utah Con.	" ...	100	....	....	1.20	.02	1.35	.15	1.35	.05	1.45	.50	2.00	.45	1.55	.65	2.90	1.50	2.50	2 10	....	....	..	....	....	....
Yellow Jacket	" . .	100	.75	.29	1.35	.22	1.75	.35	1.95	...	4.50	1.00	3.65	1.75	5.00	2.00	11.88	3.30	8.75	4.00	12.00	.80	3.15	1.10	5.25	.62

1871 to 1883.

Company.	State.	1883.		1882.		1881.		1880.		1879.		1878.		1877.		1876.		1875.		1874.		1873.		1872.		1871.	
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
Alpha	Nev.	....	....	....	....	4.87	2.00		....	33.50	11.00	17.50	7.25	24.13	6.50	75.00	17.00	....	....	28.00	19.00	....		182½	25.25	....	....
Belcher	"	.88	....	1.50	.10	4.00	1.00	97.50	2.25	9.25	2.25	11.50	2.50	12.38	3.00	38 00	9.75	36.00	15.00	117	45.00	108	57.00	1,550	450	*432	6.50
Best & Belcher	"	5.50	.18	10.50	3.75	17.25	6.13	13.50	8.13	19.25	9.75	24.50	13.00	41.75	9.50	67.00	42.00	55.00	15.00	58.00	32.00	...	....	....	....	....	....
Bodie	Cal.	2.25	.12	6.25	2.25	9.62	2.00	10.50	3.25	10.00	5.75	19.50	16 00	....	....	....	....	75.00	36.00	....	....	.. .	....	....	....	....	....
Breece	Colo.	.23	.15	.38	.20	1.90	.68	...	...	....	....	....	....	....	....	...	....	....	....	....	....	....	....	..	..	....	....
California	Nev.	...	...	....	....	2.15	.27	4 75	1.50	11.75	2.75	30.12	8.50	53.75	28.25	91.00	45.00	765	50.00	450	125	....	....	....	....	....	....
Chollar	"	....	....	....	....	....	....		.	49.00	5.88	62.00	25.00	89.00	7.50	147	71.00	117	56.00	91.00	51.00	79.00	15.00	275	33.50	76.25	29.00
Chrysolite	Colo.	1.60	1.00	6.25	.96	9.00	3.30	23.75	3.65	....	....	....	....	....	....	....	....	....	...	..	...	....	....	....	....	....	....
Comstock Tun.	Nev.	....	....	....	....	....	....	....	...	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Con. Virginia	"	1.05	.28	1.50	.25	4.75	.95	5.13	2.00	10.00	3.25	25.50	7.25	57.00	24.88	86.00	35.00	700	217	470	93.50	....	....	....	....	...	...
Con. Cal. & Va.	"	...	..	...	...	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Con. Imperial	"	.16	.02	.18	.01	.31	.06	.97	.18	2.68	.09	....	....	2.63	1.00	7.00	1.50	21.00	6.00	16.00	4.50	9 25	3.75	415	48.00	†49	6.00
Crown Point	"	1.05	.83	1.80	1.00	2.45	1.30	4.00	....	6.50	1.50	4.38	....	11.00	3.88	30.00	6.50	46.00	21.00	135	42.00	135	80.00	1,825	220	361	274
Deadwood Terra	So.Dak	.10	....	6.75	4 00	14.00	4.00	25.13	11.50	....	....	....	....	....	....	....	....	..	....	....	....	....	....	....	....	....	....
El Cristo	R. of C.	.	..	....	....	....	....	....	....	..	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Eureka Cons.	Nev.	11.28	2.65	24.50	9.13	35.00	10.88	22.00	13.75	34.00	15.00	61.50	33.00	53.88	17.00	16.00	10.00	69.00	11.00	16.00	6.00	24.00	17.50	32.50	16.00	25.00	18.50
Father De Smet	So.Dak	5.50	2.25	7.00	3.75	14.50	7.00	9.00	5.00	....	....	....	....	....	...	....	....	....	.	....	....	....	...	....	....	....	....
Gould & Curry	Nev.	3.70	2.35	5 63	2.50	9.38	5.13	....	....	12.87	4.95	18.00	6.50	19.75	4.50	24.00	10.50	65.00	14.00	55.00	15.00	26.00	7.50	520	90.00	121	45.50
Hale & Norcross	"	3.00	1.00	3.00	1.13	4.75	3.50	....	....	19.75	4.50	25.00	11.50	13.25	1.50	13.00	6.25	69.00	30.00	64.00	55.50	40.00	....	672½	235	46.00	....
Holyoke	Idaho	....	.	....	....	....	....	....	....	....	....	..	....	...	....	....	....	...	....	....	....	....	....	....	....	....	....
Homestake	Dak.	19.00	10.00	19.00	15 00	29.25	18.50	....	...	42.13	17.50	20.00	....	....	...	....	..	....	....	....	....	....	....	...	....	....	....
Horn Silver	Utah	8.63	5.00	17 38	5.63	20.00	9.00	18.50	3.95	20.00	19.50	....	....	....	...	...	....	....	...	....	....	....	....		....	....	....
Iron Silver	Colo.	3.15	2.25	2.65	1.90	2.60	1.75	3.50	3.40	....	....	....	....	....	....	....	....	....	....	....	....	....	...	...	....	....	....
Kentuck	Nev.	.. .	..	....	..	....	....	....	.	5.00	3.87	8 00	2.75	9.50	2.75	20.00	10.00	25.00	12.00	42.00	11.00	20.00	6.75	545	140	172	7.00
La Crosse	Colo.	.16	.10	.31	.14	.33	.25	.59	.20	.73	.18	.72	.31	....	...	....	....	..	....	....	....	....	....	.90	.17	.26	.12
Leadville	"	.70	.30	.75	.50	2.05	.49	4.60	.31	4.65	2.40	....	....	....	....	....	....	...	....	....	....	....	....	....	....	....	....
Little Chief	"	.88	.35	1.25	.30	2.60	.65	11.00	.58	..	....	....	...	....	....	.	....	....	....	....	....	....	....	....	....	....	....
Little Pittsburg	"	1.10	.47	2.55	.46	8.25	1.65	30.13	1.75	30.50	20.00	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Mexican	Nev.	5.50	1.90	12.00	2.90	14.75	4.13	20.75	6.00	42.00	21.75	60.25	9.00	20.88	3.25	42.00	18.37	67.00	14.00	....	....	....	....	....	....	..	....
Ontario	Utah	35.50	18.00	40.25	27.00	39.00	32.25	39.50	30.00	42.00	38.50	38.00	30.55	...	....	....	....	....	....	....	....	....	....	...	....	....	....
Ophir	Nev.	7.00	1.15	7.00	1.90	10.00	3.80	10.50	5.13	38.25	20.75	55.50	27.00	41.00	9.00	72.00	22.00	290	38.00	185	62.00	22.00	21.00	107½	32.50	....	....
Phœnix	Ariz.	....	....	....	....	....	....	....	....	....	..	....	....	....	. .	....	....	....	....	....	....	. .	....	....	....	....	....
Potosi	Nev.	....	....	1.30	.70	....	....	2.45	....	4.75	2.45	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Plymouth Cons.	Cal.	...	....	....	....	...	....	....	....	....	...	...	....	....	....	...	....	..	....	....	....	....	....	....	....	....	....
Savage	Nev.	4.00	.70	1.75	.78	4.87	.91	9.00	2.00	16.00	7.00	24.75	8.25	14.50	2.38	24.00	9.87	189	59.00	150	55.00	164	35.00	620	46.50	55.00	40.00
Sierre Nevada	"	9.00	1.88	10.00	2 50	30.00	3.05	29.00	7.00	60.00	20.50	183	3.00	11.00	1.88	28.00	8.50	24.00	10.00	25.00	8.50	....	....	..	....	....	....
Standard Cons.	Cal.	7.50	5.00	20.00	4.00	29.37	17.75	34.00	18.50	35.75	20.00	....	....	....		....	....	...	....	....	....	....	....	....	....	....	....
Sutro Tunnel	Nev.	.38	.13	1.88	.13	2.60	.88	4.25	.75	6.25	2.50				....	....	....	....	....	....	....	....	....	....	....	....	....
Union Con.	"	12.00	2.20	17.50	3.00	20.00	6.50	41.00	8.00	82.00	28.00	58.00	4.50	11.88	2.25	21.00	7.00	93.00	6.00	82.00	35.00	....	....	....	....	. .	....
Utah Con.	"	...	....	.90	....		....	5.75	.45	25.75	7.50	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Yellow Jacket	"	5.13	1.00	3 15	.70	7.00	1.62	10.75	4.00	22.00	9.00	16.50	6.25	18.50	4.63	37.00	13.00	158	55.00	160	59.00	91.00	42.00	275	59.00	75.50	38.50

* Belcher in August, 1872. A new issue of stock was made which was floated at $81 and advanced to $130. Prices from 1873 are in the new issue.
† Imperial. In June, 1872, a new issue of stock was put upon the market at $5 and advanced to $15. The prices from 1872 are on the new issue.
‡ Crown Point. In August, 1872, a new issue of stock was floated at $77, advancing to $170. The prices from 1873 are on the new issue.

The moral, not only of the facts and figures here given, but of all the history of speculation, is that it is extremely difficult to be wise in time, and that there is no sense or reason in any "boom price." It is a matter of sentiment and of fashion entirely, and the oldest speculator is at such times as liable to be carried away as the boy making his first venture.

A striking illustration of this is that the "boom" is almost always in a new and comparatively untried district, while at the same time others well proved and known to be valuable may be entirely neglected. In fact, at such times actual values have usually only a remote relation, if any, to selling prices.

The influence of fashion is well shown by the prevailing tendency in London to invest in West Australian properties. The value of the mines is, for the most part, still to be proved, the admitted difficulties of mining are great, and the cost of working extremely high; but a West Australian mine can be floated without difficulty, while a good proposition from elsewhere can hardly secure even a hearing.

To show what the possibilities are from legitimate mining, we may quote two instances from the Lake Superior district in copper mining. The Quincy copper mine has a capital of $200,000 paid in and has paid in dividends $7,690,000. It has for many years paid from $200,000 to $450,000 a year, or from 100% to 225% a year on the money invested. The Calumet & Hecla Mine, with a paid-in capital of $1,250,000, has now divided profits to the amount of $43,850,000 and pays regularly about $2,000,000, or 150% a year on the capital invested.

The Pittsburg Mining-Stock Market.

The stocks dealt in on the Pittsburg exchange are chiefly those of coal, oil, and natural-gas companies, the last-named class holding the most prominent place. There are also a few gold and silver mining companies, whose stocks are chiefly owned in Pittsburg, but the dealings in this class of stocks are small.

FLUCTUATIONS OF PRICES IN MINING STOCKS AT PITTSBURG DURING 1895.

Company.	Par Value.	Opening.		Highest and Lowest During the Year.				Closing.	
		Bid.	Asked.	Bid.		Asked.		Bid.	Asked.
				Highest	Lowest	Highest	Lowest		
Coal:									
Mansfield C. & C., Pa.	50	....	....	40	35	40	....	....	....
New York Gas Coal	50	....	46	35	....	46	....	....	....
Mining:									
Enterprise, Colo	5	....	....	36	....	....	....	....	....
Lustre, Mex	10	11⅛	13	14½	9½	16	10¾	13¾	14½
Silverton, Colo	10	....	....	....	....	....	....	....	....
Natural Gas:									
Allegheny, Pa	100	49¾	51½	49	46	51½	48	6½	7¼
Chartier's Valley	100	....	9	9	6	10	7	....	....
Manufacturer's, Pa.	100	....	....	42½	41	45	43	42	....
Ohio Valley, Pa	50	....	38	....	....	40	31	....	....
People's Natural Gas, Pa	50	33½	36	34	12	40	13	25	....
People's Natural Gas & Pipeage, Pa.	25	14½	13	13¾	3	15¼	4½	14¾	15
Pennsylvania, Pa	50	19	....	15⅛	3	15¼	4	3⅝	5¾
Philadelphia, Pa	50	18¼	18½	18⅜	14⅛	18⅝	14⅜	17½	17⅝
Wheeling, W. Va	50	21	22	44	15⅛	45	15	16	16½
Oil:									
Tuna Oil Co	....	....	....	10	....	35	20	....	....
Washington	50	....	50	38	....	50	....	....	....

The accompanying table shows the range in prices through the year. There was some increase in activity, and a considerable variation in prices is to be noted.

The Salt Lake City Mining-Stock Market.

With the close of 1895 the mining-stock market of Utah ended a year important for the reason that it was marked by a great improvement in general business and a wonderful increase of not only home but foreign interest, and eventful for the reason that a large number of heavy deals were negotiated. The mining properties of Utah are operated on a very conservative basis, and notwithstanding the low prices of silver and lead there is not one losing money for its owners, while on the other hand six of the companies pay handsome dividends and the prospects are bright for additions to this number, some old companies resuming dividends and the other new ones commencing distributions. During 1895 the six public dividend payers of Utah have paid out to their stockholders in earnings the sum of $1,550,000, making the total dividends of the properties now active $29,905,100. There are 14 dividend payers in the list, the Ontario leading with $13,175,000 to its credit and the Horn Silver coming next with $5,080,000. For the year 1895 the Centennial-Eureka led with $540,000 and was followed in the order indicated by the Bullion-Beck with $450,000, the Silver King with $275,000, the Mercur with $175,000, the Horn Silver with $100,000, and the Utah with $15,000. There have been other companies that distributed profits, but the amounts of the payments are not made public, their holdings being strictly of a private character.

The most important of the many deals proposed during the year was that involving the properties of the Mercur Gold Mining and Milling Company, in the Camp Floyd district, Captain John R. DeLamar, of New York, securing for a syndicate an option on the stock of the company at the rate of $7.50 per share. This deal also had to do with the Golden Gate properties, which are located to the north of the Mercur ground and owned by DeLamar personally. The option price fixed the value of the Mercur group at $1,500,000, and one of the terms of the contract was that the entire sum involved should be on deposit to the credit of the stockholders before the transfer of the stock took place. The deal finally fell through, however, and the option was not taken up.

During the year several of the old listed stocks were dropped, there being an entire absence of business in them, but the vacant places were filled with new securities, most of the new stocks being gold properties.

The piping of natural gas into Salt Lake City from Lake Shore was the foundation for the listing of a new stock, the American Natural Gas. Considerable business was done in the security toward the end of the year.

The fluctuations of the various stocks are shown in the accompanying table, which includes all that were actively dealt in.

The great Ontario and Daly drain tunnel was completed to beyond the property line of the Daly, and is still being extended to the westward. The completion of the tunnel solved the water problem for both the Ontario and Daly and also for the Daly-West. Much development work was done in the properties, and the two mills have been in constant operation. Both the Ontario and the Daly stocks held their own during the year.

The Horn Silver is just recovering from the effects of the great fire. Two quarterly dividends were passed in order that the surplus might be maintained at about $200,000, but this did not weaken the stock and but little is on the market and that is held at advanced quotations.

A change in the name of the Meears occurred early in the year and it is now known as the Morgan. The properties of the company are being equipped with steam hoists and preparations are being made for a greatly increased output of ore. Treasury stock was sold to raise the necessary funds for the improvements.

The dividends from Silver King were regular, $37,500 a month, and the stock held its own in the neighborhood of $14.50 per share.

Utah, at Fish Springs, continued to haul its high-grade silver-lead ores to the

PRICES OF MINING STOCKS AT SALT LAKE CITY DURING 1895.

Company.	Par Val.	January.		February.		March.		April.		May.		June.	
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
Ajax	$10	1 60	85	1 50	1 00	75	65	65	50	35	35	35	25
Alliance	1	85	65	75	70	1 00	80	1 15	1 10	1 10	1 00	1 15	1 10
Am. Nat. Gas	10	. .	. . .	35	30	25	15	25	20	22	20	22	20
Anchor	20	3 00	3 40	3 40	3 00	3 50	3 30	3 50	3 45	3 40	3 20	3 50	3 30
Bogan	10	1 25	1 00	90	80	75	60	50	45	50	40	60	50
Bullion Beck	10	10 00	9 00	9 00	8 75	9 00	8 50	9 00	8 25	9 00	8 50	11 50	10 00
Centennial	50	42 00	39 50	43 50	39 50	42 50	40 00	43 00	41 00	50 00	43 00	51 00	50 00
Comstock	25	35	30	25	25	25	20	25	25	30	25	50	40
Crescent	25	05	. .	04½	04	04	03	03	02	. . .	. . .	. .	. .
Dalton	25	03	02½	03	02½	02¾	02	01½	01	02	01½	03	02
Daly	20	8 00	7 25	7 25	7 00	7 00	6 25	7 00	6 75	7 25	7 00	7 25	6 50
Daly West	20	6 00	5 00	6 00	5 75	6 75	6 00	7 00	6 75	7 00	6 50	6 75	6 50
Horn Silver	25	3 55	2 56	2 60	2 50	2 50	2 20	2 65	2 40	3 65	2 60	2 85	2 30
Lucky Bell	10	50	. . .	50	40	40	25	40	. . .	. .	. . .	. .	. .
Mammoth	25	1 25	1 10	1 25	1 05	1 25	1 15	1 15	1 10	1 15	1 05	1 10	. .
Mercur	25	3 50	3 46	3 50	3 25	3 62½	3 50	3 90	3 62½	4 00	3 90	4 10	3 90
Morgan	25	85	75	75	. . .	85	75	85	75	75	60	85	75
Ontario	100	11 00	10 00	10 00	9 25	9 50	9 00	12 00	10 50	11 00	10 12½	10 00	. .
Rover	10	. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .	. .
Silver King	20	13 50	13 00	13 00	12 50	14 50	13 00	14 50	14 25	15 00	14 25	15 00	14 50
Sunshine	10	. .	. . .	. . .	. . .	. . .	. .	. . .	. . .	. .	. . .	. .	. .
Tetro	1	25	. . .	25	. . .	25	. .	25	. . .	25	. . .	25	. .
Utah	1	1 00	50	1 00	50	90	75	75	. . .	1 00	90	1 00	75

Company.	Par Val.	July.		August.		September.		October.		November.		December.	
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
Ajax	$10	30	25	35	25	37½	30	60	37½	50	1 45	50	45
Alliance	1	1 25	1 10	1 50	1 40	1 45	1 25	1 50	1 45	1 45	40	1 40	1 40
Am. Nat. Gas	10	30	20	25	12½	15	12½	12½	10	16½	13	14	12½
Anchor	20	3 35	3 30	3 35	3 25	3 25	3 20	3 25	3 10	3 00	2 90	3 00	2 85
Bogan	10	50	25	30	25	30	25	25	25	25	20	25	. . .
Bullion Beck	10	10 50	9 75	8 75	8 50	8 75	8 00	8 75	8 00	7 25	7 00	7 80	7 00
Centennial	50	60 00	54 00	60 00	55 00	60 00	55 00	60 00	59 00	59 00	56 00	60 00	58 00
Comstock	25	50	45	60	55	75	60	75	50	60	25	25	15
Crescent	25	. .	. .	. .	. . .	. . .	. . .	. . .	. .	05	02	05	. . .
Dalton	25	05	02	05	03	06	05	20	06	19	15	18½	15
Daly	20	6 75	6 25	6 75	6 50	6 75	6 60	6 75	6 50	6 50	6 25	6 50	6 25
Daly West	20	6 50	6 25	6 50	6 30	6 50	6 25	6 50	6 30	6 50	6 37½	6 50	6 25
Horn Silver	25	2 30	2 25	2 25	2 20	2 35	2 00	2 25	2 10	2 30	2 25	2 30	. . .
Lucky Bell	10	. .	.	. .	. . .	. . .	. . .	. . .	. . .	12½	10	12½	. . .
Mammoth	25	1 05	1 00	1 10	1 05	1 10	1 00	1 27½	1 25	1 25	1 15	1 25	1 20
Mercur	25	4 15	4 05	4 25	4 20	5 00	4 39½	7 25	5 15	7 40	5 50	7 00	6 75
Morgan	25	65	60	60	55	65	60	65	60	65	50	60	50
Ontario	100	10 00	9 50	9 75	9 50	10 50	10 00	10 00	9 40	9 25	9 00	9 50	9 25
Rover	10	. .	. .	. . .	. . .	. . .	. . .	. . .	. . .	1 25	1 00	1 35	1 15
Silver King	20	14 75	14 25	14 75	14 50	14 75	14 25	14 50	13 75	14 00	14 00	14 25	14 00
Sunshine	10	. .	. .	. .	. . .	. . .	. . .	3 00	2 50	3 65	3 10	3 70	3 50
Tetro	1	25	08	25	10	20	10	25	15	25	10	15	10
Utah	1	1 00	65	1 00	75	1 00	75	1 10	1 00	1 10	1 00	1 15	1 10

railroad over a long stretch of desert in wagons and paid its stockholders 2c. per share in dividends per month, or $2000.

The chief new developments have taken place in the Camp Floyd district, which is located some 50 miles southwest of Salt Lake City and reached by the Union Pacific Railroad and the Salt Lake & Mercur roads, the latter having been built into the district during the year. The ores seem most susceptible to treatment by the cyanide process and its modifications. The gold does not occur in a free state, or at least it can never be seen, even with the aid of a glass. The district is 7 miles long by about 3 in width and the entire surface seems to be underlaid with ore, as systematic development has brought values to the surface on every property worked up to date. During the year a large number of companies were organized to operate in this district. Chief among the new companies were the Sunshine, which has a mill at work on a seemingly inexhaustible deposit of good-grade ores; the Gold Dust, owner of one of the most promising semi-developed properties in the district; and the Rover, which has uncovered some ore bodies north of the Gold Dust. It seems evident that the two properties last named have the extension of the Mercur-Marion-Geyser veins. The Sunshine went on the market at $2.50 per share in very limited quantity and advanced over $1 within two weeks. The others made as marked gains, but still remained cheaper stocks. The extensive development work of DeLamar and the uncovering of large bodies of fair-grade ores in all parts of the district, together with the operations of the Mercur, have given the Camp Floyd district a start in reputation.

The San Francisco Mining-Stock Market.

The year 1895 was one of the most uneventful in the history of mining-stock speculation as conducted on the San Francisco exchanges. It would have been much more profitable for the Board of Brokers had the exchange been closed entirely, the majority of them having had to put their hands in their pockets to meet the current expenses of their offices, besides doing the most of the clerical work themselves. This, too, in the face of the fact that money was plentiful with the public and the times ripe for a speculative boom. Everything favored an active mining speculation from a financial standpoint, and yet the market hung fire and even settled back to a lower level of values on any effort made to change its condition for the better. The trouble was that the old manipulators all left the street, taking their capital with them, leaving stocks in the hands of small people who were doing well for themselves in financing the companies so as to keep the salary list intact; and that transactions were limited to the Comstocks and a few others in which the public long ago ceased to be interested.

The official list of transactions in the board in 1895 was the smallest on record since the doors of the exchange opened for business, and cents cut quite an important figure in the quotations. The innovation has cut down the margin of the brokers' profits considerably, and many of them incline to the belief that a great mistake was made in changing the by-laws which prohibited transactions of the kind. The assessments, while as numerous as ever, were considerably reduced in amount, and the largest companies found it difficult enough to collect on a 25-cent levy, which they seldom exceed. The reduction in treasury balances necessitated scaling salaries to some extent. As the miners' union at Virginia City absolutely refused to lower wages from the standard fixed in bonanza days, economy at that end was studied by working as few men as possible, many of the mines employing one set of men for a certain number of days and then another, so as to give all an equal chance to make a living, married men with families getting the preference as a rule.

No important new developments of ore on the Comstock were made during the year. At one time it was thought that Consolidated California & Virginia had made another bonanza find on the 1650-ft. level in new ground, but the ore gave out in a short time, much to the disappointment of the shareholders, who had calculated upon another lengthy run of dividends. Enough bullion was produced to make a disbursement of 25c. per share and leave a balance in the treasury to meet expenses. When this was paid out and the company began to accumulate an indebtedness an assessment of 25c. was promptly levied. At the south end of the Comstock Lode Crown Point and Belcher extracted from time to time some rock which ran high in gold and this helped out the finances of the companies considerably, although nothing was left to distribute among the shareholders.

Potosi and Chollar did fairly well in the matter of bullion production, and the assessments in the last quarter were correspondingly light. The other mines continued working with indifferent success, the operating expenses constituting a heavy drain upon the stockholders, especially in view of the dull market, which afforded no relief in the way of an opportunity for any profitable turns in the shares. Many mines which at one time ranked among the most famous in the lode are now of little more repute than wildcats; one by one they have quietly passed into oblivion with the men who manipulated the rascally deals in their stocks.

A new departure was made by the purchase of a certain portion of the Brunswick Lode, Best & Belcher, Ophir, and other companies at the northeast end of the Comstock acquiring certain locations for the purpose of exploration. Work is now being pushed in that direction with considerable vigor. Outside of this and the possible discovery of paying deposits on the Comstock, it would seem that the future of mining in that section depends in a great measure upon the application of some new and cheap system for working low-grade ores. Several new processes for working ores on a cheap scale are now being closely investigated by Comstock mining men, in the hope that something may be found which will permit these low-grade deposits to be used. Water power is obtainable all the year round from the Truckee River at Reno if it could be made available.

There is another movement on foot which it is believed will do much to resurrect mining on the Comstock. East of Gold Hill a number of rich properties have been worked at desultory intervals on what is known as American Flat, and here are the old Baltimore, Knickerbocker, and Rock Island mines, all of which produced ore until the management were forced to shut down after a hopeless contest with water which swamped them out when they got down to a depth of about 600 ft. It is thought that an extension of the Sutro Tunnel from its present connection with Crown Point will settle the water question by affording drainage facilities at a depth of 1400 ft. It will take, it is estimated, $200,000 to extend this tunnel to this point, intersecting in its course a number of mining claims. An effort will be made to interest the New York management of the Tunnel Company in this enterprise.

In so far as mines outside of the Comstock listed on the Stock Exchange are concerned, there are only about two left in which any public interest has been taken for some time past. These are the Bodie Consolidated and the Bulwer mines of Bodie. The former managed to work up a little excitement now and then by opening up a rich vein in the mine.

The Tuscarora mines were knocked out completely by the fall in silver, and the Quijotoas have been dropped from the list and practically abandoned by the management, who found it no longer profitable to run them.

The Mt. Diablo Mine of Candelaria, Nev., the Holmes Mine of the same place, and the Silver King Mine of Arizona are still called, but their glory has faded. New mining enterprises in California are plenty, but they keep carefully away

FLUCTUATIONS OF MINING STOCKS AT SAN FRANCISCO DURING 1895.

Name and Location of Company.	Par Value.	Jan.		Feb.		March.		April.		May.		June.	
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
Alpha, Nev	$100	..	..	..	..	..	..	..	..	..	..	..	..
Alta, Nev	100	50	30	40	30	35	21	28	12	16	05	21	06
Belcher, Nev	100	69	30	43	36	47	38	73	40	66	42	43	32
Bes.&Belcher,Nev	100	1 10	30	88	70	1 10	80	95	75	78	43	61	37
Bodtie Consol., Cal	100	1 00	65	95	80	1 50	79	1 40	1 05	1 15	45	42	25
Bulwer, Cal	100	14	05	16	11	25	14	25	09	15	04	06	05
Chollar, Nev	100	50	35	58	37	65	45	58	42	45	21	66	15
Commonwealth	100	..	..	..	..	60	..	..	..	..	..	..	..
Con.Cal.& Va. Nev	100	4 00	3 20	3 35	2 35	3 10	2 60	3 25	2 60	2 95	2 15	2 75	2 20
Crown Point, Nev	100	74	35	45	25	55	37	70	38	60	41	43	33
Eureka Cons., Nev	100	..	..	..	..	1 35	..	..	..	35	..	..	..
Gould & Curry,Nev	100	45	24	43	19	57	45	58	44	46	24	37	20
Hale & Norcross,Nev	100	1 20	73	91	67	1 25	96	1 50	1 20	1 50	80	99	12½
Mexican, Nev	100	1 05	82	86	68	1 00	78	91	77	76	38	70	29
Mono, Cal	100	35	24	25	20	30	20	30	15	21	08	09	05
Ophir, Nev.	100	2 05	1 50	1 60	1 35	2 10	1 55	1 80	1 55	1 75	1 20	1 60	1 20
Potosi, Nev	100	60	32	52	42	56	47	58	43	47	31	47	32
Savage, Nev.	100	55	37	44	34	47	34	40	26	36	15	48	30
Sierra Nevada,Nev	100	68	40	60	31	85	64	94	77	78	46	65	46
Union Cons., Nev	100	66	50	54	40	61	49	61	48	50	30	38	25
Utah, Nev	100	09	03	06	04	08	05	08	06	11	04	05	03
Yellow Jacket, Nev	100	68	39	50	40	70	50	61	38	53	20	50	39
Name and Location of Company.	**Par Value.**	**July.**		**Aug.**		**Sept.**		**Oct.**		**Nov.**		**Dec.**	
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
Alpha, Nev	$100	10	08	10	08	19	16	..	..	..	..	..	..
Alta, Nev	100	16	..	14	10	12	11	08	07	20	09	16	09
Belcher, Nev	100	33	27	60	26	60	34	45	42	42	26	38	20
Bes. & Belcher	100	96	38	1 25	26	1 15	1 00	97	75	78	55	87	59
Bodtie Consol., Cal	100	52	20	94	10	39	12	35	25	40	27	56	35
Bulwer, Cal	100	..	..	..	..	..	..	19	05	11	05	15	06
Chollar, Nev	100	61	55	68	59	61	60	56	42	40	21	57	20
Commonwealth	100	..	..	..	..	..	..	..	..	..	..	..	..
Con. Cal. & Va., Nev	100	2 80	2 45	2 95	2 60	2 85	2 65	2 70	2 40	2 55	2 05	2 35	1 92
Crown Point, Nev	100	41	37	55	38	58	52	43	30	37	24	32	23
Eureka Cons., Nev	100	..	..	..	..	..	..	..	..	..	..	..	..
Gould & Curry, Nev	100	46	28	65	35	58	54	51	38	37	22	46	27
Hale & Norcross, Nev	100	1 50	1 10	2 00	1 55	1 70	1 60	1 65	1 35	1 40	96	1 15	80
Mexican, Nev	100	70	64	74	63	80	67	74	58	57	37	63	30
Mono, Cal	100	..	..	..	..	..	..	12	05	12	08	13	06
Ophir, Nev	100	1 55	1 30	1 70	1 25	1 80	1 60	1 55	1 35	1 75	1 05	1 40	1 05
Potosi, Nev	100	46	35	65	32	65	58	68	55	69	44	71	49
Savage, Nev	100	51	36	45	36	47	40	55	30	57	32	49	28
Sierra Nevada, Nev	100	63	45	45	42	95	78	96	76	83	34	69	45
Union Cons., Nev	100	44	31	53	48	72	57	72	54	63	45	60	40
Utah, Nev	100	05	03	07	..	10	..	10	06	07	04	06	04
Yellow Jacket, Nev	100	42	37	43	31	62	42	49	32	35	20	49	17

from the exchange. The exchange has lately decided to adopt new rules in relation to the listing of mines, and has appointed special committees to induce companies to list their stocks.

During the last week in December the California Gold Mining Exchange of San Francisco was organized with the following charter members: John M. Daggett, Charles G. Yale, Horace G. Ranlett, William K. Flint, George R. Walls, S. P. Holden, Walter Turnbull, Rudolph Herold, Jr., Julius Jacobs, Clement J.

Schussler, Theodore Reichert, John H. Roberts, Wilfred Page, D. E. Miles, H. Pichoir, J. F. Wertheimer, J. F. Crossett, W. R. Smedberg, C. L. Hovey, Herman Bendell, F. Chappellett, M. Wate, and P. T. Dickinson. The organization of a new exchange free from the complications of the old one had been rumored for some time. The new exchange has the following officers: Gen. Walter Turnbull, president; ex-Lieut.-Gov. John Daggett, vice-president; J. F. Crossett, secretary; D. E. Miles, treasurer. Its object is to deal especially in the stocks of California gold-mining companies and to encourage new enterprises.

The St. Louis Mining-Stock Market.

At one time there was an active business in mining stocks in St. Louis, but after the passing of the Granite Mountain fever the market collapsed, and since then the business has practically been dead. The Mining Exchange has never been revived. There are a few brokers who congregate in the Merchants' Exchange in a circle of their own and sell local stocks. The following statement gives the bulk of the business done during the year 1895.

Small Hopes has been down to 60c. and sold up to $1; at the close 90c. was bid. American Nettie started at 30c., then fell to 10c., and 10c. was later bid. Granite Mountain opened at $3, went down to $1, and closed at $1.60. Bi-Metallic sold from $3 down to $2½ and $2½ was the closing bid. Hope (Montana) ranged from $3 down to $1½ and $1½ was the last bid in December. Adams sold from 25 to 35c. and closed at 30c.

This appears to be about the bulk of the business in mining stocks, which is generally very small, merely nominal, and hardly enough to bear quotation.

The London Mining-Stock Market.

The year 1895 will always be remembered as the year of the great mining boom. The London Stock Exchange was devoted almost entirely to the mining market, the other departments, such as American rails, beer, foreign bonds, etc., being neglected. The features of the boom may be described as the introduction of West Australian mining companies and Charterland exploration companies to the British public and of Transvaal gold companies in Paris and other continental markets. After several years of depression the mining market gradually sprang up into new life during the latter part of 1894 and early in 1895, continuing with occasional fluctuations until the end of September. By that time the prices of every description of stock became so inflated that a large section of the professional market who had previously been bulls considered that the highest possible point had been reached, and accordingly started on the bear tack. In their new capacity their chief weapon was the refusal to grant the usual carrying-over facilities. By this means the large class of speculators who cannot pay for their purchases was immediately driven out and the backbone of the boom broken. A few failures and rumors of more, together with the knock-down auction of the defaulters' holdings, soon caused a serious relapse. This relapse caused other failures, and so the declines became intensified and were continued until the fiat of the professional element was revoked.

The section of the mining market devoted to Transvaal gold and South African diamond shares has not been characterized by the issue of any new companies of importance or the opening up of new mines. The market was excited by the introduction of the stock of the already existing companies into France and the large influx of orders from that source. As usual, the class of stock which the French chose to buy was that of the regular dividend payers, but so extensive and continuous were the orders to buy that the quotations were rushed up. To show the importance attached by the English wire pullers to the continental buying, we may mention the facts that several companies have reconstructed in order to qualify for a quotation on the Paris exchange, and that agencies of all the companies have been established in Paris.

The most important event of the year in Transvaal gold, from a mining point of view, has been the commencement of crushings on the deep-level properties. The Geldenhuis Deep has led the way and the first results were published in November, and were not very favorable, being below the extraction from the main reef. The trust companies holding stock in the deep-level companies were very prominent in the market during the latter part of the boom and during the slump. Among these companies the most important are Consolidated Goldfields, Barnato Consolidated, and Barnato Bank, the latter two of which were formed during the summer to take over the extensive interests of Barnato Brothers.

The production of gold in the Witwatersrand district increased less than during the previous year, and in fact was practically stationary from May to December.

The development of the country which is being explored by the British South African Company proceeded throughout the year, but without any very definite results. The stock of that company was a favorite plaything on the exchange, and quotations were run up from £1 10s. in January to £7 10s. in August, but fell during the slump to £4@£5. In spite of Mr. Hammond's report that a series of gold-bearing quartz reefs runs through the hilly districts of Mashonaland for at least a hundred miles, nothing was done which proves the real value of these reefs and practically no gold was won. During the summer the market was flooded with prospectuses of companies formed to work these reefs, but it is to be feared that most of them had nothing to work except "claims." At the close of the year the political troubles in South Africa seriously interfered with mining.

West Australia occupied the attention of the English investor throughout the entire year, and vast amounts of capital were subscribed to purchase lands and mines in that colony. So far the land companies are the only ones which have paid dividends, with the exception of Bailey's Reward Mine, which has exhausted its rich ore and finds it impossible to pay dividends on ore assaying 1 to 1¼ ozs. per ton. The West Australian market gave the world an example of the most impudent promotion swindle which we have seen for some years in the famous Londonderry fiasco. The owners of this mine came upon a phenomenally rich pocket, and as they knew it did not extend many feet they closed the mine and floated the property on the London market for £600,000. Directly the money was secured the mine was opened and its barrenness exposed. In spite of all these various drawbacks the investment in West Australians continues.

Of improvements in metallurgical practice that were brought prominently before the investing public during the year, the zinc-lead sulphide question and its connection with Broken Hill property is perhaps the most important. At the Broken Hill Proprietary the production of lead and silver was permanently reduced owing to the system of mining the now rapidly diminishing stocks of rich ore with those of lower grade and more refractory. Experiments are being carried on in connection with the sulphides, and it is confidently expected that when the oxidized ores are exhausted an economical process for the sulphides will be in readiness. Several companies have been formed to work new sulphide processes, but the principle involved in them does not differ materially from those already known, with the exception of the Siemens electrolytic process for depositing the zinc.

The MacArthur-Forrest cyanide patent has been settled at last in the English courts. After the Chancery judge had decided that the patent was invalid through want of novelty, the Court of Appeals decided that the use of dilute solutions was a novelty, but that the patent was rendered invalid by the contradictory nature of the two claims, one for cyanide in general and the other for dilute solutions. The patentees thereupon petitioned for an amendation of their specification and were granted permission to insert the word "dilute" in the first claim. The MacArthur-Forrest patent is therefore rendered valid in English law, though those best qualified to judge are still of the opinion that the use of dilute solutions was no novelty in 1887. Two companies were brought out during the year to work new processes for extracting gold from ores. The first, the Gold Ore Treatment Company, has a process invented by Sulman & Teed, in which bromide of cyanogen is added to cyanide of potassium to hasten the solvent action. The second, the Fauvel Gold Recovery Company, is formed to work the Fauvel roasting process for treating rebellious ores. Neither of these processes has been properly tested and the latter does not appear to contain any novel feature of value.

The American department of the mining market presented a very different appearance at the close of 1895 from what it did a year before. The great boom during the spring and summer caused those interested in American mining to come forward with their properties, and those capitalists who saw the futility of Charterland "claims" and the difficulties of West Australian mining gave their attention. Quite a number of mines in the Western States were introduced to the public with fairly encouraging results. Of the actual events of the year the introduction of Anaconda stock by the Exploration Company was the most important, and will be the most potent factor in drawing the attention of English investors to American mining properties. The same company has introduced the Alaska-United, a similar property to Alaska-Treadwell, and Alaska-Mexican, both of which have helped to place America high in the estimation of capitalists. Several companies have been formed to acquire Cripple Creek mines, but no properties were placed on the London market. Properties in California and Arizona met with favorable receptions, and British Columbia attracted the attention of those who believe in genuine prospecting and mining.

Several of the old companies working mines in America came to grief during the year. The Elkhorn Company found that its silver veins have come to an end, and the company has been reconstructed in order to provide funds to purchase a new silver property in an adjoining State. The Harquahala Company abandoned its gold property in Arizona for the same reason and has acquired instead a gold mine at Coolgardie. The Richmond Consolidated Company, after making many fruitless efforts to acquire a new property in the United States, went to West Australia. The state of the Poorman Company of Idaho was not much changed. After attempting in vain to raise further capital by debentures to provide funds for a new mill, the directors reconstructed the company successfully, and after paying debts and providing for the plant, placed the treasury in a fairly good condition. A new manager was appointed and returns were expected in November, but just at this juncture a serious accident happened in the workings and the mine was closed down. The Jay Hawk Company, working silver mines in Montana, is practically at an end. At present nothing is being done, as the ore cannot be mined at a profit. Idaho, Emma, Golden Leaf, and Flagstaff abandoned their mines in America and went to West Australia. The DeLamar Company's shares were introduced into France with great success and a very large block sold there. The excellent dividends of 20 and 25%, which the company has paid for several years in succession, induced this buying chiefly, and it was helped by the report of M. Pelatan, the French mining engineer.

Mining in the British Islands was at a very low ebb during the year, and the only event worthy of note was the transformation of the Dolcoath Company from a cost-book mine to a limited-liability company. This was brought about by the specific demands of the London capitalists who were supplying the money required for sinking the new main shaft and for purchasing new machinery. Unless the Cornishmen are willing to follow this example and move with the times, their days will soon be over.

FLUCTUATIONS IN PRICES OF MINING STOCKS AT LONDON DURING 1895.

Company.	Par Value.			Opening.			Highest.			Lowest.			Closing.		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Alaska-Mexican, Alaska	1	0	0	1	5	0	2	3	9		18	9	1	5	0
Alaska-Treadwell, Alaska	5	0	0	3	0	0	5	15	0	3	0	0	5	10	0
Alaska-United, Alaska	...			...			1	10	0	1	5	0	1	10	0
Banner, Cal		4	0	...				15	0		12	6		12	6
Cripple Exp., Colo	1	0	0	...			1	5	0	1	0	0		15	0
De Lamar, Idaho	1	0	0	1	8	0	1	11	0	1	0	6	1	0	0
Elkhorn, Mont	1	0	0		12	0		11	0		2	3		2	3
Harquahala, Ariz	1	0	0		6	6		7	9		2	0		6	9
Holcomb Valley, Cal		5	0		1	9		3	6		1	0		1	0
Jay Hawk, Mont	1	0	0		2	0		3	6		1	3		1	0
Montana, Mont	1	0	0		13	0		12	6		6	9		8	0
New Guston, Colo	1	0	0		13	9		12	6		10	0		10	0
Palmarejo, Mex	1	0	0		2	3		3	9		1	3		1	3
Plumas-Eureka, Colo	2	0	0		15	0		12	6		11	3		13	9
Poorman, Idaho		5	0		2	0		4	0		1	6		1	9
Richmond, Nev	5	0	0		11	3	1	2	6		11	3		17	6
Sierra Buttes, Cal	2	0	0		12	6		10	6		9	3		11	3
Springdale, Colo		4	0		2	3		3	9		1	6		1	9
Twin Lake, Colo	1	0	0	...			1	7	6	1	5	0	1	7	6
Anaconda, Mont.	5	0	0	...			7	5	0	6	10	0	6	10	0
Cape Copper, South Africa	2	0	0	1	11	3	2	15	0	1	8	9	2	7	6
Rio Tinto, Spain	10	0	0	15	2	6	19	12	6	13	13	9	15	18	9
Tharsis, Spain	2	0	0	5	2	6	5	0	0	4	7	6	4	15	0

The copper companies managed in London improved their condition very much during the year. Taking advantage of the cheapness of money, the Rio Tinto Company converted its series of debenture bonds into new debentures bearing interest at 4% only, and thus with the help of an increased demand for copper and pyrites was enabled to pay a 10% dividend on the ordinary stock. The Cape Copper Company and the Copiapo Company reported much larger profits last year, while the Central Chile Copper Company (formerly Panulcillo) once more arrived at a profit-making stage.

The following is a list of the new mining companies registered in London during the year which intend to operate in America:

UNITED STATES.

Alaska (Glasgow) Gold Mine, Limited, with a capital of £45,000, to acquire gold mines in California.

Anglo-Pacific Exploring Syndicate, Limited, with a capital of £20,000, to explore for minerals in the west of America.

Banner Gold Mine, Limited, with a capital of £150,000, to acquire mines in California.

Bodie Syndicate, Limited, with a capital of £2000, to acquire lands in California.

Colorado-Montana Development Syndicate, Limited, with a capital of £150,000, to carry on mines owned by S. Newhouse.

Cripple Creek Agency Syndicate, Limited, with a capital of £2000, to investigate mines at Cripple Creek, Colo.

Cripple Creek Development Syndicate, Limited, with a capital of £11,000, to develop lands and mines at Cripple Creek, Colo.

Cripple Creek Exploration Syndicate, Limited, with a capital of £30,000, to acquire properties at Cripple Creek, Colo.

Cripple Creek Gold Mines, Limited, with a capital of £100,000, to acquire properties at Cripple Creek, Colo.

Doric Gold Mines, Limited, with a capital of £125,000, to acquire mines in Colorado.

Dunderberg Gold Mines, Limited, with a capital of £62,500, to work a gold mine in the United States.

Gilpin Gold Mines, Limited, with a capital of £90,000, to acquire gold mines in Gilpin County, Colo.

Gold and Silver Crown Mines of Nevada, Limited, with a capital of £260,000, to acquire mines near Candelaria, Nev.

Granite Gold Exploration Syndicate, Limited, with a capital of £1200, to acquire mines in Colorado.

Honeycomb Gold Mines, Limited, with a capital of £100,000, to acquire mines in California.

Jersey Lily Gold Mines, Limited, with a capital of £150,000, to work the Jersey Lily Mine in Arizona.

Jumper Gold Syndicate of California, Limited, with a capital of £20,000, object not specified.

Lawlers Gold Mines, Limited, with a capital of £100,000, to acquire gold mines in Oregon.

Leland Stanford Gold Mining Company, Limited, with a capital of £60,000, to acquire gold mines in Arizona.

London & Cripple Creek Reduction Corporation, Limited, with a capital of £130,000, object not defined.

Mammoth Collins Gold Mines, Limited, with a capital of £100,000, to amalgamate the Mammoth and Collins mines in Pinal County, Ariz.

Missouri Mining and Land Company, Limited, with a capital of £100,000, object not specified.

Mountain Mines, Limited, with a capital of £100,000, to acquire mines in Shasta County, Cal.

New Elkhorn Mining Company, Limited, with a capital of £300,000, to take over the liabilities of the Elkhorn Company and to acquire new mines in the United States.

North American Exploration Company, Limited, with a capital of £500,000, to introduce American mining properties in Europe.

Poorman Gold Mines, Limited, with a capital of £250,000, to take over the mines of the Poorman Consolidated Mines.

Ralston Divide Gold Mining Company, Limited, with a capital of £120,000, to acquire properties at Ralston Divide, Cal.

Redhill, Limited, with a capital of £75,000, to prospect for mines in America.

Rocky Mountain Milling Company, Limited, with a capital of £10,000, object not specified.

Stanislaus Gold and Hydraulic Company, Limited, with a capital of £100,000, to acquire properties in California.

Tinto Copper Mines, Limited, with a capital of £100,000, to acquire mines (not specified) in the United States.

Western American Exploration and Development Company, Limited, with a capital of £100, object not specified.

Wheeler Hill, Limited, with a capital of £62,500, to work the Wheeler Hill gold mines, California.

CANADA.

Anglo-Western Pioneer Syndicate, with a capital of £12,500, to explore for mines in British Columbia.

British Columbia Development Association, with a capital of £10,000, to invest money in mines and lands in British Columbia.

British Columbia Syndicate, Limited, with a capital of £2000, to explore for mines in British Columbia.

British Kootenay Exploration Syndicate, with a capital of £10,000, to explore for minerals in British Columbia.

