REPORTS ON SEPARATE MINERALS

IRON ORE

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By John Birkinbine.

The statistics which are given in this report refer solely to the iron ore mines located in the United States, excluding the insular possessions and Alaska; they show that in the year 1902, 35,567,410 long tons of iron ore were mined in the United States, 25 states and territories contributing to make this total. This includes 13,275 tons of special manganiferous iron ores obtained in Colorado. These ores were included because the labor and wages expended on them could not be segregated from those expended on the iron ores proper. The amount of true iron ore produced was 35,554,135 long tons.

The statistics included in this report do not show fully comparative data for the various census years because the inquiries at the different census periods were not identical. However, such as are shown will aid in a study of past and existing conditions.

Prior to 1880, the number of iron ore mines grew with the pig iron industry, individual blast furnaces depending largely upon mines which were adjacent to the plant or controlled by the same owners. Subsequently, as blast furnaces were enlarged requiring greater amounts of iron ore, it became necessary that several mines should be combined under the same management, or that existing mines should be exploited to a more liberal extent than before.

In Table 1 the statistics for each of the census years 1902, 1889, and 1880 are presented, but a résumé of the data, so far as it could be collated, for 1850, 1860, and 1870 is given, as follows: In 1850 the "number of establishments" was 197; the wage-earners were 2,195, receiving a total of $590,866 in wages; the cost of supplies and materials was $63,651, and the value of the product of the regular mining establishments to which these data refer was $1,217,803; but the amount of iron ore smelted was given as 1,579,309 long tons.

In 1860 the total amount of iron ore mined from 157 regular mining establishments was 908,300 short tons, or 810,982 long tons. These establishments gave employment to 3,177 persons, to whom $901,852 was paid in wages, and $249,699 was the cost of raw material. In addition, many of the large iron works of the country mined their own ore, the quantity thus raised amounting to 2,309,975 short tons, making the total quantity 3,218,275 short tons, or 2,873,460 long tons. While the short ton was not designated as the unit of measure in 1860 or 1870, it was reported in 1880 and presumably was used at prior censuses.

In 1870 there were 420 regular mining establishments, employing 15,022 wage-earners, who received as compensation $6,838,022. The cost of supplies and materials was $1,279,563. The product was 3,395,718 short tons, equivalent to 3,031,891 long tons, valued at $13,204,138. This production does not include the amount raised, between 800,000 and 900,000 tons, by some of the blast furnace operators, so that at a low estimate the production of 1870 reached a total of at least 3,831,891 long tons.

The inquiries for the census years 1902, 1889, and 1880 were more nearly identical than any of the others, and therefore a comparison of these gives results of greater immediate value. The statistics for these periods are summarized in the following table:

Table 1.—*Comparative summary, 1880 to 1902.*

	1902	1889	1880
Number of mines	525	592	(1)
Number of operators	332	(1)	[2] 805
Salaried officials, clerks, etc.:			
Number	2,405	[3] 520	1,253
Salaries	$2,113,230	$529,043	(4)
Wage-earners:			
Average number	38,851	[3] 37,707	30,415
Wages	$21,531,792	$13,880,108	[4] $9,538,117
Contract work	$425,292	$1,578,010	(1)
Miscellaneous expenses	$8,257,714	$3,795,509	(1)
Cost of supplies and materials	$9,005,608	$4,998,988	$2,894,011
Product:			
Quantity, long tons	35,567,410	14,518,041	7,120,362
Value	$65,405,321	$33,351,978	$23,156,957

[1] Not reported.
[2] Establishments.
[3] Foremen included as wage-earners.
[4] Salaries included in wages.

The number of mines in 1902 shows an apparent decrease of 67 since 1889, which was caused in part by a difference in the methods followed at the two censuses. In the year 1889 all iron mines were included which were doing exploratory work. In the statistics for 1902, however, only the mines which contributed iron ore are included, 257 which were being prospected,

or in which shafts were being sunk, or which were temporarily idle, being excluded. There have been numerous consolidations of important mines, thus reducing still further the number reported in 1902. In many instances two or three mines which were formerly operated independently have been united, connected with common shafts or slopes, and the ore usually all mined under one management. Thus, the Chapin mine, on the Menominee range in Michigan, combines what were formerly known as the Chapin, Ludington, and Hamilton mines; the Norrie mine, on the Gogebic range in Michigan, embraces the North Norrie, East Norrie, Norrie, and Pabst; and the Cary mine, on the same range in Wisconsin, represents the Cary, West Cary, and Odanah mines. Other similar consolidations in the Lake Superior and Southern districts could be mentioned.