Canada Exploration Syndicate, with a capital of £2000, to explore for mines in Canada.

Canada Venture Syndicate, with a capital of £20,000, to explore for minerals in Canada.

Cariboo Reefs Development Syndicate, with a capital of £20,000, to explore in British Columbia.

Fraser River Gold Mines, Limited, with a capital of £10,000, to acquire mines in British Columbia.

Invicta Gold Mines, Limited, with a capital of £100,000, to acquire mines in British Columbia.

Kootenay Valleys Company, with a capital of £24,000, to develop properties in British Columbia.

Lane Exploration Syndicate, with a capital of £5000, to develop mines in British Columbia.

Lillooet, Fraser River & Cariboo Gold Fields, Limited, with a capital of £50,-000, to work gold properties at Lillooet in British Columbia.

P. C. Mining and Exploration Syndicate, with a capital of £12,500, to explore for minerals in British Columbia.

Pipestone Gold Mining Company, with a capital of £100,000, to acquire mines in Canada.

Quesnelle & Cariboo Gold Fields Exploration Syndicate, with a capital of £12,000, to acquire mines near the mouth of Quesnelle River in British Columbia.

Yellow Girl Gold Mine, Limited, with a capital of £7500, to acquire mines in Ontario.

MEXICO, CENTRAL AMERICA, AND THE WEST INDIES.

Anglo-Mexican & Western Trust, with a capital of £41,000, to undertake business in Mexico.

Dominican Gold Mines, Limited, with a capital of £150,000, to acquire mines in the Republic of San Domingo.

La Bufa Mexican Gold Mines, Limited, with a capital of £160,000, to acquire mines at Batopilas, Mexico.

Malacate Mining and Smelting Company, with a capital of £500,000, to carry on mines and smelting works in Mexico.

Refugio Mining Company, with a capital of £60,000, to acquire mines from the Mexican Gold and Silver Mining and Milling Company.

Rio Manso Estate Company, Limited, with a capital of £85,000, to work the estate of Jocotepec in Oaxaca, Mexico.

Salvador Mines, Limited, with a capital of £10,000, to acquire the Divisadero gold and silver mines in the Republic of Salvador.

Tehuantepec Exploration and Development Company, Limited, with a capital of £75,000, object not specified.

SOUTH AMERICA.

Acari Copper Mines Syndicate, Limited, with a capital of £20,000, to acquire copper mines in Peru.

Bolivian Syndicate, Limited, with a capital of £5000, to work in Bolivia.

Brazilian Mines Syndicate, with a capital of £2000, to acquire mines in Brazil from La Société des Mines d'Or de Faria.

British Guiana Exploration Company, with a capital of £5000, to prospect for mines in British Guiana.

British Guiana Gold Concession and Development Company, with a capital of £100,000, to acquire gold claims in British Guiana.

British Guiana Prospecting and General Developing Company, with a capital of £100,000, to prospect and work mines in British Guiana.

Chile Gold Development Syndicate, with a capital of £10,000, to erect a dry ore crushing plant at San Cristobal, Chile.

Chile Placers, Limited, with a capital of £50,000, object not specified.

Colon Gold Mines, Limited, with a capital of £50,000, to work gold mines in Colombia.

Coquimbo Gold Syndicate, Limited, with a capital of £15,000, to work gold mines in Chile.

Gold Fields of Colombia, Limited, with a capital of £75,000, to work gold mines in Colombia.

Orinoco Iron Syndicate, Limited, with a capital of £10,000, to acquire mines in Venezuela.

Sir Walter Raleigh Mining Company, with a capital of £100, to acquire mines in British Guiana.

Victory Gold Mining Company, Limited, with a capital of £200,000, to take over the mines of the Victoria & Altamira Company in Venezuela.

The Paris Mining-Stock Market in 1895.

To write the history of the stock market for a year in a few hundred words—to compress 1895 into a page—that is not an easy task. And yet there are some people who think it can be done in a word—the Transvaal.

For a great part of the year the speculation in the South African gold-mining stocks did in fact overrule and influence the entire market. The buying of these gold stocks for investment, which was a prominent feature in 1894, in 1895 developed into wild speculation. The history of this movement is a curious one, and yet it is in a general way only a repetition of many precedents. At first only the stocks of the proved dividend payers were bought at what seemed moderate prices and put away for investment. Then as these became scarce others which seemed to promise well were added; and finally any stocks with barbarous guttural names and the Transvaal as their place of origin found eager buyers at exorbitant quotations. While the French people acquired a substantial interest in many valuable properties, they have also come into possession of a great mass of certificates which represent only possibilities of the future in some cases—in others really nothing.

There was a demand and the promoters attended to the supply. Moderate and judicious in the beginning, this demand became wild and indiscriminate in the end; and the nature of the supply was regulated accordingly.

But what will you have? It is the history of all popular movements. Just as, in politics, people begin with enthusiasm for a great principle and end by deifying a charlatan, so in Paris they began by buying Robinson and Ferreira and Langlaagte and ended by taking any wild-cat which might be offered.

It must be remembered that the Paris mining-stock market differs from others in one important point. A very large part of the buying is by actual investors, who put the stocks away and wait for their dividends; they do not buy for immediate profit and realize on every turn of the market, as they do in London and New York. The class of professional speculators is comparatively small.

In September the climax came and the reaction set in. In part this was a natural result of overtrading and of a too great appreciation of prices; one might have said that the market broke down from its own weight. In great part, however, as we now see, it was the result of a well-organized and adroitly managed speculation for the fall, operated from London and under the leadership of the same men who had had so great a share in the previous advance.

The fall carried down a few speculators, but it did not, very fortunately, succeed in frightening many French holders into selling. Most of them simply held on and refused to do anything. If a general selling movement had once been started, nothing could have prevented a panic of the most serious kind. As it was, the official brokers decided to admit no new companies and to close the lists until January, 1896. The South African shares did not recover before the end of the year and the dealing in them continued very light, while the political events of December still further depressed them.

As comparatively few of these stocks were officially listed in Paris they could not be dealt in, even on the *Coulisse*, and the buying and selling were done chiefly through London agencies, to the great loss of the brokers and *agents du change*. Not only did these dealings escape them, but their magnitude seriously affected the transactions in French stocks, which might otherwise have been large, one would expect, in view of the abundance of money and the revival of the speculative spirit, which had been dormant ever since the Baring crisis four years ago.

Outside of these gold stocks there was no very notable movement in mining stocks during the year. The copper stocks were most in demand and generally showed advances, in sympathy with the price of the metal itself, reaching the highest point in September and reacting toward the close of the year; though the closing prices were much above the quotations with which the year opened.

The only silver stock which is now much dealt in in Paris—Huanchaca—showed many fluctuations, generally in a downward direction.

The zinc shares were generally depressed, owing to the competition which existed in the absence of any agreement among the producers. The lead stocks, especially those of the Spanish companies, were quiet, as a rule, but not weak.

In one important department—the metallurgical shares—there was much depression for a great part of the year. The absence of new railroad and other construction work at home and the loss of foreign orders due to the very sharp competition of the German and the Belgian works, caused a state of affairs in the French iron trade which threatened the profits of all and perhaps even the solvency of some of the companies. The trade was bad for most of the year, though a slight revival began toward its close.

Outside of the mining-stock market there was an absence of large transactions, the Chinese loan being almost the only one of importance. Generally speaking, the Paris bankers and brokers did not have a prosperous year, and most of them do not regret the final passing of 1895.

Dividends and Assessments of American Mining Companies.

The following table shows the dividends paid by American mines for the 12 years 1884–95, inclusive. While great care has been taken to make this table as complete as possible, it does not by any means represent the total amount of profit derived from American mines, as might be hastily supposed. A large number of mines are not incorporated, but are owned either personally or in partnership by parties who do not, of course, report their profits. In many cases the stock of companies is closely held and no particulars are made public regarding the profits made. Most of the information in the table has been obtained from the companies themselves, the particulars having been furnished by their officers and the corrections supplied up to date.

The year 1895 brought some new dividend payers into the list and restored some others which had dropped out in previous years. The copper companies generally maintained or increased their dividends, while there were several additions, among them the Montana Ore Purchasing Company, which paid its first dividends in 1895, and the Kearsarge Company in Michigan, which had not paid any since 1890.

Several of the Colorado gold-mining companies made their first payments in 1895. Some of the Utah and Montana companies were able to maintain dividends notwithstanding the continued low prices of silver. In Alaska the Alaska-Mexican, which began to pay in 1894, continued its dividends in 1895, while the Alaska-Treadwell maintained its full returns. The Homestake Company, in the Black Hills, increased its payments, and the Highland, in the same district, made its first payment.

Were it possible to obtain a complete list, the amount reported would present a total very much larger than that shown in our table.

Following the table of dividends will be found a table giving the assessments levied by mining companies for the nine years 1887–95, inclusive. This table also has been made as complete as possible.

DIVIDENDS PAID BY AMERICAN MINES. (1 = $1000; total, full amount.)

Company.	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	Totals.
Adams, S., L., Colo.	83	218	240	15	....	....	....	75	8	....	....	6	$640,500
Ætna Cons., Q., Cal.	....	....	....	....	....	....	....	....	....	....	20	20	40,000
Alaska-Mexican, G., Alaska	....	....	....	....	....	....	....	....	....	....	26	80	105,381
Alaska-Treadwell, G., Alaska (*a*)	....	....	....	....	....	....	....	450	300	375	375	400	2,675,000
Alice, S. G., Mont.	150	125	75	....	25	25	95	75	....	....	....	....	975,000
Alma, G., Ida.	....	....	....	....	....	15	....	....	....	....	....	....	60,000
Alturas, G., Ida.	....	....	95	....	113	....	....	....	....	....	....	....	262,250
Amador Gold Mg. Co., Ltd., G., Cal.	....	....	....	....	....	....	31	....	....	....	....	....	31,250
American & Nettie, G., Colo.	....	....	....	....	....	150	....	45	30	....	....	....	225,000
American Belle, S., C., Colo.	....	....	....	....	....	....	....	50	....	....	....	....	50,000
American Coal, Md.	....	....	....	....	....	....	....	90	90	90	90	....	360,000
American Dev. & Mg., G., S., C., Mont.	....	....	....	....	....	....	....	....	....	....	52	24	76,422
American Turquoise, N. M.	....	....	....	....	....	....	....	....	....	60	....	....	60,000
Amethyst, Colo.	....	....	....	....	....	....	....	....	....	....	....	36	36,000
Amy & Silversmith, Mont.	....	....	205	43	....	....	....	....	....	....	....	....	247,530
Anaconda, G., Colo.	....	....	....	....	....	....	....	....	13	....	....	....	12,500
Argentum-Juniata, S., Colo.	....	....	....	....	....	....	....	....	....	....	....	39	39,000
Argyle, G., Colo.	....	....	....	....	....	....	....	....	20	....	....	....	20,000
Aspen, S., L., Colo.	....	....	....	....	80	280	200	100	100	100	40	....	900,000
Atlantic, C., Mich.	40	20	40	40	120	80	100	40	....	....	....	....	700,000
Aurora, I., Mich.	....	....	....	150	....	....	....	200	100	200	....	....	650,000
Badger, S., Can.	....	....	....	....	....	....	38	....	....	....	....	....	37,500

DIVIDENDS PAID BY AMERICAN MINES—*Continued.*

Company.	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	Totals.
Bald Butte, G., Mont							20	30	20	100	200	128	$437,500
Ballarat Smuggler, G., Colo								6					6,000
Bangkok-Cora Belle, S.,Colo						3	42					54	101,510
Bannister, S., Mont							24	72	6				102,000
Bassick, S., G., Colo	100												400,000
Bates-Hunter, G., Colo								68					67,500
Belden, F. E., M., New H.									45	60	60	48	213.000
Bellevue, S., L., Ida		88	63	38				13					200,000
Best Friend, S., Colo								70	20				90.000
Big Bend, G., Cal	72	30	66	48									258,000
Bimetallic, S., G., Mont							290	840	200	190			1,630,000
Bodie Cons., G., Cal	350	50									75		1,677,572
Bonanza King, S., Cal	150	10											185,000
Boreel, S., Colo										60	23		105,000
Boston & Montana, C., S., Mont		30	180		400	500	625	500			275	1050	3,425,000
Brooklyn Lead, L., S., Utah			20	25									127,000
Brotherton, I., Mich									40	80			120,000
Bull-Domingo, L., S., Colo							20	29	4				53,000
Bullion, Beck & Champion, Utah											425	325	750,000
Bulwer Cons., G., Cal									15				190,000
Bunker Hill & Sullivan, S., L., Ida					20								150,000
Buxton, So. Dak				5					20				25,000
Caledonia, G., Dak		20	20		16	80	56		56				192,000
California, G., Colo	32						20						116,500
Calliope, S., Colo						50	85	5					140,000
Calumet & Hecla, C , Mich	1300	1700	1000	1000	2000	2000	2000	2000	2000	2000	1500	2000	43,350,000
Carbonate Hill, S., L., Colo	10												80,000
Carlisle, G., N. M. (*b*)					175								175,000
Catalpa, S., L., Colo	30												270,000
Centennial-Eureka, S., G., L., Utah							150	330	90	188	195	510	1,470,000
Central, C., Mich	40	30	40	40	70	40	20	20					1,970,000
Champion, G., Cal							27	43	41	41	41	27	219,000
Charleston, P., S. C										140			140,000
Chrysolite, S., L., Colo	50												1,650.000
Church, G., Cal												5	5,000
Clay County, G., Colo							8	48					56,000
Cleopatra, G., S., So. Dak										450			450,000
Cœur d'Alêne Silver-Lead Mg. Co., S., L., Ida						70	160	80	72	30			340,000
Colorado Central, S., Colo		60	111	83	83	55		14	55	28			502,661
Colorado Fuel Coal, I., Colo						178	189	252	67	67			752,700
Commonwealth, S., Nev							20						20,000
Confidence, S., Nev					175	25							277,680
Cons. Cal. & Va., S., G., Nev. (*c*)			65	1118	1118	756	162	216			108	108	3,898,800
Cons. New York, S. G., Nev										10			10,000
Consolidation Coal, Md									205				205,000
Contention. S., Ariz	63								50				2,637,500
Cook's Peak, S., L., Colo								55	60				119,532
Copper Bell, S., Mont								14					13,500
Copper Queen, C., S., Ariz	200				140	70	210		140	300	200	150	1,910,000
Coptis, S., Nev. (*d*)												1	77,000
Cortez, S., Nev							173	250	95	45			735,000
Cosmopolitan, S., Utah	25												75,000
Crescent, S., L., Utah		30	30	18									238,000
Daly, S., L., Utah				375	488	450	450	450	450	188			2,850,000
Deadwood-Terra, G., So. Dak. (*e*)				100				50	100				1,140,000
Deer Creek, S., G., Ida					10	10							20,000
De Lamar, S., G., Ida								150	272	450	400	540	1,812,000
Della, S., Colo											50		50,000
Derbec, G., Cal	60	40	40	20		30	30	20					280,000
Dexter, S., Nev										100			100,000
Dunkin, S., L., Colo	10			30	100	40							390,000
Dunstone, G., S., L., Mont					6								6,000
Eclipse, L., S., Colo				20									20,000
Elkhorn, S., L., Mont		35	55	20			125	300	303	225	142	50	1,349,689
Elkton, Colo											60		60,000
Empire, G., Mont. (*f*)				71									70,500
Enterprise, S., G., Colo. (*m*)								250	450	125			825,000
Eureka Cons., S., L., Nev				50	88		38	50	13				5,112,500
Evening Star, S., L., Colo					13	25							1,437,500
Father de Smet, G., So. Dak	200	200											1,125,000
Forepaugh, Colo												16	16,000
Franklin, C., Mich	80	40	80	40	160	80	80	80	160	120	80		1,240,000
Freeland, S., Colo		80	60										190,000
Garfield, S. G., Nev			13	13	25								85.000
Glengarry, S., G., Mont								10					10.000
Golconda, S., G., Ida					120								120,000
Gold Coin, G., Colo												15	15,000
Golden Fleece, Colo												192	269,000
Golden Reward, G., So. Dak					20				60	60			125.000
Gold & Globe, G., Colo												11	11.250
Gold Rock, G., Colo								29					28,750
Granby, Z., Mo						20							20,000
Granite, S., L., Ida					8	20							83,400
Granite Mountain, S., G., Mont		580	1020	2000	1600	2400	2400	1400	520				12,120,000
Great Western, L., Cal								25	137	25			388,366

DIVIDENDS PAID BY AMERICAN MINES—*Continued.*

Company.	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	Totals.
Hale & Norcross, S.,G., Nev.					224								$1,822,000
Harquahala, Ariz.											72		126,000
Hecla Cons., S., L., Mont.	195	195	135	30	100	180	123	180	90	60	120	90	2,100,000
Helena & Frisco, L., S., Idaho							79	190	20		15	10	425,000
Helena M. & R. Co., Mont.	36	138	60										197,970
Helena & Victor, S., Mont.								20					70,000
Highland, G., So. Dak.												50	50,000
Holmes, S., Nev.			50						25				75,000
Homestake, G., So. Dak.	306	525	575	300	300	188	150	150	150	150	256	344	5,681,250
Honorine, S., Utah.	13	50	25	38									125,000
Hope, S., Mont.		36		25	50				100	175	75	10	592.252
Horn Silver, S., L., Utah.	1200					50	200	200	200	230	150	50	5,080,000
Huhert, G., Colo.					18	5							247,000
Idaho, G., Cal.	226	270	271	140	357	178	29	93	4[illegible]	105			5,489,000
Ideal, S., L., Colo.			15										15,000
Illinois, S., N. M.				25		20	20						65,000
Iron Hill, So. Dak.			112	44									156,250
Iron Mountain, S., Mont.							50	25		30	50	105	410,000
Iron Silver, S., L., Colo.	100	200	300	300	300	100							2,500,000
Isabella, G., Colo.												23	22,500
Ivanhoe, Colo.						10							10,000
Jackson, G., S., Nev.	10	15	20			5		5				2	80,000
Jay Gould, G., S., Mont.				95	226	74	22						459,000
Jay Hawk, S., G., Mont. (*g*).									33				33,375
Jumho, G., Colo.				33									33,000
Kearsarge, C., Mich.							80					40	120,000
Kennedy, G., Cal.								360	500	480	540	184	1,796,000
Kentuck, S., G., Nev.	21		3										1,350,000
Lady Franklin, N. M.				100									100,000
Lake Superior, I., Mich.									400			84	484,000
Last Chance, S.. Colo.									650				650,000
Leadville, S., L., Colo.	20	20	40	20					12	12			316,000
Le Roi, G., B. C.												25	25,000
Lexington, G., Colo.									36				36,000
Lexington, S., Mont. (*h*).	320					64							609,000
Little Chief, S., L., Colo.	40	20					20						820,000
Little Rule, S., Colo.							100	120					220,000
Maid of Erin, S., L., C., Colo. (*i*).												60	740,000
Mammoth, Utah.				20	50	130	470	320					1,040,000
Manhattan, S., Nev.		13	25										437,500
Martin White, S., Nev.			50										140,000
Mary Murphy, S., Colo.				70									175,000
Maxfield, S., L., Utah.								36	18				117,000
May Flower Gravel, G., Cal.													166,897
May-Mazeppa, S., L., Colo.							70	110					180,000
Mercur, G., Utah.										50	150	175	350,000
Metropolitan, I., Mich.													3,912,500
Minas Prietas, S.. Mex.							50						50,000
Minnesota, I., Minn.								840	840	495			2,745,000
Mollie Gibson, S., Colo.								1000	1700	1230	100	50	4,080,000
Monitor, So. Dak.						38	7						45,000
Mono, G., Cal.			13										12,500
Montana Limited, G., S., Mont.		123	617	719	413	206	178	83				205	2,890,637
Montana Ore Purchasing, Mont.												160	160,000
Moose, Colo.											108	72	180,000
Morning Star, S., L., Colo.	25	25	125	75				50					925,000
Morning Star Drift, G., Cal.								23	83	72	106	154	435,800
Moulton, S., Mont.	80	150	90	60					30		20	30	460,000
Mount Diahlo, S., Nev.		30			40	40	20	30		30			225,000
Mount McClellan, S., Colo.								13					12,500
Mount Pleasant, Cal.	15	30		45									180,000
Mount Rosa, Colo.											5	5	10,000
Napa, Q., Cal.						30	40	40	70	70	50	80	740,000
Navajo, S., G., Nev.	50	50				40							226,111
New Guston, S., Colo.					100	188	170	440	124				1,210,000
New Hoover Hill, G., No. C.		37											37,200
Newton, Cal.								10					10,000
North Banner Cons., G., Cal.								20					20,000
North Belle Isle, S., G., Nev.					200								230,000
North Commonweath, S., G., Nev.								25					25,000
North Star, G., Cal.					150	100		50	50	100			450,000
Nugget, G., Colo.											5	5	10,000
Omaha, G., Cal.							13		7	43	43		106,100
Ontario, S., Utah.	900	975	900	900	900	900	1650	900	750				13,175,000
Original, S., C., Mont.	30		3	12	6	3							138,000
Oro, G., S., L., Colo.							95						95,000
Oro Grande, G., Cal.	175	15											188,860
Osceola, C., Mich.	63			100	150	50	225	150	150	100		100	1,947,500
Pacific Coast Borax, B., Cal.								180	180	63			422,500
Pamlico, Nev.					21	12			12				189,080
Pandoro, Mont.								3	3				6,000
Paradise Valley, S., Nev.	50			10									160,000
Parrott, C., S., Mont.				54	144	144	252	360	216	138	67		1,569,000
Peacock, N. M.			50										50,000
Petro, S., Utah.								18					17,500

DIVIDENDS PAID BY AMERICAN MINES—*Continued.*

Company.	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	Totals.
Pharmacist, G., Colo	....	....	....	....	....	....	....	....	36	44	....	...	$80,000
Pittsburg, G., Nev	....	....	....	....	30	....	....	....	....	....	....	....	29,850
Pleasant Valley, C., Utah	....	....	....	....	....	....	....	....	....	20	....	....	593,056
Plumas Eureka, G., Cal	....	105	53	18	70	123	....	70	25	53	....	....	2,696,294
Plutus, S., Colo	....	....	20	....	....	....	....	....	....	....	....	....	20,000
Plymouth Cons., G., Cal	600	575	300	375	80	....	....	....	....	....	....	....	2,280,000
Poorman, G., Colo	....	....	....	....	25	15	85	....	....	....	....	....	125,000
Poorman, S., Ida. (*l*)	....	....	....	....	....	....	....	....	57	....	....	....	56,935
Portland Gold, G., Colo	....	....	....	....	....	....	....	....	....	....	67	556	623,000
Quicksilver, Q., Cal. (*j*)	13	....	118	129	283	193	257	118	....	....	....	....	2,475,082
Quincy, C., Mich	280	180	240	800	360	280	320	400	350	300	400	600	7,670,000
Red Cloud, S., L., Ida	....	....	....	....	....	....	20	80	70	10	....	....	180,000
Reed & National, S., G., Colo	....	....	....	....	....	....	45	....	....	....	....	....	45,000
Rescue, N. M	....	....	....	....	....	....	....	....	12	....	....	....	12,000
Retriever, So. Dak	....	....	....	....	....	....	....	13	....	....	....	....	12,500
Rialto, G., Colo	....	....	....	....	....	....	....	32	18	....	....	....	50,250
Richmond Cons., S., L., Nev	68	68	135	68	....	....	....	34	....	14	....	....	4,386,780
Rico-Aspen, Colo	....	....	....	....	....	....	....	....	....	50	300	....	350,000
Robinson, S., Colo	....	....	10	....	....	....	....	....	....	....	....	....	585,000
Rocky Fork Coal, Mont	....	....	....	....	....	....	....	100	100	....	....	....	200,000
Rooks, G., Vt	21	30	....	....	....	....	....	....	....	....	....	....	61,000
Running Lode, Colo	....	....	...	....	....	...	5	25	6	1	....	....	27,000
Russell, G., Cal	....	....	....	30	....	....	....	....	....	....	....	....	30,000
Saint Joseph, L., Mo	40	66	184	90	....	....	....	150	150	150	150	150	2,524,000
Security, G., Colo	25	25	....	....	....	....	....	....	....	....	....	....	56,000
Sheridan, S., G., Colo	....	....	....	....	....	....	....	75	....	....	....	....	300,000
Sherwood, Z., Mo	....	....	....	3	....	....	....	....	....	....	....	....	3,000
Sierra Bella, S., N. M	30	....	....	....	....	....	....	....	....	....	....	....	30,000
Sierra Buttes, G., Cal	15	31	76	76	15	....	....	25	36	31	....	....	1,584,933
Sierra Nevada, Ida	....	....	....	....	20	20	....	....	....	....	....	....	40,000
Silent Friend, S., L., Colo	...	....	....	....	....	....	..	60	....	....	....	....	60,000
Silver Cord, S., L., G., Colo	....	....	....	....	....	45	....	....	....	....	....	....	265,000
Silver King, S., Ariz	50	200	225	175	....	....	....	....	....	....	....	....	1,950,000
Silver King, Utah	....	....	....	....	....	....	....	....	....	....	....	263	450,000
Silver Mining of Lake Valley, N. M	....	....	....	....	25	25	180	80	....	....	....	....	300,137
Silverton, S., Colo	32	....	48	....	....	....	....	....	....	....	....	....	80.000
Small Hopes, S., Colo	800	888	775	600	....	25	25	....	38	25	....	...	3,225,000
Smuggler, Colo	....	....	....	....	....	....	....	....	....	....	650	350	1,140,000
Standard, G., Cal	75	....	....	20	50	....	....	10	40	20	40	20	3,717,868
Swansea, G., S., L., Colo	....	....	....	....	....	....	....	....	....	....	2	....	39,000
Syndicate, Cal	60	12	....	....	....	....	....	....	....	....	....	....	72,000
Tamarack, C., Mich	....	....	....	....	640	440	590	800	600	690	400	200	4,270,000
Teal & Poe, S. L., N. M	....	....	....	....	....	....	....	9	....	....	....	....	9,000
Temonj, G., Colo	....	....	....	....	....	....	....	....	....	....	....	10	10,000
Tomboy, G., Colo	....	....	....	....	....	....	....	....	....	....	....	300	300,000
Trinity River, Colo	....	....	....	....	....	....	....	....	....	15	....	....	15,000
Union, Colo	....	....	....	....	....	....	....	....	....	....	27	13	39,020
United Verde, C., S., Ariz	60	....	....	....	....	....	30	....	30	435	....	....	562,500
Utah, Utah	....	....	....	....	....	....	....	....	15	5	....	17	37,000
Valencia, M., N. H	19	19	4	....	....	....	....	....	....	....	....	....	41,250
Victor, G., Colo	....	....	....	....	....	....	....	....	....	120	105	240	465,000
Victor L. & M., Col	....	....	....	....	....	....	....	....	....	....	....	24	24,000
Viola Limited, S., L., Ida	....	....	38	38	94	....	....	....	....	....	....	....	337,500
Ward Cons., S., Colo	....	....	....	....	....	20	....	....	....	....	....	....	20,000
War Eagle, B. C	....	....	....	....	....	....	....	....	....	....	....	133	132,500
Webb City, Z., Mo	....	....	....	....	....	4	....	....	....	....	....	....	4,400
Whale, Colo	....	....	....	....	....	....	....	5	....	....	....	....	5,000
Woodside, S., Utah	....	....	....	....	....	25	....	....	....	....	....	....	25,000
W. Y. O. D., G., Cal	....	....	....	....	....	....	....	6	36	24	36	24	108,000
Yankee Girl, S., Colo. (*k*)	....	....	300	187	....	....	125	260	....	....	....	....	1,665,000
Yosemite, S., Utah	....	....	....	....	....	....	....	....	5	...	...	....	5,000
Young America, G., Cal	....	....	165	....	10	....	....	....	....	....	....	....	175,000

(*G*) Gold; (*S*) Silver; (*L*) Lead; (*I*) Iron; (*C*) Copper; (*Q*) Quicksilver; (*B*) Borax; (*Z*) Zinc; (*M*) Mica.

(*a*) Formerly the Alaska Mining and Milling Company, reorganized in 1891 as the Alaska-Treadwell Gold Mining Company; the dividends credited for 1891 and 1892 are the payments of the latter company. The Alaska Mining and Milling Company paid $700,000 previously.

(*b*) Reconstructed into the Golden Leaf, Limited, of Montana.

(*c*) Previous to the consolidation in August, 1884, the California had paid $31.320,000 in dividends and the Consolidated Virginia $42,390,000.

(*d*) Formerly the Young America South Mining Company, reorganized as the Coptls in 1891.

(*e*) Previous to consolidation, the Deadwood paid $275,000 and the Terra $75,000.

(*f*) Reconstructed as the Golden Leaf, Limited.

(*g*) Jay Hawk & Lone Pine Consolidated Mining Company, Limited.

(*h*) Société Anonyme des Mines de Lexington.

(*i*) Maid of Erin Silver Mines, Limited, formerly Henriette & Maid Consolidated Mining Company. The dividends for 1887, 1888, 1889, and 1890 were paid by the old company, and those for 1891 and 1892 by the new company.

(*j*) Including dividends paid on preferred stock and common stock.

(*k*) Yankee Girl Silver Mines, Limited, formerly Yankee Girl Mining Company. The above statement includes the payments by both the old and new companies.

(*l*) Enterprise Mining Company, of Rico, Colo.; there is also an Enterprise Mining Company in Aspen and one in Leadville.

(*m*) Poorman Mines, Limited, operating the Poorman Mine at Silver City, Idaho, which paid large dividends in 1865 and 1866.

Assessments Levied by Mining Companies.

Name and Location of Company.	Levied in 1887	Levied in 1888	Levied in 1889	Levied in 1890	Levied in 1891	Levied in 1892	Levied in 1893	Levied in 1894	Levied in 1895	Totals to Jan. 1, 1896.
Ada Con., Utah							$330		$3,000	$3,333
Alliance, Utah			$30,000		$40,000				50,000	200,000
Allouez, Mich		$80,000	40,000	$40,000	40,000			$16,000		1,440,937
Alpha, Nev	$30,000	52,500	26,500	42,250	15,000	$36,750	10,000	6,000	15,750	241,750
Alta, Nev	100,000	108,000		54,000	30,000	27,000	25,200	50,400	20,160	3,547,360
Anchor, Utah	70,000	105,000	15,000		150,000		90,000			560,000
Andes, Nev	50,000	50,000	25,000	25,000	30,000	25,000		25,000	15,000	245,000
Argenta, Nev			10,000							335,000
Atlantic, Conn	10,000									70,000
Baltimore, Nev		75,000	50,000	20,000						145,000
Belcher, Nev	52,000		104,000	104,000	104,000	78,000		50,200	50,200	3,260,420
Belle Isle, Nev	35,000			15,000		30,000	20,000			230,271
Bellevue-Idado, Idaho	31,250	18,750	12,500	16,037						104,787
Benton Con., Nev	27,000	108,000								556,000
Best & Belcher, Nev	153,200	100,800	75,200	149,485	100,800	50,000	75,600	50,400	50,400	2,581,225
Bodie Con., Cal	100,000	100,000	75,000	50,000			40,000			730,000
Bodie Tunnel, Cal	25,000	25,000		25,000	25,000	25,000				202,906
Brunswick Con., Cal					20,000	20,000		8,000	16,000	64.000
Bullion, Nev	90,000	50,000		25,000	50,000	100,000	25,000	30,000	40.000	3,010,000
Bulwer Con., Cal	20,000	20,000	50,000		15,000		10,000	10,000	5,000	170.000
Butte & Boston, Mont									1,500	1,500
Butte Queen, Cal						4,000	10,000			16,000
Caledonia Silver, Nev	15,000	15,000			150,000			50,000		3.235,000
California, Cal						6,000			4,500	16,500
Centennial Eureka, Utah			30,000							30,000
Central North Star, Cal							10,000			10,000
Challenge Con., Nev		25,000	25,000	50,000	50,000	45,200	15,000	50,000	5,000	292,500
Chollar, Nev	112,000	112,000	112,000		168,000	112,000	61,600	56,000	56,000	1,993,600
Cœur d'Alêne, Idaho		25,000								25,000
Commonwealth, Nev		50,000				30,000				190,000
Comstock, Nev	15,000									30,000
Concord, N. C	3,000	3,000								6,000
Concordia, Nev		75,000								75,000
Confidence, Nev	12,480			18,720	18,720	49,920		6,240	14,976	1,629,486
Con. Cal. & Va., Nev						108,000	6,220	108,000	54,000	378,000
Con. Imperial, Nev	125,000	25,000	25,000	75,000	150,000	26,500			5,000	2,081,500
Con. New York, Nev			25,000	45,000	30,000	20,000	25,000	5,000	10,000	160,000
Con. Pacific, Nev	9,000		15,000	6,000						198,000
Courier, Idaho	5,000									10,000
Crocker, Ariz	15,000	25,000	20,000	25,000	20,000	5,000	5,000			180,000
Crown Point, Nev		150,000	100,000		150,000	100,000	80,000	65,000	25,000	2,895,000
Dalton, Utah							3,750	5,000	5,000	38,750
Del Monte, Nev		25,000	20,000	20,000	29,050	20,000				120,000
Derbec Blue Gravel, Cal						10,000	5,000			15,000
Dexter, Nev				8,000						8,000
Diana, Nev		10,000				8,000				83,000
East Best & Belcher, Nev				25,000	45,000	20,000		20,000		110,000
East Sierra Nevada, Nev			10,000		10,000			5,000		25,000
Eureka Con., Nev			50,000						12,500	562,500
Exchequer, Nev	20,000	40,000	25,000	50,000	25,000	45,000	15,000	10,000	5,000	715.000
Felice, Ariz	20,000									20,000
Fisher, Ariz	20,000									20,000
Flowery, Nev		20,000								130,000
Found Treasure, Nev	6,000	18,000	12,500	45,000		50,000				131,500
Gold Flat, Cal						11,000	2,000			13,000
Goodyear, Mont						2,000	4,183			17,183
Gould & Curry, Nev	162,000	140,400	91,800	60,400	64,800	76,400	80,200	32,400	48,600	4,769,400
Grand Prize, Nev		25,000	120,000	25,000						785,000
Hale & Norcross, Nev	112,000			56,000	168,000	168,000	56,000	56,000	39,200	5,725,200
Hartery Con., Cal				5,000	5,000			2,000	2,000	31,000
Hartshorn, So. Dak				6,250						6,250
Hayward Group, So. Dak				2,000						2,000
Head Centre & Tranq., Nev										22,824
Heath, Idaho	20,000	5,000								25,000
Hector, Cal			45,000							45,000
Hidden Treasure, Cal							1,000			1,000
Himalaya, Utah	1,800	900			1,800	1,800				10,000
Holmes, Nev				25,000						345,000
Honorine, Utah			12,500		12,500					50,000
Hudson Bay, Cal							10,000			10,000
Huron, Mich	120,000									280,000
Independence, Nev						5,000				345,000
Iron Hill, So. Dak		36,250	15,000	20,625	15,000					169,375
Jack Rabbit, Cal						15,000	13,000	5,000		118.000
Jackson, Nev							10,000			247,500
John Duncan, Mich			2,000							4.000
Julia Con., Nev	16,500				11,000		5,000		5,500	1,484,500
Justice, Nev	31,500	52,200			26,250	42,000	30,000	75,000	20,000	3,650,000
Kearsarge, Mich	50,000									190,000
Kentuck Con., Nev					36,750	31,500	10,500	26,250	10,500	114,250

ASSESSMENTS LEVIED BY MINING COMPANIES—*Continued.*

Name and Location of Company.	Levied in 1887	Levied in 1888	Levied in 1889	Levied in 1890	Levied in 1891	Levied in 1892	Levied in 1893	Levied in 1894	Levied in 1895	Totals to Jan. 1, 1896.
Keystone, Nev	$10,000									$240,000
Keyes, Nev		$95,500	$30,000							125,000
Kingman Silver, Ariz					$5,000					5,000
King of the West, Idaho	30,000	15,000								45,000
Kossuth	10,800	10,800								433,000
Lady Washington, Nev		27,000			21,400					128,400
La Plata, Nev			3,000							3,000
Locomotive, Ariz	75,000	25,000	10,000	$5,000						115,000
Lone Star Con., Cal						$5,000				12.500
Madoc Chief, L., S., G., Idaho						4,375				4,375
Manhattan, Nev	200,000									250,000
Martin White, Nev			25,000	50,000	50,000	50,000	$25,000	$25,000		1,350,000
Mayflower, Cal	150,000	175,000	35,000							470,000
Mexican, Nev	50,400	50,400	50,400	25,200	50,400	75,600	75,600	75,000	$75,000	3,043,760
Michigan Gold, Mich						10,000				40,000
Mikado, Mich	9,200	6,000								15,200
Milwaukee, Mont					2,500					12,500
Missoula Placers, Mont	2,000									4,000
Modoc Chief, Idaho						5,000				975,000
Mollie Gibson, Colo						10,000				20,000
Montreal, Utah						750			375	4,875
Mono, Cal	100,000	25,000	62,500	12,500	12,500				5,000	777,500
Mount Terry, So. Dak				750						750
Navajo, Nev	50,000	30.000	10,000	15,000	15.251	20,000	20,000	10,000		540,548
Nevada Queen, Nev	130,000		70,000		15,000	25,000	25,000		5,000	270.000
North Belle Isle, Nev	100,000	50,000	100,000	20,000	50,000	20,000	38,075			513.075
North Bonanza, Nev	15,000	15,000	10,090							240.000
North Commonwealth, Nev		30.000	30.000	25,000	25,000		10,000			120,000
North Comstock, Nev	10,000									10,000
North Extension, Nev	25,000									25,000
North Gould & Curry, Nev			20,000		30,000	10,000	10,000	20.000		310,000
North Occidental, Nev				6,000						13,000
North Peer, Ariz		5,000	5,000	5,000						21,000
Occidental Con., Nev	25,000	45,000	50,000	75,000	25,000	50,000	55,000	30,000	30,000	388,652
Ophir, Nev	50,400	50,400	50,000	50,000	50,000	50,000	100,000	100,000	100,000	4.610,640
Original Keystone, Nev						10,000				250,000
Oro Cache, G., S., So. Dak							1,250			6.250
Overman, Nev	28,800		57,600	28,800	79,340	126,720	60,000	34,560	23,040	4,154,000
Paradise Valley, Nev		25,000								57,000
Pennsylvania Con., Cal						2.750				36,050
Peer, Nev			20,000	10,000	15,000	20,000	10,000	5,000		215,000
Peerless, Nev	25.000	25,000	96,000	25,000	10,000	5,000	5,000	5,000		410,000
Phil Sheridan, Nev	20,000	10,000	35,000							65,000
Pine Hill, Cal							3.000	3,000	5,000	15,000
Potosi, Nev	145,600	112,000	10,000	55,400	112,000	56,000	84,000	112,000	56,000	1,993,600
Queen Bee, So. Dak				3,000						3,000
Rainbow, So. Dak						1,250			438	4,343
Ropes, Mich							20,000			20,000
Sampson, Utah	25,000	100,000								288,257
San Francisco, Cal	22,000									22,000
Savage, Nev	168,000	112,000	112.000		112,000	122,000	112,000	100,800	67,200	961,800
Scorpion, Nev	20,000	10,000	120,000	90,000		5,000		5,000		415,000
Seg. Belcher & Mides, Nev		25,000	50,000	80,000	50,000	25,000	35,000	20,000	20,000	330,000
Seg. Iron Hill, Nev	2,500									8,750
Sierra Nevada, Nev	100,000	75,000	100.000	71,910	80,000	55,000	45,000	50,000	50,000	4,501,910
Silver Hill, Nev			43,200	43,200	30,000	16,200	5,400	5,400		1,992,600
Silver King, Ariz								30,000		172,858
Siskiyou Con., Cal					8,000	7,000	9,000	14,000	4,000	42,000
Standard, Cal				50,000						100,000
St. Mary's Copper, Mich							2,000		2,000	4,000
Summit, Cal		5,000	2,500							120,000
Taylor Plumas, Cal	4,000	6,000			10,000					20,006
Telegraph, Cal						975				3,575
Teresa, Mex						20,000	60,000		15,000	155,000
Tioga Con., Cal		10,000								295,000
Triumph, Idaho	10,000									20,000
Trojan, Nev		10,000	10,000							370,000
Tuscarora, Nev		5,000	10,000							15,000
Union, Utah		1,000								7,000
Union Con., Nev	75,000		75,000	50,000	80,000	50,000	45,000	35,000	20,000	2 505,000
Utah Con., Utah							25,000	5,000	5,000	405,722
Valenzuela, Mex									2,000	6,000
Wall Street, Mon						900				1,500
Waterloo, Cal							30,000			30,000
Weldon, Ariz	20,000		10,000	10,000	10,000	5,000	10,000			65,000
Wolverine, Mich									60,000	60,000
Wood River, Ida					3,000					3,000
W. Y. O. D., Cal					22,500					22,500
Yellow Jacket, Nev			60,000			156,000	90,000	90,000	90,000	6,054,000

PROGRESS IN ORE DRESSING IN 1895.

By Robert H. Richards.

The following are the general conclusions arrived at by the author from observations made during a recent visit to many of the important concentration plants of the country. They are given in the order of treatment in the mills.

Preliminary Crushing.—The Blake crusher, pitman pattern with solid cast-iron frame, is the standard crusher of the country. The Gates and Comet crushers are, however, growing in favor on account of their great capacity.

Final Crushing.—Rolls are the standard machine for crushing all the brittle ores in preparation for jigging. The steam stamps at and near Butte, Mont., are the only exception. Steam stamps are the standard crushing machine of the malleable minerals, such as the native copper of Lake Superior. The gravity stamps still hold their own for fine crushing. Several machines, however, are competing for the place occupied by the gravity stamp of which prominent examples are the Huntington and the Bryan mills.

Auxiliary Crushers for Recrushing Middlings.—The rolls, the gravity stamp, the steam stamp, the Huntington mill, the Bryan mill, and the Heberli mill are all used for this work. The rolls predominate very much over the other machines. Rolls cannot be used at Lake Superior on account of the flaky character of the copper, which will float off on the tail of the jig after the crushing of middlings by rolls. Grinders or stamps alone serve for these products.

Preliminary Washers.—Trommels are used to take out the coarser sizes preparatory to jigging in all the mills except those at Lake Superior. In some mills wire cloth is used; in others punched steel plates. Neither one of these has as yet won the day to the exclusion of the other. Separators using an upward current of water for sorting the grains preliminary to fine jigging are used in almost innumerable forms with all grades of approach to perfection of action. The one essential quality sought is that it shall stand up and do its work without causing stops and trouble to regulate it. A separator that has to be petted, however good it may be in principle, does not find favor. Settling tanks of various forms are used for separating the finest sizes preparatory to vanners and tables. They are generally of the 60° V section, with spigots arranged along the bottom near enough to each other to prevent serious banks from forming. The pulp is often fed into these long tanks at different points to prevent the earlier spigots from delivering a greater quantity than their share, while the later would have little to do. The spitzkasten of the foreign mills has not yet found its way into American works to any considerable extent.

Final Washers.—The Harz jig with the plain eccentric is more used than any other. The accelerated plunger with the crank arm, or the sliding-block motion, is favored in some districts. The Collom accelerated jig still holds its sway in Lake Superior and in some of the Montana mills. For working up the sands from the spigots of the separators or hydraulic classifiers the plain eccentric Harz jig is generally used, except in those mills which favor the Collom. The automatic discharge is used in some mills for removing the concentrates from the sieve; in others the concentrates of comparatively coarse sizes are discharged through the sieve, a side discharge being used merely to relieve an accumulation which from time to time forms. The coarsest hutch work seen by the author is in a pyrites mill in the Province of Quebec, where the sieve has a 1-in. mesh. The hutch work in this case is discharged by opening a gate and flushing out water and sand. The products of the spigots of the settling tanks are worked up by vanners or by slime tables. The former are invariably used where water is scarce. In one Montana mill the slime tables are put first and the vanners follow, thus working over the tailings of the table. In some Cœur de Alêne mills the product of the earlier spigots is treated on tables and that of the later on vanners. In one California gold plant the stamp pulp, after yielding all that the vanners can save, is treated by a hydraulic classifier, rejecting the pulp from the spigot. The pulp from the overflow is treated on canvas tables. The concentrates of these are again concentrated on a special vanner, yielding good results. The Gilpin County vanning table is used in Colorado. The Rittinger table is used in one Missouri mill.

Auxiliary Washers.—For washing recrushed middlings, trommels, hydraulic classifiers or separators, settling tanks, jigs, vanners, and tables are all used.

Machinery for Elevating Sand and Pulp.—The coarser grades of sand with water, where it is necessary, are lifted by rubber-belt elevators in almost all cases. The author has only seen three chain elevators, one at Lake Superior, one in the Missouri lead region, and one in the Cœur de Alêne. Centrifugal pumps are universally used for raising the finer pulps. The tailings of mills are elevated, when necessary, by sand wheels at Lake Superior and by rubber-belt elevators elsewhere.

Location of Mills.—Some difference of opinion exists in regard to the relative desirability of the side-hill and of the flat location for concentration works. The side-hill location is the most common among the mills visited. As extreme instances of this policy, it may be stated that several mills in Utah are placed so far up the side of the mountain that a dumping-place is obtained for tailings below the mill on the hillside. These mills hoist all the ore from the valley below and pump the water from a distance.

The Tendency of Modern Mills.—The tendency is distinctly toward graded crushing, sizing, and washing. The jigging of larger ore is being experimented upon until certain mills are jigging 1½ to 1 in. lumps, with good results in prevention of slimes and in diminishing the cost of crushing. The plan of breaking the whole lot of ore to a small size before abstracting any portion of the values is being supplanted by the jigging of coarser sizes for the extraction of the lump ore, returning the gangue rock for recrushing to the No. 2 rolls. A double saving is made by this plan: the lump ore is not slimed with its resultant losses and the power for crushing it is saved.

Samplers.—The use of samplers for systematically sampling the mill tailings to keep up the quality of the mill work is extending. Systematic sampling within the mill for guaranteeing the work of individual machines is not much done as yet.

In reviewing the literature for the year we have abstracted the following more important articles:

CRUSHING.

*The Merralls mill** is a well-constructed Chile mill in which hydraulic pressure is applied to the rollers. A hinge permits the roller to pass over any obstruction that may get into the mill. Between the hydraulic piston and the shaft are ball bearings running in oil. The manufacturers claim that the 6-ft. size has the capacity of a 10-stamp mill and requires less power. On a test run† 54 tons were discharged through a 50-mesh screen in a day (hours not given), but it is not stated what kind of rock was treated.

The Reliance crushing rolls,‡ made by the E. P. Allis Company, are compact and aim to secure the greatest possible strength with a small amount of iron. The adjustable roll is mounted on swinging pillow blocks pivoted at the bottom and secured at the top by adjustable tension rods. The fixed roll is driven by a heavy pulley of large diameter, but the other has a pulley of only half the diameter and face of the first. The journal boxes are made on the ball-and-socket principle to avoid unequal strain on the bearings. The setting and removal of the roller shells is made convenient by the use of tapering split compression rings, one on each side, held together by bolts. These shells have chilled outside surfaces with a tough texture inside, thus combining great wear with a lessened tendency to fracture. The large rolls for coarse crushing are fitted with heavy pinion and gear drive, the gears being so disposed as to remain in mesh with the wear of the shells and motion of the adjustable roll.

The Roger crushing rolls § are so arranged that one roll is above the other, the plane connecting their axes making an angle of 45° with the horizontal. On the larger sizes no springs are used, the weight of the upper roll crushing the ore. The journal bearings are protected from dust and the frame is substantial and compact. The makers claim that these rolls have a larger capacity for fine crushing and require less power than those of the ordinary pattern.

An improved dry air crusher ‖ as described by R. D. Langley consists of two pans, one above the other. The upper revolves horizontally upon a vertical axis; the lower is stationary. In the upper are two chilled cast-iron Chile mill rollers with a fixed axis; in the lower are four with a single axis revolving horizontally

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* *Engineering and Mining Journal*, Nov. 30, 1895, p. 517.
† *Ibid.*, Dec. 21, 1895, p. 591.
‡ *Ibid.*, June 15, 1895, p. 561.
§ *Ibid.*, Dec. 21, 1895, p. 587.
‖ *Ibid.*, July 27, 1895, p. 81.

with the upper pan. The upper two rollers are caused to revolve by their contact with the upper pan. The lower four rollers are arranged two on each end of the single axis and are driven by bracket hangers suspended below the upper pan. The weight upon the lower rollers may be reduced by two bolts which lift the upper pan. Three tons per hour crushed to 50 mesh is claimed as its capacity, 8 to 10 horse-power being required.

The Niagara dry crusher * is of the revolving cylinder type with an internal roller. The pulverized ore is drawn off by an air current. Cleats lift the pulverized ore and allow it to drop through the draft of air.

Suckling's stamp for dry crushing, † into which air is blown for the removal of fine ore as soon as it is crushed, is being discussed, and Crosse's experiments show a gain over wet crushing in saving finely divided gold. The feed is from a pivoted shelf with a tight joint. The fines are removed as fast as made by the rush of air caused by the blow.

F. S. Pheby's knee frame for batteries, although it is heavy and of greater first cost, is solid and permits shafting and belting to be put overhead, out of the way, and the use of horizontal belts run without tighteners on large pulleys, which have been proved most economical of power. The "A," the reverse "A," and the double-brace frames can be made sufficiently strong and are simpler and less expensive than the knee frame. Intimate connection of the battery with the ore bin should be avoided, for a displacement of the timbers in the latter may injure the setting of the battery frame.

Steam Stamps.—F. F. Sharpless ‡ gives a *résumé* of Lake Superior practice in the use of the steam stamps and shows in the following table the variations of the different types:

	Atlantic.	Tamarack.	Calumet & Hecla.
Number of stamps	5	5	22
Pattern of stamps	Ball.	Allis.	Leavitt
Foundations	Solid & spring.	Solid.	Solid.
Horse-power per stamp about	140	....	150
Blows in foot-tons about	21	21.4	20
Tons crushed per stamp per day.	210	300	....
Character of rock	Amygdaloid.	Conglomerate.	Conglomerate.
Water per ton	30 tons.	35–40 tons.	....
Life of shoe	3,000 tons or 14¼ days.	3 to 4 days worn 700 to 200 lbs.	5 to 6 days.
Life of screen about	8,820 tons or 42 days.	3 to 5 weeks.	1 month.
Character of screen	4 cast-steel plates 9¼x48", No. 11 slot holes 3/16" long.	4 steel plates 9x25x3/16", 3/16" punched holes.	Steel plates 3/16" round holes.

The Hall Stamp Battery. §—This machine, which is almost universally used in the Dahlonega district, Georgia, is of light construction, the stamps weighing 450 lbs. The frame is self-contained and the usual long battery blocks and rock foundation are dispensed with, a 2-in. plank platform being practically the only

* *Colliery Guardian*, Oct. 4, 1895, p. 652.

† *Engineering and Mining Journal*, April 27, 1895, p. 392, abstract from *South African Mining Journal; Mining and Scientific Press*, June 15, 1895, p. 376.

‡ *Proceedings* Lake Superior Mining Institute, II., p. 99.

§ American Institute Mining Engineers, Atlanta meeting, October, 1895: "Condition of Gold Mining in Southern Appalachian States."

foundation. The mortar is narrow and has liners intended to bring the ore immediately under the shoes. With new dies the discharge is 2 in. above the die. The average drop of the stamps is 9 in. and there are 90 drops a minute. Quicksilver is fed to the battery. The latter is easy of access for repairs and clean up, the whole clean up of a 10-stamp mill taking only half an hour. The capacity varies from 2 to 5 tons per stamp in 24 hours. The size of the screen is not given.

COST OF CRUSHING.

At the Minnesota Iron Company's Works* the cost of crushing hard hematite has been 7.9c. a ton, and it is assumed that 40% of the ore did not need crushing. There are two crusher plants, each having a 14x36-in. Reynolds-Corliss engine and three 28x30-in. Blake crushers. Wearing surfaces of chilled iron, tank steel, armor plate and cast steel have been tried, the last giving twice the service of either of the others.

WASHING ORES.

The Rittinger Table.—Anton Kávánt† has improved the Rittinger table, as shown by the following comparative figures:

	Old.	New.
Length	2.4	1.3
Frame	Iron.	Wood.
Weight	1,300 kgs.	160 kgs.
Impulses per minute	100	300
Ore treated per hour	29 kgs.	159 kgs.
Water per minute	120 liters.	64 liters.

These tables are arranged in groups of three. The second re-treats the middlings of the first and the third the tailings of the first. Two sets or six tables require ⅓ to ½ horse-power.

Drying Coal.—Mr. J. J. Ormsby has designed a moving belt screen‡ for unwatering washed coal. It consists of 12-mesh wire netting 3 ft. wide running on wooden drums 3 ft. in diameter. The screen is cleaned by a revolving brush placed diagonally across its discharge end. Screens made of iron last six weeks; those of brass last much longer.

The Oberegger Coal and Ore Screen.§—This screen is made in three forms. One of them is shaped liked a spiral staircase. The material comes to the coarsest sieve first. The finer size below lies under and extends beyond the coarser. The different sieves may each be made of the length suitable to the work they have to do. The whole set of sieves is given a gyratory motion by the revolution of the vertical central shaft, which is eccentric to its bearings. With 11 sq. meters area a screen can sift 6½ wagons per hour.

* *Proceedings* Lake Superior Mining Institute, III., p. 93.
† *Zeitschrift für Berg-, Hütten-, und Salinenwesens*, Feb. 23, 1895, p. 91.
‡ *Colliery Engineer*, May, 1895, p. 222.
§ *Oesterreicher Zeitschrift*, Nov. 23, 1895, p. 628.

Jigs.—At Lautenthal,* in jigging blende when the latter is not intimately mixed with quartz, satisfactory jigging has been done without close sizing upon grains between 32 and 13.3 mm. and also between 13.3 and 2 mm. The figures for the jigs are:

	32–13.3 mm.	13.3–2 mm.
Size of sieve	6.5 mm.	2 mm.
Discharge, inverted dam above the sieve.	45 mm.	15 mm.
Plunger strokes	40 mm.	30 mm.
Strokes per minute	140	130
Capacity	1 cu. m. in 50 min.	1 cu. m. in 42 min.
Quality of bed	Hard.	Soft.
Tails	With some clean blende.	With very little blende.

Water Recovery.—Schulz and Zeuner† describe an installation at Tarnovitz, Prussia, for recovering the water used in a concentrator. The tailings water passes successively through two settling basins, two more being in reserve. The water from the second basin is sufficiently clear to be pumped back to the washer. When one of these is to be cleaned, about once a month, the slime settlings from it are pumped into another basin on the hill, the wall of which is made of the tailings and is made water tight by filling the interstices on the inside with fine slimes. The water simply evaporates. In this way there is economy of dumping ground and the valuable land in the neighborhood is not injured.

Slime Washing.—C. Blömeke‡ discusses the advantages and disadvantages of some of the common slime-washing machines. He considers the Linkenbach slime table with a double ore feed one of the best of its class on account of its large diameter, especially for medium-size material. Shaking tables have the advantage over slime tables of a convenient adjustment of slope. They are superior for reworking middling products.

The Musterschutz slime feeder§ consists of a revolving concave conical disk having spiral ribs and sloping toward the center, which delivers the slime from a bottomless box on one side, nearly resting upon the disk, through openings near the center. Water from a spray pipe is delivered on the disk at half a revolution from the box mentioned, and the pulp flows evenly down from the center to the slime table. The adoption of this feeder has doubled the capacity of the tables.

Pulp Raising.—W. H. Storms‖ describes a convenient device for raising pulp short distances by means of a water jet in use at the Keystone Mill, Amador City, Cal. The water jet causes a semi-vacuum and the pulp rises in the pipe.

The Karop coal bar screen¶ has fixed longitudinal bars and a little above them rotating lateral bars of oval section. The long diameters of adjacent oval bars are at 90° to one another, which arrangement maintains the openings of constant size. The coal is moved forward by these bars without being broken, yet with sufficient rapidity to shake out the small pieces.

* *Zeitschrift für Berg-, Hütten-, und Salinenwesens*, 1895, p. 214.
† *Ibid.*, XLIII., p. 184.
‡ *Berg- und Hütten Zeitung*, June 28, 1895, p. 223; July 12, 1895, p. 243.
§ *Zeitschrift für Berg-, Hütten-, und Salinenwesens*, XLIII., 3, p. 215.
‖ *Engineering and Mining Journal*, Nov. 16, 1895, p. 466.
¶ *Zeitschrift für Berg-, Hütten-, und Salinenwesens*, 1895, p. 216.

The Briart screen,* which consists of longitudinal bars receiving motion from two sets of eccentrics (set 180° apart), has been improved by the insertion of rollers between adjoining bars to maintain a constant distance between them.

The Borgmann Screen.—At the West works of the Royal Mine the Briart screen has been replaced by Borgmann's screen.† This has longitudinal fixed bars and lateral revolving round bars. These round bars are 60 mm. diameter and carry spikes projecting 1 cm. This screen yields an end product of more uniform size than the Briart.

Conveyors.—The Jeffrey Manufacturing Company‡ makes a conveyor having iron scrapers fastened to two steel chains by a special swivel. The chains move in iron guides which keep them away from the material being moved and support the scrapers free from the trough bottom, thereby lessening friction and wear.

COAL WASHING.

Elliot's patent coal washer § consists of an inclined wrought-iron or steel trough with scrapers attached to an endless chain moving up the incline and delivering the dirt at the upper end of the trough. The coal is fed midway of the length of the trough and the water near the upper end. The coal is discharged at the bottom and the dirt at the top. The water is circulated by a pump and used continuously. Almost no repairs are needed and washing is said to have been done for about 4c. a ton, the results being excellent.

The Robinson coal washer‖ at Pratt Mines, Alabama, is an inverted cone 11 ft. high, 11 ft. 6 in. upper diameter, 1 ft. 10 in. lower diameter. There are four horizontal wooden arms, each with three vertical iron stirrers revolving round a vertical shaft. In the center of the cone, at the lower end of the stirring shaft, there are four short stirring arms. The feed is coal passing through ¾-in. spaces in a grating. It is fed at the top of the cone through a vertical central-feeding tube 1 ft. 3 in. high and 6 ft. in diameter. The hydraulic water is fed by a 6-in. pipe at the apex of the cone and is distributed by an annular pipe around it from many upward-directed holes. The good coal floats to the surface and is discharged by a spout 7 in. deep, 3 ft. wide on one side, and is unwatered on a screen with $\frac{1}{12}$-in. holes. The waste slate and pyrite sink to the bottom and are discharged by a lock consisting of two gates. The upper fills the space between the two, the lower empties that space. An average of 10 days' work showed a reduction from 10% ash in the crude to 5% in the concentrated coal. The expense was 2¼c. per ton.

The Murton coal washer ¶ is of the trough type, but the trough is in the form of an endless traveling steel belt made in water-tight sections. It is 60 ft. long, 3 ft. wide, and 8 in. deep, has a slope of 1 in. in 18 and travels 8 to 10 ft. a minute. Dams 2 in. high fixed in the trough carry away the dirt at the upper

* *Zeitschrift für Berg-, Hütten-, und Salinenwesens*, 1895, p. 216. † *Ibid.*

‡ *Engineering and Mining Journal*, July 27, 1895, p. 80.

§ *Canadian Mining Review*, March, 1895, p. 64.

‖ American Institute Mining Engineers, Florida meeting, March, 1895.

¶ *Journal* Iron and Steel Institute, 1895, I., p. 381, abstract from *Transactions* Federated Institute of Mining Engineers, IX., p. 42.

end. It washes 400 tons of coal in 10 hours and uses 450 gals. of water a minute. It uses about 1½ horse-power. The cost is 1½c. a ton, which would be lessened if the washer was at the mine.

The Franconia coal washer * is a jig whose plunger is raised by a steam piston and falls independently by gravity. This produces a very uniform cycle of operations on the sieve, for if a portion of the sieve becomes obstructed the water will not have an increased flow through the loose part of the bed, as the plunger pressure remains constant; while in the ordinary jig the plunger has a constant rate, and any blinding of a portion of the sieve causes a more rapid flow of water through the remaining portion. The use of a steam lift tends to produce a constant suction, for any variation in resistance on the sieve so affects the steam as to cause a nearly uniform pull on the plunger. An unusually thick bed is used, which decreases the loss of coal in the hutch work. Four tons of material from 5 to 8 cm. diameter may be washed in an hour, 5 to 6 tons an hour of material 1 to 3 cm. diameter, and 7 to 8 tons an hour of nut size with the proper dimensions of the machine.

Reworking Anthracite Culm Banks by Washing.—Arthur W. Shaefer † gives figures from three washing plants showing percentage of coal recovered from culm and the proportions of the different sizes. The Furnace culm bank recovered 40% in 1892 and the same in 1893. The Draper recovered 42% in 1892 and 50% in 1893. In some cases about half and in others considerably more than half the product was "buckwheat" or smaller (*i.e.*, through ½-in hole).

The Ramsay sludge tank‡ has been designed to remove fine dirt from the wash water in a coal-washing plant. It consists of an iron tank, cylindrical in section at the top and funnel shaped at the bottom. Near the top is a horizontal deflecting disk. The water, charged with fine coal and impurities, is delivered on the center of this disk and evenly distributed. The impurities settle to the point of the cone and are drawn off at intervals by opening a valve. The water is drawn off through a pipe that reaches nearly to the under side of the disk. The relation between the diameters of the disk and the tank depends on the amount of coal and impurities in the water and on the difference in the sp. gr. of these materials.

Coal Washing in England and Scotland.—Kubale§ gives general descriptions of various common coal-cleaning apparatus and comparative tables of costs and results.

Machine.	Ash in Unwashed Coal.	Ash in Washed Coal.	Loss of Coal.
	Per Cent.	Per Cent.	Per Cent.
Coppée	22.64	3.24	5.70
Ramsay	25.35	13.51	Trace.
Robinson	27.23	18.24	3.80
Bell & Ramsay	13.84	3.40	13.38
Sheppard	15.37	9.06	4.25
M'Culloch	39.26	....	38.13

* *Revue des Mines*, August, 1895, p. 166.

† *Trans. A. I. M. E.*, Vol. XXIV., p. 364.

‡ American Institute Mining Engineers, March meeting, 1895.

§ *Zeitschrift für Berg-, Hutten-, und Salinenwesens*, 1895, p. 54.

Machine.	Cost.	Water Used per Ton of Cost.	Running Expense per Ton.	Depreciation and Interest per Ton.
	Dollars.	Liters.	Cents.	Cents.
Bell	2,500	908	5.1	0.8
M'Culloch	3,000	908	6.1	1.0
Robinson	1,250	136	2.0	0.4
Coppée	12,500	1,362	6.1	4.0
Sheppard	2,500	....	4.1	0.8

PHOSPHATE-DRESSING PLANT.

Near Mons, Belgium,* there is an extensive plant for the dressing of phosphate. The mine ore falls on a movable bar screen driven by eccentrics and having two ⅜-in. spaces. The oversize is hand picked and yields waste which is thrown away and good phosphate which is crushed to about 2⅜ in. diameter and then unites with the undersize, the whole being then reduced to a maximum of ⅜ in. in three Bourdais disintegrators. The mineral, mixed with water, is raised by sand wheels to two trommels with 16-mesh screens. The oversize from the latter is waste. The undersize passes to trough classifiers yielding earlier spigots to 40 jigs, and the last spigot to two spitzkasten, and the overflow to waste. They yield spigots to eight cement-surface Linkenbach tables, the overflow going to two Linkenbach tables. The overflow from the concentrates settling tanks is pumped back to the spitzkasten. This plant will handle 250 tons of crude ore in 10 hours and uses 120 horse-power. The crude ore contains from 20 to 30% of phosphates and the concentrates 40 to 50%.

CONCENTRATING RIVER SAND.†

Mr. J. C. Pierson and Capt. Herman Davis have constructed a plant to recover gold, amalgam, mercury, and sulphurets from the bed of the Carson River, Nevada. The portion of the plant in the river includes a dredge and a series of grizzlies, trommels, riffles, settlers, and amalgamating plates. What passes through a 30-mesh screen is pumped ashore and treated on 10 Woodbury and 12 Warren concentrators.

TECHNICAL PAPERS.

From the papers on ore dressing published during 1895 we select the following:

Concentration of Auriferous Sulphides in California.‡—In this paper W. H. Storms describes a number of concentrating plants in use at California mills. Mr. C. C. Gates has a canvas plant to save the fine sulphurets and mercury which the vanners fail to catch. The tails of 24 vanners are conducted to 4 V-shaped separators with hydraulic devices for discharging the heavier particles which are waste from the spigot, while the overflow goes to 24 canvas tables 12 ft. wide, 13 ft. long, and having a slope of 1½ in. to 1 ft. The sulphurets are washed off

* *London Engineering*, Nov. 22, 1895, LX., p. 633.
† *Mining and Scientific Press*, Feb. 16, 1895, p. 97.
‡ *Engineering and Mining Journal*, July 13, Nov. 9, 16, 1895.

every hour by a spray of clean water. The fine concentrates thus obtained are further treated on a small specially constructed end-shake vanner. The plant and method are patented.

The Utica and Stickles mills, in Angels, stamping about 250 tons each of rock in 24 hours, deliver the vanner tails each to 90 canvas sluices 20 in. wide and 42 ft. long with a slope of 1½ in. in 1 ft. The pulp fed to these sluices carries a great deal of slime, for much of the ore is soft and the stamps have a high discharge (11 in. above the top of a new die). The pulp runs for 4 hours over the tables, when the flow is stopped and clear water turned on to wash away the lighter sand. The sulphurets are then removed by a broom aided by clear water.

The Golden Gate Mill in Sonora, Tuolumne County, is similar to the Utica Mill, but carries the concentration further. There are two sets of canvas tables, the tailings from the first being treated on the second. The tables have a slope of 1 in. in 1 ft. and are 20 in. wide in the clear. The upper row are 75 ft. long and the lower row 35 ft. Each section of table receives about 2 tons of pulp in 24 hours. The canvas is cleaned about every half-hour.

At the Keystone Mill in Amador City the vanner tailings pass through a mercury trap to a distributor, which delivers them to 10 wooden sluices 12 in. wide, 104 ft. long, with a slope of ⅝ in. in 1 ft. As the pulp passes it is raked and stirred toward their head, and the sulphurets obtained on them are cleaned on a separate vanner. The distributors for these sluices size the pulp, and so some of them yield coarse and others fine sand, the coarse going to one set of canvas-covered sluices, the fine to another. These canvas sluices are 20 in. wide, 30 ft. long, and have a slope of ¾ in. in 1 ft.

At the Gover Mill the battery pulp is divided into two sizes by a separator, the coarse going to Frue, the fine to Woodbury vanners. The tailings from the vanners are also sized, the coarse going to one set and the fine to another set of canvas tables. The sulphurets from the canvas tables are cleaned on a Woodbury concentrator.

*California Gold-Mill Practices.**—Ed. B. Preston gives a detailed account of construction and practice in California gold mills. The latest arrangement for working the self-feeder is by a collar on the stem instead of by tappet. He gives the following table of power used by different mill parts:

Each 850-lb. stamp dropping	6 in.	95 times	a minute	requires		1.33	horse-power.
" 750-lb.	" "	6 in.	95 "	"	"	1.18	"
" 650-lb.	" "	6 in.	95 "	"	"	1.00	"
" 8-in. by 10-in. Blake crusher requires....................						9.00	"
Frue or Triumph vanner, 220 revolutions a minute, requires..						0.50	"
Four-foot clean-up pan,	30	"	"	"		1.50	"
Amalgamating barrel,	30	"	"	"		2.50	"
Mechanical batea,	30	"	"	"		1.00	"

He shows the advantage of a shaking plate below the apron by stating that in one mill this shaking plate collected more amalgam than the second of two consecutive apron plates. He describes an automatic tailings sampler.

Philosophy of Stamp Milling.†—Mr. T. A. Rickard shows how the closest ap-

* *Bulletin No. 6*, California State Mining Bureau.
† *Engineering and Mining Journal*, March 16, 1895, p. 243.

plication of technical science may occasionally be practiced at the expense of the best commercial results, and that stamp milling is sometimes commercially superior to a process that seems technically better adapted to an ore.

*Variations in Milling Gold Ores.**—Mr. T. A. Rickard's series of papers on "Variations in Milling Gold Ores" has been completed by a description of the present practice in the Black Hills. He closes with a general discussion of the subject and maintains that stamp milling will long hold its position as a successful method of gold extraction.

Washing Diamondiferous Earth.†—The usual method of treating the diamond-bearing earth in South Africa involves its exposure to the weather for from 3 to 6 months, which treatment disintegrates it. But the New Gordon Diamond Company of Kimberly has had built a plant to wash its material as soon as mined. The rock is dumped on grizzlies, the coarser size passing to a crusher, after which everything is reduced by rolls. The latter deliver to 4 jigs working at a high speed. The heavy material passes through the sieve and the lighter portion passing to rolls is elevated to 4 jigs, whose tailings are again crushed and treated on 6 jigs. The concentrated—*i.e.*, hutch work—material from these different jigs is again treated on 5 finishing jigs. It is expected that this plant will reduce the cost of pulverization from $2.50 or $3 to only a little more than $1 a load.

Magnetic Concentration of Iron Ore.‡—Mr. C. M. Ball points out both the technical and commercial advantages of removing impurities from an ore, and shows how it may often pay the furnace-man to bear the expense of concentration before smelting. He gives the following results from the Ball-Norton machine:

	Benson Mines.			New Bed Mines.	
	Fe_3O_4.	S.	P.	Fe_3O_4.	P.
Crude ore	45.5	1.00	0.15	66	0.7
Concentratings	88.5	0.21	0.032	94	0.012
Tails	4.0	....	....	8	....

Dr. William B. Phillips§ gives an account of the magnetization, by means of producer gas, of non-magnetic ore, using a modified Davis-Colby furnace, and the subsequent magnetic concentration of the ore. A furnace holding 110 tons treats that amount in 24 hours with a consumption of 3 tons of good coal. The average ore sent to the concentrator contained 45% iron and 30% silica, while the concentrates contained 58.9% iron and 11.5% silica. It is estimated that 1 ton of concentrates can be produced for $1.15 from 3 tons of ore.

Magnetic Separation of Non-Magnetic Materials.—H. A. J. Wilkens‖ in a recent paper states the scope of this new invention. The full extent of the field in which it will be commercially applicable has yet to be determined. Mr. Wil-

* *Engineering and Mining Journal*, Sept. 7, Oct. 11, 26, 1895.

† *London Engineering*, March 29, 1895, p. 405.

‡ American Institute Mining Engineers, Atlanta meeting, October, 1895.

§ *Ibid.*

‖ *Ibid.*, Pittsburg meeting, February, 1896.

kens explains that the "non-magnetic materials" referred to are such as are considered "non-magnetic" in the art and practice of magnetic separation, as, for instance, franklinite, garnets, red hematite, spathic iron ore, and other materials containing iron or manganese in any degree of oxidation. The process and machine are the invention of Mr. J. Price Wetherill, of South Bethlehem, Pa., and have been used on a large scale with success at the works of the Lehigh Zinc and Iron Company, in that place. Scientifically speaking, all the minerals which Mr. Wetherill's machine will magnetically attract are, according to Faraday's famous classification, "paramagnetics"—that is, they are in some degree attracted by the magnet, whereas all other substances (called by him "diamagnetics") are in some degree repelled. But Faraday's paramagnetics are practically divided into two classes, the first of which (comprising iron, magnetite, pyrrhotite, and a few other minerals) is characterized by very high magnetic susceptibility and is therefore generally called "magnetic," while the other class possesses so little susceptibility in comparison as to have been hitherto practically lumped with all the diamagnetics as "non-magnetic." In other words, the paramagnetics do not constitute a continuous series, from metallic iron down, exhibiting a gradual decrease in this property. On the contrary, there is a startling gap in the series, widely separating the two groups of this class. If the force with which metallic iron is attracted under given conditions be taken as 100,000, then magnetite stands at 40,227; and (ignoring pyrrhotite, which has not been accurately determined, but probably comes close to magnetite) the next in the descending series thus far accurately tested is specular iron ore, which rates at only 533. Roughly speaking, there seems to be nothing between about 40% and about 0.5% of the susceptibility of iron. Mr. Wetherill's machine has extracted powdered ferrous sulphate, the susceptibility of which is rated at 98, or less than 0.1% of that of iron. The above figures as to relative attraction are taken from the paper of Plücker, published in 1848, in Poggendorff's *Annalen.* More detailed statements are to be presented later; but those already given are sufficient to show that Mr. Wetherill's invention really enters a field heretofore untrodden in the art of magnetic separation. As regards its commercial importance (apart from the special problem which it has successfully solved at South Bethlehem, by cleanly separating franklinite, garnets, and zinc silicate), it may be sufficient to point out that experiments made at South Bethlehem indicate that the Clinton red fossil ores of the South can be concentrated without roasting, which has not heretofore been considered possible. On the other hand, some desirable applications may prove to be impossible. For instance, the separation of chromic iron ore from serpentine has proved, in preliminary tests, unexpectedly difficult, on account of the magnetic susceptibility of the serpentine. But it would be unsafe to express any conclusions at present as to the possible scope of the new invention.

Lead Burning.

By John E. Rothwell.

In the treatment of gold ores by the barrel-chlorination process, also in sulphuric-acid manufacture and some other chemical work, it is necessary to use tanks and other apparatus lined with pure sheet lead, to withstand the corrosive action of acids, chlorine and other solutions. All the joints of this lead must be soldered or, as it is technically termed, "burned" with lead. This operation is not generally understood, and the very limited number of skilled lead burners command high rates of remuneration. It seems important, therefore, that the knowledge of this almost secret art should be more extended. The present paper, giving a full and detailed description of the apparatus used and the methods followed in lead "burning," is contributed to The Mineral Industry, Its Statistics,

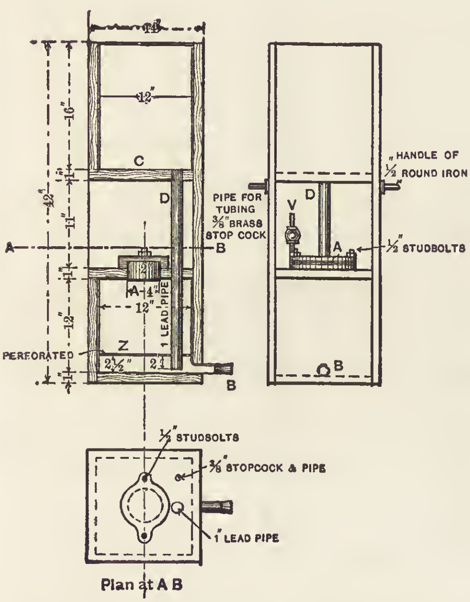

Fig. 1.—Hydrogen-Gas Generator.

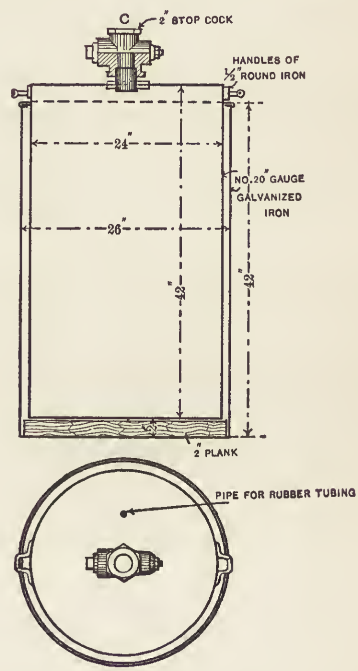

Fig. 2.—Air Tank.

Technology and Trade, where all engaged in every department of this great industry have learned to look for information on important points, especially on those which are known to but few, and those few too often will not tell.

The apparatus required in lead burning consists of a generator for hydrogen gas; a reservoir for the storage of air under pressure; rubber tubing; blowpipe and attachments; and finally, a small kit of plumber's tools.

The Hydrogen-Gas Generator.—The accompanying drawing (Fig. 1) shows the construction of this generator, the dimensions given being for a machine suitable for the work usually required at a gold-chlorination plant. Where continuous and heavy work is to be done the generator should be larger, both to give a greater pressure of gas and to obviate the necessity for frequent recharging. The machine must be made of pure sheet lead, of about 6 lbs. per sq. ft. weight; the lead is framed in with 1-in. boards to stiffen the structure and to protect it from injury when it is necessary to move it.

The hydrogen gas is generated by the action of dilute sulphuric acid on zinc, according to the chemical formula $Zn + H_2SO_4 = ZnSO_4 + 2H$. In operation from 40 to 50 lbs. of zinc, in pieces approximating 1-in. cubes, is charged through the hand hole *A* on to the false bottom *Z*, the valve *V* is closed, and the draw-off stopper *B* put in. About 6 in. of water should then be poured into the top chamber *C* and 10 lbs. of sulphuric acid (of 66° strength) added and thoroughly stirred into the water. It is well, though not necessary, to do this some time before using the generator, so as to allow the solution to cool down, since consider-

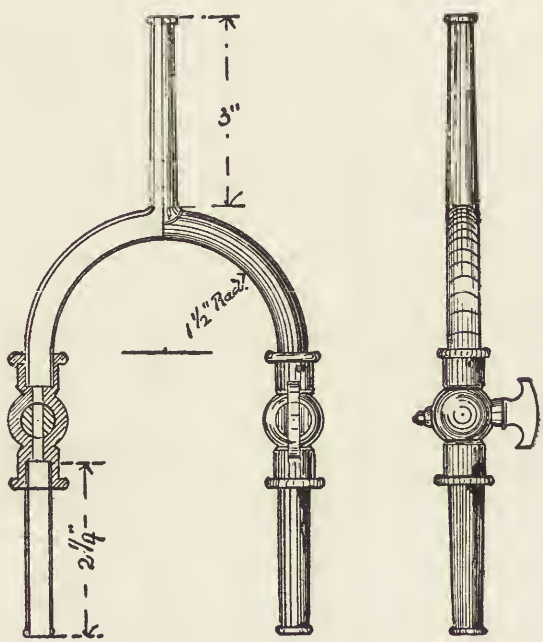

FIG. 3.—BLOWPIPE FORK.

able heat will be generated by the mixture of the acid and water and cause steam, which will pass over into the tubing and be a source of annoyance. The gas outlet valvé *V* is then opened and the solution allowed to run down through the pipe *D* into the lower compartment, where it comes in contact with the zinc on the perforated false bottom.

The action of the acid solution on the zinc generates hydrogen gas, and if the valve *V* is closed again, the gas accumulating in the lower compartment forces the solution back up the pipe *D* into the compartment *C*. When the pressure of gas has forced the solution below the false bottom on which the zinc rests, gas ceases to be generated; when gas is being drawn off a certain amount of the solution again comes in contact with the zinc, generating the gas as required, the balance standing in the pipe *D* and chamber *C*, thus maintaining a constant pressure.

The zinc used in the generator should be the purest commercial zinc obtainable, since if arsenic or sulphur is present arseniureted or sulphureted hydrogen will be formed. These compounds are not only dangerous to the health of the operator, but when burned they coat the metal and prevent the flowing together of the molten lead. Should these gases be formed they can be partly eliminated from the hydrogen by allowing the gases from the generator to bubble through a wash bottle filled with water. The water will soon become saturated, however, and must frequently be changed. For the same reasons the sulphuric acid used should be the purest commercial article obtainable.

Air Reservoir.—Air is used instead of oxygen to produce rapid combustion and sharpen the flame. It is maintained under pressure in a gasometer, as shown in Fig. 2. In operation the lower tank is filled to a depth of 20 in. with water; the upper tank is then put in and sufficiently weighted to raise the water to nearly the top of the lower tank. The blocks of zinc in the shape they are purchased form very convenient weights for this purpose. When it is necessary to recharge

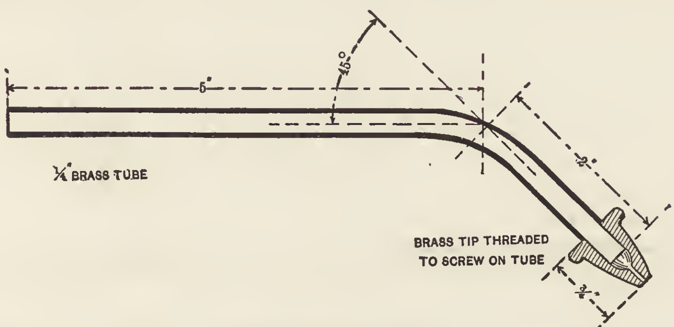

Fig. 4.—Blowpipe.

the reservoir with air the valve *C* is opened and the tank raised; the valve is then closed and the tank reloaded.

Blowpipe Apparatus.—This consists of two pieces of ¼-in. soft rubber tubing each 30 ft. long and one piece about 5 ft. long. The fork over which the tubing is fastened, of which a drawing is given in Fig. 3, is made of ⅜-in. brass tubing, with valves and extension pieces as shown. This fork is sometimes made of ¼-in. gas pipe with malleable iron "tee" and "ells." When made this way it is necessary to have all joints perfectly tight. The jet, or burner, is made of ¼-in. brass tubing, as shown in Fig. 4, with a screw thread at one end on which different tips can be screwed with perforations to suit the different weights of lead being burned.

Other Apparatus.—Other tools required are the ordinary plumber's tools as follows: Turn pin, dresser, bossing stick, shave hook, double-edged saw, snips, mallet, drift plugs, and chipping knife. The last-named tool is shown in Fig. 5.

Construction of Tanks.—The framework of the tanks to be lined with lead should be amply strong to stand the weight of the tank full of solution without springing, as lead, being devoid of elasticity, will take a permanent set, and in a tank where the bottom or sides are insufficiently supported the constant bending will in time crack the sheet and make a leak. It is usual to build these tanks of ordinary pine plank and timber, and as it is not necessary to have tight joints in the woodwork, very little dressing of the planking is required.

The sheet lead used for lining tanks in a chlorination mill is usually what is called 6-lb. chemical sheet lead. The sheets are ordered from the mill cut to the size of the tank they are to fit. Lead is rolled of a width of from 9 ft. to 9 ft. 2 in.; therefore when tanks are wider or deeper than this it is necessary to piece out to the size required.

In putting the lead in, the bottom sheet or sheets are laid in first, then the side pieces in rolls are placed on the top edge of the tank, the edge of the sheet with about a 2-in. lap nailed there, and the sheet unrolled down the side and flanged at the bottom to lap the bottom sheet, then dressed back against the side of the tank. To hold it in place it is nailed close along the edge of the lead to the

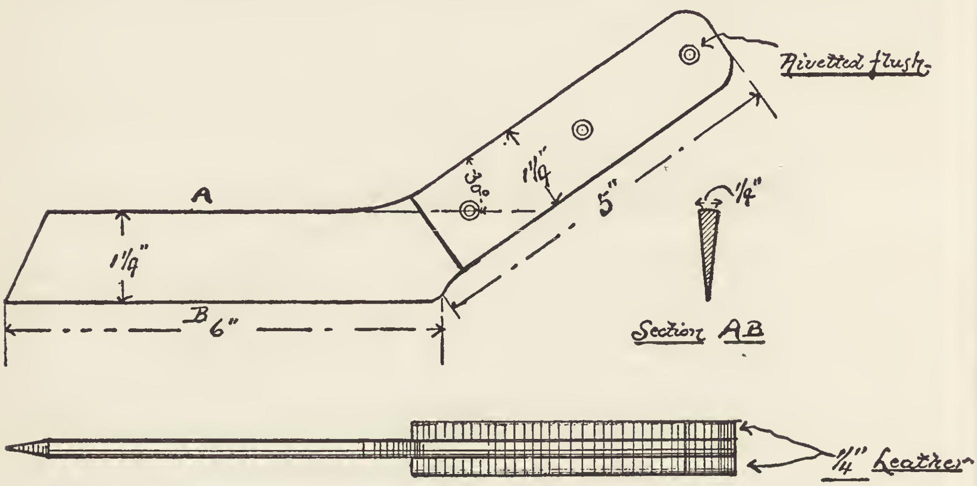

FIG. 5.—KNIFE FOR CUTTING LEAD.

planking, the sheets at the joints shaved clean, and the seams burned from bottom to top. In some cases the sheets of lead for two of the sides are ordered sufficiently long to turn the corners; this arrangement reduces the number of vertical seams to be burned. Large pieces of lead are put into a tank by unrolling the sheet on a temporary swinging platform placed on the top of the tank, shaping the lead to fit the corners of the tank, fastening the edge of the sheet to the top of the tank, and swinging it into place. It is then dressed back and the seam burned in the usual way.

MANIPULATION.

The Blowpipe Flame.—Two kinds of blowpipe flames are used in burning, the sharp-pointed flame shown in Fig. 12 and the brush flame as in Fig. 13. The pointed flame is used for all seam burning, while the brush flame is used when it is necessary to fill a large opening or where a considerable quantity of molten lead is required.

These flames can be obtained with a little practice, the brush by using a good head of gas and small amount of air, the pointed by using a greater head of air. The proper length of flame for the different weights of lead will vary from 2 in. in length for 3-lb. lead, 5 in. for 6-lb., and 7 in. for 8-lb., while with 10, 12, 18, and 24 lb. lead the flame will vary from 8 in. to 14 in. in length. The flame must always be reducing rather than oxidizing in its action. The hottest part of the flame is the point of the small incandescent flame in the center of the larger one.

Care must be used in lighting the gas when starting with a fresh charge in the generator, as an explosive mixture of gas and air may be encountered, which when lighted at the burner will flow back through the tubing and explode the generator. The safest method is to allow the gas to blow through the tubing for from 3 to 5 minutes before attempting to light it. Care must also be taken not to allow the gas to work back into the air tank, as in that case also the explosive mixture may be formed.

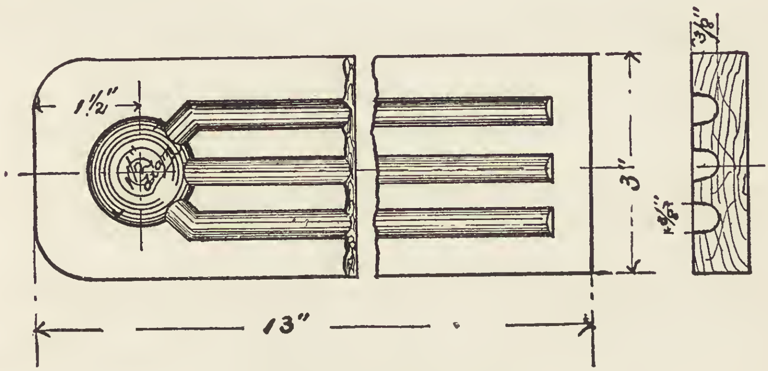

Fig. 6.—Lead Strip Mold.

Cutting the Sheets.—To cut sheet lead of a thickness as great as 8 lbs. per sq. ft. it is usual to score it as deeply as possible with a heavy jack knife or pruning knife on the marked lines. If the cut is then started at one end for about 4 or 6 in. the lead will tear easily along the line scored. When a greater thickness of lead is to be cut it is usually done with the chipping knife and hand hammer.

A V-mold (Fig. 6) is made of wood or sheet iron of the dimensions given and molten lead poured in and cast in strips to be used as a filling when burning horizontal flat seams.

Burning Flat Horizontal Seams.—In burning flat horizontal seams it is usual to lap the sheets of lead on all lead up to 8 lbs. per sq. ft.; when thicker than this joints are made butt joints. In making a lap joint the surface of the lead is shaved free of the surface oxide where the joint is made; the blowpipe is started and the flame suited to the weight of lead produced. Then a stick of lead is held so that when the flame is applied to the end of it the molten lead will drop on to the joint being made; as the lead from the stick drops the lead of the upper and lower sheets is softened by the flame sufficiently to permit the welding of the whole into a solid mass. The work goes on in this way with a slight swinging motion of the blowpipe, the lead from the stick and the joints being melted together forming a solid joint. Care must be used not to heat the lower sheet of lead to such an extent as to perforate it, while at the same time it is necessary to be sure that the lead is perfectly welded or melted into the preceding portion and no pin holes left, otherwise the joint is liable to leak. Fig. 7 gives an idea of how the joint should appear when properly done.

In burning these joints in lead heavier than 8 lbs. per sq. ft. a butt joint is made, the edges of the lead being shaved down as shown in Fig. 8. Then the

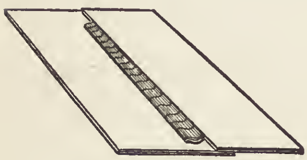

FIG. 7.—HORIZONTAL SEAM.

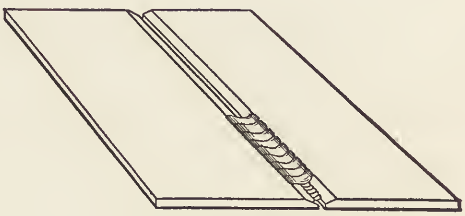

FIG. 8.—SEAM IN HEAVY LEAD.

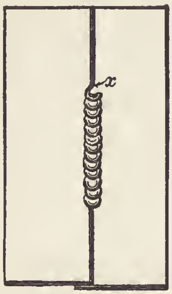

FIG. 9.—VERTICAL SEAM.

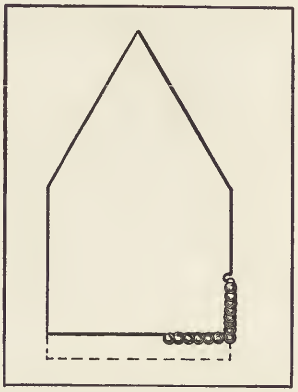

FIG. 10.—PATCH ON SIDE OF TANK.

lead of the lower part is fused and run together, filling slightly with lead from the stick. After this part of the joint is made for some length it is shaved bright and the rest of the groove filled up slightly above the level of the sheet with lead melted from the stick and welded thoroughly into that below.

Burning Vertical Seams.—In burning vertical seams, such as those on the side of a tank or chamber, considerable care is required at first to acquire the knack of handling the blowpipe and learn the proper flame to use. The beginner should practice on separate pieces of lead by tacking them to a board that can be shifted into a vertical position or placed at any angle required before attempting any permanent work on a tank or chamber. In vertical work the lead stick is seldom used, the lead employed to make the joint being taken from the overlapping sheet. It is necessary, therefore, to shave the oxide film from both surfaces of this sheet about $1\frac{1}{2}$ in. back from the edge of the sheet and from the under sheet on one side about the same distance back. Fig. 9 shows the appearance of an upright joint when being burned.

As will be noted, the lead is melted at the point on x the upper sheet and built up drop by drop on the under sheet, only heat enough being applied to the under sheet to form a weld between it and the drop of lead brought down. It is necessary when starting an upright seam to have the drops of lead form a shelf on which the next succeeding drop can be lodged and to which it can be melted. The lead should be heated only just enough to cause it to flow, so that when the flame is removed it will immediately solidify. If too much heat is applied the lead will drop off the shelf and fall to the ground, making it more difficult to catch up with the joint again. It is best to start with a short, sharp flame and to work carefully until the proper hand movement is obtained, when a stronger flame can be used and faster work accomplished.

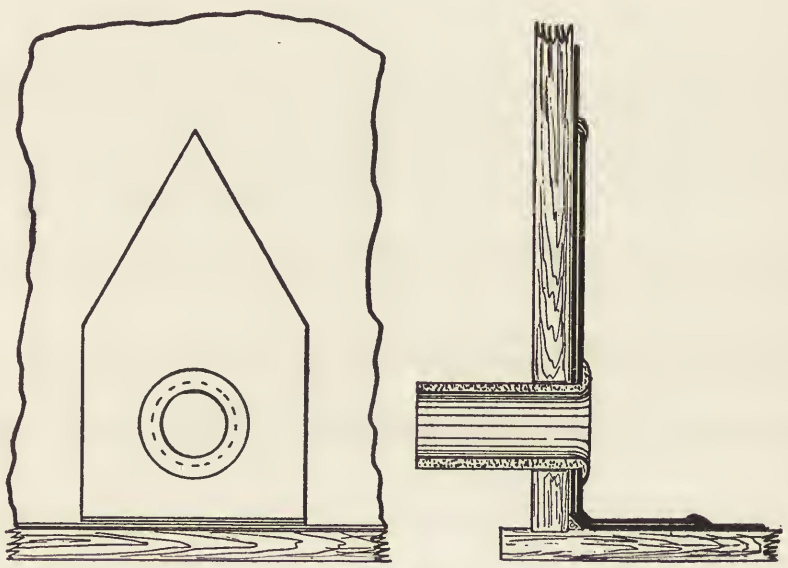

Fig. 11.—Pipe in Side of Tank.

Patches and Pipes.—In making a patch on the side of a tank the method usually adopted is to cut a horizontal slit in the lead below the place to be patched and open it wide enough to take a piece of lead sufficiently large to cover the hole to be patched. This piece is then cut to a point above the hole and the edges to be burned shaved bright; then it is not very difficult to burn all round the edges of the patch. Fig. 10 will give an idea of how this patch is made. The most troublesome seam in it to burn is the horizontal one, at the bottom of the patch; this must be started so as to draw the lead from the outside lap and carry it down and weld it to the patch sheet. On this account, when a hole to be patched is near the bottom of the tank, it is simpler to let the lower part of the patch come down to the bottom sheet so that a flat seam can be burned.