In the 1880 census the number of establishments was reported as 805; this included a number of small operations, especially in the eastern section of the United States, which were afterwards abandoned because improved transportation facilities permitted the utilization of the richer ores of the Lake Superior district where operations on a large scale were possible.

The number of wage-earners and salaried officials was 38,227 in 1889 and 41,256 in 1902, but the compensation paid them increased from $14,409,151 in 1889 to $23,645,022 in 1902. It would appear, therefore, that the proportionate increase in the amount paid was much greater than in the number employed. This is due, in part, to the different methods used in the calculation of the average number of men employed. In 1902 the number of employees in active mines only were considered, and the average number employed during the year was reduced to correspond with the number which would be required at "continuous employment for twelve months to produce the quantity of product reported." Thus, if 200 men were employed at an open cut mine which, owing to climatic conditions, could be operated for only nine months during the year, the average number for the entire year, as determined in 1902, would be 150 instead of 200. The proportionate increase in the amount paid, therefore, is not so much greater than that in the number of employees as it might seem from the statistics.

Moreover, in the 1889 census all of the persons employed at mines which were active, or might again become active, were included. If to the number given for 1902 in Table 1 those employed in the exploitation of mines not yet shipping ore and in mines temporarily idle be added, the total number of persons employed would be increased from 41,256 to 41,551, and the wages from $23,645,022 to $23,822,339. In addition, in 1902, 1,365 men were employed by contractors in active mines and in development work, the contractors receiving $641,460.

In the year 1889 the cost of supplies and materials was $4,998,988, the amount paid in wages and salaries was $14,409,151, contract work cost $1,578,010, and miscellaneous expenses $3,795,509, a total of $24,781,658. In the year 1902 the total wages and salaries were $23,645,022, contract work cost $425,292, supplies and materials $9,005,608, miscellaneous expenses were $8,257,714, a total of $41,333,636.[1]

Table 1 indicates that in 1902 the quantity of ore mined was about five times the product in 1880, but that the value of the ore produced in 1902 was less than three times that of 1880.

The total value at the mines of the 35,567,410 long tons of iron ore produced during the year 1902 was $65,465,321, an average of $1.84 per ton. The value of the 14,518,041 long tons produced in the year 1889 was $33,351,978, or $2.30 per ton. This shows an increase in quantity of 21,049,369 long tons and in value of $32,113,343. Because of the greater use of labor-saving appliances, and other economies, resulting in part from the consolidation of contiguous mines, the average value per ton shows a reduction of 46 cents, or 20 per cent.

In the following statement the average value at the mine per ton of iron ore is presented for the census years from 1860 to 1902, inclusive. The figures for the regular mining establishments are taken for the earlier years, as the difference in total amount would make little change in the average value per ton of product.

CENSUS YEAR.	Average value at the mine per long ton of iron ore.
1860	$2.69
1870	4.35
1880	3.25
1889	2.30
1902	1.84

In the earlier census years the mines were nearer the furnaces, while in the later the ore was carried long distances to points of consumption. This explains, in part, the higher value at the mines in former years.

Development work.—In connection with mining a certain amount of preparatory or exploratory work is always required. In most of the producing mines the labor, cost of supplies and materials, and miscellaneous expenses incidental to such work are charged to the regular operating expenses and do not appear separately in the reports. There are, however, in addition, a number of mines which are mere explorations or developments, not having produced any ore, or old mines which, having been abandoned, have been reopened. It is difficult to obtain accurate information in regard to the expenditures for work done preparatory to the actual shipping of the ore, especially where a company has not been organized, but such data

[1] 1902 figures are exclusive of development work.

as could be secured are summarized in the following table:

TABLE 2.—*Development work, by states: 1902.*

	United States.	Michigan.	Minnesota.	Utah.	All other states.[1]
Number of mines	37	6	19	4	8
Number of operators	33	6	15	4	8
Salaried officials, clerks, etc.:					
Number	28	9	6	3	10
Salaries	$20,715	$8,259	$2,236	$1,000	$9,220
Wage-earners:					
Total average number	267	98	117	4	48
Total wages	$156,602	$58,356	$73,700	$1,410	$20,136
Above ground—					
Average number	221	68	112	1	40
Wages	$125,383	$39,387	$70,295	$1,080	$14,621
Below ground—					
Average number	46	30	5	3	8
Wages	$31,219	$18,969	$3,405	$3,330	$5,515
Contract work:					
Amount paid	$216,168	.....	$215,868	$300	.....
Number of employees	286	.....	284	2	.....
Miscellaneous expenses	$68,533	$63,405	$2,346	$140	$2,642
Cost of supplies and materials	$143,541	$71,691	$66,310	$2,030	$3,510

[1] Includes operators distributed as follows: Alabama, 1; California, 1; Colorado, 1; Iowa, 1; New Jersey, 1; New York, 1; Pennsylvania, 2.

Table 2 shows that there were 37 nonproductive mines engaged in development work in the United States in 1902, employing 28 salaried officials and an average of 267 wage-earners, who received $177,317; the cost of supplies and materials being $143,541 and the miscellaneous expenses $68,533. These mines were capitalized at $2,685,000.

While these figures do not represent the full amount of expenditures for this class of work during 1902, they give some idea of the expense necessary before mines become productive. The most active exploitation of new deposits was in the states of Minnesota and Michigan. In most of the older states, such as New Jersey and New York, little exploratory work was done, except by active companies; such work was included in the reports of the active mining operations of these companies.

In addition to the mines included in the above table, there were 220 mines which appear to have been entirely inactive during 1902 as regards production or development work, no expenses for such work having been reported.

The mines classed as idle should not be considered as including abandoned mines or openings which have been idle for a long time with no effort made to revive them, nor do they include mines which have been dismantled. The purpose was to add to the record statistics covering such mines or operations as may be producers in the near future.

Capital stock of incorporated companies.—It is difficult to arrive at a fair determination of the proportion of capital stock and bonds properly chargeable against iron ore mines when operated by corporations owning blast furnaces and rolling mills, coal mines, railroads, etc., or by companies subordinate to parent organizations, or where the mining property is leased. Thus, A leases an iron ore property to B, who for this lease pays either a definite sum or, more often, a fixed or sliding scale royalty per ton for the ore taken out for a given time, usually a minimum annual output being stipulated. The operations may be upon a small part of the property owned by A, but if A places a value upon it, this value would probably include the entire tract. B can fix no value for the iron ore property, being merely a lessee, and would probably base his valuation upon the royalty he pays capitalized, which will be constantly changing as the mines are worked energetically or otherwise, or as the demand for ore is active or slack. The owner or the lessee may or may not be interested in the manufacture of iron. There are cases where the mines of an iron producing company are worked under lease for the advantage of another company, because of the location of the deposit as related to the works of the owner or the lessee.

In some instances companies organized years ago with moderate capital own or control large mines or land containing reserves of ore, the properties representing many times the capital stock of the company. In one instance there is a record of a company whose dividends in one year equalled the entire capitalization of the company. On the other hand, organizations capitalized in late years have iron ore holdings of comparatively small value, or are apparently over capitalized if the market value of the stock is considered. In the state of Minnesota some mines are owned in fee simple; others are on lands belonging to the state, which issues a mining lease at a fixed royalty. Some of these mining leases were secured by parties who sold them for a lump sum varying according to the amount of ore which is believed to exist on the property, or leased the property subject to the first and also a second royalty, usually from 5 to 20 cents per ton, a minimum amount of ore being specified to be won each year. In such cases the companies operating the mines are in reality sublessees, and there are instances where a third lease has been made, and the par value of the stock may not represent anything like the true value of the ore deposit. In some of the Southern states a number of mines are worked by mining companies, who win the ore from the deposits and deliver it f. o. b. at the mine at a fixed rate, which is paid by the owners of the property, and in this case the returns from this mining company would merely represent the value of the equipment used, and would not include the value of the ore property, which may be many times greater than that of the machinery, tools, and appliances used by companies which are really contractors.

In the Southern states and in the Lake Superior region many mines are leased, the capitalization of the operating company representing merely the value of the lease and not of the land. In addition to earnings on the capital stock of the company a fixed or, in some cases, a sliding royalty is paid, which, in the latter case, is based upon the market price of the ore; this royalty value is not recognized in the capitalization.

The following table presents the details of the capitalization of the incorporated companies:

TABLE 3.—CAPITALIZATION OF INCORPORATED COMPANIES: 1902.

	United States.	Alabama.	Colorado.	Georgia.	Maryland.	Michigan.	Minnesota.	Missouri.
Number of incorporated companies	214	27	18	9	1	41	31	5
Number reporting capitalization	183	25	18	8	1	32	26	4
Capital stock and bonds issued	$247,798,970	$22,122,470	$27,765,000	$4,274,300	$1,000,000	$96,458,000	$56,532,200	$305,000
Capital stock:								
Total authorized—								
Number of shares	12,358,397	1,237,756	6,464,150	130,520	5,000	1,585,350	848,500	63,250
Par value	$265,053,900	$19,927,600	$28,669,000	$12,419,000	$500,000	$101,340,000	$64,590,000	$335,000
Total issued—								
Number of shares	10,672,491	1,099,443	5,464,110	48,308	5,000	1,495,390	758,922	33,250
Par value	$233,933,470	$17,477,970	$27,665,000	$4,197,800	$500,000	$94,039,000	$56,532,200	$305,000
Dividends paid	$6,329,405	$420,999	$102,000	.....	.....	$3,270,483	$1,720,983	$40,000
Common—								
Authorized—								
Number of shares	11,700,397	1,147,956	6,464,150	114,770	5,000	1,331,350	598,100	63,250
Par value	$204,052,400	$14,823,600	$28,669,000	$11,391,500	$500,000	$76,240,000	$39,550,000	$335,000
Issued—								
Number of shares	10,126,625	1,037,656	5,464,110	32,558	5,000	1,282,870	550,002	33,250
Par value	$182,651,625	$13,693,600	$27,665,000	$3,170,300	$500,000	$73,087,000	$35,640,200	$305,000
Dividends paid	$3,183,440	$200,000	$102,000	.....	.....	$1,845,500	$296,000	$40,000
Preferred—								
Authorized—								
Number of shares	658,000	89,800	.....	15,750	.....	254,000	250,400	.....
Par value	$61,001,500	$5,104,000	.....	$1,027,500	.....	$25,100,000	$25,040,000	.....
Issued—								
Number of shares	545,866	61,787	.....	15,750	.....	212,520	208,920	.....
Par value	$51,281,845	$3,784,370	.....	$1,027,500	.....	$20,952,000	$20,892,000	.....
Dividends paid	$3,145,965	$220,999	.....	.....	.....	$1,424,983	$1,424,983	.....
Bonds:								
Authorized—								
Number	47,607	5,239	100	753	500	10,900	.....	.....
Par value	$22,647,500	$5,239,500	$100,000	$203,000	$500,000	$10,350,000	.....	.....
Issued—								
Number	37,363	4,644	100	189	500	2,969	.....	.....
Par value	$13,865,500	$4,644,500	$100,000	$76,500	$500,000	$2,419,000	.....	.....
Interest paid	$521,111	$268,291	.....	.....	.....	$5,250	.....	.....
Assessments levied	$64,300	.....	.....	.....	.....	.....	.....	.....

	New Jersey.	New York.	Ohio.	Pennsylvania.	Tennessee.	Virginia.	Wisconsin.	All other states.
Number of incorporated companies	7	10	5	12	9	18	7	[1] 14
Number reporting capitalization	7	10	5	11	9	11	6	[2] 10
Capital stock and bonds issued	$5,988,400	$10,129,900	$598,000	$5,464,225	$1,040,000	$5,702,600	$7,335,375	$3,083,500
Capital stock:								
Total authorized—								
Number of shares	63,750	90,200	5,475	58,326	9,480	70,650	300,200	1,425,490
Par value	$5,745,000	$8,995,000	$650,000	$4,381,300	$948,000	$6,065,000	$7,520,000	$2,969,000
Total issued—								
Number of shares	54,784	85,849	4,895	39,614	8,950	56,026	292,815	1,225,135
Par value	$5,388,400	$8,559,900	$587,500	$2,614,225	$895,000	$5,102,600	$7,335,375	$2,733,500
Dividends paid	$75,000	$314,021	.....	$43,579	.....	$52,500	$280,000	$9,840
Common—								
Authorized—								
Number of shares	38,150	75,200	5,475	57,426	9,480	64,400	300,200	1,425,490
Par value	$3,185,000	$7,495,000	$650,000	$4,336,300	$948,000	$5,440,000	$7,520,000	$2,969,000
Issued—								
Number of shares	29,184	70,849	4,895	38,575	8,950	50,776	292,815	1,225,135
Par value	$2,828,400	$7,059,900	$587,500	$2,573,250	$895,000	$4,577,600	$7,335,375	$2,733,500
Dividends paid	.....	$314,021	.....	$43,579	.....	$52,500	$280,000	$9,840
Preferred—								
Authorized—								
Number of shares	25,600	15,000	.....	1,200	.....	6,250	.....	.....
Par value	$2,560,000	$1,500,000	.....	$45,000	.....	$625,000	.....	.....
Issued—								
Number of shares	25,600	15,000	.....	1,039	.....	5,250	.....	.....
Par value	$2,560,000	$1,500,000	.....	$40,975	.....	$525,000	.....	.....
Dividends paid	$75,000	.....	.....	.....	.....	.....	.....	.....
Bonds:								
Authorized—								
Number	1,000	2,675	70	25,371	145	504	.....	350
Par value	$600,000	$1,675,000	$35,000	$2,850,000	$145,000	$600,000	.....	$350,000
Issued—								
Number	1,000	1,570	21	25,871	145	504	.....	350
Par value	$600,000	$1,570,000	$10,500	$2,850,000	$145,000	$600,000	.....	$350,000
Interest paid	.....	$63,500	$420	$141,150	.....	$25,000	.....	$17,500
Assessments levied	.....	.....	.....	.....	$62,000	$1,800	.....	$500