In putting pipes into the sides of a tank the piece of pipe is first burned into a piece of sheet lead of the shape shown in Fig. 11. The hole for the pipe through the planking of the tank is made a close fit and the pipe put through it; the sheet of lead is then burned to the lining of the tank.

In burning the lead in a lead-lined iron vessel a sheet of felt paper must be put between the lead and the iron where it is to be burned. Otherwise if the

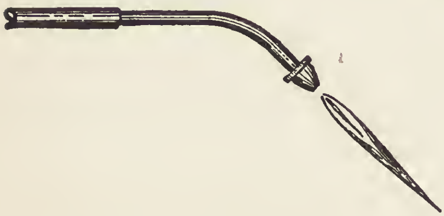

Fig. 12.—Pointed Flame.

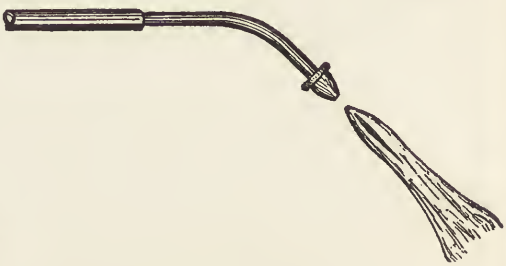

Fig. 13.—Brush Flame.

lead were dressed back against the iron it would be found impossible to make a perfect joint, owing to the rapid chilling of the lead by the iron.

Conclusion.—Efficiency in lead burning, as in most other arts of the kind, depends upon quickness and skill in manipulation. To acquire this and also to learn the best methods of handling the blowpipe, the beginner should practice on separate pieces of lead as much as possible before undertaking any important work, such as tank lining.

THE FORMATION OF ERUPTIVE ORE DEPOSITS.*

BY J. H. L. VOGT.

ORE deposits formed in direct genetic connection with eruptive processes may be classified, with regard to the mode of formation, into two chief groups, namely, (1) deposits formed by "magmatic differentiation"—*i.e.*, by the concentration of some metallic parts within the still fluid eruptive mass (magma)—and (2) deposits formed by processes subsequent to the eruption, such as sublimation (or in general pneumatolysis) and not cursive; fumaroles, solfataras, mofette, suffioni, geysers, and hydrothermal phenomena.

ORE DEPOSITS FORMED BY MAGMATIC CONCENTRATION.

As shown by numerous modern petrographic investigations† of eruptive districts, there often takes place within a still fluid eruptive mass a whole series of transmigrations of matter, because the molecules or the ions change their places. The cause of this is to be sought in the different physico-chemical laws which are at work producing physical equilibrium in the different parts of the molten magma, which is now considered as essentially a solution. As an example of these laws, the nature of which has been but little investigated, we may mention the law of the osmotic pressure (Soret's principle), according to which the dissolved matter is concentrated in the coolest part of the solution. This law corresponds to the well-known Gay-Lussac-Mariotte's law for gases, that, for instance, the concentration of the gas molecules (therefore also the specific weight of the gas) in a closed tube is greatest where the temperature is lowest. In the case of eruptive magmas, which may properly be considered as molten solutions, we may also ascribe a very important influence to the attraction of gravity—or Gouy and Chaperon's principle. According to this law the dissolved constituents are concentrated downward when the dissolved matter is specifically heavier than "the dissolver." This law explains the fact that the heavy constituents, especially iron

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* This treatise is a summary of the two *brochures* of the author in the *Zeitschrift für praktische Geologie*, entitled "Bildung von Erzlagerstätten durch Differentiationsprocesse in basischen Eruptivmagmata" (1893, parts 1, 4, and 7) and "Beiträge zur genetischen Classification der durch magmatische Differentiationsprocesse und der durch Pneumatolyse entstandenen Erzvorkommen" (1894, parts 10 and 12; 1895, parts 4, 9, 11, and 12). For the bibliography, see these publications.

† We refer specially to the researches of the following authors: W. C. Brögger (Norway), J. R. Dakyns (England), Orville A. Derby (Brazil), A. Harker (England), J. P. Iddings (United States), J. W. Judd (England), A. Lagorio (Poland), A. Rosenbusch and J. Roth (Germany), J. J. Harris Teall (England), and J. H. L. Vogt (Norway).

or perhaps nickel-iron, as in meteorites, are concentrated in the interior parts of the globe. Besides these two laws—that of temperature and pressure and that of gravity—and Berthelot's principle as set forth in a treatise by Harker, there are doubtless various factors which are also important, but which have not yet been deeply investigated.

As the result of all these diffusions or differentiations it follows that an originally homogeneous molten mass divides or splits up into a greater or lesser number of sub-magmata. Therefore instead of meeting within the same eruptive district one single type of eruptive rock of constant chemical composition, we find a whole series of eruptive rocks of varying composition, yet marked by a close genetic kinship that Professor Iddings has aptly called consanguinity. The minerals chiefly affected by these differentiations of magmas are the earliest crystallizations—that is, the group usually called the ores. It embraces the oxides of iron and titanium, the sulphides of iron, of zircon, apatite, and some rarer minerals. After these the second group of crystallizations is most influenced. It includes the ferro-magnesian silicates, olivine, biotite, and the pyroxenes and amphiboles of all varieties.

When these differentiations progress far enough the result may be actual ore deposits, which are not only of theoretical, but also of considerable practical interest. According to the chemical nature of the differentiation, these ore concentrations may be classed into groups of oxides, of sulphides, and of native metals. As further sub-groups we might also distinguish those consisting largely of phosphates and again those marked by abundant zirconia.

CONCENTRATIONS OF OXIDES.

The best investigated of these are the numerous segregations of titanic iron ore which we find in different gabbros, including under the name labradorite rock and anorthosites, and in augite-syenite, nepheline-syenite, etc.; in a word, in intermediate rocks with about 56 to 57% SiO_2 as a maximum. With the titanic acid and the iron oxides there have always been concentrated greater or lesser quantities of ferro-magnesian silicates, and the abundant magnesia has, in connection with alumina, often occasioned a special concentration of aluminate of magnesia in spinel. For the same reasons a surprisingly large quantity of magnesia, as $MgTiO_3$, is often absorbed in the ilmenite [$(Fe,Mg)TiO_3,nFeFeO_3$]. In these concentrations we often meet with some chromic oxide (0.1 to 2.5% Cr_2O_3), sometimes also a little vanadic acid (about 1% Va_2O_5 in the Taberg ore in Sweden), occasionally also some zirconia (particularly in the mineral brazilite—*i.e.*, pure zirconia, from Jacupiranga, Brazil, according to Hussak's investigations).

In most of these ore segregations the phosphoric acid has not been notably concentrated. As an exceptional case, however, we meet in some nepheline syenites with very important enrichments of apatite. When these processes of concentration reach their maximum they afford masses of almost pure titanic iron oxides, either ilmenite or titanomagnetite. On the other hand, at the different intermediate stages there arise more or less ferriferous rocks, consisting on the one side of ilmenite or titanomagnetite (exceptionally with perofskite, $CaTiO_3$) and on the other side of some ferro-magnesian silicates, as hypersthene, enstatite, diallage, augite, olivine; sometimes a little mica, often also spinel; and occasionally some feldspar, for the most part labradorite or nepheline.

Various ore segregations of this type which have of late years been carefully investigated * the world over have, according to their mineralogical constitution, received the following names: Ilmenite-norite (*i.e.*, norite or hypersthen-gabbro, rich in ilmenite, Ekersund, Norway), titanomagnetite-olivinite, cumberlandite (consisting of titanomagnetite and olivine, Taberg, Sweden; Iron Mine Hill, Cumberland, R. I.), titanomagnetite-spinelite (Routivara, Sweden; Hellevik, Norway), titanomagnetite-pyroxenite (jacupirangit, with perowskite, brazilite, etc., Jacupiranga, Ipanema, Catalao, Brazil), ilmenite-gabbro (Mesabi range, Minnesota), ilmenite-enstatite, titanomagnetite-diallagite (Lofoten, Norway), etc., etc.

Many of these ore segregations are distinguished by their considerable, or even enormous, dimensions (for instance, Taberg and Routivara, Sweden; Ekersund, Norway; in the Adirondack Mountains, New York; Jacupiranga and Ipanema, Brazil). At present, however, this group of ore deposits is technically of small importance. In the first place, besides the iron oxides there has always been concentrated some titanic acid, so that the deposits are titaniferous throughout. It is exceptional to find as little as 1 to 2.5% titanic acid, TiO_2 (as for instance some deposits in Lofoten, Norway); most frequently the deposits contain 5 to 8% titanic acid (Taberg, Langhult, and some other deposits in Sweden, some in Norway) or 8 to 10% titanic acid (Ulfö, Alnö, Sweden; Iron Mine Hill, Rhode Island); 10 to 15% is also quite common (Routivara, Sweden; many deposits in the Mesabi range); often we may also meet with 15 to 25% titanic acid (several deposits in the Adirondack range), even 40 to 50% titanic acid (Ekersund, Norway).

In the first place, this titanic content is a drawback in metallurgical work, and in the second, the titanic acid reduces the iron content of the ore itself. Adding to this that these iron ores are almost always mixed with more or less of silicates, especially ferro magnesian silicates, as hypersthene, diallage, and olivine, they are generally somewhat poor or only moderately rich in iron. Most frequently their iron content will be between 35 and 50%, on an average of 45%. Exceptionally we do meet with ore of 55, even of 60% iron. In spite of such drawbacks, these ores have in several places, on account of their dimensions and the consequent cheapness of production, given occasion to some mining (for instance, Taberg, in Sweden; Ekersund, in Norway; in many places in Brazil and Mesabi range†), and it seems likely that these deposits will in the future be of a still greater importance.

Exactly in the same relation in which the segregations of titanic iron ore stand to gabbros and syenites, the deposits of chromite or chrome iron ore stand to their mother rocks, the peridotites (or olivine rocks). While the gabbros, the augite,

* Besides my own treatises about these themes we may especially refer to the researches of F. D. Adams (Canada), Orville A. Derby (Brazil), S. F. Emmons (United States), A. Harker (England), E. Hussak (Brazil), A. Högbom (Sweden), J. P. Iddings (Chicago), J. F. Kemp (New York), W. Petterson, A. Sjögren, Hj. Sjögren, and A. E. Törnebohm (Sweden), M. E. Wadsworth (on Cumberland, R. I.), and N. H. and H. V. Winchell (on Mesabi range, Minnesota).

† The Adirondacks are probably meant. They have never been worked in the Mesabi range.

and nepheline syenites without exception distinguish themselves by some titanic content, mostly 0.5 to 1, often 2% TiO_2, the peridotites (also eruptive) are characterized by a low content of chromic oxide, mostly 0.15 to 0.5%, exceptionally 1 to 3% Cr_2O_3. Here, on the contrary, the titanic acid, as well as the phosphoric acid, the zirconic acid, and the sulphides are mostly wanting in the mother rock and consequently also in the segregations. In accordance with the chemical composition we find as constant constituents in the gabbros and the intermediate basic syenites some ilmenite or titanomagnetite, but in the peridotites, chromite and chrome spinel, and while the magmatic segregations in the gabbros are titanic iron ore, in the peridotites they consist of chrome iron ore.

Most of these peridotites are now more or less serpentinized; thus the deposits of chrome iron ores occur most frequently (but not always, as we shall see in the following) in serpentine. This has induced several earlier investigators to suppose that the formation of the chromite deposits themselves was to be referred to the metamorphosis (serpentinization) of the peridotites into serpentine; in other words, that the chromite deposits were formed through secondary processes nearly in the same way as the hydrated silicates of magnesia and nickel, garnierite and noumeite, which occur only in metamorphosed peridotites. Familiar localities are New Caledonia, Riddles in Oregon, Revda in the Urals, Frankenstein in Silesia, etc. That such an explanation cannot be applied to the chromite deposits is shown with absolute certainty by the fact that these have lately been described by myself from perfectly fresh peridotite in the Hestmandö district of Norway. The peridotite consists of perfectly fresh olivine and enstatite in which there is not a sign of serpentinization. Step by step we may follow the transition from the normal peridotites, containing, as we may judge, about 1% chromite and chrome spinel, into chromite-peridotites, with 5, 10, 25, and 50% chromite, and further into purer chromite segregations, with 75, 90, 95, and even with 99 to 100% chromite, $FeCr_2O_4$. The iron is, however, always replaced by some magnesium and the chromium by more or less alumina and iron. In the different stages of transition it may, moreover, be evident that the chromite is of earlier crystallization than the accompanying magnesian silicates, olivine, and enstatite, which leads us to think that the chromite was already formed during the period of the cooling of the peridotite magmas.

The deposits belonging to this group produce all the chrome iron ore which is brought into the market, namely, about 20,000 tons, with 50% Cr_2O_3, annually. About half is derived from Asia Minor and Greece; the remainder from Bosnia, the Banat, Styria, Silesia, Norway, the Urals, Japan, New Caledonia, New Zealand, Australia, and California.

Among the segregations of sulphides we shall especially notice the well-known deposits of nickeliferous pyrrhotite, with some copper pyrites, that are characteristically found in gabbros and that are plentifully met in the Sudbury district in Canada, in different places in Norway (Ringerike, Bamble, Evje, Senjen, etc.), in Sweden (Klefva), in Varallo, Lombardy, the Gap Mine in Pennsylvania, etc. The following characteristic minerals are common to this "world group:" Nickeliferous pyrrhotite, mostly with 2 to 4%, sometimes with 4 to 6%, or a maximum of 10 to 11% Ni and Co; pyrites (in Norway relatively rich in cobalt); eisennickelkies or pentlandite (Fe,Ni)S, partly 2FeSNiS, partly FeSNiS; polydymite (R_4S_5; Ni_4FeS_5); millerite (NiS), etc., together with some copper pyrites and some of the titanic iron ore that is always in gabbro rock. Other ores, as galena, zinc blende, compounds of arsenic and antimony, are either completely wanting or are at hand in very insignificant amounts. All these sulphides are mixed with the ordinary constituents of the gabbro, and we may often observe the transition step by step from the ordinary gabbro, which always contains a little pyrites or pyrrhotite, to "pyrrhotite-gabbro," that is, gabbro with from 5 to 50 or 75% pyrrhotite, and further to pure pyrrhotite ore. It is particularly characteristic of these deposits alike in Norway, in Canada, in the Gap Mine, Pennsylvania, in Varallo, etc., that the deposits are found in the outer portions of the intruded rock and just on the contact with the surrounding walls.

The transitional types—that is, the pyrrhotite-gabbros that are intermediate between the normal gabbro and the rich ore—indicate to us that the sulphides were formed during the cooling and crystallization of the gabbro-magma, and that they were not formed by those pneumatolytic processes that we shall take up in the next section, but by the segregation of the ores in the molten rock itself. Pyrrhotite and pyrite are simply ordinary constituent minerals of the gabbro. The monotonous uniformity of these deposits the world over, and the absence of the characteristic boracic and fluoric minerals always attendant on pneumatolytic processes, furnish additional evidence of the truth of the above.

According to this theory, which was more precisely and fully set forth in 1891–92 by the writer in the papers referred to* at the outset, the nickel, cobalt, and copper contents may be explained as a direct consequence of the mode of rock formation itself. Further support may be adduced from the fact that sulphur† when dissolved in a molten magma of silicates, presumably in most cases as FeS, will extract the other metals on cooling in accordance with the grades of affinity set forth in Fournet's series. His series corresponds with the results of our experience in the ore deposits in gabbros, for nickel, cobalt, and copper accompany the iron sulphide, while lead and zinc practically fail. The following formula expresses the reaction so far as nickel is concerned:

$$FeS + NiOnROmSiO_2 = NiS + FeOnROmSiO_2.$$

Of the more uncommon heavy metals, nickel and cobalt are present in the greatest quantity in the basic eruptive rocks, no doubt especially as bases in the mineral olivine, and consequently they must also have been present in the original eruptive magmas. It is therefore not surprising that it is nickel, mixed with some cobalt, which is characteristic of these sulphidic segregations. Copper was presumably in the original magma in a considerably smaller quantity than nickel. We must ascribe its relatively increased richness in the ore bodies to its strong

* A corresponding train of ideas, though not so fully developed, has been stated, independently of my works, by H. E. Barlow and R. Bell (1891, Canada) and H. B. von Foullon (1892, Wien). Later the most essential points of my papers have been supported by H. Laspeyres (Germany), B. Lotti (Italy), F. D. Adams (Canada), J. F. Kemp (United States), and several others.

† That eruptive magmas may have kept dissolved even very considerable quantities of sulphide is supported by the fact that the basic blast-furnace slags usually hold 3 to 5% sulphide, especially CaS and MnS; likewise the basic and ferriferous slags from the copper, nickel, and lead smelting may contain 4 to 6% FeS, the basic zinc slags even 6 to 8% ZnS.

affinity for sulphur, which leads to an even greater concentration than in the case of nickel and cobalt.

To illustrate more precisely the quantitative relation between the metallic contents of the ore segregations on the one side and of the eruptive rock itself on the other, it may be mentioned that if we were to distribute the whole metallic contents of the ore deposits through their respective mother rocks, these would have in some of the Norwegian deposits the following percentages of the metals: Erteli, Ringerike, 0.03% Ni, 0.005% Co, 0.015% Cu; Nysten, Meinkjar in Bamble, 0.12% Ni, 0.017% Co, 0.05% Cu; Beiern, 0.085% Ni, 0.008% Co, 0.02% Cu. These results are just about what we would anticipate from our knowledge of the nickel contents in olivine, and generally in the basic silicates of rocks. According to the theory which is here developed there exists in Norway, as well as in Canada, a certain connection or dependence between the size of the gabbro-intrusion and that of the ore mass within it. At all events, very small eruptive districts are characterized only by small segregations. The reason why these sulphidic segregations in many cases appear just on the contact of the eruptive with the surrounding rock may be explained to some extent by Soret's principle, which was mentioned above; but other factors, the nature of which we do not yet fully understand, have assuredly had some influence. The segregated molten sulphides and the ordinary silicate magma will be related somewhat, as oil to water or as matte to slag.

At present these sulphidic segregations produce about half or a little more than that of the world's annual production of nickel. This is about 4000 tons metallic nickel. The Sudbury district in Canada yields about 2000 tons. Norway in former years afforded 300 tons annually, but latterly only 50 to 100 tons. At the Norwegian mines the ore is screened to about 2% nickel net (at one mine 1.7%, at another 2.2%), and at the best Canadian mines the content of the smelting ore is a little greater, commonly 2.5 to 3%. The second great producer of nickel is at present New Caledonia, where the ore is garnierite (hydrous nickel-magnesian silicate), the nickel content of which is also derived from the little nickel content in the basic eruptive mother rock, not by any magnetic process, but by a secondary alteration (serpentinization).

Referring to the interpretation given by me of the deposits of nickel-pyrrhotite that are at present mined, the Italian geologist B. Lotti has in similar way explained the ore bodies neare Monte Catini, in Tuscany, which also contain copper pyrites and bornite in basic eruptives (serpentine and ophiolite).

The segregations of native metals in the eruptive rocks may be classified into two chief groups: (*a*) Nickel-iron alloys, as the Greenland Disco iron with 0.4 to 3% Ni in basalt; awaruite (Ni_2Fe, with 67.9% Ni and 0.7% Co) in New Zealand peridotites; josephinite (Ni_5Fe_2) from Oregon; to this group we also reckon the meteoric iron, which, as we know, is always nickeliferous; (*b*) platina metals, partly platina-iron alloys and partly osmium-iridium alloys, in peridotites and olivine-gabbros.

The chemical composition of all these alloys results as a direct consequence from the constitution of the eruptive magmas. Let us imagine a piece of metallic iron dissolved in a basic eruptive magma; the iron will according to the reaction

$Fe + NiOnROmSiO_2 = Ni + FeOnROmSiO_2$ first precipitate (or alloy with) the nickel, cobalt, and copper present in the silicate magma. It may here be noticed that copper in very small quantities is shown in many meteoric irons, in the Disco iron, and in josephinite. It this manner we shall have an alloy first poor and afterward richer in nickel and cobalt. By the continuation of this process the platinum group of metals, which are contained in very small quantity in the magmas, will be precipitated (or cemented). In this way there will first result the native platinum (namely, platinum in alloy with iron and copper, mostly 6 to 12% Fe and 0.3 to 1.5% Cu), and then toward the close of the whole process the native osmiridium.

Among all these eruptive ore segregations there is a whole series of chemical and geological connecting points, which we now proceed to discuss. The segregations of titanic iron ore belonging to gabbros, etc., always contain some chromic oxide (0.1 to 2.5% Cr_2O_3).* The deposits of nickel-pyrrhotite likewise contain some titanic iron ore, and the segregations of nickel-pyrrhotite and of titanic iron ore are sometimes connected in the same eruptive, so that we may point out the transition between these two segregations step by step. The nickel-pyrrhotite deposits and the nickel-iron alloys are both characterized by the presence of nickel and cobalt. In the nickel-pyrrhotite deposits there is found at Sudbury, Canada, and at Klefva, in Sweden, a recognizable amount of the platinum group of metals. In Canada a new platinum mineral, sperrylite ($PtAs_2$), has been identified. Sometimes the natural platinum in the peridotite just appears (in the Urals) in the chrome iron ore segregation.† These intermediate stages, which we might easily multiply, serve to confirm the correctness of our general reasoning.

I. ORE DEPOSITS FORMED BY THE "ERUPTIVE AFTER-ACTIONS."‡

To describe more precisely the formation of deposits of ores and other useful minerals belonging to this group, we shall explain in some detail the tinstone deposits connected with granite and the genetically analogous apatite deposits which are involved with gabbro. As regards tin, this will be principally based on the ingenious researches of the celebrated French investigators Elie de Beaumont and A. Daubrée from 1840–50.

At every place—in the Erzgebirge, in Cornwall, Malacca, Banca, Billiton, in the so-called "Northern Territory" in Australia, in Queensland, New South Wales, Victoria, Tasmania; Black Hills in Dakota, Wyoming, and other places

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* It is interesting to note that Cr_2O_3 was detected in menaccanite in the Adirondack labradorite rocks by Dr. A. R. Leeds in 1876. The menaccanite was separated from the usual rock and in instances yielded over 1% Cr_2O_3. *Thirtieth Ann. Rep. N. Y. State Museum of Natural History*, 1876, reprinted in *Chemical News* March, 1877. See concluding paragraph. (J. F. K.)

† Charles Bullman collected from the gravels of El Choco, Colombia, several years ago, a nugget of platinum weighing 53.5 grams and of sp. gr. 13.58, a large part of which is chromite. It is now in the geological collections of the School of Mines, Columbia College. See also THE MINERAL INDUSTRY, Vol. II., p. 378. The wall rock is not known, but Bullman speaks of diorite pebbles, probably meaning a dark rock. (J. F. K.)

‡ That is, by pneumatolysis, fumarole action, hydrothermal agents, and the like, directly consequent on the eruption.

in the United States; further, in Finland, France,* etc.—the ordinary tinstone deposits are connected with granite or with the surface eruptives that correspond to granite (*i.e.*, rhyolite, as in Durango, Mexico). Corresponding tinstone lodes never occur with basic eruptives, so that we may immediately draw the conclusion that cassiterite is in some way genetically dependent on the acid eruptives. The tinstone lodes are sometimes crossed by granite dikes; consequently they originated during the last phase of the eruptive period of the granite. In a word, the formation of the lodes must have followed immediately on the eruption of the silicate magma itself. It was largely limited to the upper parts of the eruptive, and this clearly solidified before the formation of the lodes. The most characteristic minerals of the tinstone dikes are fluoric and boracic minerals, such as fluorspar with 48.7% Fl; topaz with 14 to 18% Fl; and potassium micas with 4 to 9% Fl; fluoric apatite and the borosilicates tourmaline, axinite, and datolite.

Some of the other minerals of the tinstone lodes are cassiterite, columbite, topaz, and beryl, all of which we sometimes meet in pegmatitic granite dikes. These minerals were formed either in the dike or in direct connection with its eruption by "pneumatolytic" processes—*i.e.*, by processes in which vapors ("pneuma") have played an important part. Some of these minerals are also proved to be primary constituents in some granites.

As of very important moment we must further point out that the rock in immediate contact with the tinstone lodes has always been more or less metamorphosed into greisen, tourmaline rock, topaz rock, etc. The lodes chiefly appear in the peripheral parts of the granite intrusions, partly in the granite itself and partly in the adjacent rock.

The French investigators a long time ago drew the conclusion that the dependence of the tinstone lodes on the granite was due to the fact that the lodes were formed by "pneumatolytic after-actions" directly following the eruption of the granite. As a special support to this conclusion, the correctness of which has been verified by numerous investigations in recent decades, the French investigators have also pointed out that by laboratory experiments along these lines we may produce a great many of the minerals of the tinstone lodes, as for instance by the action of suitable gases upon each other or on solid bodies. Artificial cassiterite was obtained by volatilizing stannic chloride and causing it to react with steam, thus—$SnCl_4 + 2H_2O = SnO_2 + 4HCl$. Apatite was obtained in a similar way and a product of the composition of topaz. The metamorphosis of the surrounding rock (wall rock) to greisen, tourmaline rock, topaz rock, etc., was explained by the corroding attacks of solutions in the lode fissures, and especially by the action of hydrofluoric acid.

We next proceed to give a summary of the geology of the apatite lodes that are connected with gabbro, with special regard to those in the south of Norway. Similar lodes have also been found in the north of Sweden and in Canada. As was shown in Norway in 1860, and in still greater detail by Brögger and Reusch

* The deposits belonging to this group annually produce about 65,000 to 70,000 tons tin, nearly the production of the whole world. The remainder, 2000 to 3000 tons annually, comes from some characteristic tin-silver lodes in Bolivia, which we shall later mention.

in 1870, the Norwegian as well as the North Swedish and Canadian apatite lodes occur in genetic connection with a gabbro rock. In Norway it is olivine gabbro, with 50 to 54% silica, much magnesia, and considerable titanic acid. The apatite occurs in the gabbros as veins, and must consequently have been formed after the solidification of the gabbro. The apatite lodes are sometimes crossed by diabase dikes, in the same manner as the tinstone lodes by granite dikes, as earlier cited. The minerals of the apatite lodes are characterized by appearing in colossal individual crystals, which indicate a very slow process of formation, and we must conclude that they were produced soon after the eruption of the gabbro. Particularly characteristic of the Norwegian and North Swedish apatite lodes is a metamorphosis of the wall rock quite similar to that just described for the tinstone lodes. The gabbro is most often metamorphosed into a scapolite-hornblende rock.

Chiefly for the reasons above mentioned Brögger and Reusch long ago drew the conclusion that the apatite lodes were formed by pneumatolytic processes after the eruption of the gabbro—a conclusion which has now been agreed to by almost all the geologists that have studied them.

As I have recently and more precisely explained in the *Zeitschrift für praktische Geologie*, 1895, the metamorphosis of the wall rock into an aggregate of scapolite and hornblende is principally owing to its saturation under high pressure with chlorides, especially sodium chloride and calcium chloride. The alteration of the labradorite of the gabbro into scapolite is chiefly due to an addition of 4.5 to 5% NaCl and $CaCl_2$. The scapolite, which on an average contains 2.5% chlorine, is almost precisely of the same composition as the primary labradorite of the gabbro, plus the addition of chlorides.

We may also point out that the Norwegian apatite is always a chlorine-apatite without fluorine, and that it contains up to 5.8% Cl. In Canada, on the other hand, the occurrence of scapolite is rare, and it may be owing to the fact that the usual NaCl has been partly replaced by NaF, for the apatite is a chlorine-fluor-apatite.

To illustrate the theory which we are now going to set forth, we shall mention the quantitative proportions between phosphoric pentoxide (or P_2O_5) and chlorine (or Cl) in the apatite deposit of Idegaarden at Bamble, without comparison the most important in Norway. Up to this time the mining has opened up 5,800,000 cu. meters of the gabbro intrusion. Since 1872 110,000 tons containing 90 to 95% pure apatite have been produced. Counting the poorer "apatite ore" and the apatite lodes left untouched in the cubic mass thus explored, the whole rock mass of 5,800,000 cu. meters may be reckoned to have contained 200,000 tons of apatite. If we consider this proportion between gabbro and apatite to hold good for the entire deposit, each 100 parts by weight of the original gabbro magma should have contained 0.49 or say about 0.50% P_2O_5. We may take it for granted that this has been originally extracted from the gabbro magma. As the gabbro now yields on analysis about 0.2% P_2O_5, the primary contents of the magma should have been about 0.7% P_2O_5.

The scapolite-hornblende rock itself contains on an average 1.5% Cl, and about nine-tenths of the whole mass of the gabbro have here been metamorphosed into the scapolite-hornblende rock. In the original gabbro there was, then, 1.35% Cl. Add to this the 0.05% chlorine in the chlorine-apatite of the apatite lodes and the total will be 1.4% Cl. Supposing that this quantity of chlorine was in the form of hydrochloric acid, HCl, dissolved in the primary gabbro magma, it follows that 1.4 to 1.5% HCl must have been sufficient to extract more than two-thirds of the original phosphoric acid in the magma.

Between the tinstone lodes of the granites and the apatite lodes of the gabbros there are many analogies. Thus the lodes in both cases occur as "stock works" within the respective mother eruptives and partly as lodes in the surrounding rock. In both places the saalbands or walls have been metamorphosed to the greatest extent by the tinstone lodes. We attribute this to the hydrofluoric acid, which is a very strong reagent.

Besides these geological analogies there are also a great many mineralogical ones. Thus the SnO_2 of the tinstone lodes corresponds to the TiO_2 of the apatite lodes, for we recall that rutile, ilmenite, and titanite are very abundant* in the apatite lodes. The tinstone lodes, as contrasted with silver-lead veins like those at Freiberg, Schneeberg, Clausthal, Andreasberg, Przibram, Kongsberg, etc., contain apatite, although it must be admitted not in great quantity, but apatite has been cited in the *Mineral Resources of the United States* as occurring in the tin veins of Dakota in "abundance" and in "large quantities." Moreover, in Zarza la Major and Marvao, Spain, and in Beïra, Portugal, apatite lodes are found within the granite. Thus we may point out a whole series of transitional links between the tinstone lodes and the apatite lodes.

Silica and certain silicates are also especially characteristic of both sorts of lodes. For the tinstone lodes they are principally quartz, lithium-mica and potassium-mica, topaz, beryl, tourmaline, and others; but for the apatite lodes magnesium-mica, enstatite, hornblende, and scapolite. As an important point we may emphasize the large quantities of the haloid elements which we meet in these lodes: in the tinstone lodes fluorine; in the Norwegian apatite lodes chlorine with but a trifle of fluorine; in the Canadian, to the contrary, chlorine and fluorine in almost equal proportions. The chemical-mineralogical composition of the tinstone lodes, as well as of the apatite lodes, proves that the material of the lodes must have been extracted from the respective eruptive mother rocks, or magmas. Especially characteristic of the tinstone lodes are Sn, Si, Be, Li, P, Bo, F; further, W, U, Nb, Ta, Mo—thus in short the same group of elements that is so characteristic of granite and of granite-pegmatites; and the apatite lodes are specially characterized by P, Ti, Si, Mg, Fe, Na, Ca, and Cl—thus by a group of elements which is closely connected with the composition of gabbros. These facts, together with the above-mentioned large quantities of the haloid elements F and Cl in these lodes and the early conclusions reached by the French investigators, that these lodes were formed by pneumatolytic processes in direct connection with the rock eruptions, lead us to the conclusion that the material of the tinstone and apatite lodes was extracted from the original still molten magma, and further that the hydrochloric and hydrofluoric acids dissolved in the magma have effected this extraction.

*A Norwegian apatite lode at Fogue has produced 125 tons of rutile since 1875, and now the annual production is 15 to 20 tons of pure titanic acid, which is used on majolica.

We shall now point out in a few words how easily the chemical-mineralogical nature of the lodes may be explained in accordance with these processes. The phosphoric acid is one of the constituents that would be most easily attacked; P_2O_5 must consequently be extracted by the dissolved HFl or HCl in the primary magma, and the apatite results that is so characteristic of the apatite lodes and of those with tinstone. Experience shows that the gabbros generally contain much more apatite than do the granites; so that it is not surprising that the pneumatolytic lodes of the gabbros are exceedingly rich in apatite. The stannic acid (SnO_2) has strong affinities neither for the bases nor for the silica, and consequently it may easily be extracted from the granite magmas, which usually contain some tin. The tin itself as $SnFl_4$ will on this account be concentrated to an exceptional degree in what we will name the "acid extract."

What we have here pointed out concerning the stannic acid of granites is almost word for word true of the titanic acid (TiO_2) within the gabbros. A high concentration of potassium and still more of lithium is especially characteristic of the tinstone lodes. This may depend upon the fact that these two are just the metals which possess the strongest affinities for chlorine and fluorine. They will therefore be excessively attacked by these acids, and lithium more than potassium.

In the "acid extract" of granite magmas silicon in $SiFl_4$ and boron, probably as $BoFl_3$, or Bo_2O_3, H_3BoO_3, will also be concentrated, and the same is true of the heavy metals W, Mo, U, Ta, Nb, etc., of which we may say the same that we did about tin. The "acid extract" having been concentrated during the eruptive period will reach a state of emanation at its close. That from granites contains the following: $SiFl_4$, $SnFl_4$, $BoFl_3$ (or Bo_2O_3), KFl, LiFl, P_2O_5, etc., and that from the gabbro-magmas P_2O_5, $TiCl_4$, Fe_2Cl_6, NaCl, etc., in both places attended by HFl and HCl, further by H_2O, H_2S, CO_2, and probably also by a little of the normal silicate magma.

During the emanation the minerals will be formed by pneumatolytic processes, and the surrounding rock will be subjected to a pneumatolytic metamorphism. In the last-mentioned process, in which with granites HFl and with gabbros NaCl will be most active factors, some of the material of the surrounding rock will also share in the filling up of the lode itself.

In accordance with the view here set forth, which is but a further evolution of the ideas long ago developed by Elie de Beaumont and Daubrée, we are able to explain all the special characteristics of the tinstone and apatite lodes, and particularly how some of the elements of the primary magmas have been concentrated in such an exceedingly high degree in the products of the pneumatolytic action. In this paper we have chiefly laid stress on the explanation of the chemical-physical processes by which the various concentrations of the elements, originally disseminated in a minute quantity in the magmas, took place during the eruptive periods. First we reviewed the segregations of titaniferous magnetite, of chromite, of nickeliferous pyrrhotite and chalcopyrite, and of the platinum group of metals; next of cassiterite and of apatite.

Both the latter deposits give us much more varied phenomena than the former, because in the former only one process has been active—the process of magmatic concentration; but in the latter at least two processes have operated independently of each other, namely: (1) the formation of the "acid extract" and (2) its emanation. Moreover, the available quantities of the active acids will be of great importance, and it should not excite surprise that the pneumatolytic processes facilitate the quantitative separation of the elements more than the processes of magmatic concentration.

Besides the two groups of ore deposits just discussed we have also a whole series of others which have been formed by similar processes. Thus we may direct attention to the important silver and gold deposits represented by the Comstock, Potosi, Schemnitz, and others in younger eruptive, as andesite, trachyte, and rhyolite; many copper ore deposits, scattered all over the world, in eruptives at times basic, again intermediate, and again acid; many mercury deposits which have the appearance of being formed by pneumato-hydatogene processes (*i.e.*, processes involving both vapor and liquids), etc. Many of these deposits are connected by intermediate types with the above-described pneumatolytic deposits. We may, for instance, arrange the following in a series:

1. The ordinary tinstone lodes by granite.
2. The Mexican deposits of tinstone with the usual associated minerals of the typical lodes, but occurring in the younger acid eruptive rhyolite.
3. The Bolivian tinstone-silver deposits in dacite, trachyte, and andesite.
4. The normal silver-ore deposits of the type of the Comstock lode, of Potosi, and Schemnitz, in andesite, trachyte, and rhyolite.

We might easily carry out the series of related types to a much greater degree even than this. It must be reserved to future investigations to determine the exact chemical reactions involved in these processes more fully, and especially those by which a minute quantity of the metals copper, mercury, silver, and gold disseminated through a vast amount of rock can be concentrated. We shall content ourselves at this time with merely pointing out that solutions of alkaline sulphides, like Na_2S, and of carbonic acid (CO_2) may have operated much as have the hydrochloric and hydrofluoric acids in the formation of the tinstone and apatite lodes. Water charged with carbonic acid readily dissolves, for instance, the bicarbonate of silver, $AgHCO_3$, and similar reactions have no doubt played their parts.

When we bring together deposits of similar mineralogical and geological characters and examine them with care so as to determine their methods of formation, we are likely to reach results no less valuable in their scientific bearings than in the influence they will have on actual mining.

AN OUTLINE OF THE VIEWS HELD TO-DAY ON THE ORIGIN OF ORES.

By J. F. Kemp.

In The Mineral Industry for 1893 (p. 835) the writer gave a short historical sketch of the "Development of Views on the Origin of Ores." With a brief reference to the conceptions of the ancients the growth of opinions toward the trusted doctrines of to-day was outlined, in the hope that this bird's-eye view might stimulate observation among those in active mining and in a position to observe the fleeting phenomena upon which all our reasoning is of necessity based. There is no more attractive field of study and there are few in which to a greater degree well-based conclusions lead to larger practical results. Leaving to this earlier paper the historical portion of the subject, it is the writer's purpose in the present one to give as far as possible a photograph of our general attitude to-day as to the origin of ore bodies and to carry out for this subject the design of the editor in shaping the course of these volumes year by year.

So far as the standpoints of geologists to-day may be briefly summarized they are as follows. If we understand "veins" to imply filled fissures with more or less attendant impregnation or replacement of the walls, and if such occur in stratified or massive rocks that have not been so much disturbed or metamorphosed as to obscure the relations, we practically all believe that they have been filled by solutions which, in most cases, have ascended from interior and probably more heated parts of the earth. Thus if an ore body is found in what is clearly a filled crack, either along an important fault line or in one of a series of them, or along a crushed strip (shear zone), or some such line of fracture that indicates a previous movement of the walls, there seems slight if any doubt that these views hold true. Some may think that the solutions have seeped into a standing pool in the fissure from the walls, but if such solutions are assumed to have been at the time anywhere near the surface, the conditions are so unfavorable for dissolving in cold natural waters such insoluble minerals as are most ores that the explanation has small claims to credibility. If the walls are assumed to have been at great depth, we have practically the same conditions as in the other view. And it may be remarked that in regard to veins we are never to forget that the geological period of formation is of vital importance, for in the interval since the fissure was filled an indefinite amount of surface rock may have been eroded and what now remains may be merely the stump of former greatness. The barrenness of some outcropping veins that have shown rich spots below and the rich outcrops of others with lean spots in depth give ground for regarding the vein filling as essentially variable, and where the means are available and the vein persistent there is always a good chance for subsequent explorations to repeat these changes, it may be several times over. In recent years we have advanced so much in our understanding of the development of topographic forms and in the detection and interpretation of old peneplains,* base levels of erosion, river and lake terraces, and many less evident marks which indicate the amount to which a region has been worn down, that from these phenomena conclusions may at times be drawn of the former vertical extent of a vein. Its relations are bound up in the geological history of its district, and no careful observer should fail to appreciate the suggestive character of these auxiliary lines of evidence.

The extremely common case of ore bodies that lie along intruded dikes and sheets of igneous rock is much the same as that of veins, because the surface of contact, be it vertical or inclined or horizontal, has exercised a directing influence on the solutions and has served to localize the deposit. Attention may be directed to the interesting grouping of veins suggested by J. B. Hastings,† that is in large part based on the fact as to whether the intruded rock is a dike, a laccolite, or a bathylite.

The alteration of ore above the water line, the attendant formation of oxidized minerals and the zone of enrichment which is often met at the water line, are assumed to be such familiar phenomena as to deserve no further comment.

Now, while we feel fairly sure of the truth of these generalities for individual cases, we may go further and inquire what was the chemical composition of the ore-bearing solutions; whence they obtained their ore; what relations do the cavities or groups of cavities show among themselves and how were they individually and collectively formed in accordance with sound principles of mechanics. On all of these questions we are especially indebted to the work of G. F. Becker.

Mineral springs suggest to us and artificial experiments to a great degree confirm us in the belief that the solutions have been alkaline, and that the metallic sulphides have often been dissolved with alkaline sulphides or other alkaline salts, and that their precipitation has been largely hastened by the loss of pressure and heat near the surface. Acid springs are also known and such may have played their part in some districts. In these views we are probably not far from the truth, although there may be obscure and elusive reactions that have escaped us, because it is so difficult to reproduce artificially the natural physical conditions and the long intervals of time of which in geology we must take cognizance. The field is, however, an inviting one and further contributions are to be expected and welcomed.

As to the original source of the ore, increasing experience leads us to look with especial favor on the igneous rocks, whose widely disseminated, although when

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* Peneplain is a term suggested by W. M. Davis to describe the topography of a country whose drainage systems have at one stage in its history reached their full development—*i.e.*, have worn down the land almost to a plain, but not quite, because a slope is needed to carry off the water. If now such a completed or base-leveled topography is again elevated and carved deeper, the stumps of the old base level will remain, with their summits nearly in a plain, or in other words they will form a peneplain, just as we say peninsula for what is almost an island. Peneplains are extremely suggestive as regards the extent of former erosion.

† "Sub-Classification of Xenogenous Ore Deposits," *Engineering and Mining Journal*, March 23, 1895, p. 268.

considered in comparison with their mass, whose small percentages of all the metals except the invariably abundant iron suggest to us original stores for leaching. We are also attracted to them as a source because without doubt all the other rocks must be ascribed to them in the last analysis; because they are so often in close association with ores as mined; and because, above all, they are natural stimulators of those heated solutions to which we can with most reason attribute the results. Of their direct part in the formation of orc bodies which are an integral part of themselves further mention will be subsequently made.

Regarding the regions of the earth especially accessible to solutions we have of late had some important contributions. It will be recalled that Posepny* has given the discussion definiteness by establishing the two contrasted subterranean circulations, the "vadose," or that near the surface and caused by the tapping off of overlying waters by some more deeply located vent that opens out to daylight, and the "deep-water" circulations that come up, so far as we know, from a point far below any known or conceivable outlet and that are tapped in many deep shafts. Undoubtedly the motive power of the last-named currents is in large part the internal heat of the earth or of neighboring igneous rocks. But even to allow of them in any notable degree considerable permeability of rock is necessary and cavities must be assumed that will supply waterways. Our reasoning receives still further definition by the recent contribution of C. R. Van Hise† presented at the Philadelphia meeting of the Geological Society of America, in December, 1895. As the result of very extended work on the metamorphic rocks, Van Hise is led to assume the existence of three concentric zones in the earth. The outer or upper one admits of shattering under stress and of the formation of cavities; a middle one is marked by shattering and flow both; while the lower one yields to overwhelming pressure only by flowage. On the principles of mechanics Professor Hoskins, of Stanford University, has made a series of calculations for Professor Van Hise, and has shown that if pressure is brought to bear on the walls of a cavity equally from three directions at right angles to one another, the cavity will be closed when the pressure reaches two-thirds of the ultimate strength of the walls. If the pressure be applied from only one direction the full crushing stress will be needed. With these results as a guide and allowing for the presence of water in the cavities but free to escape, and by assuming also the strongest of rocks, Van Hise estimates the maximum depth at which such water-filled cavities can exist as 10,000 meters. The result is of extreme interest as regards ore bodies, because it gives a maximum depth for the "underground" circulations of Posepny and establishes the portions of the crust of the earth which can yield their metallic contents to leaching. Uprising igneous magmas alone bring from greater depths the metallic contents of the interior. But the outer zone and the upper part of the middle zone of Van Hise, which latter allowed of both shattering and flowing, are in their practical relations the most favorable area for the actions of solutions, and both of these are above the ultimate depth of possible cavities. We may with considerable confidence look upon the outer 3 to 5 miles of the crust as the scene of the formation of all veins properly so called, but once formed some may have been carried down by subsequent depression to

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* "The Genesis of Ore Deposits," *Trans. A. I. M. E.*, Vol. XXIII., p. 197.

† A short report appears in *Science* Jan. 10, 1896.

somewhat greater depths. Small as is this fraction of the total radius of the globe, we may console ourselves with the conclusion reached by A. C. Lane in a paper elsewhere in this volume, that 10,000 ft. is about the extreme limit for practical mining.

Aside from the simple typical veins and related contact deposits which we have had before us in the preceding lines, there are many ore bodies deserving mention whose history is by no means so clear. Thus great bodies of galena have been found impregnating the Cambrian dolomites in the southeastern portion of Missouri so extensively that in one case, at Bonne Terre, the workings, according to Winslow, are 1300x800 ft., and breasts have been stoped as much as 100 ft. high. The ore spreads laterally parallel to the general bedding of these almost undisturbed strata. Faults are practically lacking, and the comparatively few crevices that have been found to drip a little water from the roofs of the chambers left by the mining are almost insignificant when compared with the extent of the ore. The ore must have been brought to its present position in solution, for there is no other conceivable process. But the precise method is a very difficult thing to trace. There is no local evidence of uprising currents; there is no good reason apparent why lead-bearing solutions should migrate for long distances through the same rock as that in which they are now found and escape precipitation in transit; and all the crevices coming down from above appear disproportionately small or tight. Nevertheless we cannot but appreciate that Mr. Winslow in his recently issued report to the Missouri Geological Survey has made a strong argument in favor of the last-named process, even if we still feel that the difficulties surrounding these particular ore bodies have not been all cleared away. As a somewhat similar case, it may be added that we should all welcome further light on the method of formation of the great chutes of copper-bearing conglomerate and amygdaloid on Lake Superior and on the presence of what is practically the oxidized zone with native copper at a depth of several thousands of feet. We cannot but raise the question, Will the native copper pass into a sulphide in depth, and did the solutions that brought the copper to the little cavities come up from below or descend from above? *

Where veins occur in large normal faults or intersecting series of such, the immediate occasion of the fracture must be the rearrangement of the subterranean materials so as to cause sagging of the foot wall and elevation of the hanging. In all such cases the subterranean flowage just referred to may have contributed or the local strains caused by igneous intrusions may have played no small part. We must not fail to appreciate in this connection the importance of the principle of "isostasy," so called, in accordance with which within certain limits the sphere of the earth must be in hydrostatic equilibrium; that is, if we imagine it made up of tapering pyramids of matter that have their apexes together at the center and that swell from the center outward, the heavier pyramids will be shorter and will afford depressed areas, as under the sea bottoms, while the lighter ones will stand in relief as in the continental areas. The disturbance of this equilibrium beyond the limit of resistance of the natural stiffness of the crust, such as might be brought about by the transference of sediment, great

* Since the above was written the question has been discussed by H. L. Smyth in *Science* Feb. 14, 1896, p. 251, but the possibility of lower-lying sulphides is not considered. Uprising solutions are favored.

volcanic outbreaks, and the like, will occasion readjustments and bring about those disturbances that lead to faults and mountain-making elevations on a grand scale. Great generalities like these and others that might be cited from the domain of dynamical geology can perhaps seldom be sharply applied in the study of a limited district, but they are all fundamental to correct conceptions in the large way. The field observations and the remarkable artificial experiments of Bailey Willis* in illustration of the structure of the Appalachians and the relations of folds and faults to the character of the rock that enters into the substance of the mountains are extremely significant.

When we come to deal with ore bodies in metamorphic rocks, the difficulties that are met in arriving at correct explanations and an understanding of them are greatly multiplied. In many respects the problems of metamorphism are themselves so obscure, and the results from the changes superinduced on igneous and sedimentary rocks alike are so similar, that it is not easy even to decide on the original character of the walls. In America and among the earlier geologists the clearness of our thinking undoubtedly suffered from a tendency to refer the lamination of metamorphic gneisses and schists to former bedding planes, and thus to regard them as all of necessity of sedimentary origin; but as a proper appreciation of the effects of shearing stresses has become more widely spread, we have realized more and more that the laminations could be induced in massive rocks, and that even in sediments they might run directly across the original bedding planes. It has also been shown by Geikie and Teall that a very pronounced banding in the gabbros of the igneous districts in the North of Scotland† was caused by layers of different mineralogical or at least of widely different chemical composition in the original magma, and that they had formed before the crystallization of the still imperfectly fluid mass. All these later advances in our correct geological knowledge have a direct bearing on the problems of the ore bodies that occur in such rock as walls. The first step, therefore, in their solution is to decide on the character of the laminations or foliations. If they are to be referred, as they so often are, to dynamic disturbances and to the flowage of rock masses under pressure, we cannot longer speak unreservedly of magnetite and specular hematite lenses or of similar deposits of pyritous minerals as "beds," for bed implies a position parallel to the general stratification of sedimentary rocks. If we conclude that the lamination is due to a shearing stress, it is not a great additional step to trace out a close parallel between these obscure imbricating lenses and a series of fissure veins. If, however, the geological series *does* present the characteristics of a series of concordant sediments, we may describe the ores as "beds." When such ore bodies have clearly shared in the general metamorphism of the country, they must certainly have originated in accordance with some of the well-understood methods that apply to the simpler problems. It is not often that the problem of the magnetites in our eastern Archæan regions has been studied with this appreciation of the nature of folia-

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* "Mechanics of Appalachian Structure," *Thirteenth Annual Report Director U. S. Geol. Survey*, p. 217. "Studies in Structural Geology," *Trans. A. I. M. E.*, Vol. XXI., p. 551. *Engineering and Mining Journal*, Oct. 22, 1892, p. 390.

† "On the Banded Structure of Some Tertiary Gabbros in the Isle of Skye," *Quar. Journ. Geol. Soc.*, November, 1894, p. 645.

tion. The recent paper of J. E. Wolff* on the extensive deposits at Hibernia, N. J., is the more striking for this reason. It resulted as a minor part of long-continued and extended study of the Archæan areas of New Jersey, for which Professor Wolff had gained a vast amount of valuable preparation in the less obscure although still very complex field of the Green Mountains in Vermont and Western Massachusetts. The fortunate discovery at Hibernia of a peculiar and well-marked garnetiferous, graphitic gneiss made it possible to demonstrate a stratigraphical succession and a top and bottom to the series. The whole series is folded into a synclinal trough that pitches sharply to the northeast. Wolff's conclusions give us excellent ground for regarding the rocks, despite the fact that they are so thoroughly crystalline and made up of the minerals most commonly seen in the igneous rocks, as of probably sedimentary origin. The full paper is to be strongly commended to all who are situated in similar districts and who are pondering over related geological problems.

The bodies of pyrites that favor schists and slates and that often exhibit a lenticular outline, and the so-called segregated veins of quartz, frequently auriferous, are more and more assuming the characters of veins as they are carefully studied; and as we appreciate the part played by dynamic disturbances in the development of the schistosity, this conclusion seems the more natural. G. F. Becker's† work in the auriferous slates and schists of California and of the southern Appalachians leads to this conclusion.

The importance of the recent studies on the iron ores of the Lake Superior region cannot readily be overestimated. Lines of investigation begun by R. D. Irving nearly twenty years ago have been continued with far-reaching results by C. R. Van Hise. Many seasons of patient and systematic traversing of the woods and swamps have served to record the facts, so that the complicated geological structure begins to yield its secrets. The ores of the Gogebic range, lying as they do in the apexes of pitching troughs, are referred to the alteration of cherty carbonates of iron, which, standing at high angles, have been gradually leached of their iron so that by the simple process of the circulation of atmospheric waters it has become concentrated below. To a large degree the same general explanation applies also to the soft ores of the other south shore districts. The original cherty carbonates are supposed to be marine deposits, either organic or chemical or both. As a further point, J. E. Spurr has shown in the cherts of the Mesabi range the presence of glauconite, and regards it as a possible antecedent of the carbonates. If this be true it brings the source of the ores back to a familiar and widespread form of marine deposit of which we have long known in the green sands.

In a scheme for the classification of ore deposits recently published by W. O. Ctosby‡ one of the four grand groups is devoted to those ores that have originated by aqueo-igneous methods, such as we all think have played an important part in the development of the veins or dikes of pegmatite or giant granite. In-

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* *Annual Report State Geol. of New Jersey*, 1893, p. 357.

† "The Structure of a Portion of the Sierra Nevada of California," *Bull. Geol. Soc. of America*, Vol. II., p. 49. "Reconnaissance of the Gold Fields of the Southern Appalachians," *Sixteenth Annual Report Director U. S. Geol. Survey*.

‡ "A Classification of Economic Geological Deposits Based on Origin and Original Structure," *Amer. Geologist*, April, 1894; *Technology Quarterly*, April, 1894.

deed, we hardly know whether to speak of them as veins or dikes as deposited by solution or fusion. J. H. L. Vogt,* of Christiania, has also written of them as well as of those ores which may with reason be referred to purely igneous methods, and to whose consideration we shall shortly pass. Elsewhere in this volume will be found a sketch of Professor Vogt's views from the distinguished author's own pen. It is a matter of common experience that as soon as an intrusion of igneous rock begins to cool and consolidate a vast amount of vapors is given off. As a general thing these are much more abundant and effective in the case of acidic magmas or those high in silica than in basic ones. They are the chief agents in causing contact metamorphism, to one of whose varieties this form of ore deposit must be referred. Basic rocks furnish us with examples of "dry" fusion and seldom exercise much effect on their walls. J. J. Stevenson has informed the writer that he once saw in the West a seam of bituminous coal penetrated by a dike of basalt a foot thick that did not cause the slightest change in the coal, and it is a common experience around the shores of Lake Champlain to see basaltic dikes penetrating bituminous shales and black limestones without producing the least observable alteration, even when the latter are thickly set with fossils. Highly siliceous magmas such as yield on crystallization rhyolites and granites are characteristically rich in tin, and as Professor Vogt elsewhere shows at length they yield cassiterite with a long list of associated minerals of peculiar composition. We have come to regard apatite veins as probably formed in the same general way from gabbros, although as regards the Canadian deposits it must be confessed that the relations are much less easily cleared up by this explanation than are those of Scandinavia. Referring the reader to Vogt's paper for particulars, it will only be added that this is true because we only have the scapolite rock, or "apatite-bringer" as the Scandinavians call it, rather rarely developed in Canada. In fact, it took somewhat extended microscopic search to identify it at all. But the petrography of the Canadian apatites is a very complex theme and will require much patient and detailed observation to unravel it.†

There remain for consideration the ore bodies that are so related in their occurrence as to suggest strongly that they have been derived by direct crystallization from cooling igneous magmas. As Professor Vogt has said, they may at once be separated into three groups: (1) those containing oxides, chiefly, as a matter of practical moment, of iron and titanium or of iron and chromium; (2) those containing sulphides, of which the double sulphides of iron and nickel and of iron and copper are the most prominent; and (3) those containing metals of the platinum group in the native state or as alloys with more or less iron, which itself is also known in masses of notable size, although of no practical moment.

There has been as much activity among geologists in the study of rock magmas in recent years as in any other line of investigation. By combining field observation with microscopic study and extended series of chemical analyses, we have all come to realize more and more strongly that a molten-rock magma is in many respects an unstable thing, and that it tends to break up into more or less distinct separate magmas with sharp contrasts in their percentages of silica and of

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* *Zeitschrift für praktische Geologie*, October, December, 1894.

† An important contribution to this subject has recently been made by C. H. Gordon: "Syenite-Gneiss (Leopard Rock) from the Apatite Region of Ottawa County, Canada," *Bull. Geol. Soc. of America*, Vol. VII., p. 95, 1895.

the bases. If two separate layers over and under result in the reservoir, we have successive eruptions of different lavas. If an intruded magma cools in position, by some obscure process the bases become increasingly rich toward the outer margins, while the central portion is higher in silica. The heavy minerals have also been observed in a concentrated condition in the bottom portions of horizontal sheets, to which situation they have sunk while the molten mass stood at rest before chilling. It has also been noted that where great areas are covered with rocks of the gabbro family we meet great variations of type. In some parts we may find rocks that are nearly pure feldspar, in others normal mixtures of feldspar and pyroxenes, and in still others non-feldspathic aggregates of pyroxenes and olivine. As a less common phase we also meet great bodies of titaniferous magnetite, and see no escape from the inference that when such are in a purely massive rock they are one of the developments of the magma and are an extreme case where it is practically all bases. This view may be taken with great confidence, because all that it implies is an exceptional richness of a common and well-recognized constituent mineral of the usual run of gabbros and of related rocks. With the sulphides the case is perhaps less well established, although it seems to many observers, including the writer, that it is the only one that will fit the geological relations. Posepny has taken strong ground against it and has pronounced it a chemical impossibility. It is the purpose here to state the case as impartially as possible and in more definite detail than did Posepny, whose argument is little more than a series of dogmatic statements, for he seemed to feel a curious and decided prejudice against an igneous method of origin in any of its forms and an unwillingness to attribute any importance to it. The geological relations of these sulphides are briefly as follows. In the outer portions of intruded masses of gabbros or related rocks are found enrichments of pyrrhotite and chalcopyrite that are sharply terminated by the walls of the intrusion and that fade gradually out as the contacts are left. They are thus entirely in the gabbro and are mixed through its substance in all degrees of richness. The gabbro is oftentimes massive, with no evidence of having suffered from dynamic metamorphism, and again it has been changed to amphibolite or hornblendic rock, commonly called at the mines diorite.

Almost all the observers who have seen such ore deposits have concluded that the relations were only to be accounted for by attributing to the ore the same igneous origin as to the gabbro, and by viewing it as a result of the same sort of a magmatic reorganization as that which makes gabbros more basic at the edges than in the centers. As to the precise nature of these chemical changes we are still much in doubt, and it must be admitted that the process is obscure. An analogy has been traced between the splitting up of molten magmas and the reactions of a furnace smelting sulphurous ores for slags and mattes, and the similarity of the products has been emphasized. The most interesting contribution to this phase of the subject in recent years is the paper by Mr. David F. Browne,* the chemist of the works at Sudbury, on "Segregation in Ores and Mattes." Mr. Browne shows by numerous analyses and diagrams that in a pot of matte the nickel tends to concentrate toward the center, while the copper is much richer at the outer margins. This is exactly the experience in mining. The nickel is

* *School of Mines Quarterly*, Columbia College, July, 1895, p. 297, with an appended note by J. F. Kemp.

much richer in the central portions of the ore body, while the copper is more abundant on each side of it. These observations are extremely important, showing as they do the migration of metallic matter even in so viscous and quickly chilling a mass as a pot of slag.

Well-grounded objection has been made, however, to the drawing of inferences regarding rocks from the reactions of a furnace, and although not definitely stated, this is doubtless the point that Posepny* had in mind. In a furnace we have a strong reducing atmosphere kept alive by the combustion of the coal, which not alone produces heat, but neutralizes the action of any oxygen that is present and that might otherwise make the formation of sulphides of the metals an impossibility. In a magma we have no carbon, of course, and the question arises as to whether there is an oxidizing condition of things—a neutral one or a reducing one. Any watery vapor that might be conceived to be present at the temperatures of fusion would have long since been dissociated unless held intact by overwhelming pressure. The question becomes one of thermo-chemistry, and its solution is involved in the possible existence of H_2S and SO_2 and of the relation of these to metallic oxides and sulphides that may be present. Under ordinary conditions thermo-chemistry teaches us that the order of the formation of compounds from a fused mass or a solution will be determined by the amount of energy (heat) that they develop or set free on crystallizing, a principle that was applied by G. F. Becker† with some modifications ten years ago to the crystallization of the igneous rocks, although it has not received the general recognition from students of rocks that it deserves and that in the nature of things it must. It is not possible to cite the amount of heat developed by all the compounds here in question (such as pyrrhotite, chalcopyrite, and the silicates) in their formation even at ordinary temperatures, because the amounts have not been determined; but Muir and Wilson,‡ quoting largely from Thomsen's researches, give the following for ordinary temperatures and pressures: H_2O, 68,360 calories; SO_2, 71,080 calories; SO_3, 103,240 calories; H_2S, 4740 calories; Fe_2O_3,yH_2O, 191,150 calories; FeS, 25,000 calories; Cu_2S, 20,270 calories; NiS,yH_2O, 19,400 calories; CoS,yH_2O, 21,740 calories.

It is evident from these figures that H_2O and SO_2 set free nearly the same number of calories and that H_2S liberates a much inferior number. In other words, H_2S is quite readily dissociated, because a comparatively small amount of energy is sufficient to restore and exceed the amount liberated in the union of the H and S, and whenever this excess is supplied the atoms must of necessity part company. As regards, therefore, the condition of the three elements H, O, and S in the molten magma, we are justified in inferring that they are all present in the free state, except so far as the last two are united already with metals. The question of their relation to the oxides of iron, nickel, and copper in the magma is much the same as that discussed by St. Claire Deville in his beautiful explanation of the apparently contradictory behavior of a stream of steam passing over red-hot iron filings in a tube, and of hydrogen passing over similarly heated particles of iron oxide. In the former case the metallic iron is oxidized

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* *Trans. A. I. M. E.*, Vol. XXIII., p. 329.

† "A New Law of Thermochemistry," *Amer. Journ. of Science*, 1886, Vol. XXXI., p. 120.

‡ *The Elements of Thermal Chemistry*, Appendix I.

and hydrogen is set free; in the latter the oxide is reduced and metallic iron and water result, two phenomena that are apparently contradictory. In Risteen's *Molecules and Molecular Theory*, p. 110, the case is so clearly presented that it is here quoted verbatim:

"Let us first consider what forces are involved in the problem. (1) The hydrogen molecule being double, we have first to consider the attraction of its two component atoms for each other. (2) We have likewise to consider the attraction that the atoms of an iron molecule exert upon one another, and also (3) the attractions existing among the atoms of the steam molecule and (4) those existing among the atoms of a molecule of the oxide of iron. Let us now return to the first experiment, in which steam is passed over red-hot iron. In this case the motions of the steam molecules are accelerated by the heat to such a degree that some of them are torn asunder, and oxygen and hydrogen atoms are liberated and mingle with the molecules of steam. If no iron were present these dissociated atoms of oxygen and hydrogen would occasionally chance to collide with one another again, and in some cases the speed of the colliding atoms would not be great enough to prevent them from recombining and forming new molecules of steam. The steam molecules are therefore always dissociating and re-forming, and it is plain that at any given instant the proportion of such molecules that are in a state of dissociation will be greater the higher the average speed of the steam molecules—that is, the higher the *temperature*. As a matter of fact, however, some of the liberated oxygen atoms come in contact with the iron that is present and combine with it to form black oxide, and the hydrogen atoms that were formerly their partners pass on with the steam. In the second experiment the phenomena are very similar. The heat partially dissociates the iron oxide, the oxygen atoms thus liberated find partners among the hydrogen atoms flowing overhead, and the steam thus formed is swept away in the stream of hydrogen and is prevented from again coming in contact with the reduced iron that has been left behind. Hence it is plain that if the steam that is formed is continually swept away by a current of hydrogen, the result will be that the oxide of iron will be all ultimately reduced; while if the hydrogen that is liberated is swept away by a current of steam, the iron will be continuously oxidized until it is all converted into oxide."

Turning now to the gabbro magma, we may consider it to form a molten intrusion in which the bases and especially the metals are concentrated near the walls, either by Soret's principle or some other that we do not clearly understand. That the bases *do* collect in these portions as a matter of observation there is no doubt whatever. Further, that watery vapor, sulphurous acid, and sulphureted hydrogen emanate from many volcanic vents and are present in many fused magmas there is abundant evidence likewise as the result of observation. If now a stream of these gases finds a way of escape along the outer border of the intrusion and comes in contact with the oxides of iron, copper, and nickel especially concentrated there the parallelism is close with the experiments above cited. The sulphide of iron, with its 25,000 calories, would be the first and most likely one to form, while the sulphide of copper, with 20,270, and of nickel, with less than 19,400 (to allow for the yH_2O), would closely follow or accompany it, depending more or less on the amounts of each present in the particular spot.

More or less of the oxide of iron would remain unchanged, and indeed it is always present in greater or less quantity in the actual ore deposits. The relations of oxides and sulphides would largely depend, just as in Deville's experiments, on the relative amounts of oxygen, hydrogen, and sulphur in the emanations. The reaction is an interchangeable one, as in the earlier case, and the conditions are very much the same as if we were to bessemerize fused oxides and silicates with a hot blast of sulphur, hydrogen, and oxygen. The same reactions would be brought about by the gases traversing a solidified but still red-hot and shattered intrusion. The local distribution of the deposits as met in mining at some portions of the borders of the intrusions and not uniformly around them may be accounted for both by the local concentration of metallic bases and by the local character of the sulphurous and other emanations. The reactions will hold good, even though from the assumption of oxidizing conditions in a magma (although its exact expression is not easy to locate in the textbooks) many observers have been inclined to regard the presence of microscopic or larger crystals of pyrites and other sulphides in thin sections of igneous rocks as due to secondary introduction in solution and as not being original minerals. Nevertheless many others, of whom the writer is one, who are occupied with the microscopic study of rocks, and especially of gabbros, never have questioned the original character of the sulphides, and from their relations in the rocks see no reason to do so. Masses of sulphides are very common in pegmatite veins, and in the circumstances under which these were formed by the vaporous, if not actually fused, emanations of heated intrusions, the oxidizing conditions were necessarily much more marked than in the cases of normal fusion. The writer takes pleasure in acknowledging his indebtedness to Dr. Ferdinand Wiechmann, instructor in physical chemistry in the Columbia School of Mines, for many suggestions in connection with the above.

If, on the other hand, we believe that the conditions in the parent magma of the sulphides were either neutral or reducing, or if there was more than enough sulphur present to satisfy all the uncombined oxygen, there are no chemical difficulties in the way of the igneous formation of the ores, except as we may be in doubt as to the method of their concentration near the outer walls of the intrusions.

Furthermore, if the thesis above advanced holds true it alters in a certain degree our point of view, for whether the conditions are such in the magma as to admit of the presence of a moderate amount of sulphur vapor with free oxygen and hydrogen or of a great excess of sulphur over the other two, the bodies of sulphides along the borders of basic igneous intrusions are to be interpreted as the result of the action of "mineralizers" or of fumarole processes in the still molten magma. We have been accustomed in general in the discussions of ore deposits to only take cognizance of the results wrought by the vaporous emanations in neighboring rocks and in the formation of metallic or other minerals outside of the igneous magma itself. If, however, we imagine a molten intrusion surrounded by impervious and relatively cool walls, the emanating gases would naturally pass upward through the fluid rock and restrict their action to it, a result that coincides with our experience in finding the ore sharply confined to the intrusion.

It would appear to the writer that some of the difficulties in the full elucidation of the method of formation may be thus cleared away, and that the reactions can be founded on a sound chemical basis. The ones involved are not more apparently contradictory or interchangeable than are those involved in the experiments explained by Deville. It is to be regretted that for the above discussion the actual calories liberated in the formation of pyrrhotite, chalcopyrite, pentlandite, and the anhydrous sesquioxide of iron were not available in order to give a greater exactness to the conclusions.

As a general rule, minute quantities of sulphides disseminated in igneous rocks with which they have ascended from the depths of the earth are the most reasonable source to which to refer all ores except those of iron. Worldwide experience with volcanic vents indicates beyond question that sulphur is one of the commonest elements in volcanic magmas and of necessity is one of those taken up with them from deep-seated sources, but it may have formed the sulphides by bessemerizing the magma after it had come to a state of rest.

HOW DEEP CAN WE MINE?

By A. C. Lane.

The answer to the question how far into this planet on which man is but a parasite he can penetrate must be somewhat indefinite. It is like asking how deep a boy can dive. The water pressure and resistance can be reckoned upon, but the strength of boys varies. So in mining the difficulties are fixed, but with the advance of ages man has more power to overcome them. If before the days of explosives, before the days of steam and power drills, the Eselschacht at Kuttenberg, in Bohemia, was sunk 3778 ft., how much greater things may we expect with our present appliances. And we ought not to suppose that we have reached the goal of perfection in mining, even though we may reasonably suspect that future advances will be less important than those already made.

The ultimate depth of mining will be the limit approached by the depth that it pays to mine in the most favorable circumstances after the richest deposits and with the best of skill. We shall treat the question from this point of approach as a question of limits, and shall ask how deep it will pay to mine with due regard to the threefold conditions of reward of mining, resistance to mining, and resources of the miner both in skill and in machinery for overcoming the natural difficulties.

First, then, a passing word as to the possible reward of mining. We may leave out of account beds of solid diamonds and rubies, for if such were discovered the price of the product would immediately fall. Even a mine of solid silver, which is now worth nearly $18,000 a ton, would knock the price of silver still further down, and it is a long jump to such realities as the value of the rich Comstock lode, which is said to have averaged but $43.86 a ton. (Query: Were the stolen slimes included ?) Solid copper, such as is often found in masses in such mines as the Quincy, Central, and Cliff, would be worth $280 per ton at 12½c. a lb. Practically, however, such mines as the Tamarack and Calumet get about 50 lbs. of ingot, or but $6 to $7 a ton, since of the 4% or so of copper about ¾% is lost in stamping. From this, as per Table I., a dollar must be subtracted for expenses after the rock has reached surface, stamping, smelting, etc., leaving the value of the rock as hoisted from $5 to $6 a ton. If, however, they were not making a profit by hoisting lean rock, they could by selecting the rock get a much higher grade. The Homestake and Treadwell are working in ore which runs less than $4 a ton. The better grades of iron ore also command about $4 to $5 a ton. Thus practically $5-a-ton ore in large quantities is a promising outlook.

So much for the actual and possible rewards of mining. We turn now to our proper subject, the resistance to mining or the obstacles which depend upon the depth.

I need remark that there are many factors in the success of mining enterprises which do not depend upon the depth, such as the rate of wages, amount of water, hardness of the ore, and firmness of the walls, only to warn the reader that such things find merely incidental mention here. I assume generally favorable conditions, and most of the figures are drawn from the experience of the Lake Superior mines. This is not only the district with which I am most familiar, but one which contains the deepest mines. Some figures as to rate of wages, by which one can correct for other scales of wages, are given in THE MINERAL INDUSTRY, Vol. I. As a general thing, however, cheap labor is poor and unintelligent and associated with such climatic, social, or political conditions as largely neutralize its apparent cheapness.

I give in Table I. an analysis of the accounts of the Atlantic Mine, which is a phenomenally cheap producer, and of the Tamarack Mine, which is practically

TABLE I.—ANALYSIS OF EXPENSES OF ATLANTIC AND TAMARACK MINES, 1886–94.

ATLANTIC MINE.

	1894	1893	1892	1891	1890	1889	1888	1887	1886	1885	1884	1883	1882	1881
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
Cost of air drills, etc. (*a*)	8	9	8	9	10	11	8	9	(*b*)	8	(*b*)	(*b*)	(*b*)	....
Cost of fuel for engines	7	7	7	6	6	5	5	5	....	4	....	....	....	....
Other underground expense	51	53	57	67	69	60	58	59	58	60	61	73	83	77
Other surface expense	10	10	12	12	19	13	12	13	13	16	22	19	26	41
Total running expense at mine	75	79	84	95	104	88	84	87	81	79	93	101	118	118
Transfer to mill and stamping	26	28	28	29	31	31	30	31	30	34	42	42	41	47
Total running expense	102	108	112	125	135	119	114	118	111	114	136	144	159	166
Construction	45	34	3	11	10	14	8	4	3	5	6	6	.005	4
Total, including construction	146	142	115	136	145	133	122	122	114	119	142	150	160	170
Smelting, freight, and marketing	17	18	18	18	20	20	21	23	24	25	28	28	30	31
Total cost, less construction	119	126	130	143	156	139	135	141	135	139	164	172	190	197
Total expense to market	165	160	133	154	166	153	143	145	138	144	170	178	191	201
Thousand tons stamped	315	316	301	297	278	279	298	256	247	241	210	196	190	176
Estimated average depth	1250	1200	1150	1000	950	900	850	800	750	700	650	600	550	500

TAMARACK MINE.

		1894.	1893.	1892.	1891.	1890.	1889.	1888.	1887.	1886.
		Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
Cost of air drills, etc. (*a*)		....	14	18	21	25	21	20	(*b*)	(*b*)
Cost of fuel for engines		....	19	24	22	31	33	23	23	....
Other underground expense		....	130	134	142	165	151	140	166	....
Other surface expense		....	28	26	26	25	30	30	25	....
Total running expense at mine		....	191	202	209	246	235	213	215	201
Transfer to mill and stamping		....	46	19	47	59	64	72	85	100
Total running expense		246	237	221	256	305–303	300	285	(*c*)300	(*d*)301
Construction		60	45	80	124	05	40	01	194	267
Total, including construction		306	282	301	380	310	340	286	495	....
Smelting, freight, and marketing		72	81	77	76	107	107	128	88	82
Total cost, less construction		318	323	298	332	412	307	413	332	382
Total expense to market		378	368	378	456	417	447	414	583	649
Thousand tons	Broken	....	413	392	330	182	197	163	107	....
	Hoisted	....	369	363	301	163	179	152	100	38
	Stamped	(*e*)350	346	339	283	155	169	144	91	36
Estimated average depth		3100	3000	2900	2800	2700	2600	2500	2400	2300

(*a*) Pumping also included in the Atlantic Mine accounts. (*b*) Figures not separated. (*c*) $3.32 per ton stamped. (*d*) Per ton stamped. (*e*) Estimate not official, affecting all the figures in this column.

N. B.—The expenses after stamping depend really on the amount of copper rather than on tons of rock. The two mines are not in general comparable, as they are working different kinds of rocks. The cost of pumping is included in the cost of running the air drills in the Atlantic Mine, but not in the Tamarack. The totals vary two or three cents sometimes, owing to neglected fractions, from the results of direct addition. The expense is per ton stamped in the Atlantic Mine, per ton hoisted in the Tamarack, but practically all the rock hoisted is stamped at the Atlantic.

the deepest mine in the world, for the Tamarack is stoping rock at a depth of 4450 ft. from the surface, 3200 ft. below sea-level, and has a shaft started which will reach the lode at a depth of 5000 ft. The Red Jacket shaft of the Calumet & Hecla Mine is down 4800 (4780) ft., but they have done no work in the lode below 3300 ft.

I have tried, so far as the reports permit, to separate the items more or less dependent upon the depth of mining, and have expressed the cost in cents per ton hoisted. These figures must not be used without due consideration of the attendant circumstances, but they are sufficient to bring out that which we wish —the cost of mining until the rock reaches the surface, the small proportion of the cost directly dependent on the depth, and *the trifling effect that increasing depth has as yet had.* It has in each mine been *completely overshadowed* and counterbalanced by the effect of increasing output and general mechanical improvement. The depth of a mine tends to raise the cost directly by the greater amount of energy involved in hoisting and by the longer time of hoist, and hence the decreasing capacity of the deep shaft, and indirectly by the increasing pressure and temperature encountered. Let us consider the direct hindrances first.

1. Obviously a certain number of foot-pounds of energy is expended in hoisting so many tons of rock to the surface. But besides the ore, the skip and rope must also be hoisted. While this last leak can be largely obviated by using balanced skips, all the men, drill-bits, etc., must be hoisted and timber lowered, and finally the mine must be pumped. Now, if the water were allowed to run to the bottom of the mine this would be a serious factor, as the volume of the water increases steadily and also the distance which it must be lifted. Thus the energy used would increase more rapidly than the depth. It is therefore the usual practice to have a series of pumps, at not too great intervals, theoretically each level, to pump the water. This arrangement admits of the use of various kinds of pumps, including those air pumps which are especially useful in the case of corrosive waters, such as are likely to occur at great depths. If, as in the Quincy, an adit level can drain the upper levels, that is a great gain, as very often the bulk of the water comes from the surface, and the deeper you go the less water you find. It is decidedly embarrassing to find much water at great depths, for more reasons than one, as we shall later see. The Keweenaw mines generally have very little water at the bottom. So, for example, in one mine the water is pumped from shafts by steam pumps at various depths down to 1000 ft. The little water coming in below 1000 ft. goes to the bottom and is hoisted on cages in water cars. The Calumet & Hecla has a series of electric pumps, concerning the working of which reports conflict. The electric pumps that were installed in the North Tamarack shafts have been taken out.

The cost of pumping is in the figures of Table I. for the Atlantic Mine included in the cost of operating the air compressors. It will be noticed how small the cost must be. The modern air, electric, and Riedler pumps, capable of running, if need be, against a head of even 2350 ft. or more, seem capable of doing all the pumping necessary for almost any reasonable depth without becoming a dominant factor in the cost. We shall see that there are other more important difficulties. With all possible care and improvement there must yet be a certain amount of energy used in hoisting, and theoretically this would be proportional to the depth, but would be only about 1c. a ton for 1000 ft. hoisted if coal were $5 a ton.

If now practically we look at Table I. we see in the Tamarack that the fuel bill, where the cost of this energy should appear, is only a small part of the whole cost—less than 10%—and that it does not increase as the years go on. In the Atlantic it does seem to increase slowly, and the proportion to the whole expense —not merely the expense itself, which of course varies according to local circumstances—seems to be larger. Since in other respects the Tamarack rock is in general harder to mine, it seems to me also fair to say that the increased proportional expense of the fuel bill in the Tamarack is partly due to greater depth. We must account, then, for the yearly decrease of the fuel bill in the Tamarack by the increased output and by a greater proportion of stoping to exploratory work. The decrease shows, however, that with a given hoisting plant additional work up to the capacity of the plant costs but little additional. This we can easily see to be true.

The really important way in which depth comes in as a factor in the cost is in the larger and more expensive machinery and in the longer time required for hoisting. And of these two factors the cost of the machinery will probably be paid for long before a mine reaches its maximum depth, so that it would not enter into the question of how far we shall mine after the mine is started, except in connection with putting in an improved plant. Where a large output can be maintained the machinery cost will be slight. Tamarack No. 2 rock and shaft house and boiler and engine cost but little over $100,000—not a dollar a ton on a year's production.

The time required for hoisting is a consideration not so easily disposed of. The deeper the shaft or hoist, the longer the time required to make the trip, and consequently, other things being equal, the less the capacity and the output from the shaft. This tendency may be counterbalanced for a while by enlarging the size of skips, which involves heavier ropes and heavier machinery, by increasing the hoisting speed, and by seeing that the hoisting of men, timber, etc., does not take up too much time.

We have no difficulty in observing the progress in increasing the shaft capacity. In the last *Encyclopædia Britannica* a hoist of three tons 1548 ft. in 45 seconds was quoted as fastest. In 1886 the average hoisting speed at the Tamarack was given by Captain Daniells as 1500 ft. per minute. In the Tamarack the distance of 3000 ft., more or less, is now made in a minute and a half, while in the North Tamarack 4500 ft. takes a minute and three-quarters, which can be whittled down to a minute and a quarter. This would indicate a maximum speed of about 100 ft. a second, while in the English case the maximum speed was 50 ft. a second. The Quincy Mine shaft No. 2 has a new hoisting plant with a speed regulator set at 3000 ft. per minute. This is an inclined shaft and consequently slower. It averages three trips every 10 minutes and is working at various depths in a shaft 3600 ft. deep. The irregularity in the level from which it is hoisting causes considerable delay, and they could easily hoist steadily from the bottom at a faster rate. In another mine with inclined shafts and 5-ton skips a trip of 2900 ft. is made in 1 m. 40 sec.

Then, again, the skips are being made larger. No. 2 Quincy, just mentioned, has a 6-ton skip, and 7-ton skips have been introduced, whereas a while ago 2 and 3 ton skips were used. Man cars also are in use, to get the men up not merely more conveniently and safely, but more quickly. Even the reluctance to have visitors which obtains in certain mines is justified by the considerable expense involved owing to the delay thereby caused. All these heavier skips and this greater speed involve heavier ropes and greater strains in overcoming inertia and thus much greater liability to break ropes. Ropes have in fact been broken more often lately, I think, and though it is hard to set a limit to the march of improvement, we can see that there is a limit not far ahead, unless some means can be devised by which several skips may occupy one shaft compartment at the same time. This would of course increase the capacity of a shaft almost indefinitely. Here is a chance for the inventor. If an electric vertical trolley can be devised to do away with all the putting in motion of a great mass of wire rope, which may amount to 2 or 3 tons per 1000 ft., and permit a procession of skips to go up one compartment and down another, it would do away with the difficulty we are considering. Undoubtedly such a road could be made, but could it do the work economically?

In the mean time, we see that when the maximum capacity of a shaft is reached, any further sinking will mean a diminution of output or increased cost in shaft sinking and equipment, and if the total cost remained the same the cost per ton would be inversely proportional to the diminution. I believe this point of maximum capacity will be reached by any existing shaft within 6000 ft., but for some it may be deeper than 5000 ft. If the cost of mining for other reasons is increasing, this effect will be piled upon the other effects.

We pass next to the effect of pressure. This will increase as we go downward, both in the rock pressure, requiring heavier timbering, and in the atmospheric pressure. In face of high rock pressures it will be probably best to plan to stope so as to let the mine cave afterward. Such is the plan adopted at the Tamarack, where, however, the property lines are such as to make it particularly easy to do this. I have no figures connecting the cost of timbering or the amount of creep with the depth, for the condition of the hanging wall rock as to fissures and slips and general stability is so variable that they would amount to little. No increase of timbering dependent on the depth has been observed.

I give in Table II. figures as to the increase in rock pressure for various depths and also the crushing pressure of various rocks. From this it appears that with the hanging as rigid as hard trap a depth of at least 20,000 ft. must be attained before the rock pressure would crush it as in a testing machine. However, the conditions of crushing in a tube in a mass of solid rock are different from those in a testing machine. Granite needs less depth and sandstone requires still less. From this point of view only we see that a limit of mining regardless of cost would come near 20,000 ft.

In descending a shaft, also, we have an increase in atmospheric pressure which in a quick descent is likely to be felt as a pressure on the ear drums. The effect of this extra air pressure on the men may be dismissed in a word. What little there is is good. They get more oxygen for a given amount of breathing, and while it is true that there is such a thing as caisson disease, due to too great atmospheric pressure, men can work readily at a depth of 50 ft. of water, which would be a total pressure of about 37½ lbs. to the sq. in., corresponding to a depth considerably greater than 20,000 ft. below sea-level. (See Table II.)

The increase of pressure has more effect on compressed air than on the men, and since I know of no tables which show the application of Airy's formula to depths below 2000 or 3000 ft., I have computed also for Table II. a column showing the barometric pressure for various depths below sea-level. We must not forget in using this column to allow for the altitude of the mouth of the shaft above sea-level.

The effect on machinery driven by compressed air is to seriously diminish the efficiency. For example, a machine taking in 600 cu. ft. of air per minute at sea-level, that is, under a barometric pressure of 30 in., would give out but 300 cu. ft. of air at a pressure of 60 in.—*i.e.*, at a depth of about 20,000 ft. Thus the efficiency is inversely proportional to the barometric pressure.

The efficiency of the air drills is favorably affected by the increasing temperature, and we turn to consider this.

TABLE II.

Depth.	In Pounds per Square Inch.			Pressure by Airy's Formula of Column of Air. Temperature Correction, $\frac{T_1 + T_2 - 900}{1000}$		Loss of Efficiency in Transmitting Air at 75 lbs. Pressure Through 10-inch Pipe (*c*), Terminal Gauge Pressure.		Rise in Temperature of Rock Due to Earth's Heat from a Surface Temperature of	
	Weight of an Equivalent Column of Water.	Weight of an Equivalent Column of Rock whose Sp. Weight is 27.	Crushing Strength of Some Rocks.	In Inches of Hg.	In Lbs. per Sq.In.	2,000 Ft. Air per Minute.	5,000 Ft. Air per Minute.	40° F. 1° per 100 Feet.	60° F. 2° per 100 Feet.
....	....	....	....	30.00	14.73	75.00	75.00	40	60
1,000	433	1,170	....	31.11	15.28	....	....	50	80
2,000	867	2,340	....	32.26	15.84	74.82	73.85	60	100
3,000	1,300	3,510	....	33.46	16.43	....	....	70	120
4,000	1,733	4,680	....	34.71	17.04	74.61	72.56	80	140
5,000	2,167	5,850	(*a*) 6,350	35.99	17.68	....	....	90	160
6,000	2,600	7.020	....	37.35	18.34	74.39	71.16	100	180
7,000	3,033	8,190	....	38.75	19.03	....	....	110	200
8,000	3,467	9,360	....	40.21	19.75	74.15	69.69	120	220
9,000	3,900	10,530	....	41.74	20.49	....	....	130	240
10,000	4,333	11,700	....	43.33	21.28	73.9	68.1	140	....
11,000	4.767	12,870	....	44.99	22.09	....	....	150	....
12,000	5,200	14,040	....	46.75	22.95	....	....	160	....
13,000	5,633	15,210	....	48.57	23.85	....	....	170	....
14,000	6.073	16,380	....	50.48	24.79	....	....	180	....
15,000	6,500	17,550	....	52.49	25.78	73.3	64.1	190	....
16,000	6,933	18,720	....	54.61	26.82	....	....	200	....
17,000	7,367	19,890	....	56.84	27.91	....	....	210	....
18,000	7,900	21,060	....	59.18	29.06	....	....	220	....
19,000	8,230	22,230	....	61.66	30.28	....	....	230	....
20,000	8.667	23,400	(*b*) 23,770	64.28	31.56	72.7	60.8	240	....

(*a*) Lake Superior sandstone (Moldenke). (*b*) Franklin Mine trap (E. Kidwell). (*c*) From Ingersoll-Sargeant Catalogue, No. 50, 1895, p. 69. This shows the lowering of pressure due to pipe friction, etc., only, and is not to be confused with the loss of efficiency due to increased barometric pressure, which shows itself in a diminution of the amount of air available.

The last difficulty that we have to encounter in deep mining is the increase in temperature. In the Comstock Mine this rise in temperature was exceptionally rapid, but anywhere that we penetrate the earth we are sure to find more or less of rise in the temperature of the rocks, as we should expect when we consider that the earth is a cooling globe. This increase is, however, quite variable. At Schladebach at a depth of 1716 meters (about 5628 ft.) the temperature was 56.63° C. (133.9° F.). The well at Wheeling, W. Va., which was quite dry, reached 111° F. at 4462 ft. These were unaffected, of course, by mining operations. On the other hand, in mines the increase varies from 3° F. in 100 ft. in the Comstock lode to 1° in 100 ft. in some of our Michigan copper mines. Professor Wheeler published some figures on the rise in temperature in these mines which show this exceptionally low gradient, or rate of increase in temperature. This may be due in part to the chilling of the last glacial period felt far down, just as in Scotland Forbes found his thermometer 24 feet under ground warmest in winter, and at Lisbon 5 meters under ground it was coldest in June. The rapid increase in temperature at the bottom of the Wheeling well points the same way. Still, as the local surface temperature now is only 40 to 42° F., and since the temperature of water at its maximum density—*e.g.*, at the bottom of Lake Superior—is 39°—that is, almost the same—we cannot look back to the days of glacial Lake Warren for the cause of this cooling effect. Nor has Professor Wheeler's theory that the low gradient is due to the cooling effect of Lake Superior on the flank of the range much value for the same reason.

I am rather inclined to attribute the low gradient to the cooling effect of descending waters. We may in general expect a less increase of heat in mines where the ores are the native metals, or the carbonates, oxides, and silicates, than in mines of coal, sulphides, antimonides, etc. The reasons for this I cannot consider in this article. However this may be, it is certain that in the Lake Superior region the rate of increase of rock temperature is not far from 1° in 100 ft. from a surface temperature near 40°. For example, at 4450 ft., the bottom of the North Tamarack shaft, the rock is at 84° F. and the air temperature about 77° F. I have heard the rate of increase in the Calumet & Hecla spoken of as very low and indeed alluded to as 1° in 300 ft. This rate might be reconciled by supposing degrees centigrade to be meant and feet taken along the lode instead of vertically. President Alexander Agassiz has just given the following temperatures: At 105 ft., 59° F.; at 4580 ft., 79° F.; that is, 1° F. for 223.7 ft. Since, however, at 105 ft. the rock temperature should be near the mean annual temperature of the locality, and since the mean annual temperature of Calumet is, according to all isothermal maps, near 39°, and a mean annual temperature of 59° is found somewhere near Tennessee, I do not think we can safely assume a gradient very much less than 1° in 100 ft., after all.

So well is the importance of the temperature understood that both the Calumet and Tamarack have undertaken careful series of experiments to determine the rate of increase in temperature, and the Calumet has also investigated the influence which the mine ventilation has on the temperature. I have accordingly prepared in Table II. two columns showing the temperature corresponding to different depths, (1) if it increases 1° F. for every 100 ft. from 40° F. and (2) if it increases 1° in 50 ft. from 60° F. Now in considering the effect of temperature on men we must remember that we are long past the days of hand drilling, that tramming may be done by power at slight additional cost, if any, so that the enervating effect of temperature will have much less effect than in the old days, when mining meant hard work and lots of it. In fact, an increase of temperature up to a genial summer heat can do no harm, but will be rather an advantage than otherwise, as it actually stimulates the air drills. Beyond 100°, however, it will certainly be hard on the men, and they will have to be freely supplied with cold water. Up to 125° we have a temperature which is reached in the shade at some parts of the earth's surface. The same temperature is toward the limit of endurance in handling hot bodies, and yet the Comstock lode at 3000 ft. was worked not merely in the face of hot rock (157° F.), but of hot water, which has a greater specific heat and imparts heat more rapidly to adjacent objects. But men have worked at higher temperatures than this. The temperature of the stoke holes of steamers mounts far up, and in Captain McGiffin's account of the battle of the Yalu is said to have been near 200°. But exposure to such a temperature even for a few hours means disablement, and we quote it merely as the utmost limit of endurance.

In considering this question of temperature very much depends upon whether the heat is wet or dry. The human body retains its normal temperature, when surrounded with hot air, through evaporation, which aqueous vapor checks. Moist air also checks the cooling effect of evaporation from the walls.

Above a rock temperature of 90° F., however, cooling and not merely ventilation will become at first desirable and then necessary. Before we consider how far this may be done we shall turn from the effect of heat on men to consider its effect on machines.

We recognize that in air machines, which are the principal machines used underground and may be made to do all the work that can be done by power, reheating has long been known to be beneficial. Every increase of 5° F. above 40° adds almost exactly 1% to the efficiency. Furthermore, the rise in temperature checks the increase of barometric pressure, the depth required to reach the pressure given in column 5 of Table II. being increased above that given in column 1 by 900 plus the surface temperature plus the bottom temperature divided by 1000. There is also a loss of efficiency from the compressor to the air drill, due to the increase in barometric pressure and pipe friction, etc., as we see in columns 6 and 8. Hence the deeper the mine the higher should be the pressure of the air in the compressor. This loss is in part counterbalanced by the gain due to the increase of temperature, supposing that the temperature of the air taken in is the same. But there are other possible advantages. As the need of cooling in ventilation grows stronger the air will be taken in colder. Now, all the dealers in air-compressing machinery emphasize the gain in taking in cold air, and yet I have often seen the air taken in from an engine room whose temperature was above 60°, when the thermometer outside was near 0°, losing some 12% in efficiency. Yet this was not quite so careless or irrational as one might at first think. The air as it comes from the drills was ice cold, and a lower degree of cold might have been unpleasantly felt in the mine, or even clogged the drills with ice. Suppose for a moment that there were no loss of heat or energy in the air drill and air-compressor cycle of machinery. Then the air going through the drill would do the work that had been done by the compressor and come out at the temperature at which it went in. Such is not the case. The air discharged from the rock drills in the North Tamarack is at 32° F., but there is a corresponding effect, and so thorough is the ventilation of the copper mines, in which of course the air drills play only a small part, that a raw, chilly day is distinctly felt down in the Quincy Mine (the No. 2 shaft of which is now 3600 ft. from the dump), even on the forty-sixth and forty-seventh levels. The ventilation is also better in winter than in summer. But if the mine were so warm and the air so warmed in transit as to make the temperature of the air at discharge desirable, there would obviously be a considerable gain in taking in colder air. Moreover, in taking in colder air we should be sure to get dryer air, which is on many accounts desirable, not only making the machines more efficient and less liable to ice clogging, but it will also stimulate evaporation from the skin and from the rock and thus be cooling.

The higher the pressure of the air used the greater the effect of the rise in temperature. There are, however, a host of petty annoyances connected with very high temperature and great depth: the rock harder to handle, more care needed to look out for leakage of nitroglycerine, perhaps, indeed, a change of explosives, effect on men, etc. Water when it does occur is a very strong solvent, highly mineralized, and a very strong corrosive. The water at the bottom of the deep mine is a strong solution of $Ca\,Cl_2$, etc. It rots clothes and produces boils, and in consequence of it more than the heat the wages of the men in the Red Jacket shaft of the Calumet & Hecla have been raised. A damp heat also weakens timbering and the drill bits will be less easily kept cool. All these things become more and more serious nuisances as the temperature rises. If we ask, now, how far the temperature can be kept down by ventilation and by the air from the air drills, we have a question impossible to answer in broad generality, for which, indeed, the data are still lacking for precise particular solution. The air of the Comstock is said to have come forth at a temperature of 92° and saturated with moisture. The average temperature to which it was exposed was probably between 100 and 140°. But water has about twice the specific heat of rock and parts with it more rapidly through convection and evaporation.