[1] Includes companies distributed as follows: Connecticut, 1; Kentucky, 3; Massachusetts, 1; Montana, 2; North Carolina, 3; Texas, 1; Utah, 2; Wyoming, 1.
[2] Includes companies distributed as follows: Connecticut, 1; Kentucky, 3; Massachusetts, 1; Montana, 1; North Carolina, 1; Texas, 1; Utah, 2.

In the statistics presented in Table 3, where the iron ore lands were owned by companies operating blast furnaces, steel mills, or other industrial enterprises, an effort was made to secure an approximate proportion of the capitalization which would properly be chargeable against the iron ore mines, but without success, and in such cases the statistics are for the entire capitalization of the company.

The table shows that a large proportion, 64.7 per cent, of the capitalization of stock and bonds was reported from the iron mines in Michigan, Minnesota, and Wisconsin, which, with the exception of a few outlying mines, are embraced in the Lake Superior region. These three states produced 76.1 per cent of all the ore mined in 1902.

Next to the Lake Superior region, Colorado shows the largest capitalization, but much of the iron won in that state is from mines of the precious metal. In some instances this argentiferous iron ore is the only mineral at present won from the operation, and there-

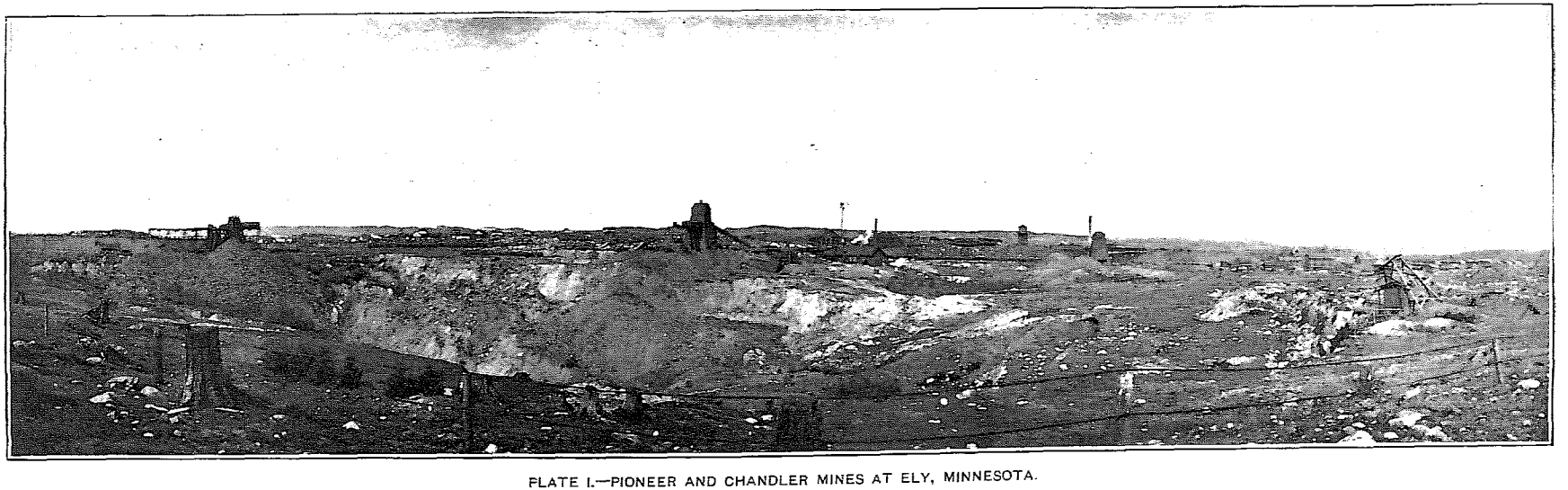


PLATE I.—PIONEER AND CHANDLER MINES AT ELY, MINNESOTA.

fore the entire capitalization (originally based on the supposed value of the mine as a precious metal producer) is included in the iron ore report.

Alabama ranks next to the Lake Superior region and Colorado in the capitalization, as would naturally be expected from the large amount of iron ore produced. New York, New Jersey, Virginia, Pennsylvania, and Georgia follow in the order named, the remaining states being comparatively unimportant, so far as the capitalization of their iron mining companies is concerned.

In the year 1902 the capitalization, including funded debt, of 183 incorporated companies owning active iron ore mines reached a total of $247,798,970. In the year 1889 returns were secured from the 592 different mines of the value of the land, buildings and fixtures, tools and implements, and the amount of cash and stock on hand, showing a total of $109,766,199. Therefore, no information of comparative value is obtainable from a study of the reports of the capital invested in iron ore mines at the two census periods.