In the Comstock Mine ice was largely used, for the men drank large quantities of iced water, but it is not likely that that means will ever be resorted to again, when we find that even above ground processes like the ammonia process are so largely used for cooling and for making ice.* Now, all these processes depend on expansion of some gas or volatile liquid carried through pipes to the place of cooling, and it is obvious that this is a system adaptable to mine use; not only that, but is in actual use in every air-compressor plant. Every man experienced in mining will tell you of the enormous difference in mine ventilation that has been made by the introduction of air drills. Of course ordinarily the circulation by up and down cast shafts of large bodies of air is more effective, but there are certain places even now where the compressed-air circulation is almost essential; for example, in the sinking of deep shafts, before connection is made with others, and in remote drifts and headings where there is no through circulation. Moreover, in very deep mines, unless there are a large number of openings, the question of getting enough air 4000 or 5000 ft. down a few shafts thoroughly to ventilate a large mine, the bottom of these shafts being warmer than the top, will be an increasingly difficult problem. In face of high temperatures we shall more and more have to depend on compressed air, which will at the same time cool and ventilate the mine, cool water for drinking, and do whatever work we assign it, borrowing energy from the very heat that troubles us, to assist it in

* See *Technology Quarterly*, May, 1889, article by C. H. Peabody on cost of refrigeration by air and ammonia machines.

doing its work, whether that be pumping or drilling or tramming, for which it can also be used. The air comes out from air pumps colder than from air drills, and the Ingersoll air pumps have aided materially in cooling the Baltimore rock tunnel, where a temperature of 92° F. was reached.

There is another point in which compressed air has an advantage over common ventilation. The compressed air comes forth from the compressor at a temperature of 250 to 300° F. *Hence no temperature that it meets on its way* will do otherwise than cool it. Then on being released from compression it sinks to a temperature dependent on the release of pressure and the amount of work it has to do to get free. It is commonly cold (32° measured) and not infrequently below freezing. Thus we may cool our water or produce any desired temperature at any point in the mine. The *absolute* temperature falls roughly as the cube root of the pressure in the case of free release, *i.e.*,

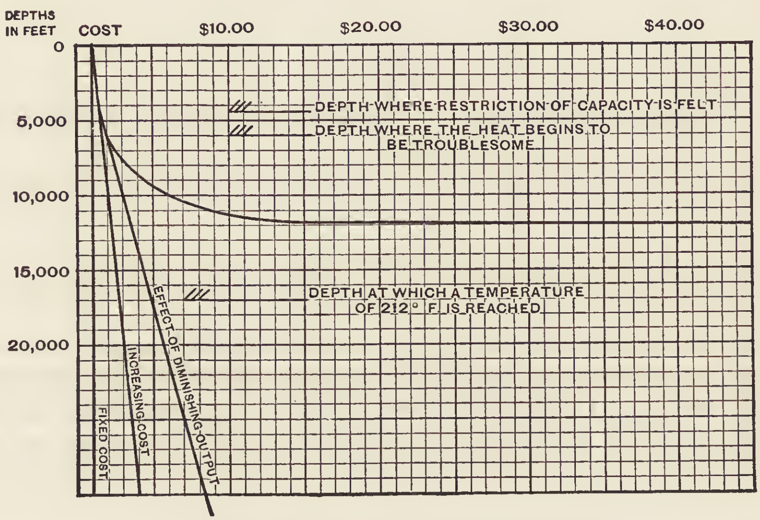
$$\left(\frac{461 + F}{461 + F^1}\right) = \left(\frac{P}{P^1}\right)^{\frac{0.41}{1.41}}$$

By cooling the air with Lake Superior water or conducting it through an underground conduit, the copper mines might put air into their compressors at not over 45° F. in summer and at temperatures about 0° in the winter at little or no additional cost.

Some light may be thrown also by the conditions of hot-water heating where a radiating surface of 1 sq. ft. to 24 to 65 cu. ft. of space to be heated is allowed. But the iron of the steam-heat system has about 32 times the conductivity, about 1.75 the heat capacity, of common rock. In mines the ratio of radiant surface to room to be heated will vary from 20 : 24 in a 6x4 drift to 2 : : *w* where *w* is the width of the stope in stoping. It would seem, therefore, that with perfectly dry rock ventilation could be maintained so as to keep the air at a comfortable temperature, even if the rocks were very hot. In the North Tamarack at present the air is 6 to 7° cooler than the rock. But when we come to ask how much the rocks themselves can be cooled down it is quite another question. The thermal capacity of air is but 0.000307 to that of 0.5 for rock, so that it will take a great deal of air to cool the rock. Probably the cooling effect from evaporation would be more important, but this will, while cooling the rock, heat the air. The heat and moisture from the miners and their lamps have not been neglected. It is, however, not difficult to see, comparing the slight thermal capacity of air and the slow conductivity of the rock, that the effect would not be deep. The Calumet & Hecla has been conducting some experiments which will be of great interest to determine how far the cool effect of the mine is felt. In general, in less ventilated parts of a mine the change in rock temperature is very slight, only a few degrees at the outside. Every fresh blast will of course expose rock of the unmodified temperature, and as soon as that gets to about 140° the expense of handling it will be much increased. It will be a very unpleasant kind of hot stuff! Of course it must be remembered that we are not discussing ordinary ventilation, but merely the modifications which interior heat may make necessary. In less ventilated winzes and levels the air temperature may rise to 90°, while the rock heat is but 60 or 70°, due, of course, to the heat of the miners, their lamps, etc. Electric lights would be advantageous if worth while.

Let us see now what we can do toward expressing the cost of mining as dependent on the depth. We will choose the most favorable circumstances, and I think the way has been outlined so that each one can make a rational discount for his particular case if the necessary figures are known.

In the first place, there are a lot of expenses—stoping, tramming, superintendence, etc.—that have no direct connection with the depth of mining. Even of these, however, many are remotely or slightly affected. For example, a man does a little less work the further he has to go to get to it. For these expenses we will assign $1 a ton, as it is curious how in different parts of the world, under very different circumstances, mining is conducted on a large scale at from $1 to $2 a ton. The Atlantic copper mine, the Mesabi iron mines, the Deadwood mines of South Dakota, the Treadwell mines of Alaska, the Ropes gold mine of Ishpeming, are



Increase of Cost of Mining with Depth.

widely different, but the cost in all is between $1 and $2 per ton hoisted. Next there are the expenses which will increase steadily with the depth—the energy consumed in hoisting, pumping, and keeping up timbering, etc. This group of expenses will be directly proportional to the depth. If we use the Tamarack and Atlantic figures and assume that from 8c. at 1000 ft. they increase to about 32c. at 3000 ft., I do not think we shall overestimate them.

The next difficulty will in some cases be the limited capacity for hoisting, in others perhaps the heat. It is obvious from what we have said that the possibilities of ventilation are so great and the good effect of compressed air so marked that up to at least 100° F. the increase of temperature will be rather an advantage than otherwise. Indirectly, however, the increased temperature of the rock may be injurious by favoring the formation of highly mineralized corrosive waters. The Calumet & Hecla has, as has been said, already raised the wages of men working in its 4800-ft. shaft, which is down to the Kearsarge conglomerate, owing to the trouble made by the water in destroying clothes and producing boils. The same difficulty is beginning to be encountered in the main mines. One must also be exceedingly careful about rubbing his eyes with his hands.

This in the most favorable circumstances will carry us down 7000 ft. As to the other question, that of capacity, it must be remembered that it will be practically met by new or enlarged shafts and more powerful hoisting machinery. But as that will also mean increased cost, the simplest way of treating this factor will be to figure on the diminished output. Now, when we ask at what depth the maximum capacity of a shaft will be reached, we ask a question that also depends on local circumstances. The Calumet & Hecla shafts can easily handle all the rock that can be got to them for a good while yet. Such shafts as the Calumet & Hecla Red Jacket shaft, now 4800 ft. down, and still more the new Tamarack No. 5, just started, which will not even reach the lode until 5000 ft., will perhaps not reach their capacity even at 7000 ft. But they are proportionately more expensive (about $1,000,000 has been set aside for shaft No. 5), and as we have assumed minimum figures for fixed and hoisting expenses, we must rather consider shafts starting from the surface and working slowly down.

Such shafts will, I think, between 3000 and 5000 ft. reach a point where enlargement or a new and more powerful equipment will be necessary. The Quincy, already mentioned as 3600 ft. deep on the lode (dip 55°), has just been extensively reëquipping. The Atlantic put down a new shaft in the last five years. Now, suppose the cost of running the mine not diminished by the diminished output. There are a large number of expenses that go on regardless of output, and though a less output means less stoping and tramming, the extra costs already mentioned will make up for this. Let us suppose, at any rate, that this is true, and that the limit of capacity is reached at 5000 ft.: by somewhat over 10,000 ft. the output will be halved, as the time of trip is doubled. Hence the cost per ton will be doubled. In other words, making due allowance for the amount of time occupied in the round trip of a skip by slowing up and loading, etc. (and if the loading is going on from different levels this is an important factor), which may be done by reckoning the depth from a point 1000 or 2000 ft. above the top of the shaft, the cost of hoisting will be proportional to the depth in a shaft too deep for its capacity.

This rate of increase in the cost may continue until the heat becomes a serious annoyance. This may happen at the temperature beyond which the fresh-broken rock will be too hot to handle. It is at the same time a temperature which has been faced in the Comstock lode, and not as high as those which were met in the very wet and hot drifts. Even below this temperature the heat would be a serious annoyance if the mine were a wet one. This temperature will be reached by the Keweenaw mines at the present rate at about 8000 ft. Below this depth the expense due to heat will rise more and more rapidly. It will be remembered also that this extra cost must be divided among an increasingly smaller number of tons output, so that from here on the cost will rise more rapidly yet. We may safely put 234° F. as the limit of possible temperatures even at the most exorbitant cost. Rocks full of steam instead of water would probably give it off too rapidly for any system of ventilation and cooling, and steamed timber would have no supporting power. This temperature will then be the asymptote of our curve of costs. We thus get the outlines of the curve I have sketched, from which it appears that mining may be carried to a depth of nearly 10,000 ft. under the most favorable conditions at a cost of less than $10 a ton.

We may thus reasonably expect some of the Keweenaw mines to reach nearly this depth. They are indeed hoisting rock that is not worth $10, but by a little selection of ground they could much raise the average. When the increasing depth proves too much for the capacity of the existing shafts and is at the same time so great as not to justify the cost of more shafts (and the preparation which has been made for the cost of sinking the Tamarack No. 5 shows that at some depth that point will be reached), then, though the output must be curtailed, much ground now hoisted and paying well could be left standing so that the value per ton of the selected rock would run above the 40 to 50 lbs. of copper to the ton that it now yields, and at the same time the cost of timbering would be reduced. On the other hand, we may not apply the above figures to other lands without considering what the rate of increase of temperature is there.

I trust that this paper, general as it must be, has nevertheless pointed out the things to be considered in estimating the available depth of mining, and has figures which will help one who will apply them with suitable modifications to estimate the probable cost of deep mining elsewhere. It may, indeed, be urged that by suitable provision in the beginning the enhanced cost due to the depth outgrowing the hoisting capacity may be overcome. To a certain extent this is true, but there will be a corresponding increased initial cost. Of course after the mine is once started this increased first cost cuts no figure in determining how deep mining will be prosecuted. But it does cut a figure in the eye of the business man in planning his works.

The Tamarack is a good illustration of a mine planned to work at depth. Here such planning was necessary, as they did not strike their lode until 2270 ft. Their cost is higher than the figures I have given, but owing to an increasing output the cost per ton has been diminished since starting. The limit of capacity with depth has not been reached, for the sinking of No. 5 is due as much as anything to the fact that their lode dips so flat ($37\frac{1}{2}°$) that it is getting uncomfortably far away from their vertical shafts, so that little or no sinking has been done on No. 1 for the past year.

For such a mine as the Tamarack we may, therefore, have put the point of maximum capacity rather too high, but the cost will hardly fall below the curve given because at 3000 ft. it is so much higher. It may probably approach the curve. If the surface temperature were 60° F. and the rate of increase 1° in 50 ft., which is the more usual rate, a glance at Table II. will show that so far as heat is concerned 5000 ft. would be as bad as 12,000 in the exceptionally favorable region of Lake Superior. On the other hand, in the northern part of Siberia or Alaska, as at Yakutsk, where the ground is frozen for 700 ft., if the rate of increase of temperature were slow enough the circumstances might be yet more favorable, the temperature at a given depth less, and the supply of air for cooling the mine colder.

I cannot close without one more suggestion. The United States Geological Survey has subsidized the boring of a well at Wheeling, W. Va., and the German

Government one at Schladebach for the light they would throw on geological problems. Now, the bottom of a deep shaft would furnish an admirable place for a boring, either by diamond or churn drill, with fine opportunities for hoisting core barrels, etc. In fact, the wire rope of these deep shafts has a good deal more churn—that is to say, up-and-down spring—to it than is ordinarily pleasant or desirable. I sincerely hope that when we have what we may be fairly sure is the deepest shaft on Lake Superior its bottom may, before it is abandoned, be used for such an exploratory boring. If to the depth of this shaft be added the depth of such a boring as that planned at Parvschovitsch, in Silesia (8200 ft.), or even the 5000 ft. regularly advertised, what a magnificent record we should have. Thus and thus only may we attain some direct knowledge of the state of affairs 15,000 ft. beneath the surface.

To sum up: the conditions of the deepest mining must be—on the part of nature, valuable deposits, low surface temperature and low increase of temperature, a dry mine, and a firm country rock; on the part of the miner, economical management, balanced skips or something better, rapid hoisting, and good ventilation, involving a large use of compressed air at increasing pressure, from the coldest and dryest possible source.

It seems to me that under the able management of the men in charge in the Lake Superior mining region we are likely to have a conjunction of all the most favorable circumstances, except that the deposits might be richer.

To be sure, it will be impossible to keep up the rate of increase in production which has made the cost per ton grow less. The Calumet & Hecla has been unreliably reported as reducing its output from 160 tons copper per day to about 6,000,000 lbs. per month. But on the other hand, an enormous amount has been spent in surface equipment, in the elaborate system of water works by which water is obtained from Lake Superior, 5 miles off and 700 ft. below, which will not need to be repeated.

In conclusion, then, we may confidently expect that mines 10,000 ft. deep and enormously rich deposits might lead man to fight his way well toward 15,000 ft., but from our present knowledge we cannot foresee his ever reaching 20,000 ft.

I trust that the numerous friends who have given me personal information, as well as the long list of prominent firms who have so kindly answered my inquiries regarding the working of air, electricity, rapid hoisting, etc., whose names are among the *Engineering and Mining Journal's* advertisers, will pardon my omission of personal acknowledgment. Their name is legion and would resemble Homer's catalogue of ships.

THE FORCE OF THE UNITED STATES MINERAL-LAND PATENT.

By Rossiter W. Raymond.

The policy of the United States as regards the disposition of its public lands has been settled by a long series of legislative acts and judicial decisions, in the light of which the special provisions of the United States mining law are to be interpreted. After the unsatisfactory experiment, lasting from 1807 to 1846, of leasing the lead mines in the public domain of the Northwest, all idea of making such use of the mineral lands owned by the United States was abandoned, and they have been regarded ever since (except for a brief period, from 1866 to 1872, of which I shall speak presently) simply as tracts to be sold outright, like agricultural lands.

That a United States patent for land passes to the patentee (in the absence of explicit reservations authorized by law) all the interest of the United States, whatever it may be, in everything connected with the soil or forming any portion of its bed or fixed to its surface—in short, everything embraced within the term "land"—was declared long ago in the cases arising out of the Mexican land grants in California (see Fremont *vs.* Flower, 17 Cal., 199, and other cases). The very acute and sound decisions of the Supreme Court of California in these cases (the chief credit for which is due to Stephen J. Field, now on the bench of the United States Supreme Court) may be said to have placed upon indestructible foundations the public-land system of the United States, the corner-stone of which is the completeness and invulnerability of the title of the patentee. It is worthy of notice that in these cases the land in question had been granted by the Mexican Government with reservation of the precious metals, the deposits of which that government has always claimed to own, and the ownership of which therefore passed, under treaty, unimpaired by the agricultural grants, to the United States. Nevertheless, it was held that, in confirming the Mexican grants and issuing its patents for the territory, the United States actually conveyed to the patentees rights which they had never obtained from Mexico, on the broad principle that the unqualified grant of a patent for "land" *gives all.* In other words, though the United States might have reserved the mineral right, it could only have done so in explicit terms, failing which, all its interests passed with its patent. The wisdom of this timely decision is universally admitted. Unquestionably it saved us from an intolerable chaos and confusion. No one who has carefully studied the subject can fail to perceive that there is no practicable middle course between the Mexican system and our own. Unless the United States Government is to retain the ownership of its mineral lands and lease them upon royalty, as is done in Mexico, it should sell the minerals with the land containing them. The former course no one advocates. It is inconsistent with the spirit of our Government and people. But all its evils, without any compensating advantages, would be involved in a half-way policy, by which, after the sale of public lands, the Government should retain an indefinite or dormant ownership of a part of their contents.

Prior to the act of July 26, 1866, digging for minerals on the public domain was a trespass, restrainable by injunction and entitling the Government to damages. This principle was never enforced by the Federal Government on the gold and silver bearing lands of the Pacific Coast and the Rocky Mountains; but it was clearly laid down, early in this century, in the case of Gear (3 How., 120), in which the defendant was held guilty of trespass in mining for lead upon the public lands in Illinois.

The act of July 11, 1846, authorized the sale of the reserved mineral lands in Illinois, Arkansas, Wisconsin, and Iowa. The reserved mineral lands in Missouri had shortly before been offered at sale; and those in Michigan were offered in 1847. The act of September 26, 1850, abolished the distinction between agricultural and mineral lands in Michigan and Wisconsin.

Every one of these steps was simply a measure for the sale of land previously reserved from sale; and the title to such land conveyed by the United States patent was absolute and comprehensive, including everything comprised, according to common law, within the term "land."

Meanwhile, the ownership of the United States in the mineral lands of the States and Territories of the Rocky Mountains and the Pacific slope was not asserted against the pioneers and prospectors who were overruning and rapidly developing that vast and mostly unsurveyed region; and a system of possessory titles, under local laws and customs, had grown up, which was respected by State, Territorial, and Federal courts (Section 910, R. S.).

The act of July 26, 1866, formally threw open the mineral lands of this region to exploration and occupation. This statute was an attempt to legalize the possessory system which had grown up in the absence of Federal legislation, and under which the possessory owner claimed the discovered and located lode, with only the use, for mining purposes, of the surface overlying his mine. Section 2 of the act authorizes the claimant of a lode to file a diagram of the same (*i.e.*, a diagram of the location) and to "*enter such tract and receive a patent therefor*, granting such mine, together with the right to follow such vein or lode, with its dips, angles, and variations, to any depth, *although it may enter the land adjoining, which land adjoining shall be sold subject to this condition.*" Section 3 provides that the patent shall issue upon payment of *five dollars per acre*, etc.

The phrases I have italicized above certainly indicate a sale of land. The clause "although it may enter the land adjoining" implies that in the absence of this provision the owner of the land adjoining would unquestionably own that portion of the lode which was within it. And the direction that the land adjoining shall be sold subject to this condition clearly indicates that in such sale the

United States would part with its entire interest in the land. The one apparent exception was in favor, not of the United States, but of a specified third party, who had previously become or might subsequently become, in a specified way, entitled to benefit by it.

But "the land adjoining" in the act of 1866 was practically held to mean only non-mineral land, and the mineral land embraced in the patent to a miner was practically held not to have been really "sold" at all; for the practice of the Land Office and of the courts under the act of 1866 was to regard the title of a patentee to the surface of a lode location as an easement only, subordinate to the ownership of the lode, and as insufficient to exclude trespassers above or under ground, so long as these did not intrude upon the patented lode or interfere with the working of it.

The correctness of this construction it is now too late to challenge. Probably it could never have been successfully overthrown. A case or two in the Territorial courts, in which the lode locator under the act of 1866 obtained an injunction against parties "exploring" within his claim, encountered prompt reversal on appeal; and although this appeal was not in any case, so far as I know, carried as far as the United States Supreme Court, that tribunal seems to have accepted the view that the land of a lode location was not fully conveyed by a patent under the act of 1866, though it was paid for by the acre. Certainly the practice of the General Land Office was based on this view; for patents were granted without hesitation for conflicting locations covering in parts the same territory, and each locator paid $5 per acre for the whole of his location, though portions of it had been similarly paid for by one or more previous patentees. In other words, the United States sold the same land over and over again to successive applicants, on the theory that it was not really the land, but a certain right to use it, that was granted, and that each new purchaser acquired that easement in connection with a new lode. In the use of the right the prior locator had the preference. The land itself, subject to this easement, remained the property of the United States; but the title of the United States was not set up in cases arising between mining locators, except so far as it barred the right of any locator to eject intruders from the surface of his location.

The experiment was, however, brief. In 1872 the present system was introduced, and if there had been in 1866 a departure from the established principles of the public-land laws, the return was clearly made.

The features of the act of 1866 are important to the present discussion only as showing beyond doubt that the effect of the reservation of the extra-lateral lode rights of neighboring locators upon the title of a purchaser of public land applied under that act certainly (and perhaps exclusively) to the holders under ordinary agricultural-land patents. In other words, all land titles were (and, as will be shown, still are) affected alike by this reservation.

We now come to the consideration of the law of 1872 as embodied in the present Revised Statutes.

Section 2318, R. S., reserves from sale in all cases, except as directed by law, "lands valuable for minerals."

Section 2319 declares all valuable mineral deposits in surveyed and unsurveyed public lands to be free and open to exploration and purchase, "*and the lands* *in which they are found to occupation and purchase,* by citizens," etc. This distinct mention of the occupation and purchase of the *land* was not in the act of 1866.

Section 2325 prescribes the manner in which a patent for *any land claimed and located for valuable deposits* may be obtained.

These three sections, 2318, 2319, and 2325, constitute the foundation of the title under the mineral-land patent of the United States. The first declares that mineral lands shall not be sold in any other way than as prescribed by law; the second declares that all the mineral lands *are* for sale; and the last prescribes the manner of sale and the delivery of title by patent.

It is a common mistake to look to Section 2322, R. S., as the basis of the grant made by a mining patent. *That grant is based upon Section 2325, as modified by Section 2322.* For the sake of clearness I give the text in full:

SEC. 2322. The locators of all mining locations heretofore made or which shall hereafter be made on any mineral vein, lode, or ledge, situated on the public domain, their heirs and assigns, where no adverse claim exists on the tenth day of May, eighteen hundred and seventy-two, so long as they comply with the laws of the United States, and with State, Territorial, and local regulations not in conflict with the laws of the United States governing their possessory title, shall have the exclusive right of possession and enjoyment of all the surface included within the lines of their locations, and of all veins, lodes, and ledges throughout their entire depth, the top or apex of which lies inside of such surface lines extended downward vertically, although such veins, lodes, or ledges may so far depart from a perpendicular in their course downward as to extend outside the vertical side lines of such surface locations. But their right to possession to such outside parts of such veins or ledges shall be confined to such portions thereof as lie between vertical planes drawn downward as above described, through the end lines of their locations, so continued in their own direction that such planes will intersect such exterior parts of such veins or ledges. And nothing in this section shall authorize the locator or possessor of a vein or lode which extends in its downward course beyond the vertical lines of his claim to enter upon the surface of a claim owned or possessed by another.

This section conveys to the lode locator that title of the United States to located land which was not given by the act of 1866 as generally construed. I am aware that in some of the district courts the attempt has been made to draw a subtle distinction between "the exclusive right of possession and enjoyment of all the surface," here granted, and the absolute grant of the land and its contents (qualified only by the condition in favor of the extra-lateral rights of neighboring locators). According to such reasoning, proceedings in trespass and ejectment would lie against intruders on the surface, but not against intruders underground. But this view appears to me quite untenable, even as regards the rights of the locator; and at all events, when those rights have been confirmed and defined by a patent, it is perfectly clear that they must comprise a complete title to the land and its contents, except as to explicit reservations made in the patent. This is the very essence of the fundamental decisions of our courts cited by me at the beginning of this article. As I have shown, those decisions concerned United States patents issued in confirmation of surface grants only. The original Spanish grants reserved certain mineral rights. But the United States patents confirming the grants did not repeat this reservation, and were therefore held to have conveyed the whole title of the United States. It is too late at this day to unsettle the principle thus established, and it may be safely assumed, therefore, that a mineral-land patent issued in accordance with Section 2322, R. S., confirms to the patentee the ownership of the land, subject only to an express reservation as to certain lodes therein.

In cases where patents issued under the law of 1866 cover overlapping locations, the present law simply makes the first locator of each piece of ground common to two or more locations the legal owner of it, subject to the easements already granted by the United States to others.

Now, if Section 2322 should be struck out of the law (without reviving the act of 1866), public mineral lands would still be open to occupation and purchase under Section 2319 and purchase could still be made under Section 2325. But in that case the purchaser would receive the "common-law title," neither more nor less. Under the modification effected by Section 2322, the lode locator acquires on the one hand something and on the other hand loses something not contemplated by the "common-law title," namely, the extra-lateral rights upon lodes having their apexes in his ground, on the one hand, and the corresponding subjection to the extra-lateral rights of neighboring apex owners, on the other hand. The exclusive right of possession and enjoyment of all the surface within the lines of the location would accrue to the *patentee* by virtue of the patent if Section 2322 did not exist. But this section secures it to the *lode locator*, for the double purpose of protecting his possessory occupancy prior to application for patent and of limiting by express terms the operation of the extra-lateral lode rights of his neighbors. This is done also in the last sentence of Section 2322.

That this view of Section 2322 is correct appears further upon considering the fact that the section refers explicitly to lode locations only. Placer locators who take no steps to become purchasers are neither endowed by this section with the exclusive right to the surface nor required under Section 2324 to maintain possessory title by annual expenditure. Yet they do unquestionably obtain the exclusive surface right when they proceed to obtain patent, for the simple reason that this is the meaning and purpose of a patent as contemplated by Section 2325 of the Revised Statutes.

Section 2322, I repeat, is not the source of the grant contained in a lode patent. It is a modification affecting all titles to land sold by the United States outside of certain accepted regions. Concerning the special addition which it makes to the rights of a lode locator, I raise no question here. The point I wish to consider is the deduction which it makes from the rights of all purchasers of public land. Subject to that deduction, they have the fee simple. Now, what is the nature of that diminution of the fee ?

1. It is not a reservation of the title of the United States to veins partly within a patented tract which have their apexes outside of it. The reservation expressed in the act of 1866, and conceded to be neither more nor less than that in the present law, is in favor of a specified third party, namely, the lode locator, whose location shall include the apex of the lode concerned. If that third party is already in existence at the time of the sale of the land, then his rights are already in force, and the United States sells to the land purchaser the whole of its remaining interest. If the third party is not yet in existence (*i.e.*, if the apex of the lode has not yet been covered with a lode location), then the United States reserves the right of the future locator, not to itself, but to him. The portion of the lode within the ground which may be affected by such a reservation is not a remaining portion of the public domain. The United States could not make any other disposal of it. Nor has the United States, or any other party except the one specified lode locator, any right to intrude upon it. The Government

has sold to the patentee everything in the land, and gives him a title "ironclad" against all persons except that one specified person.

2. More than this: if for any reason or in any way that person should forfeit the extra-lateral lode right (as he might do by making an agricultural location instead of a lode location or by making a fatally defective lode location), then the land purchaser has a perfect title to the portion within his ground of the lode concerned.

This was, I think, clearly declared by the United States Supreme Court in the well-known case of the Iron Silver Mining Company *vs.* the Elgin Silver Mining and Smelting Company (118 U. S., 197). In that case the Elgin Company (plaintiff below) sought to eject the Iron Silver Mining Company from ground beneath the surface of plaintiff's patent. The defense was an apex right arising from the adjoining Stone claim, which belonged to the defendant. The Supreme Court decided on the appeal that the lines of the Stone location were so drawn as to forfeit the extra-lateral rights of that location, and declared, *not* that the part of the lode in question was consequently a remainder of the public domain; *not* that the owners of the surface could not eject intruders from it; but that "the premises in controversy are admitted to be under the surface lines of the Gilt Edge claim eastward from the defendant's claim, *and the plaintiffs were therefore entitled to recover them.*" In other words, the neighboring locator having forfeited his extra-lateral right, the surface owner's common-law right was complete. It follows, further, that if the same lode should be found to continue in its downward course into ground covered by a location (of whatever kind, agricultural, lode, or placer) beyond the Gilt Edge, the surface owner of that location would own whatever part of the lode was included beneath *his* surface. All extra-lateral rights having been once for all extinguished as to that lode by the failure of the only party who could acquire them to legally do so, that which takes their place is not the miserable burlesque of a buried public domain with no land attached to it, but the honest, sound, simple title to the land itself with all that it contains, which the seal of the United States attests.

3. An analogy to the situation, presenting also instructive differences, may be found in the case in which real estate is held by a devisee, subject to a contingent limitation of the fee in favor of an heir yet unborn, who, if born, will inherit the property. In such a case it is clear that whenever (as, for instance, in the event of the death of the prospective parents without issue) the birth of the expected heir is rendered impossible, then the cloud upon the title of the occupant of the estate will be completely removed. (This parallels the case of a land owner whose neighbor has forfeited the extra-lateral lode right.) But while the birth of the heir is still possible, the occupant is unquestionably the owner of the property as against all others. He may possess and enjoy it fully, except that he may be held responsible for waste of the estate.

To make the illustration clearer, we may imagine such a limitation to run with the land, so that the occupant might sell his title to another as freely as if it were a fee simple. This parallels the case of a land owner under United States patent in Colorado, for instance, who has as yet no neighboring lode locator. He owns the ore bodies that are within his land, whether their apexes are within or without it; he can possess and enjoy them; and he is not responsible for any waste of the estate that he may commit by mining and removing their contents. In this point probably the analogy between the two cases breaks down. At least, while the extent and nature of the responsibility of an occupant to an unborn heir is matter of some doubt, there is no doubt at all that the occupant of mineral land, whether by patent, or location, or mere possession under Section 2319, R. S., is not responsible for waste to anybody prior to the initiation of a private title superior to his own. Thus the patentee is for all practical purposes the complete owner of a certain body of valuable mineral within his land, and may mine and sell the valuable mineral from it until the day when some other person locates a claim, outside of his land, containing the apex of that body. From that time on he may be held liable in damages to the new lode locator for mineral extracted and sold; but no one will pretend that he could be made to pay to the new lode locator, or to the United States, or to anybody else, damages for what he had previously extracted. For the United States does not grant to each lode locator a virgin lode. It gives him his lode location with its appurtenant rights, whatever they may be. Many a non-patented lode claim has been worked, abandoned, relocated, and reabandoned, over and over again, before it finally came to be patented. At each relocation the locator has taken what he found. More or less of the lode may have been removed by previous occupants and explorers, but he has expected no compensation for that.

And when the United States reserves, in favor of a future lode locator, a certain extra-lateral right within the boundaries of a granted tract, it reserves only the right of that "unborn heir" to the estate, in the condition in which it may be when his birth takes place.

The nature of the diminution of the title of a land patentee by the extra-lateral lode rights of neighbors is most clearly indicated by the language of the act of 1866 (Section 2), "which land adjoining shall be sold subject to this condition." It is a *condition*, not an *exception*. The difference between the two is so well established in law that this statement needs no further comment. I would simply emphasize the significance of the fact that in this, the only direct reference ever made in a Federal statute to this matter—the passage which, although not contained in the Revised Statutes, confessedly constitutes the basis of their construction and administration and has shaped the practice of the executive departments of the Government for nearly twenty-five years—the definite legal term "condition" is employed.

4. The extra-lateral right of a lode locator, which thus originates a "condition" of the title to neighboring land conveyed by patent, is dependent upon compliance by the locator with the requirements of the law; and in determining the fact of such compliance the provisions of the law are to be construed strictly against the claimant of the extra-lateral right. For the latter is a special privilege, bestowed on certain conditions; and if these have not been fulfilled, the force of the patent, under the general principles already explained, must override any presumption in favor of the claimant.

For instance, in order to be entitled to the extra-lateral right the location must be made "on" a lode "situated on the public domain;" the "end lines" must be parallel, etc. These provisions are vague and the courts have not yet finally settled their meaning in all respects. But whatever the ultimate answers to such questions may be, three things are clear, namely:

a. That there is some relation between the form and position of a location and its claim to extra-lateral rights, and some lode locations (as, for instance, the Stone claim, in the Elgin case already cited) fail to carry such rights and become merely tracts of mineral land under the same title as placer locations.

b. That the relation between the lode and the location, on which the extra-lateral right depends, concerns the located lode only, and not any other lode which may be within the location (*e.g.*, if the Stone claim, for the reasons given by the Court, had no extra-lateral right on the Stone lode, then it could have none on any other lode; the extra-lateral right to "all" lodes apexing within the location having been based by the law upon the correct location on the Stone lode).

c. That the requirements of the law, whatever they may be held to mean, should be strictly enforced as conditions of the extra-lateral right.

5. It is the latter proposition which seems to be very generally ignored. A great deal is said about the miner's right, and the hardship and injustice to him of having it curtailed by reason of failure on his part to fulfill the requirements of the law. This feeling had its origin before the present law was adopted and when priority of discovery was recognized as a ground of locator's rights. Under such circumstances, there was better foundation for the feeling than under the present "law of the apex," which puts the right of discovery altogether in the background. A simple example will show the difference thus effected in the situation.

A discovers by pits a lode which does not come to the surface, and locates on what he supposes to be its highest edge or apex. But B, who has subsequently located on another lode, alongside of A, finds the true apex of A's lode to be in his ground. He can claim that lode, regardless of A's prior discovery and location, by virtue of his own extra-lateral right. Should not B be strictly held to the conditions of that extraordinary right before he is allowed to enforce it?

Even when priority is with the claim it may work injustice to a later claimant. Irregularities in the earlier location may affect inequitably the rights of the later one. The first locator has had the opportunity to make his location so as to secure the benefit of the extra-lateral right, but has failed to do so. The second, respecting the lines of the first, makes a strictly proper location upon a lode which leaves the first location through a side line, and the side line of the first location is made an end line for the second. The lode in question, let us suppose, is not the one upon which the first location was made, and was first discovered by the second locator, though partly covered in ignorance by the location of the first. That the claims of the first should be strictly construed in favor of the second seems to follow not only from natural equity and legal principles, but from the words of the decision in the famous Flagstaff case, in which the Supreme Court, speaking of a locator whose claim is laid crosswise of the lode, says: "If he does locate his claim in that way, his rights must be subordinated to the rights of those who have properly located on the lode." In that case the circumstances were different; but the spirit of the remark is significant.

ELECTRICITY IN MINING WORK.

By Timothy W. Sprague.

In the electrical field the year 1895 was marked by an increase in the number of applications of electricity to the transmission of power in mines and to the operation of mining machinery, rather than by new discoveries or notable improvements in methods or apparatus. This activity was apparent throughout the entire field, both in coal and metal mining. The subject can perhaps be best considered by taking up its several branches in succession.

Transmission of Power.—A number of important installations for the transmission of power have been made during the year, many of them for purposes other than mining, but interesting nevertheless as examples. The number of water powers—some valuable, some probably worthless—to which rights have been taken by promoters would furnish a volume of business in this direction in years to come, and doubtless many of the plans will be carried out. The use of the alternating current in several different forms has made possible the transmission of enormous amounts of power over distances which a few years ago would have been considered absolutely prohibitive.

The patent situation regarding alternating-current apparatus is interesting. Despite claims of exclusive ownership on the part of one company, several companies are in the field offering multiphase alternating-current apparatus, and the business does not seem to be affected by possible complications to follow. In England, possibly from the greater caution and conservatism there prevailing, but little has been done in multiphase transmission, and probably little will be done until the patent situation has been straightened out.

The Niagara Falls transmission plant remains the most prominent of its class in this country, although in many features it is surpassed by the plant started during the summer in California, by which the city of Sacramento is supplied with 4000 horse-power from the falls of the American River at Folsom, 26 miles distant. This plant was started July 14, 1895, and has been successful from the start. The power house contains four 750-kilowatt three-phase generators of General Electric type, direct coupled with four water wheels. The voltage of transmission on the line is 11,000. The power is used in Sacramento for driving the entire street-railroad systems of the city, for all the city lighting, both arc and incandescent, for general power purposes, and for heating. A telephone circuit consisting of two No. 12 bare copper wires is run on the same poles carrying the high voltage power wires and works without difficulty.

The Nevada County Electric Company has in operation a transmission in California using power derived principally from the south fork of the Yuba River, 1800 ft. above the power house. Pelton wheels operate Stanley two-phase generators of 1000 horse-power total capacity, and wound for a potential of 5500 volts. The line for distribution is 8 miles long, passing through Nevada City to Grass Valley, and consists of eight No. 3 bare copper wires carried on poles with two cross arms and supported on triple petticoat top-grooved porcelain insulators 5 in. across the bell. The greater part of this power is for mining uses in Grass Valley, where the high cost of fuel had seriously curtailed mining operations. The generators are guaranteed to have a commercial efficiency of 94.6% and an electrical efficiency of 98%, while the line loss is 5%, so that the efficiency obtained from the water-wheel shaft to the motors at the points of application is 89.87% for 1000 horse power carried 8 miles. The present installation is only a portion of the plant contemplated, and as enough business is already contracted for to provide for the fixed charges, additions will probably follow in a short time.

The plant described in Vol. III., which supplies the Standard Consolidated Mining Company of Bodie, Cal., with power from a waterfall over 12 miles away, the Westinghouse single-phase system being used, has been enlarged at the point of application of the power, the electric apparatus having proved satisfactory and reliable.

The plant now under construction for the San Joaquin Electric Company of Fresno, Cal., while not for mining purposes, contains some features of interest. The 1400 horse-power of generators, three-phase General Electric type, is obtained from a 1410-ft. head of water which has to be carried only 4000 ft. to obtain this head. The line here is 35 miles long and consists of six No. 3 bare copper wires.

The Big Cottonwood Company of Utah is installing generators of nearly 3000 horse-power capacity at a water power 15 miles from Salt Lake City, the power from which will be transmitted by three-phase alternating current into Salt Lake City and then utilized for general power, lighting, and railroad work. These are but a few of the many power-transmission plants installed or under contract, but they serve to show the character of such installations and illustrate the possibilities in such work for mining purposes.

In other countries there has been marked activity also, and American electrical manufactures are becoming an important item of export trade. In Mexico, in the State of Hidalgo, about 100 miles north of the City of Mexico, is a water power on the Arroyo del Regla with a minimum capacity of 1500 cu. ft. per minute, and a head of 800 ft. is obtained. This power is utilized by 5 Pelton wheels and five 400 horse-power three-phase generators of General Electric manufacture wound for 700 volts. Step-up transformers raise this to 10,000 volts for transmission. The power is distributed at distances varying from 18 to 23 miles from the power station, and is applied to all varieties of mining work for the Real del Monte Company, which employs over 8000 men and whose works are scattered over the country within a radius of 20 miles. Pumps, hoists, stamp mills, crushers, and ventilators are electrically operated. One motor of 150 horse-power and one of 100 horse-power operate reduction mills. Two 50 horse-power motors are geared to Dow pumps formerly operated by steam. Three 50 horse-power motors drive Chilean mills and rock crushers. Four 75 horse-power motors are operating triplex plunger pumps 7¼x12 in., and two of about 20 horse-power each are used with sinking pumps. The cost of steam power in this district was about $250 per horse-power per year, and it is not surprising, therefore, that the capacity of the generating plant has been contracted for at such remunerative rates that the entire transmission plant, costing about $300,000, will be paid for in two or three years. The current is transformed by step-down transformers to different voltages as required for different work at the substations throughout the district. Low voltages are generally used where the apparatus is below ground and has to be handled, and higher voltages for the large stationary motors for surface work or where little handling is required. For instance, the sinking-pump motors are wound for 110 volts and some of the stationary-pump motors are wound for 1000 volts. The sinking pumps have a capacity to handle 150 gals. per minute each against 300 ft. head. Everything about the driving mechanism is water tight, so that they may be completely submerged while in operation. A very ingenious mechanical device allows the multiphase motors a full starting torque with high running efficiency, so that the pumps can be started under full rated load and over. Other Mexican plants already in operation have added to their electrical equipment.

In Japan, at the mines of the Ashio Copper Company, an American mining locomotive of about 30 horse-power capacity has been installed. It is built for 24-in. gauge track and operates at a speed of 10 miles per hour on a voltage of 450.

South America is also using electric apparatus in transmission work. Illustrating its reliability, so important in isolated locations, a letter from the purchaser of a plant in Peru states that on the trial run of his apparatus the machines were kept in operation four days and four nights without a single stop, and the plant was then shut down to repair a belt lacing which had been put in for only a short run.

In the Singapore tin-mining district electricity is now employed to transmit power used in pumping and miscellaneous work and for lighting.

The use of electricity for power transmission using steam for initial power has received much attention in the technical press during the year. For coal-mining operations with the natural advantage of cheap fuel the centralization of power plants is worthy of careful attention, and in one or two cases where such a plant has been put in operation its success has justified expectations.

The South African Republic has been a particularly active field for electric work of this character during the year. The Consolidated Gold Fields of South Africa, with headquarters at Johannesburg, has ordered mining apparatus aggregating many hundred horse-power for pumping, hoisting, haulage, and ventilating. One order was for ten 75 horse-power Knowles triplex pumps, 5½x8 ft., equipped with General Electric multiphase motors. With these were ordered two 350 horse-power three-phase generators direct connected to Ide engines, the entire outfit to be shipped complete.

Other orders received from the Transvaal include a transmission plant and four electric locomotives for the Simmer & Jack Gold Mining Company. In the Chartered Company's territory the Willoughby Consolidated Company has ordered for its mines at Buluwayo a complete electric generating equipment for power and lighting; the first application is to be made to four Lidgerwood hoists.

The arrangement consummated in March, 1896, between the General Electric and Westinghouse companies, the details of which are not yet made public, but which it is expected will put an end to expensive patent litigation between these two coporations, will have a particular bearing on long-distance transmission installations, as one of the principal clashes was on multiphase-current apparatus for this purpose. It is generally supposed that the truce does not extend beyond the limits of the United States, so that the hesitancy in adopting multiphase transmission abroad will probably not be affected.

The development of induction motors which have no commutators and no brushes is of great interest in connection with installations in fiery mines where the sparking at the commutator on direct-current motors is a menace. The introduction of such motors will give interest to the subject of safety wiring, which up to the present time has received little or no attention in this country, but is widely discussed in England.

A plan which will undoubtedly meet with general favor for the distribution of high-tension currents overground and their introduction underground through bore holes from the surface, after having been transformed at the surface to low potentials, has been tried and is successful. This plan does away with all peril from carrying dangerous pressures on wires in confined spaces, and at the same time shows a marked economy in cost of copper over using low potentials throughout. The cost of drilling bore holes where steam is employed, as would be necessary in the case of new work before the electric installation was complete, is approximately $2 per foot for the formations usually overlying the coal measures. In most cases the electric plant would be in operation before the need of the overground high-potential transmission were realized, in which case electric drilling would be employed. A 500-ft. hole 6 in. in diameter would on the steam-drilling basis cost $1000. With copper at 15c. per lb. this would mean an expenditure equal to an investment in 6667 lbs. of copper. But if, for example, by this means several hundred horse-power could be delivered in the mine a distance of two, three, or more miles from the central generating station, using a voltage of 5000 or 10,000 for transmission, when otherwise this transmission would have to be made underground at a potential of 250 or 500 volts, the bore hole would be the better investment, notwithstanding it would have no value as an asset when the power was no longer needed, which the copper would, and notwithstanding the cost of transformers which this plan would involve.

The alternating current, as has already been pointed out, has an advantage as a means of power transmission from the fact that it may be readily transformed by static apparatus to a higher or lower voltage and also may be converted into a direct current by means of a rotary transformer. This last quality is of particular importance in mining work where electric haulage is an important branch of application, no alternating-current locomotive having as yet been perfected. A street-railroad plant in Lowell, Mass., is of interest in this connection, as it uses alternating current at a high potential for transmission to distant parts of its lines, there converting it to lower potential direct current for street-car work. Until such time as an alternating-current locomotive is put in practical operation, this is exactly what must be done in mining plants where alternating currents are used for transmission, and haulage is a part of the work to be done by electric power. This Lowell plant has been in operation nearly a year and is entirely successful. The three-phase alternating-current generators have special commutators and direct and alternating currents are taken simultaneously from the same machines, the direct current feeding into the trolley wires near the station and the alternating current passing over the feeders at a high voltage to distant points of the system, where it is transformed as mentioned. The two generators are run in parallel both on the alternating currents and on the direct currents, and the direct current leads are also in multiple with other direct-current generators.

In mining applications aside from those where water is the initial power there has been a tendency toward centralizing the generation of power so as to supply more than one mine from one power house. Several examples of this tendency were mentioned in these pages last year as just having been installed, and their success has been unquestioned. At the present time the plan meets with general approval from a technical and economical point of view, the difficulty lying in the matter of business arrangements between the operators to be benefited where more than one interest is to be included. Another tendency, and one which augurs well for the future of the application, is toward better plants—better designed, more substantially erected, and with better construction work throughout. Mining plants are now showing the latest and best practices in the line of electric work. In several of the latest plants the generators and engines are direct connected. The old idea has been that such a plan did not pay except where land was extremely expensive, when the saving in floor space was an important economy. Under certain conditions, however, it is found that while the direct-connected apparatus costs more than the machines designed for belting, the saving in foundations, size of building, cost of belts, and higher efficiency make its use advisable.

Electric Haulage.—That activity rather than marked improvement has been noticeable during the year in electric applications is perhaps better illustrated in haulage than in any other line. The starting in use of the mammoth Baltimore & Ohio Railroad locomotives was the principal event of the year, dividing with it in interest the use of electric propulsion on several suburban railroads hitherto operated by steam locomotives.

In mining work the year has seen the production by both the Jeffrey Manufacturing Company and the General Electric Company of standard locomotives built for 18-in. gauge tracks for metal-mine haulage, the former for Montana and the latter for Montana and South Africa. Another novelty in electric mine haulage is a locomotive now building by the General Electric Company for the Hillside Coal and Iron Company, wherein the general plan of the Baltimore & Ohio locomotives is followed, modified as is necessary for mine work. The result is a locomotive of some 8000 lbs. draw-bar pull to run at 8 miles per hour, the most powerful machine ever used in mine haulage. For the operation of this locomotive and the several others which the Hillside Company has been using for years, two new 150-kilowatt direct-connected generators are being installed. The cost of haulage by electricity during 1895 was about the same as the figures given for 1894. The steady increase in the use of electric power for haulage, pumping, and hoisting which the Hillside Company has made since its first electric installation in 1889 is one of the best commentaries on the merits of the system.

The chief advance of the year has been in the increase in the use of electric locomotives for gathering trips in coal operations, thereby entirely displacing mules. One of the first plants to be so operated was that of the Berwind-White Company at its Eureka Colliery No. 22. The results here were such that an entirely new rope-haulage plant at their Atlantic Colliery No. 1 was taken out and electricity substituted, electric gathering of trips being depended on entirely. Electric haulage is also installed at other operations of the same company, and it has in use at present eight of the electric locomotives of the General Electric type, varying in size from 1000 lbs. draw-bar pull up to 3000 lbs. In the Atlantic Mine the grades run as high as 5% against the loaded trips for distances of 1000 ft. and 3% against loads for nearly 2000 ft.

The Blossburg Coal Company at Arnot, Pa., has for several years entirely dispensed with mules in its mines, three electric locomotives doing the entire gathering and haulage work. The seam is low and a considerable saving is effected in yardage as well as in the cost of gathering and hauling. The miners push their cars to the mouths of rooms and the locomotives take them from these points and deliver empties at the same places. The size of the cars, which are small, makes this method feasible where in higher seams it might be objectionable, if not impracticable, from the size and weight of mine cars.

The central station plant of the Youghiogheny River Coal Company at Scott Havon, Pa., which furnishes current for five mines for haulage, coal cutting, drilling, pumping, and ventilation, has proved very successful and stands as an example of what can be accomplished in this direction. The same is true of the Essen Coal Company's plant near Pittsburg, which also supplies current for various purposes in more than one mine.

At the Vintondale, Pa., operation of the Vinton Colliery Company a Jeffrey electric locomotive is doing both gathering and main haulage work. Among other companies which have installed Jeffrey locomotives during the year are the Great Kanawha Colliery Company, Mount Carbon, W. Va., 60 horse-power; the St. Clair Company, Eagle, W. Va., 60 horse-power; Charles M. Blanchard, Winterburn, Pa., 60 horse-power; the Corona Coal and Coke Company, Corona, Ala., 60 horse-power; J. H. Somers, Belle Vernon, Pa., 80 horse-power; Ellsworth, Morris & Co., Suterville, Pa., 80 horse-power; Red Run Coal Company, Ralston, Pa., two, 60 horse-power each. In many of the above plants are included also the Jeffrey chain coal cutters and other electrically operated apparatus such as fans, pumps, drills, etc., and electric lighting.

In addition to the plants already mentioned, the General Electric Company has installed haulage apparatus during the year for the Delaware, Lackawanna & Western Railroad, Bellevue, Pa., 80 horse-power; Derry Coal and Coke Company, Bradenville, Pa., 50 horse-power; Enterprise Coal Company, Excelsior, Pa., 50 horse-power; O. S. Johnson, Green Ridge, Pa., 50 horse-power; New York & Scranton Coal Company, Peckville, Pa., two, 50 horse-power each.

The Link Belt Machinery Company has installed several haulage plants in different sections of the country, and the Essen plant, which was started early in the year, has been visited, at the invitation of both the Link Belt Company and the Essen Coal Company, by large numbers of operators, as being one of the largest and newest plants in operation. Among other prominent haulage plants of this company recently installed are those of the Black Diamond Coal Company, Drakesboro, Ky., the Bessemer Land and Improvement Company, Birmingham, Ala., and the Pittsburg Block Coal Company, Fort Pitt, Pa.

Another manufacturing company which has been active more particularly in the coal-cutting line, the Morgan-Gardner Company, has installed two locomotives for the Old Pittsburg Coal Company, Hymera, Ind.

The Westinghouse Electric Company and the Baldwin Locomotive Works are now building in combination mining locomotives, but up to the present time none has been put into practical use.

Both in the number of new plants and in the additions very generally made to existing plants, a gratifying appreciation of the value of electric haulage has been shown during 1895, and there is every prospect of its becoming more general during the present year.

Coal Cutting.—There has been a considerable increase in the use of electric motors in this direction. The Jeffrey Manufacturing Company, for instance, sold 90 electric-chain machines. The Jeffrey plant installed at Westville, Ill., for the Westville Coal Company, consisting of 6 machines, generator, etc., was put in operation as soon as the main shaft was sunk, the first cut having been made with the machine in the cage at the bottom of the shaft, and since then all mining has been done with machine and electric drills. The field where these machines are operating has been considered unsuitable for machine mining, but such an opinion is proved erroneous by the success of this plant. Another plant in a new field was that put in for the Corona Coal and Coke Company, Corona, Ala., for coal cutting and haulage, 5 machines, 2 drills, and a locomotive being installed. It is the first plant of this character in Alabama. The Corona seam is from 30 to 35 in. in thickness, and the cut is made partly in the coal and partly in the underlying fireclay. Among other Jeffrey coal-cutting plants installed during the year and not already mentioned are those of M. T. Davis & Co. at Montgomery, W. Va.; the Knob Coal Company, West Brownsville, Pa.; and the Black Diamond Coal Company, Coal Creek, Tenn.

Another plant which has been largely increased during the year as a result of the trials of Jeffrey machine cutting is that of the Southwest Virginia Improvement Company at the Pocahontas mines. At this plant from 12 to 15 machines are in almost constant use, some of them in pillar work. The coal is soft and a speed of cutting of about 3 minutes for a 7-ft. undercut and withdrawal is reached on the latest machines. The power house is now being enlarged to give the extra capacity needed for the increase in electric work. This plant is interesting also from the completeness of its system of inspection and repair of machines.

The marked development in coal cutting during the year was the introduction of the three-phase induction-motor coal cutter by the General Electric Company.

This machine has been operated in several mines throughout the bituminous coal fields, the company sending about with it a box car containing engine, boiler, and dynamo, with wire and cable, for connecting with machine inside the mine, making in fact a complete portable plant for practical demonstration of the merits of the machine. The machine has very few parts and is substantially built. The motor is of the regular three-phase induction type with armature shaft vertical, and has the advantage of running without brushes or commutator and being practically indestructible from overloading. One plant using this system has been installed at the New Lisbon, Ohio, mines of the Sterling Coal Company and is reported as doing its work satisfactorily in a coal difficult to cut.

Another plant under contract for this type of machine is that of the Davis Coal and Coke Company of Thomas, W. Va., which will use seven coal cutters and several stationary induction motors.

The Link Belt Machinery Company's Independent coal-cutting machine has been installed during the year in the mines of the Winifrede Coal Company at Winifrede, W. Va.; the Central Coal and Iron Company at Rend, Ky.; the McHenry Coal Company, Echols, Ky.; the Quinnimont Coal Company at Quinnimont, W. Va.; the Norfolk Coal and Coke Company, Maybeury, W. Va.; the Webster Gas Coal Company, Webster, Pa.; the J. H. Somers Fuel Company, Belle Vernon, Pa.; and in connection with haulage plants already enumerated. The Independent cutter has been used in several places, notably at the mines of the Winifrede and Houston companies, for cutting in the middle of the seam some distance from the floor, being mounted for this purpose on an adjustable truck.

In Ohio and Indiana particularly the Morgan-Gardner chain coal cutter is largely used. The Brazil, Ind., Block Coal Company uses 22 chain undercutters and 1 pick machine; the Cambridge Fuel Company, Cambridge, Ohio, 8 chain and 3 pick machines; Harder & Hafer, Shelburn, Ind., 3 chain and 3 pick machines; while other plants installed during the year are those of the North Star Coal Company, Oakdale, Ohio; the Somers Fuel Company, Dillonvale, Ohio; C. L. Poston, Nelsonville, Ohio; the Raybould Coal Company, Orbiston, Ohio; W. H. Brown's Sons, Monongahela, Pa.; the Columbus & Hocking Coal and Iron Company, New Straitsville, Ohio; the Northern Fuel Company, Jacksonville, Ohio; the Catsburg Coal Company, Monongahela, Pa.; the Congo Coal Company, Congo, Ohio; Osburne, Saeger & Co., West Newton, Pa.; and the Old Pittsburg Coal Company, Hymera, Ind. This enumeration of operators who have installed coal-cutting and other apparatus during the year is intended not only to show the increase in and widespread adoption of electric apparatus, but also to inform any one interested in the subject just where to apply for practical information and where to visit working plants representing the latest practice.

Electric Pumping.—The year has seen a large increase in electric-pumping applications. So much has been written on the subject of the efficiency of electric pumping that the result of a test on a municipal pumping plant at De Kalb, Ill., is of interest here. The plant consists of a deep-well pump capable of raising 300 gals. per minute against 190 ft. head, which is operated by a 25 horse-power motor and 2 Goulds service pumps, 10x12 triplex, each capable of handling 500 gals. per minute and each operated by a 50 horse-power motor. These two pumps raise water into the standpipe, or in case of fire pump directly into the mains. The deep-well pump is of Downie manufacture and belted to the motor, and the service pumps have geared connection with their motors. The General Electric Company, which furnished the motors, guarantees that repairs shall not exceed 2% per annum during the first five years in which they are used. The engineer of this plant, Mr. Daniel W. Mead, states that the efficiency of the pumps, including motors, under test was 78%. Under half load the motors alone showed an efficiency of 84% and under full load 91%. The cost of pumping by steam was 11c. and by electric power 4c. per 1000 gals.

The use of small portable pumps such as those made by the Goulds and the Knowles companies has largely increased during the year, particularly in coal mines. They are mounted, with the motor direct connected, on a truck and with a reel of suitable cable for connection with the permanent wiring of the mine, and can be easily and quickly put to work wherever a local dip may require pumping.

The Lehigh Valley Coal Company has installed an electric plant which, in addition to a hoist, operates a 10x18-in. duplex double-acting Jeansville mine pump capable of handling 600 gals. of water per minute against 350 ft. head.

A pumping plant illustrating control from a distance has been installed at Ciudad Porfirio Diaz, Mexico. The transmission is 3000 ft. and the pump, which handles 400 gals. per minute against 250 ft. head, is entirely controlled from the generating station 3000 ft. away, a special controlling circuit being run for this purpose.

The Colorado Fuel and Iron Company has contracted with the General Electric Company for a large electric plant at its Rouse, Colo., coal mine, principally for pumping, consisting of generator, 2 motors for Deane horizontal duplex pumps, 2 motors for Deane vertical pumps, 1 slow-speed motor running 20-ft. ventilating fan, and a stationary motor for the machine shop. The distance of transmission is 3000 ft., of which 2700 ft. is overland, and direct current at 500 volts potential will be installed. The pump motors are compound wound, the series coils giving necessary starting torque, while there will be no danger of the motors running away should the water become exhausted. This plant is of particular interest as being the first coal-mine installation of any size in Colorado, and more particularly as electricity here replaces compressed air, with which much of this work was being done, and it was only after a thorough investigation that it was decided to substitute electricity, because even with the low price of fuel, slack being used, electricity will save enough in power to justify the purchase of an entirely new plant.

Hoisting.—Among the hoisting applications to be noted we find that the Hillside Coal and Iron Company is installing at Forest City mines, Pa., a hoist of 100 horse-power capacity, which is driven by two motors so arranged that they may be run in series giving full hoisting pull at slow speed, or in multiple giving full speed and the same pull. This hoist will be used on a slope too steep for locomotive haulage.

The Mount Lookout Coal Company, also near Scranton, which has used electric haulage and pumping for nearly two years, has now added a 50 horse-power Lidgerwood hoist and General Electric motor to its plant and has doubled its generating power, now having 270 electrical horse-power available. Another hoist of about the same size has recently been installed in the silver mine of F. M. Coghlan at Vanegas, Mexico. The plant already described in these pages at Catorce, Mexico, has also recently added a large electric hoist.

In connection with the pumping plant above described, the Lehigh Valley Coal Company, which has been extremely conservative in adopting electric power underground, has installed a 200 horse-power 500-volt direct-current General Electric generator for supplying current to a Lidgerwood 100 horse-power friction cone-clutch single-drum hoist, and the pump mentioned above. The motors are inclosed as a protection from danger of ignition of gases from sparking at the commutators. Both are situated in the center of a long slope in the main coal seam, and by the use of electric transmission 6000 ft. of underground steam piping is done away with. The line from the generator to the hoist and pump is carried about a mile over ground on a pole line, and thence down a vertical bore hole 350 ft. in depth. The cable passing down the bore hole is iron armored and suspended by this armor. The average work of the hoist is the hauling of 15-ton trips up an 8° slope at an average hoisting speed of 500 ft. per minute. The total length of the rope is 1600 ft. and the hoist also handles 5-ton loads down the same slope.

In hoisting work where reversals of the driving power are required frequently, it is necessary with three-phase induction motors to use collector rings and brushes and an external resistance for starting, which places the three-phase motor on much the same basis as the direct-current motor for this variety of work.

Ventilation.—Applications of electricity for purposes of ventilation are without exception made in connection with other applications, and many have already been noted. For some time there was a prejudice against the use of motors for this purpose, it being thought that they were unreliable and dangerous to use in so important a connection as ventilation. This has entirely disappeared, and the foremost engineers now advocate and install electrically operated fans, often thousands of feet from the power station and requiring only infrequent inspection.

Drilling.—Boring coal drills are in use in almost every mine using electric undercutters, and do their work extremely rapidly and well. Electric percussion drills have again come into prominent notice from the improvements made by the Marvin Electric Drill Company and the Siemens & Halske Company in their respective types of this apparatus. The Marvin Company claims to have overcome the faults which the earlier solenoid percussion drills showed, and to have now an entirely practical and successful piece of apparatus. Its drills have met with success in the limestone quarries of the Solray Process Company, near Syracuse, N.Y., where they have been in operation for several years and are very well liked by their users.

The Siemens & Halske Company has developed two types of boring drills, one a rotary drill and the other a mechanical percussion drill, so called to distinguish it from the solenoid percussion drills already spoken of. These drills can be operated from any power circuit, not requiring a special generator or special wiring. The motive power for both the types is separate from the drills themselves and connected with them by means of flexible shafting. In the rotary drill, which is intended to be used with diamond bits in hard rock and steel in softer material, the rotation of the motor is directly conveyed to the bit by the flexible shaft. In the percussion drill the mechanism consists of a crank motion in which the crank is connected permanently by means of powerful springs with the reciprocating body. Contrary to the fears of the manufacturers, the springs show a long life. A flywheel weighing about 40 lbs. is mounted directly in the crank shaft. These drills have met with practical success in Germany, but have not as yet been applied in this country.

Miscellaneous Applications.—The development of the sparkless motor for use in powder mills, oil refineries, etc., has a bearing on mining work as illustrating apparatus suitable for fiery mines. During the year electric motors have been installed by eight or ten of the leading powder manufacturers of the country, and while in general the motors are removed from points where sparking would be sure to cause trouble, the sparklesss feature of the multiphase induction motor commends it particularly for this work, as also for use in gaseous mines. One type of absolutely sparkless motor may be seen at the Tidewater Oil Company's refinery at Bayonne, N. J.

The development of electric carriers, suspended on wires which serve a double purpose as mechanical supports and electric conductors, has been rapid during the year, as exemplified in the experiments with electric canal-boat towage and in the handling of logs, etc., by suspended carriers of this sort in the boggy timber lands near Norfolk, Va. The system, called the Lamb system, from its inventor, will probably find a use in ore and coal handling and the handling of supplies in mining districts, and may also be applied to the handling of coal barges, which in periods of low water is a most serious problem on many of our rivers. In the canal-boat towage system the carrier or "electric mule," as it is called, is carried on two wires, one vertically above the other, which also serve as conductors. The motor is geared to a driving wheel around which the smaller cable passes, and thus the pull is obtained. The motor is controlled from the canal boat through a flexible cable connection, and may be started, stopped, or reversed instantly from the deck of the boat, or its speed controlled from a few feet per minute to its maximum. In logging work the operator of the motor rides on the suspended carriage. In this system the natural trees are utilized to hold the brackets supporting the cables, which are run wherever wanted without regard to curves. In the Virginia forests no other method of logging had ever been successful, owing to the treacherous nature of the swamp, it being impossible to utilize horses or mules to build roads or to lay any kind of a track on the surface.

Frazer & Chalmers have installed during the year electric apparatus for milling work in Mexico and the West. The Omaha & Grant Smelting Company in its Denver works has increased an already extensive electric power plant, and now uses about 150 horse-power in operating a sampler, blower, hoist, lathes, and other apparatus. The increase in the use of electric motors is due to a preference for divided units instead of shafting pulleys and belts or rope transmission, and the plant is the only one of the kind in use in a smelter in the United States.

The Niagara Electrical Plant.—The first application of the power generated by the great plant of the Cataract Construction Company at Niagara was to the manufacture of aluminum, and the contract for supplying this power was made with the Pittsburg Reduction Company. The translating apparatus consists of eight 200-kilowatt transformers, with ventilating arrangement, and rotary converters of total capacity of 1600 kilowatts. The air-blast transformers reduce the voltage from the two-phase generators in the power house from 2500 volts to 115 volts. The rotary converters transform the two-phase current at this voltage into direct current at 160 volts. A new contract has recently been closed whereby the plant for the Pittsburg Company will be increased to 3000 kilowatts, with corresponding static transformer capacity and station equipment.

The second application of power was to the manufacture of carborundum. This apparatus consisted of a 1000 horse-power transformer and regulator, which varied the pressure from 250 volts to 100 volts, in accordance with the requirements of the process of manufacture. The carborundum plant consisted, in addition to this transformer of extraordinary size, of a multiphase motor for pumping the oil required for cooling the transformer and of a switchboard equipment. An interesting feature of this installation is a water rheostat, in parallel with the main switch, which enables the main circuit to be broken when full load is on the transformer.

Conclusion.—The rapid increase in the number and scope of electric mining applications makes a complete record of what has been done during the year almost impossible, and the standard nature of a large number of such installations makes their enumeration of no particular interest. The object has been, therefore, to call attention to what is new or in the nature of an improvement and to indicate in a general way the extent to which electricity is now being applied in the work of mining.

The Progress of Electro-Chemistry and Electro-Metallurgy in 1895.

By Dr. W. Borchers.

When in April, 1894, a few German scientists and technical men met in Cassel to consider the organization of an electro-chemical society in which science and practical experience were to support one another for the advancement of electro-chemistry, so great an interest in the movement as was really manifested was unexpected. The society counts nearly 500 members to-day, and indeed no better proof could have been given that electro-chemistry is no longer to be dealt with as an incidental branch of chemistry. Scientific electro-chemistry has already built up a new and solid foundation for the whole chemical science, and practical electro-chemistry has demonstrated the fact that hardly any branch of the chemical industry can get along without electricity.

It is not my intention to enumerate all the novelties which have been brought to public notice during the past year, but rather to pick out the more promising results of the harvest of 1895.

I. GENERATING AND STORING ELECTRICITY BY CHEMICAL PROCESSES.

Since Professor Nernst (Göttingen) a few years ago succeeded in furnishing the final proof of a sound theory on the mechanism of the voltaic battery, a theory which was based upon his own experimental researches and those of Professors Van Hoff, Ostwald, and Arrhenius, the task of finally solving the problems of producing electric energy cheaply from chemical energy seemed to gain more interest than ever before. Professor Ostwald outlined the scientific rules for the construction of the fuel battery of the future in a very interesting lecture before the association of German electricians in 1894, and when, induced by this lecture, I communicated the results of my own experiments for solving the problem practically to the German Electrochemical Society at its first meeting in Berlin a few months later, a lively discussion followed in the technical journals. Though I had distinctly said that the process and the apparatus as they were described at that time gave too poor results to be fit for practical use, a great many eager reporters magnified the mouse into an elephant, so that equally eager critics had a chance to cut the elephant down to a mouse again and to reduce the latter to the smallest scale. Nevertheless the first results have not been discouraging enough to force us to abandon the method chosen, which consists in the application of a gas battery in which, by the aid of cuprous chloride as an electrolyte, carbon oxide or other coal gas was to be oxidized by air or oxygen in any other form. New forms of apparatus will be completed in 1896. Coal itself, which was also tried as the anode substance in the battery mentioned, proved to be too slow in entering the solution. The impurities of the coal are another obstacle to the application of coal anodes, as their residues (ash) would soon accumulate in the electrolyte to such an extent as to necessitate a frequent and costly renewal of the latter. In order to utilize the chemical energy of our fuel as electric energy by the aid of voltaic batteries, gasification of the coal seems to be unavoidable.

Referring to batteries of the common type according to which metals, especially zinc, are used as current-producing anodes, significant improvements cannot be reported. A scientific problem connected with galvanic batteries in general may be mentioned, as it was recently solved in a very ingenious way by Professor Ostwald. He determined the location of the electro-motive force in galvanic batteries by explaining an interesting, though not quite unknown experiment, called the chemical heart, from the convulsions of a drop of mercury when touched by a pointed iron wire under the influence of a solution of chromic acid. Though the experiment and the explanations of the same as given by Professor Ostwald do not mean any immediate practical progress, they will aid in throwing light upon the theories of the interior working of galvanic batteries. We cannot review the lecture of Professor Ostwald concerning this problem in a few words, and must therefore refer to the original publication (*Zeitschrift für Elektrochemie*, Vol. II., 1895–96, pp. 123–133).

Storing electric energy is another task for practical electro-chemistry which is occupying a great many minds. The lead accumulator still continues to defy competition, though experiments with the alkaline zinc-cupric oxide battery have not yet been given up; but it is strange to note that as the Faure monopoly approaches an end the original Planté system is coming into fashion again. The efforts of other inventors to avoid the taxes levied by the Faure patent owners have produced a variety of electrodes, the most prominent features of which consist in the development of the pocket electrodes and the "masse" (active material) plates. The majority of inventors of this line of battery elements, as they are using lead terminals in or around such plates, have been compelled to pay the Faure royalty.

To metallurgists a patent of Coehn (German Patent No. 79,237) may be of interest, though its practical applicability has not yet been demonstrated. The inventor proposes to store a part of the electrical energy necessary for electrolytically precipitating metals from solutions in all cases, when insoluble anodes are required, by using lead oxide plates as anodes. They will be oxidized to lead peroxide, which may be used as cathodes in galvanic batteries consuming coal or other fuel as anode substances.

II. APPARATUS FOR PREPARING ORES AND CHEMICAL PRODUCTS FOR SMELTING BY ELECTRO-MAGNETIC SEPARATION.

The apparatus of this class have been lately developed chiefly by American electricians. No new plants of this kind were built in Germany in 1895. The most successful one at the Friedrichssegen mines, near Ems, has been working since 1880 for separating spatheisenstein ($FeCO_3$), after a preliminary roasting, from zinc and lead ore.

III. ELECTRICAL HEATING, ROASTING, AND SMELTING OF ORES AND METALS.

The development of electro-metallurgy is to a large extent due to the benefits derived from the facility of transferring electric energy into heat. Our best regenerative gas furnaces are not able to produce temperatures anywhere near those of the electric furnace. But the most important features of electric heating appliances are that no other apparatus allows the concentration of an almost unlimited amount of energy in an equally small space and that the heat may be produced in the center of the very body to be heated. Just this latter fact has become the key for solving the most difficult problems of the mineral industries. The methods of utilizing electricity for producing heat are the following:

1. The substance to be heated is wholly or partly made a resistance in an electric circuit of large quantity. This is an old principle of electric heating. For commercial purposes it was first applied by Messrs. Cowles Brothers for making aluminum alloys. It is well known that in this process the same carbon that was to decompose the aluminum oxide was serving as resistance in the circuit to produce the necessary heat for this process. Héroult, electrolyzing his electrolyte by currents of such density that the contents of his apparatus were kept fused by electrically produced heat, opened the only way by which to-day pure aluminum can be produced. In spite of the decision in the Cowles-Pittsburg Reduction Company suit, there is no way of depositing pure aluminum except by electrically producing the heat necessary to keep the electrolyte fused. The same process of reducing refractory oxides by electrically heated carbon is to-day applied in the manufacture of carborundum and in the manufacture of calcium carbide (see 6, Inorganic Chemicals), and by the very same process and a very simple apparatus the author has succeeded in reducing all oxides heretofore supposed to be unreducible (Borchers, *Elektrometallurgie*, 1st ed., 1891, 2d ed., 1895).

For the purpose of fusing metals or keeping them fused by using them directly as heating resistances in electrical circuits, Taussig, De Laval, and Wikström have constructed new apparatus which the *Engineering and Mining Journal* has described. A further application of this method of electric heating has been made in a great variety of processes for the purposes of welding, forging, rolling, molding, tempering, and annealing metals. There are, however, few works in Germany which have permanently introduced any of the great number of new apparatus and propositions, among which those devised by Elihu Thomson and by Coffin hold the first rank.

2. In that class of apparatus in which the heating resistance is not immediately in contact with the substance to be heated, but where the body is imbedded in other heat-accumulating or heat-distributing bodies, we find those appliances which are constructed for an even distribution of heat rather than for very high temperatures. In England the firm of Crompton & Dowsing and in Germany Paul Stotz (Stuttgart) are promoting this branch of industry. The latter firm is using the Schindler-Jenny patents. Wires of platinum, nickel, or other metals and alloys are imbedded in asbestos, stoneware, or metal bodies. In the latter case the wires must of course be isolated from the supporting metal. The wires are heated by a suitable current, and the heat thus produced enters the supporting body, by which it is distributed over a larger surface and conducted to the substance to be heated. Though the apparatus manufactured by the firms named are chiefly intended for cooking and baking purposes, they are also recommended for heating liquids which are to be concentrated or especially for heating those substances which are very sensitive to fluctuations of temperature. There is no doubt that with a reliable source of current such apparatus will allow a very good regulation of temperature, so that, besides some mechanical trades, chemical works and laboratories may derive benefit from them in the manufacture of fine chemicals.

3. A third class of heating appliances in which the substance to be heated is

made an electrode of an electric arc has a long history. Not to speak of the crude constructions from the galvanic-battery age, the Siemens furnace of about 15 years ago is still recognized as a pattern for the more modern constructions. Among the latter a more recent furnace, patented by Urbanitzky (German Patent No. 82,164), may be named. It is a decided improvement on a former patent (German Patent No. 77,125) concerning a cupola furnace near the hearth of which electrodes were introduced through the side walls. The new furnace is a short crucible, having a hollow metal bottom, which may be cooled and which serves as negative terminal of an electric circuit. The main body of the crucible consists of any suitable refractory substance packed into an iron box. Through the hollow metal cover, which may also be cooled, carbon plates are introduced as positive terminals. Openings for feeding and for the escape of gases are also provided in the cover. The Urbanitzky crucible is one of the few constructions which show a good appreciation of the practical difficulties of electrical smelting. It may be used not only for heating ores, metals, and other chemicals by the electric arc, but also for heating such products according to the method mentioned under No. 1.

The Deutsche Gold- und Silber- Scheideanstalt at Frankfurt-am-Main is building small electric arc smelting crucibles, which may be recommended for experimental purposes. A widespread application of this kind of electric heating seems to be made in the mechanical branches of the metallurgical industry.

The Benardos process of soldering and smelting metals is too well known to need further explanation here. It may only be mentioned that in soldering iron articles the fused joints are rather brittle after cooling. The fusing metal, which, to avoid burning, must be made the negative electrode of the arc, while a carbon rod is used as positive pole, takes up a great deal of carbon, which is transported from the positive to the negative pole during the heating process. Slavianoff has tried to avoid this dangerous electrolytic action by using as anodes rods of the same metal as the object under treatment. This process is chiefly recommended to repair cast-iron or steel articles which on account of their intricate forms or for other reasons can be cast only at a larger expense than common castings. The metallic anode of course melts away and the molten metal dropping off fills up the cavities of the article to be mended. Though this is the very purpose of the Slavianoff process, it is a difficult task to keep up the arc while the metal is constantly dropping off from the anode rod. This difficulty, however, seems to have been overcome lately by the application of automatic guides for the anode.

The Lagrange & Hoho process, which may be included in this class of electric heating methods, is too well known to require a description here. Apparatus for applying this process have lately been patented in the United States by Burton, Coffin, and Hunter. The conditions for the success of this process are to be looked for in the manufacture of large quantities of articles of the same cross section, such as bolts, rivets, etc.

4. Another modification of electric arc heating appliances aims to make the arc independent of the object to be heated. The arc is produced between carbon electrodes, which may be placed above, below, or around the material to be

heated. This idea is not nearly as new as modern inventors wish to admit. In 1853 Johnson applied for an English patent to smelt ores by introducing them into the hearth of a furnace inside of which an electric arc was produced between carbon electrodes. Most of the modern inventors of this kind of furnace are far from having given us anything new. To put the substance to be melted into a shallow crucible and arrange the arc electrodes above it, or to heat the former inside of a muffle or a tube around which the electrodes are placed, or finally to introduce the batch for an electric open-hearth furnace by means of tubes surrounded by arc electrodes and projecting into the hearth room of such furnace, may be noted as some of the many useful variations of a popular idea, but they can hardly be recognized as inventions in the patent-law sense of the word. Yet some of them have been patented in American and European countries (for instance, Ducretet & Lejeune's furnace, Chaplet's furnace, and others).

The fact that the electric arc between two electrodes is frequently changing its position and that in some cases it is confined to too small a space has given rise to the idea of spreading it over a larger area or of giving it a certain direction by deflecting it by means of electro-magnets. From the more recent constructions that of Girard & Street may be named, in which the arc is made to rotate around a crucible. For the metal workshop the Zerener process of soldering and welding metallic articles may be noted. An electric arc produced between two carbon electrodes slightly inclined to a horizontal line is deflected by an electro-magnetic field crossing the path of the arc. The arc now resembles the flame of a downwardly directed blowpipe. The electro-magnetic blowpipe may be moved across the joint to be soldered or welded, or the articles, placed on a support, may be drawn through the arc underneath the arc-producing apparatus. Several German firms are using the Zerener apparatus to their satisfaction.

IV. PRODUCING METALS ELECTRICALLY.

1. Alkali metals. As yet the Castner electrolytic process is furnishing the largest part of the supply of sodium metal for the manufacture of cyanides, which are consuming the bulk of this metal according to the old Erlenmayer process. In electrolyzing caustic soda Castner requires only a very low temperature to keep the electrolyte and the separating metal in a liquid state. The loss of sodium in consequence of redissolving is therefore lower than in any other process known. In several chemical works, however, where a lead-sodium alloy answers as well as sodium itself, the Hornig-Borchers process (United States Patent No. 544,153) is being tried to replace the Castner process.

2. The alkaline earth metals are of too little importance to demand a discussion of the conditions of their manufacture. Magnesium is still the chief product of the Hemelingen Works, near Bremen, and it may be again noted that for six or seven years it has no longer been made by the Graetzel process.

3. Glucinum metal has been asked for by the Emir of Afghanistan for jewelry purposes, and Mr. N. N. Warren (Liverpool) has supplied the demand electrolytically.

4. Among the earth metals aluminum is the only one which supports an industry by itself. Preparations have been made to increase the output by en-

larging the works in France and the United States and by establishing new works in Norway and Ireland.

5. The heavy metals. Among these copper refining continues to rank as high as ever among electro-metallurgic processes, though the prospects for European refiners cannot be called very encouraging. The efforts to meet competition by improving the process and apparatus are naturally great at such periods, and many material changes have come to public notice. The most remarkable improvement in electrolytic copper refining has, however, not been noticed at all by technical journals, though it was taken into practical use about 8 years ago. Messrs. H. & K. Borchers, proprietors of chemical works at Goslar, in the Harz Mountains, Germany, have constructed an almost ideal apparatus for keeping up a lively circulation of the electrolyte. Within a large lead pipe, *b*, which is open

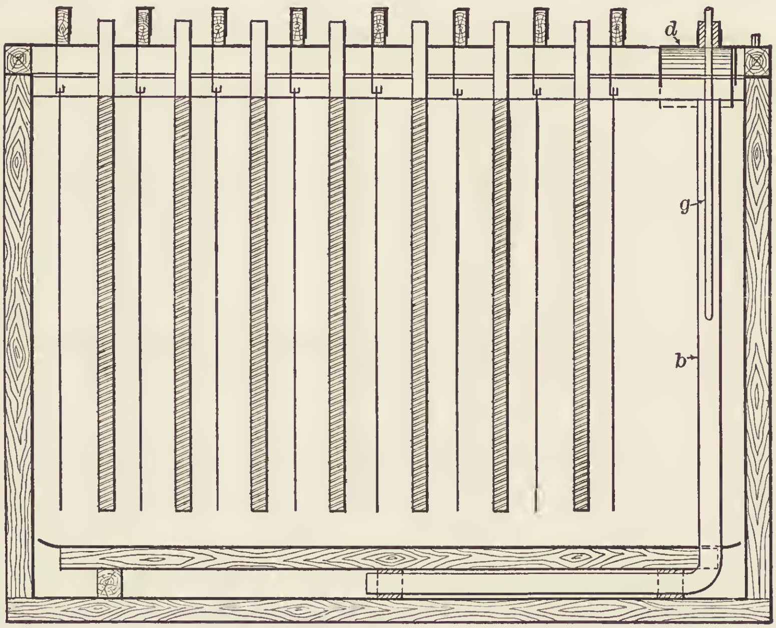


FIG. 1.—SIEMENS-BORCHERS COPPER-REFINING TANK.

at both ends and which connects the center of the bottom of the electrolytic bath with the surface of the liquid at one end of the tank, a fine jet of air is blown into the liquid some distance from the surface of the latter by means of a glass tube, *g*. The column of fluid above the lower end of the glass tube *g*, mixed with small air bubbles, grows lighter than the bulk of the liquid in the tank; it will rise and flow over the upper end of the pipe *b*, while at the lower end of the same pipe a constant current of heavy liquid rushes in. An almost noiseless but very lively circulation is the result of this process. To prevent waste of liquid by ejection a lead cover, *d*, with an opening toward the electrodes, must be put over the pipe *b*.

It is no longer necessary to have the electrolyte run from one tank to the following one of a long series. The impurities of one tank are not carried through the whole line. Each bath works independently from the rest. No leakage of electric current, no wasteful overflows of liquid can be complained of. The electrolyte remains in the bath from the start to the point where it must be set off. At all times the liquid will be found perfectly clear, a very important point in hunting up the cause for any troubles in the line. One pipe line only is required to fill and to empty the tanks by air pressure and suction. And last, but not least, another important advantage may be named. The current density may be raised to three or four times that of the old method. This means nothing less than the possibility of turning out three or four times as much as by the old method; or a given amount of metal will require only one-third or one-fourth of the former plant.

To recover copper directly from matte Messrs. Siemens & Halske are erecting two new works, one in Spain and one in Austria.

For separating copper alloys which contain a large amount of precious metals, an electrolytic process of Dietzel (German Patent No. 68,990) is being introduced into a large German refinery. The inventor is using the alloy in a granulated state as anode. He dissolves copper and silver in the electrolyte (nitrate of copper), leaving the gold in the anode compartment of his apparatus. From the solution the silver is deposited by copper outside of the electrolytic bath. The copper solution is then conducted into the cathode cell, where the copper is precipitated upon revolving copper cylinders.

For separating auriferous silver bullion the Deutsche Gold- und Silber- Scheide-anstalt at Frankfort is using the Moebius process.

Electrolytic zinc has lately made its appearance in the German metal market, though in small quantities. Under the management of Professor Dieffenbach (Darmstadt) extensive experiments have been made at Siegen to recover zinc from roasted blendic pyrites which contain up to 8% of zinc. The success of the experiments has encouraged the Gewerkschaft Sicila & Siegena to start a large plant at Duisburg, commencing with a force of 600 horse-power. The company succeeded in obtaining a very dense metal in the shape of thick plates similar to electrolytic copper plates. Unfortunately the machinery, which was devised to utilize the power with the utmost economy, has been the cause of some delays, so that the works had to stop for a while. They will be in running order in a few months. The special conditions of the process at the Duisburg works are kept secret. The zinc is deposited from solutions obtained by chlorination and leaching of roasted blendic pyrites.

A plant at Fuerfurth, Germany, has been erected to try the Hoepfner processes of recovering zinc electrolytically.

The quality of commercial electrolytic zinc is very good with reference to foreign impurities. It is obtained in the shape of fairly thick and dense plates, but unfortunately these plates are too brittle to be rolled out to sheets, and in smelting them about 40% of dross is obtained. As was shown by a very interesting investigation by Mylius & Fromm, of Berlin, it is very difficult to deposit zinc electrolytically free from zinc oxide. Zinc oxide, and not the hydrogen, as was generally believed, is the real cause of the difficulties encountered in the electrolysis of zinc solutions, and zinc oxide is the cause for the heavy loss in smelting electrolytically deposited zinc plates.

Solid or liquid zinc of very good quality may be obtained by electrolyzing molten zinc chloride. To make a suitable chloride is not nearly so difficult a task as the electrolysis of a watery zinc solution, and the electrolysis of zinc chloride offers all the advantages of a very good conductor of electricity. It is possible to apply very dense currents at a low electro-motive force, so that large quantities of zinc may be deposited in very small apparatus. The construction of the latter and the mode of working are much like those applied for depositing aluminum.

Electrolytic tin is only obtained from tin-plate scrap. There are several large factories in Germany recovering the metal in this way. They are selling the tin in the metallic state as well as in the shape of tin salts for dye works. The iron scrap obtained as a by-product in this process is so pure that it can easily be sold to iron works. The process itself, as far as electrolysis is concerned, is so well known that a further description of it may be omitted.

Excepting the usual number of patents, no further remarkable novelties in electro-metallurgy have come to public notice.

V. METALLOIDS.

Electrolytically very few of the metalloids are made on a commercial scale. Hydrogen is obtained as a by-product in large quantities from the electrolytic manufacture of caustic soda. The Vereinigte Chemische Fabriken at Leopoldschall is selling the gas compressed into steel bottles under a pressure of 125 to 150 atmospheres. It is used for lead burning, for smelting and soldering platinum, and for other smelting operations. For either of these purposes it is very important that the hydrogen gas be very pure. Hydrogen made from zinc and sulphuric acid usually contains small quantities of arseniureted hydrogen, which by itself or in the products of combustion endangers the health of the lead burner and the qualities of metals like platinum. Electrolytic hydrogen is practically chemically pure, so that it can be used without previous purification for all purposes. The convenient packages (small steel bottles) facilitate its application. Considering the troublesome work of charging and cleaning the old hydrogen generators, there is no doubt that even lead burners will use the bottled hydrogen, especially as the price of the latter is in most cases lower than the expense of making it from zinc and acid.

For making oxygen by electrolysis of water several apparatus have been patented and published, the principal features of which consist in the application of iron and nickel electrodes in an electrolyte of caustic-soda solution. These apparatus are giving oxygen and hydrogen, of course. But since hydrogen, as just stated, is obtained as a by-product from other processes in quantities more than sufficient to supply the demand, it is very doubtful whether the electrolysis of water for the manufacture of oxygen will pay. Manufacturers of gas motors will have to consider the necessity of constructing hydrogen gas engines in order to utilize the large quantities of electrolytic hydrogen produced by the growing electrolytic soda and potash industries for generating motive power and electrical energy. The solution of this problem does not offer insurmountable difficulties, but it ought to reduce the expense of manufacturing caustic alkali, chlorine, and oxygen.

The manufacture of ozone has been perfected to a degree that will permit a pretty extensive application of this compounded oxygen. On the latter subject the well-known electrician Froelich, of the firm of Siemens & Halske, read a paper at the first annual meeting of the German Electrochemical Society in 1894.

Antimony is produced in very dense though thin plates by the Austrian branch of Siemens & Halske. Electrolytic antimony may therefore be expected as a specialty in the market sooner or later.

The remaining metalloids, except those of the chlorine group, which will be mentioned later, have not been made electrolytically as yet. The help of electrical energy in the manufacture of some of these elements is restricted to the production of the high temperatures necessary for their reduction. Thus the old Liebig process is at last called to the front, since electrical heating has overcome the difficulty of securing a suitable material for building the smelting and distilling retorts. Mr. Readman and the English Electric Construction Corporation will hardly succeed in blockading the application of the Liebig process by their patents, though Liebig himself may not have thought of electric heating.

Efforts have been made to produce two modifications of carbon artificially by electric heating. Graphite is said to be produced in the arc furnaces of Girard & Street, while diamond is claimed to have been obtained by Moissan. The first process, though its financial success is not yet proved, is practicable. Moissan's diamonds, however, with a high percentage of silicon, will hardly be recognized as real diamonds; the name of carborundum will fit more closely the true character of that product.

VI. INORGANIC CHEMICAL PRODUCTS.

Referring to the preceding section, no apology will be needed for not mentioning chlorine there. The manufacture of free chlorine by electrolysis will never by itself make an industry. For obtaining gaseous or liquefied chlorine practical electro-chemistry appears to offer many opportunities, among which two large industries seem about to overcome the last difficulties they have so far been struggling against: the electrolytic zinc industry and the electrolytic alkali industry. We have discussed the chances of the zinc industry. Before entering into details on the manufacture of caustic alkali two other products may be mentioned which are manufactured and used on account of their chlorinating or oxidizing power—hypochlorites and chlorates.

The hypochlorites of alkalies and other metals may be obtained directly by electrolyzing solutions of the respective chlorides at low temperatures by the action of liberated chlorine upon the hydrate formed at the cathodes. This process, however, will only furnish solutions of the hypochlorides, the well-known bleaching liquids. Bleaching powder is always made from gaseous chlorine, though the latter may be obtained electrolytically. On evaporating the bleaching liquids the hypochlorites will decompose. It is necessary, therefore, to make such solutions on the spot of their consumption and use them directly. Paper mills and cotton mills have taken hold of these products, putting electrolyzers directly into their bleaching vats. There are especially the apparàtus of C. Kellner, Vienna, manufactured by the Austrian branch of the firm of Siemens &

Halske, those of Hermite, Paterson & Cooper, and those of Knöfler & Gebauer which have been introduced into practical use. None of these apparatus and, as has been proved by Oettel's careful investigations,* no apparatus whatever will furnish very strong solutions, yet the liquids are sufficiently powerful bleaching agents if made and used without delay in paper and cotton mills, and judging from the publications of Oettel, Schoop, and Engelhardt, the cost of making them on the spot of their consumption compares favorably enough with the price of other bleaching agents. There is no doubt that such solutions may also be fit for extracting metal from ores.

The existence of a growing electrolytic chlorate industry is a well-known fact. Beyond the patents, which have been regularly reviewed in technical journals, the manufacturers naturally keep secret the results of their experiments and experiences. Some laboratory investigations, however, which have been published by the well-known practical and scientific electro-chemist Oettel in the *Zeitschrift für Elektrochemie* (1894 and 1895) have given us very valuable information on the conditions for the manufacture of chlorates. He recommends strongly alkaline solutions, high density of the current, and a moderate temperature of the bath, or solutions containing little free alkali, at a moderate density of current and high temperatures. A most remarkable result of these experiments is the fact that 82 to 87% of the electric energy employed has been obtained as chlorate of potassium or chlorate of calcium, without using the diaphragms. Besides the French works at Vallorbes and at Saint-Jean de Maurienne and the Swedish works at Mansboe, chlorate is being manufactured at the Actien-Gesellschaft Elektron (Frankfurt-am-Main) and the Elektrochemische Werke in Bitterfeld.

Returning now to the electrolytic alkali industry, we find the patent lists of 1895 continuing to offer the usual number of so-called inventions, yet very few of them are worth mentioning. In a previous report on the progress of technical electro-chemistry† in 1894 I mentioned that the success of the electrolytic alkali industry was to be sought in the construction of apparatus in which electrolysis could be carried on without osmotic diaphragms, and indeed the year 1894 gave us a few very good constructions of this kind; for instance, those of the Farbwerke (formerly Meister Lucius & Brüning), of Le Sueur, of Bayly & Guthrie, of Stoermer, and of Carmichael. In 1895 we cannot register the slightest progress in this line of apparatus, though there is no doubt that the principle of the processes named is a very good one.

Among those processes which are working with the aid of separating partitions approaching the osmotic diaphragm the latest apparatus of Hargreaves & Bird and of Hulin (filtering electrodes) deserve the most recognition.

The principle applied since 1891 by Sinding-Larsen, Castner, Kellner, and others of using mercury for transporting the alkali metal from one cell of the electrolytic decomposing tank to another has lately been viewed with favor. Sinding-Larsen and Kellner have been perfecting their apparatus in a very remarkable manner. This mode of electrolyzing salt solutions will not do away with that source of loss of energy which consists in the electrolysis of a part of the

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* *Zeitschrift für Elektrochemie*, 1894 and 1895.

† Nernst-Borchers, *Jahrbuch der Elektrochemie*, W. Knapp, Halle-a.-d.-Salle (Bd. I.).

caustic alkali already formed in the cathode cell, yet it offers the advantage of furnishing very pure though not very strong solutions of the hydrate.

There is hardly any alkali manufacturer to-day who is not experimenting with a view to making his caustic electrolytically, and it is very hard to say who has really passed the experimental stage. The A. G. Elektron (Frankfurt-am-Main, Germany) is said to be in running order manufacturing alkali and chlorine. The Elektrochemische Werke at Bitterfeld has not yet made any public statements as to whether, besides chlorates, it has succeeded in making alkalis; the Consortium für Elektrochemische Industrie is about to start a 2500 horse-power plant for making caustic alkali and chlorine at Golling, near Hallein. The Deutsche Solvay Werke at Berneburg and the Vereinigte Chemische Fabriken at Leopoldschall, near Stassfurt, are known to be experimenting on a manufacturing scale.

From the remaining inorganic products, in the manufacture of which some remarkable progress may be noted, we will have to mention in the first place

CARBIDE OF CALCIUM.

The publications of Mr. Willson and his friends in 1894 have aroused a very lively interest in this product and its manufacture. I obtained this product while experimenting to reduce the oxides of the alkaline earth metals by electrically heated carbon about eight years ago, yet, looking for the metals themselves, I did not care at all for the dark residue I obtained in some of these experiments when using a surplus of carbon, though I observed the evolution of an ugly smelling and combustible gas (acetylene) when the product was thrown into water. If we are to talk about the process of manufacturing carbide of calcium I must state that neither the Willson process nor any other one of the lately patented processes is new. From the historical data on carbides the truth of this statement will readily be confirmed.

1. In 1836 E. Davy (not Sir Humphry Davy) observed that the residue from the manufacture of potassium when thrown into water developed a combustible, badly smelling gas—acetylene.* This fact leaves no doubt that oxides of the alkali or alkaline earth metals when reduced in presence of carbon will furnish carbides of said metals.

2. In 1862 Wöhler, the well-known German chemist, succeeded in directly combining calcium and carbon, obtaining a carbide corresponding to the formula CaC_2 by heating an alloy of calcium and zinc in presence of carbon. He also recommended this carbide for the synthesis of acetylene.†

3. In 1891 the author of this article published in the first edition of his book on electro-metallurgy‡ that he had succeeded in reducing by electrically heated carbon all oxides theretofore considered to be unreducible. The following simple apparatus was used to demonstrate any of the reductions desired:

The thick carbon rods *K K* are connected by a thin rod, *k*, the cross section of the latter being about one-tenth that of the rod *K*. To fasten the thick carbon

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* *Ann. d. Chemie und Pharm.*, Vol. XXIII., p. 144.

† *Ibid.*, Vol. CXXIV., p. 220.

‡ Borchers, *Elektrometallurgie*, 1st ed., 1891 (published by H. Bruhn, Braunschweig, Germany). The second edition published in 1895, contains all data on carbides known up to that time.

rods they are laid between bricks A, B, C, D. Bricks S close to the sides of the heating chamber, while the bricks F give the foundation to the furnace. After the heating chamber, containing the rod k, has been filled with a mixture of the oxide to be reduced with coal, a current is passed through the carbons, which are connected by the clips V and the cables L to a suitable source of electricity. The density of current in the thin carbons, to produce the necessary heat, should be from 5 to 10 ampères per square millimeter cross section, according to the degree of reducibility of the oxide under treatment. No electrolytic action takes place

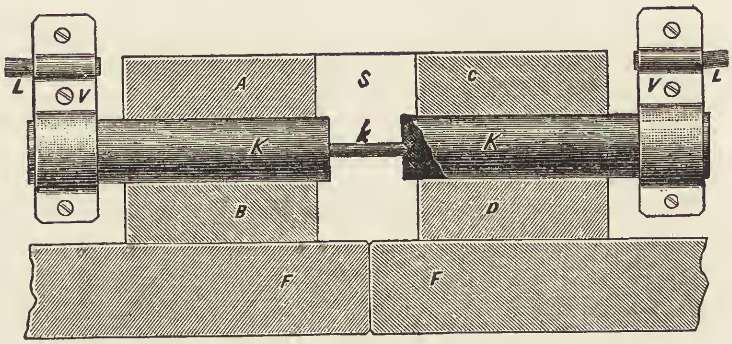

FIG. 2.—BORCHERS' APPARATUS FOR REDUCING OXIDES.

in this furnace; it is a simple reduction accomplished by electrically heated carbon. In the same volume I repeatedly stated that some of the products of these reductions contain a great deal of carbon and have completely lost their metallic character.

We will have to stop here a moment before continuing the history of carbides, in order to state that since 1891 the following two reactions have been publicly known:

$$CaO + C = Ca + CO.$$
$$Ca + C_2 = CaC_2.$$

The latter chemical process was discovered by Wöhler in 1862, the former by Borchers in 1888 (published in 1891).

If now we are considering the claims of Willson and of Moissan, not to speak of the commercially impossible processes of Maquenne and Travers, it is rather difficult to find any novelty in their mode of working. For what are they doing to obtain calcium carbide? They are heating electrically a mixture of calcium oxide and carbon; they are utilizing two reactions known since 1862 and 1891. Neither of these two reactions has been patented. Nobody is entitled to claim the exclusive use of these well-known chemical reactions, no matter if the necessary heat is produced in the way described by Borchers, which kind of heating has been known since 1815, or by the electric arc, which has also been often applied in electro-metallurgy. In reply to the questions raised by the editor of the *Engineering and Mining Journal* lately, it may safely be stated that there can be no patents covering the substance calcium carbide or any other carbide, and that the production of calcium carbide (according to the reactions described above) in the electric arc furnace as well as in other electric resistance furnaces is free to anybody. There is a large number of works in Germany producing calcium carbide for sale as well as for their own use without paying royalty to patentees.

Regarding the question of the expense of calcium carbide, we will certainly find it quite natural that those who are now making this product on a large scale are not at all anxious to publish statements of their experience. One kgm. of calcium carbide is sold in Germany to-day for about 10c.; that will amount to about $90 per 2000 lbs. Considering that this is a retail price and that now, when the whole chemical industry is experimenting with calcium carbide, a much higher price would gladly be paid, the selling price in the present phase of development of the carbide industry must be called low. There is no doubt that it will steadily grow cheaper as the demand and the consumption increase.

The question as to which way of producing the heat in the electric furnace will prove the most economical one has not yet been settled. To judge from my own experiments, the method of heating by the aid of a solid resistance (carbon), which may form part of the mixture to be heated, seems to be preferable whenever the carbide obtained is to be used on the spot for making other products, like acetylene. In this case the fusion need not be a perfect one and the electric arc spends more heat than is necessary. But calcium carbide that has to be stored and shipped ought to be thoroughly fused so as to form solid lumps, which will not be influenced too quickly by air and dampness. In such cases electric arc heating may prove more advantageous than the former method. Improved furnaces, however, will enable us to obtain thoroughly fused carbide by resistance heating as well as by the arc heating process, and at a lower figure. Furnaces of this kind have been devised and constructed, but not yet published.

The chemical industry in Germany is quietly making practical tests, and no doubt the present year will bring revelations of a more solid foundation than the optimistic speculations heretofore advanced.

OTHER INORGANIC CHEMICALS.

The manufacture of persulphuric acid ($H_2S_2O_8$) and several persulphates is gaining practical interest. It will hardly be worth while to enumerate the patented propositions, for Professor Elbs (Giessen) and Dr. Schönherr (Giessen) have so thoroughly investigated the conditions for the formation of these compounds that we may refer to their publications on this subject in the *Zeitschrift für Elektrochemie* (1894 and 1895). The specifications of patents do not say nearly as much as the papers of these chemists. They have found that the electrolysis of a moderately dilute sulphuric acid (sp. gr. 1.4) or saturated and strongly acidulated solutions of alkali sulphates by means of currents of high density (10,000 ampères per sq. meter anode surface) at a low temperature sustained by artificial cooling will return the highest percentage of persulphuric acid or of persulphates.

A number of patents referring to improvements in the manufacture of well-known inorganic chemicals, such as white lead and others, may be left to prove their usefulness. At present it is hard to recognize their practical value.

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Winthrop W. Fisk, Mining Engineer and Geologist, Boston, Mass.: "Vol. I. of the Mineral Industry is at hand, and I congratulate you most sincerely on the great success you have made of it, from the binding and general make-up to the vast amount of valuable matter to be found in it. The character of the advertisements shows conclusively the high standing of the *Engineering and Mining Journal.* The early appearance of the first edition of a work of such magnitude is a great credit to the ability and energy of an American institution, and is a worthy adjunct to the leading mining journal of the world."

A. G. Charleton, Mining Engineer, Villa Henriette, Argelis, Hautes Pyrenees, France: "It gives me great pleasure to express my appreciation of the thoroughness and practical utility which characterize its compilation throughout. You have handled and condensed an immense amount of statistical and other material in a most masterly manner, and placed it in a form which will be invaluable to engineers, metallurgists, and business men. If it is not on the bookshelf of every one who is interested in mines and mining, it ought to be, and those who are without it will certainly miss an opportunity of enlarging their ideas and knowledge."

C. W. Stickney, General Manager, Phi Kappa Mining Company, Limited, Ketchum, Idaho: "I find the Mineral Industry to be the most thorough work of its kind ever attempted in the domain of mining and metallurgy. No one engaged in mining or metallurgy, or expecting to be so engaged, can afford to be without it. It is just what it purports to be, a correct photograph of the present state of the entire mineral industry of the world. I prize it as one of the most valuable of my reference books; for I find it completely filled with important information which one often wants in a hurry, and which is not to be obtained from any other easily accessible source."

John Heard, Jr., Paris, France: "I am confident of being one of a noble and large community of intelligent men when I bring, among the rest, my thanks and my slight tribute of admiration for what you and your staff, who have been able to accomplish, as it were in a day, what the many handed government idol has been unable to accomplish in much over a year and a day. The volume is a masterpiece of modern co-operation and it would be both interesting and instructive to read an article telling tersely how it was done. The book is a model of its kind. The only question that some little demon (who evidently does not like you) whispers in my ear is—'Ask him about Vol. II.'"

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The *Engineering News*, of New York : "The several technical articles are written by specialists, and the statistical matter bears evidence of careful preparation, and is well arranged."

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The *Oil, Paint & Drug Reporter*, of New York : "It is a volume of over 600 pages, which will be found valuable for reference by all interested in the mineral and metal products of this and other countries."

The *Bulletin of the American Iron and Steel Association*, of Philadelphia, Pa.: "It . . . is one of the most comprehensive and ambitious statistical and technical compilations that has ever appeared in this country."

The *Times*, of Denver, Colo. : "It is much more exhaustive than the federal government's annual statement covering the same great industry, and there is no question as to its being received with more reliance."

The *Popular Science Monthly*, of New York : "It is the most comprehensive work of this nature which has ever been put before the public. . . . Mr. Rothwell is to be congratulated upon the very useful volume."

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The *Marine Review*, of Cleveland, O.: "The enterprise shown in undertaking a publication of this magnitude is highly commendable, and the comparative promptness with which the results have been presented to the public is especially creditable."

The *Public Opinion*, of Washington, D. C.: " This volume . . . is a wonderful summing up of the facts of what might be called, not as of old, the Iron or the Golden, but the Mineral Age. . . . It is a volume well worthy of the Columbian year."

The *Investors' Guardian*, of London, England: " This is by far the most valuable volume ever published on general mining work. . . . Miners in all parts of the globe will find their intelligence stimulated and their learning increased by the study of this remarkable book."

The *Chemical News*, of London, England: " This most useful work is designated as the Statistical Supplement of the *Engineering and Mining Journal*. . . . This work will meet with a large demand among miners, metallurgists, and consumers of or dealers in metals."

The *Industry*, of San Francisco: "Every engineer, mine owner, economist and what we call ' public man ' should have a copy for reference now that this important industry is so classified and arranged that a moment's time discloses the main facts and quantities of the past year."

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El *Minero Mexicano*, of the City of Mexico: "Con todo probabilidad este tomo es la obra más importante que jamás se ha publicado sobre la estadistica de la industria mineral. . . . Repetimos que esta obra es de mucha importancia y recomendamos su adquisción a todos nuestros lectores."

The *Press*, of New York: "The book is a statistical supplement to that publication (The *Engineering and Mining Journal*). Another volume, entirely new, supplementing the data given in this, will be issued, so that after four or five years the statistics of the mineral industry of the world will be complete in the set."

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The *Proceedings of the American Society of Civil Engineers*, published in New York: " It must prove of value to all interested in the industry. The work is one which must commend itself, through its admirable arrangement and the value of its statistics, to every mining engineer and to the mining world in general."

The *Independent*, of Helena, Montana: " The most valuable publication of the year, so far as relates to the mineral industry of the world, is a volume just issued by the Scientific Publishing Co., of New York. . . . The publication is one that no mining man who desires to be well informed can afford to be without."

The *Bulletin*, of San Francisco, Cal.: "A vast amount of information is collated and arranged in such an orderly way that it is not only a complete reference book for mineralogists but for the much greater number who will have occasion to search for particular facts cited under the head of some one of the subjects here treated."

The *Review of Reviews*, of New York: " This volume . . . will be indispensable to the chemist, metallurgist, manufacturer, legislator and all in any way concerned with the mineral production of the United States and foreign countries. Its accurate, full and recent tabulations are a monument to modern methods in statistical work."

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Kritischer Vierteljahresbericht, of Freiberg, Germany: "Diese bedeutende Publikation geht uns so eben bei Schluss dieser Nummer zu und wir wollen nicht verfehlen, unsere Leser auf dieses mit ausserordentlichem Kostenaufwand unter Mitwirkung eines ganzen Generalstabs von Mitarbeitern herausgegebene Werk hiermit vorläufig aufmerksam zu machen."

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The *Australian Ironmonger*, of Melbourne, Australia: "This is a handsome and important book . . . and is really a monument to enterprise and skill and knowledge of the requirements of the mineral industry. . . . The volume is one of the greatest possible value to all interested in mines and minerals, and it will certainly become a standard work of reference."

The *School of Mines Quarterly*, Columbia Coll ge of New York: "Technical articles by competent authorities give the recent progress in each department of mining, metallurgy and chemical industry, forming a valuable work of reference. The tables of itemized cost of production of many of the minerals and metals afford valuable information to all interested in the industry."

The *Queenslander*, of Adelaide, Australia: "Under this title (The Mineral Industry) the editor of the New York *Engineering and Mining Journal* has gathered together a vast store of statistical and other information relating to mining in every part of the world. No mineral is too scarce or insignificant to receive attention, and the result is a rather formidable looking volume of over 600 pages."

The *Southwest*, of Cincinnati, O: "It is a marvelously complete and fresh report, bringing statistics down to the end of last year. . . . For solid information few books will be as valuable to the student as this, of which the *Scientific American* says that it has been compiled with the greatest possible care, and which the *Industrial World* calls an 'encyclopædia of statistical facts.'"

The *Mexican Trader*, of the City of Mexico: "The work bristles with facts, figures and information of all kinds relative to the mineral industry, and pays considerable attention to Mexican mining matters. We intend in future issues to devote considerable space to reproducing portions of the volume in the interest of our mining readers, whom we, however, strongly recommend to purchase the work."

The *Tribune*, of New York: "It is the outgrowth of the annual review which *The Engineering and Mining Journal* formerly printed each year, and which was found of great value for reference, and to people engaged in the various trades . . . the volume is especially valuable for its completeness of statistical information regarding the growth of the various industries, both in this and other countries."

The *Herald*, of Boston, Mass.: "It is a very exhaustive statement of everything pertaining to the mineral productions of the whole world. . . . Too much cannot be said in regard to its value to those who have to do with the common and precious metals. It is a work entirely unique of its kind, and every year the new volumes will increase the value of the work as a complete and authoritative record of all that goes in the name of this line of mineral products."

The *Advertiser*, of Newark, N. J.: "Our mineral industries, as they presented themselves at the close of last year, are treated in the annual statistical number of the *Engineering and Mining Journal* in a way that makes the publication of great value to all interested in this important subject. Not a single mining industry of any value is found wanting in this admirable review of the business, and both the commercial and industrial features of the trade are discussed."

The *North China Daily News*, of Shanghai: "We feel confident that this volume will be welcomed most readily by all who are in any way brought into contact with or affected by mining, and just now it would not be an easy task to say who is excluded from the category. To the producer, manufacturer or merchant it will give much valuable assistance, and the expert practically engaged in mining will particularly appreciate its scope, accuracy and conscientiousness."

The *Chattanooga Tradesman*, of Chattanooga, Tenn.: "It is a magnificent achievement and is a perfect storehouse of useful information, being in reality indispensable as a reference book for all matters pertaining to minerals. The Tradesman ventures frequently into the line of statistical publications, and in the light of this experience can unhesitatingly pronounce this work as a marvel of completeness and an invaluable contribution to statistical and scientific literature."

The *Black Diamond*, of Chicago, Ill.: "The work . . . represents a vast compendium of most useful information and detailed work. Its wealth of information will make it a welcome and most valuable volume of reference. It is a valuable and complete exponent of the industries of the country, and should be upon the library table of all interested in iron, coal, copper, tin or cognate matters. Its compilation is a testimony of and reflects the highest credit upon its author."

The *South African*, of London, England: "Little use is it to glance at the imprint of this work to see that it emanates from America. It is only there that such enormous masses of numerical literature are hurled at the public at the low price of the book before us. It is a statistical supplement to our popular and talented contemporary, the New York *Engineering and Mining Journal*. . . . The amount of information . . . compressed with these flimsy covers is nothing short of wonderful."

The *Electrical Industries*, of Chicago, Ill.: "The various metals and minerals, copper, mica, asbestos, platinum, asphaltum, etc., enter largely into the manufacture of electrical apparatus and the information regarding them contained in this volume will be of great interest and value to the manufacturer, to the dealer and the user. The large number of professional, scientific and practical men who have been employed in the production of this work point to the reliability of the matter it contains."

The *Canadian Mining Review*, of Ottawa, Canada: "A most valuable addition to mining literature is the very comprehensive review of 'The Mineral Industry, its Statistics, Technology and Trade in the United States and Other Countries,' presented in a handsome volume of some 600 pages by our esteemed contemporary the *Engineering and Mining Journal*, of New York. This volume covers so wide a field that we can do no more at present than recommend it most heartily to every reader of the Review."

The *Statist*, of London, England: "Its comprehensive title is 'The Mineral Industry,' and exhaustive statistical information is given, besides facts as to prices, cost of production, etc., of all the minerals and metals. And what is an interesting feature besides is the same information extended to each important country. . . . We have to congratulate Mr. Rothwell, the editor of the Journal, upon his latest comprehensive work, and the manner in which that work has been compiled and, we may add, printed."

The *Wall Street Journal*, of New York: "The annual statistical number of the *Engineering and Mining Journal*, just issued by Mr. R. P. Rothwell, its editor, is a 600 page volume, treating the geography, geology, mineralogy, statistics, metallurgy and economics of every mineral produced in the world that is of commercial value. . . . Statistics . . . are accompanied by elaborate tables, in which are to be found cost of production, It is a book of reference which every broker and banker will find useful."

The *Courier*, Plainfield, N. J.: "Within our limited space no adequate account of the detailed information contained in this book or of the enormous labor involved in gathering it can be given. . . . Within our knowledge this information is not to be found in any other one book nor in any half dozen; no encyclopædia contains one-tenth of it. . . . The book is no one man's work, but is made up of contributions from many of the most prominent mining engineers, metallurgists, and chemists in this and foreign countries."

Revista Minera, Metalúrgica y de Ingeniería, Madrid, España, Junio 24 de 1893: "En este gran libro de 600 páginas de nutrida impresión no es sólo una estadística de la industria minera y metalúrgica, sino que es al mismo tiempo una historia de las explotaciones de minerales de los más remotos tiempos, así como una exposición de los procedimientios metalúrgicos nuevos y más interesantes, abordando también las cuestiones de tráfico, de coste de producción, marcha de mercados y cuantas pueden interesar á los que en cualquier sentido se ocupan de Minería y Metalurgia.

The *Times*, of New York; "It is an admirable and remarkably comprehensive collection of valuable statistics, brought down to a time within a very few days of the date of publication. We do not know that any other collection of statistics in this field, even approaching the excellence of the Journal's supplement, has been published in any part of the world. The change of form has enabled the Journal to extend the scope of its supplement and to add many new features. We are confident that the new volume is the most complete and valuable of all publications of this kind."

The *Financial Times*, of London: "We turn for light on the subject to the instructive volume just issued from the office of the *Engineering and Mining Journal*, of New York, which we have already noticed. The paper is recognized as the best mining publication in the world. Its correspondence is extensive and widespread, its information generally impartial and reliable. In its first volume of the work entitled 'The Mineral Industry, its Statistics, Technology and Trade for 1892,' the mining of the past year throughout the world is elaborately reviewed."

The *Morning Call*, of San Francisco: "This handsome volume of over 600 pages is a veritable mine of information on the subject of which it treats. It embraces a complete history of the mineral industry, its statistics, technology and trade in the United States and other countries from the earliest times to the close of 1892. A careful examination of the book shows that the ideas of the editor have been carried out in a manner deserving the highest commendation. Indeed the work is invaluable to all interested in the important subject of which it treats, and no library without it can be called complete."

Le *Bulletin des Mines*, of Paris, France: "Il est regrettable que nous n'ayons pas en France de livre similaire et qu'on y soit obligé, le cas échéant, de consulter un ouvrage, écrit en anglais et ne s'adressant par conséquent qu'à un nombre limité de personnes. Mais la rédaction d'un ouvrage semblable, qui est une véritable enclyclopédie, exige beaucoup de spécialistes compétents, et si la *Scientific Publishing Company*, grâce surtout à l'*Engineering and Mining Journal*, en dispose, nous croyons bien qu'aucune autre publication de Londres ou de Paris ne serait en mesure de rivaliser avec elle à ce point de vue."

The *Chronicle*, of San Francisco: " A volume of particular interest on this coast, and wherever mining of any kind is carried on, is " The Mineral Industry." . . . When the fact is stated that it covers the entire mineral history of the world, an idea of its scope is afforded. The work is the outgrowth of the annual statistical numbers of the *Engineering and Mining Journal*, but, in addition, contains much other data; all of which is drawn from the most authentic sources. Chapters are devoted to all the leading metals, giving in interesting shape the important facts in connection with their discovery, development and use."

Le *Génie Civil*, Paris, France, le 7 Octobre, 1893: " Un Journal de New York, The *Engineering and Mining Journal*, organe des mines et de la métallurgie, a publié la statistique minérale complète des États-Unis et du monde entier pour l'année 1892. L'ouvrage, un beau volume de 600 pages, constitue une véritable encyclopédie des mines et de la métallurgie. On y trouve la monographie de tous les métaux industriels, avec la description et l'indication de provenance de leurs minerais, l'étude des procédés métallurgiques nouveaux, les fluctuations de cours pendant l'année et des considérations économiques tirées de la comparaison de l'offre et de la demande."

The *Dixie*, of Atlanta, Ga.: " Mineral Industry . . . is a work which will be absolutely indispensable to every one interested in any department of the industry, whether as producer, as manufacturer, as merchant dealing in the mineral products, or as consumer. The information it contains has never before been collected, and it has great value to every intelligent man connected with the industry, and the volume will be kept on the desk throughout the year as a necessary book for constant reference. . . . This volume . . . gives the statistics to the end of 1892, or information just a year later and very much fuller than in the report of the United States Geological Survey just issued."

Rand & McNally's Monthly, of Chicago, Ill.: " Volume I. of this laborious work makes an addition to our library that we are not only greatly pleased with, but a feeling, we think, of just pride is added, that such a work comes from the American press, and from an American author. In the United States every man interested in mine-owning and working of mines and minerals will doubtless have this book without delay, and it must find its way into the libraries of thousands of others who desire the complete in their collection of permanent books. That able and thoroughly technical publication, the *Engineering and Mining Journal*, has our congratulations, being a co-operative associate of this work."

The *Florida*, of Ocala, Fla.: " When we first take up this unabridged encyclopædia of the mining industry we are surprised that so much can be put up for so small a price. As the volume opens and the superior quality of the work appears on every page, the wonder grows, and we are convinced that the miner or mining investor who does not have this book ready at hand is of that class which from its money is soon parted ; and this work is much more prompt and available than if it had been done by the governmental artisans, who, like all people at a picnic, don't care a custard pie for the needs of a man back in the busy market, who must have some accurate knowledge on which to base his figures for a 'future' sale."

The *Journal of Geology*, Chicago, Ill.: " In conclusion, it may be said that as a piece of statistical work, relating to an industry that is world-wide in its scope, combining accuracy with full detail and systematic arrangement, and issued so soon after the close of the time to which it relates, the Mineral Industry has never been equaled in this country or abroad. . . . In the Mineral Industry we have an epitome of the mining operations of every quarter of the globe, published almost immediately after the close of the time to which they refer, a feat which heretofore would have been declared impossible. . . . The volume will be found of the greatest value to the economic geologist, the miner, the engineer and the business man."

The *Iron and Coal Trades Review*, of London, England: "This volume . . . is without doubt the most important and the most valuable contribution to the literature of the mineral industry ever published, and Mr. Rothwell, the talented editor, is to be heartily congratulated upon its appearance. The present volume is only a first installment of the information promised, but its contents is of such a varied and practical nature that by itself it would form an indispensable book of reference. . . . Never before were such valuable data so assiduously collected, and never before was it attempted to collect and publish so promptly the statistics of all the minerals and the chemical industry in the United States and in most of the foreign countries."

The *Science*, of New York: "In the years of 1874-75 and '76, the *Engineering and Mining Journal*, of New York, published the first complete reports of the coal production of the United States, and in 1889, as special government agent for the census, the editor of the Journal, Mr. Rothwell, collected the statistics of gold and silver. The scope was gradually extended until in January, 1892, a magnificent volume of statistics was given to the world and universal encomium heaped upon the Journal and its staff for their wonderful work. Indeed, such was the unstinted praise accorded it, we can but wonder what language will be used for the present volume, no longer a supplementary number in journal form, but a handsome library volume of 628 pages."

The *American Mechanic*, of Chicago, Ill.: "The volume is a statistical supplement of the *Engineering and Mining Journal*, which, as the leading representative of the mineral industry has accumulated a large amount of statistical matter and has created facilities for securing minute and accurate details. These facilities have been attained through financial outlay and no little painstaking and mental labor. The volume of 628 pages before us is replete with stores of valuable information which is not confined to statistics, but is embellished and intensified in interest by illustrated descriptions of mining machinery and operations. . . . The work is one of great usefulness and value, whether regarded as a work of reference or as one containing reliable information upon mineral and metal industries."

The *Report*, of San Francisco, Cal.: "One of the most valuable books recently published, 'The Mining Industry,' has just been issued by the Scientific Publishing Co., of New York. The book . . . is a valuable work of reference. It is crammed full of matter with reference to all branches of the mineral industry, the production, statistics, technology and trade in the United States and other countries from the earliest times to the close of 1892. The editor very truly says that statistics must be fresh to be valuable, and as a consequence everything has been brought up to the latest date possible. In this respect the book differs very essentially from most of the Government publications, in which, too often, so much delay has occurred that the matter when published has lost most of its value."

The *Capitalist*, of London, England: "Mr. Rothwell, the editor of this valuable book, is also the editor of the *Engineering and Mining Journal*, of New York, a periodical of world-wide fame among the mineral interests and their allied and collateral industries. The fame of the journal is founded upon its excellent work, the information gathered together from the four quarters of the earth being exhaustive, and presented in a manner to be useful and instructive. The book now under notice is called a 'statistical supplement' of the Journal, a description which by itself will be sufficient recommendation. In fact, the contents of the volume go far beyond the statistics, good as they are in themselves. . . . Altogether there is a fund of valuable matter for reference which is not to be found in any other book."

L'Echo des Mines et de la Métallurgie, of Paris, France: "Cette publication réunit pour la première fois tous les renseignements sur la production des mines et usines, exportations, importations, statistiques, etc. On y trouve des renseignements précieux sur les métaux et mineraux exploités dans les États-Unis, nous citerons les articles sur l'aluminium, les produits chimiques, charbon et coke, cuivre, étain, zinc, plomb, or et argent. Cette partie, la plus considérable de l'ouvrage, a été traitée avec une très haute compétence par tous les collaborateurs. Cette publication renferme les statistiques du monde entier sur les mines et la métallurgie, et est indispensable aux producteurs et aux consommateurs ; elle fait le plus grand honneur a son éditeur, M. Rothwell, qui en a fait une véritable édition de luxe."

The *Industries and Iron*, of London, England: "This volume is a striking example of American journalistic enterprise. Covering 628 pages, in addition to the 115 pages of advertisements, it contains very full mineral statistics compiled with commendable promptitude. The various sections of the work have been intrusted to well-known specialists, the list of contributors including about fifty eminent names. The result of their labors is a complete epitome of our knowledge of the mineral resources of the American continent, with supplementary information relating to other parts of the world. Mr. Rothwell's great work is deserving of very hig praise. It constitutes an important work of reference, the value of which is greatly enhanced by the fact that the statistics it contains have been so promptly publis ed."

The *Age of Steel*, of St. Louis, Mo.: "It is in fact a great work, representing a large amount of labor and money and a wealth of information that is practically invaluable to every one interested in any department of the mineral industry, be he producer, manufacturer or merchant. To each and all of these it has a claim on his desk and interest not to be questioned by any practical business man. In accuracy and completeness it is evidently all that painstaking and conscientious bookmaking can make it, while the ground it covers has its only limits in the subjects it handles. It has also a special value as being the first volume of a series that in an annual form will eventually include the mineral statistics and progress of all nations, and be an invaluable encyclopædia of all matters pertaining to mineral industries. If you want to keep abreast of the times, get *it*."

The *Herald-Democrat*, of Leadville, Colo.: "It has usually been the custom of the *Engineering and Mining Journal* to issue each year a statistical number relating to the mineral industry of the world. The vast sources of information at the command of this great journal, its generally accepted accuracy in all that pertains to mining in all its branches, and the universal favor with which its statistics have been received by experts have induced the publishers to undertake the publication of a larger and more complete statistical volume, which is now issued. The title is 'The Mineral Industry; Its Statistics, Technology and Trade in the United States and Other Countries, From the Earliest Time to the End of 1892,' all of which is comprised in a handsome volume of 700 pages, octavo, in which is compressed a vast store of information brought down to the beginning of the present year."

The *Industrial World*, of Chicago: "One of the principal advantages of this work, aside from its riches in knowledge for every-day uses, is its prompt appearance, in which it far outranks the publications issued by the government. . . . Eminent men and experts, extending into a long list, have contributed to the contents. Neither labor nor expense has been spared in the preparation of the volume, which is really an encyclopædia of mineral resources and development in the countries brought under view, with especial elaboration as regards the United States. Moreover, the work will fill a long unoccupied niche in both public and private libraries, and must prove an invaluable adjunct to both. It is a work of reference which any reviewer can conscientiously recommend as well worth the price of its purchase; for its standard of excellence places it in the highest rank of reliability."

The *Railroad Gazette* of New York: "This volume is a result of the development of the annual statistical numbers of the *Engineering and Mining Journal*, of which we have had occasion to speak very favorably before. For some years that journal has collected statistics of the mineral products of the United States and published them promptly at the close of each calendar year, and his publication has been very useful as well for its accuracy as for its remarkable promptness. This work has been compiled, enlarged and collected into the volume now published, in which are given statistics of nearly all of the minerals and metals produced in the United States and in many other countries for the year 1892, and in many cases from early times. The mass of information collected is certainly very great, and the volume is a valuable addition to the library of the scholar, and is a triumph of enterprise."

The *Iron Trade Review*, of Cleveland, O.: "In this volume the *Engineering and Mining Journal* has reached the climax of its splendid achievements in mineral statistics. Its annual statistical numbers have been marvels of completeness and promptness, giving within a short time after the close of each year the figures for production in every line of the mineral industry. And to fullness and timeliness, the Journal has also added accuracy. The great octavo volume that is before us, with its excellent typographical dress, its cloth binding, and its 628 pages of information, covering the whole field of mineral production, is the last evolution of the annual statistical number. The different departments of the work have been put in competent hands, the list of editors including names that will be recognized at once as lending the stamp of authority to whatever is credited to them. The task of bringing out so early in the year so comprehensive a volume is simply stupendous."

The *Stone*, of Chicago, Ill.: "It has been said that statistics are dry reading. That is not always the case. . . . This is the view held by Richard P. Rothwell, editor of the *Engineering and Mining Journal*, when he compiled the work above named, and by the way, the noted journal he has the honor of editing is among the greatest of successful achievements in technical journalism, and "figures" have made it such. The book here mentioned is the mass of these boiled down for more handy reference than the files of the ponderous weekly, from which they are derived, could be—hence must be of almost priceless value to the miner and engineer, and we find in this work not only the statistics of the mineral industry of this and other countries, but as well the technology of discovery, improvement and development during all times up to the beginning of the present year. If the tables are of value to the practical reader, these descriptions are equally so. . . . We would advise its purchase by every one who desires authoritative information of the character given."

L'Extrait des Annales des Mines, of Paris, France: "Ce volume, dû a l'initiative de la direction du journal, de M. R. P. Rothwell en particulier, renferme sur l'industrie minérale non seulement des États-Unis, mais de tous les pays du globe, des données du plus haut interêt, et dont la valeur est garantie par les noms des différents collaborateurs de l'œuvre, choisis parmi les spécialistes les plus competents. . . . Cet énorme volume de 650 pages, qui ne saurait être trop recommendé a l'attention de tous ceux qui s'intéressent à l'industrie minérale et aux données statistiques qui s'y rapportent. . . . L'ouvrage comprend une série d'articles spéciaux des plus remarquables consacrés a chaque substance en particulier : on y trouve des données d'un grand intérêt sur les gisements soit de la susbtance elle-même, soit des minérais dont on l'extrait, puis les tableaux de production. . . . Enfin, le volume se termine par des statistiques spéciales, très documentées et riches en renseignements intéressants sur différents pays du globe. . . . Cet ouvrage mérite d'être signalé comme un merveilleux exemple de ce que sait réaliser l'initiative privée aux États-Unis."

The *Colliery Engineer*, of Scranton, Penn.: "This book gives an account of the geographical and geological distribution of the metallic and non-metallic minerals, together with numerous historical facts and chronological data relating to the development of mining, as well as statistical tables showing the commercial importance of the different minerals. The contributors to the volume include many experienced mining engineers, expert chemists, and skillful metallurgists, who, in the respective subjects on which they write, supply a valuable collection of useful and technical information relating to the chief mineral products of the world, their properties, their mode of occurrence, their geological situation, and their treatment and utilization in the arts. The composition of the work is the result of a large amount of honest labor by men, who, by their practical training, were well qualified for the task. A study of the tabular matter, relating to the amount and cost of production—the amount and value of imports and exports of the various minerals cannot but be of great interest to the statistician. The information contained in the book is very full, and is brought down to the latest possible date. The mining engineer will value it as a work of reference for the practical information which it contains relating to the various mineral deposits, the chemist and metallurgist for the different methods of treatment described, and the commercial man for the detailed particulars it gives relating to produce, sales, cost, and consumption. The work may be considered a cyclopædia of the mining industry, and is one, the publication of which the editor has every reason to be justly proud."

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Ferry, Charles.
Hanahan, J. Ross.
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Dealers in Mining, Milling, Smelting, and other Machinery and Supplies.

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Adams, W. H.
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Chemical and Geological Essays, Second Series.
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Gates Iron Works. Risdon Iron Works.

Quicksilver.
(See METALS.)

Rails.
Bethlehem Iron Co.
(See METALS—IRON AND STEEL.)

Railways.
(See TRAMWAYS.)

Red Lead.
Cookson & Co.

Reducing Valves.
(See MACHINERY.)

Rock Breakers.
(See CRUSHERS.)

Rock Drills.
(See DRILLS—MACHINERY.)

Roll Shells.
Chrome Steel Works.

Rope.
(See CABLES.)

Sampling and Testing Works.
Ledoux & Co. Mecklenberg Iron Works.
Mariner & Hoskins. Ricketts & Banks.

Sampling Machinery.
Allis, Edw. P., Co. Gates Iron Works.
Fraser & Chalmers. Mecklenberg Iron Works.
Risdon Iron Works.
(See MACHINERY.)

Sawmill Machinery.
(See MACHINERY.)

Schools.
Massachusetts Institute of Technology.

Screens.
Fraser & Chalmers. Gates Iron Works.
Jeffrey Mfg. Co.
(See MACHINERY—PERFORATED METALS.)

Sectional Track.
(See MACHINERY.)

Shafting and Shafting Pulleys.
Bethlehem Iron Co. Mecklenberg Iron Works.
(See MACHINERY.)

Sheet Lead.
Cookson & Co.

Shoes and Dies.

Chrome Steel Works. Gates Iron Works.
Krupp, Fried., Grusonwerk.
(See MACHINERY.)

Silver.

(See METALS.)

Smelters and Refiners.

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Boston & Colorado Smelting Co.
British Columbia Smelting & Refining Co.
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Lewisohn Bros.
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Montana Ore Purchasing Co.
Old Dominion Copper Mining & Smelting Co.
Omaha & Grant Smelting Co.
Orford Copper Co.
Picher Lead Co.
Roessler & Hasslacher Chemical Co.
Russell Process Co.

Spelter.

(See METALS.)

Spiegeleisen.

(See METALS.)

Stamp Mills.

Allis, Edw. P., Co. Gates Iron Works.
Fraser & Chalmers. Hammond Mfg. Co.
Krupp, Fried., Grusonwerk.
(See MACHINERY.)

Steam Regulating Devices.

(See MACHINERY.)

Steel.

(See METALS.)

Steel Cams.

Chrome Steel Works.
(See MACHINERY.)

Stone Breakers.

(See CRUSHERS.)

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Matthiessen & Hegeler Zinc Co.

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Eustis Mining Co.

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Chrome Steel Works.

Tin.

(See METALS.)

Tool Steel.

Bethlehem Iron Co. Chrome Steel Works.
Gates Iron Works.
(Sec METALS—STEEL.)

Tools.

(See MACHINERY.)

Tramways.

California Wire Works. Hammond Mfg. Co.
Fraser & Chalmers. Jeffrey Mfg. Co.
Gates Iron Works. Lidgerwood Mfg. Co.
Risdon Iron Works.
(See MACHINERY.)

Valves.

(See MACHINERY.)

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Fraser & Chalmers. Krupp, Fried., Grusonwerk.
Gates Iron Works. Risdon Iron Works.
(See MACHINERY.)

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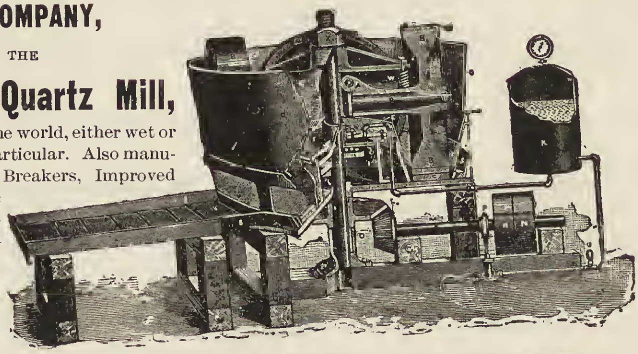

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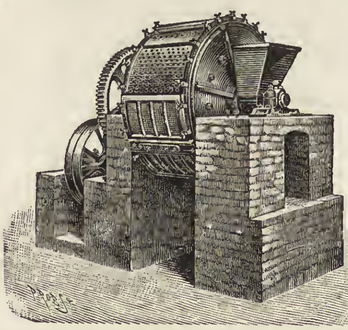

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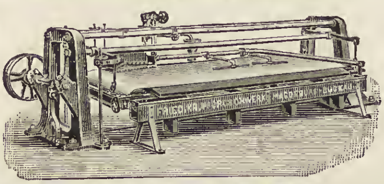

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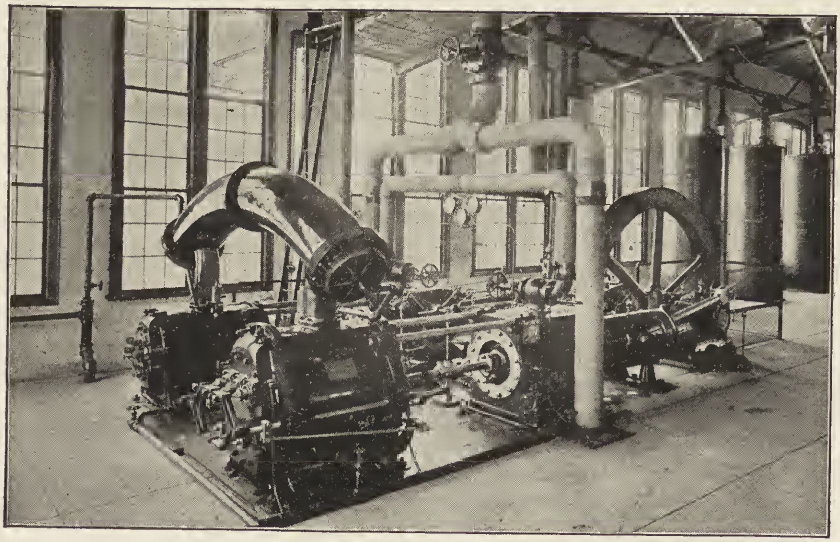

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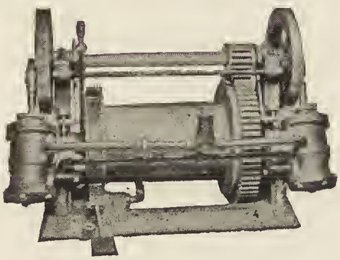

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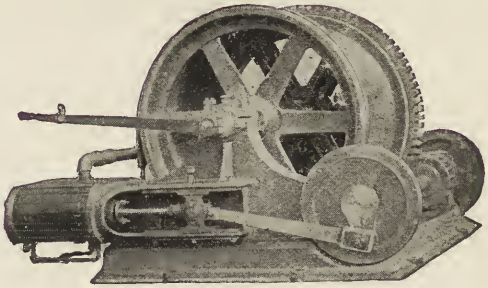

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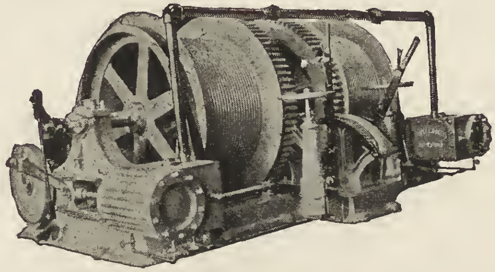

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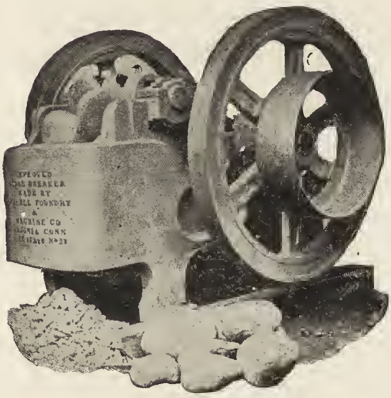

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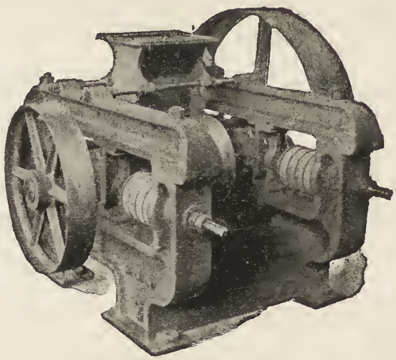

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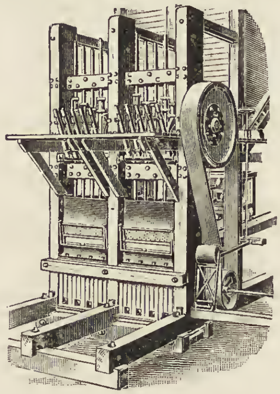

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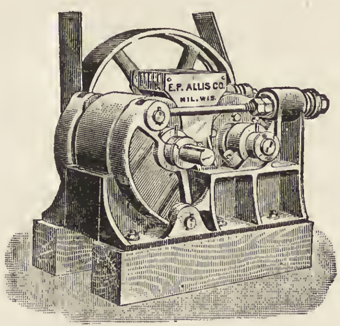

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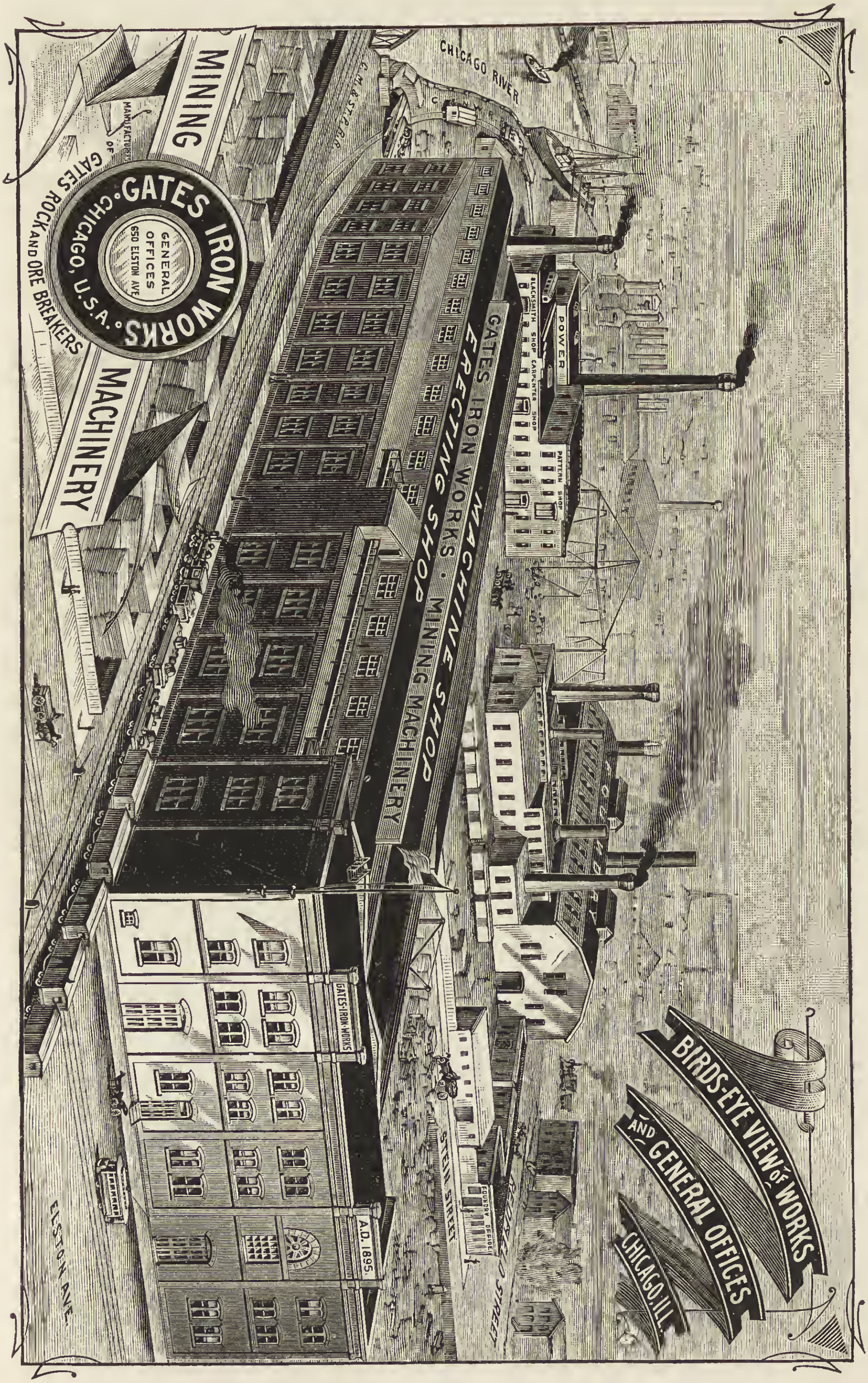
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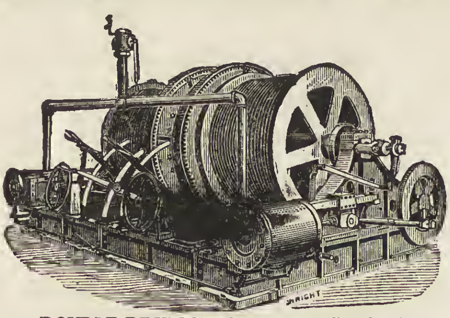

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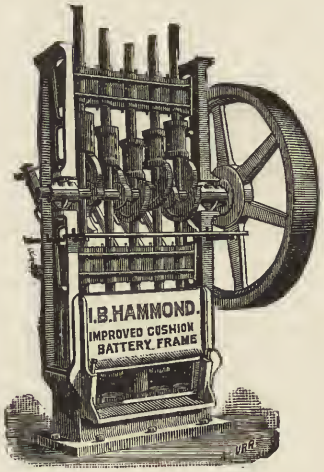

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