Employees and wages.—The following table shows the average number of wage-earners employed during each month in iron ore mining, by states and territories:

TABLE 4.—AVERAGE NUMBER OF WAGE-EARNERS EMPLOYED DURING EACH MONTH, BY STATES AND TERRITORIES: 1902.

	United States.	Alabama.	Colorado.	Georgia.	Maryland.	Michigan.	Minnesota.	Missouri.	New Jersey.	New York.	Ohio.	Pennsylvania.	Tennessee.	Virginia.	Wisconsin.	All other states and territories.[1]
Total average number	38,851	4,864	418	688	76	14,456	8,256	148	1,660	965	111	1,140	1,299	2,686	1,361	723
Average number of men 16 years and over	38,333	4,738	418	647	64	14,446	8,254	147	1,655	963	111	1,118	1,205	2,493	1,354	720
January	33,854	4,358	437	562	30	13,415	6,210	108	1,453	965	34	1,074	1,126	2,136	1,393	553
February	33,195	4,403	428	559	30	12,858	6,198	113	1,535	862	69	1,021	1,113	2,104	1,372	530
March	34,714	4,616	425	644	80	13,373	6,416	113	1,580	928	112	990	1,134	2,337	1,355	611
April	36,829	4,655	433	659	75	13,946	7,370	134	1,684	1,007	115	1,076	1,208	2,396	1,393	678
May	39,291	4,693	409	670	83	14,803	8,449	147	1,732	959	125	1,102	1,250	2,664	1,429	776
June	39,311	4,715	413	673	47	14,399	8,759	153	1,769	989	158	1,100	1,271	2,682	1,403	780
July	40,594	4,850	390	661	92	14,977	9,102	182	1,775	894	141	1,229	1,257	2,845	1,392	807
August	41,426	4,887	406	664	85	15,340	9,456	182	1,762	978	137	1,179	1,271	2,846	1,421	812
September	41,259	4,861	412	647	83	15,441	9,659	164	1,694	946	104	1,184	1,217	2,718	1,336	793
October	40,958	4,987	407	630	72	15,449	9,449	156	1,647	1,019	121	1,153	1,225	2,577	1,346	720
November	39,859	4,939	437	705	50	14,911	9,308	156	1,617	996	127	1,158	1,195	2,318	1,227	715
December	38,706	4,892	419	690	41	14,440	8,672	156	1,612	1,013	89	1,150	1,193	2,293	1,181	865
Average number of boys under 16 years	518	126	.....	41	12	10	2	1	5	2	.....	22	94	193	7	3
January	405	113	.....	33	2	7	2	.....	5	2	.....	10	85	141	2	3
February	397	102	.....	40	2	6	2	.....	5	2	.....	10	86	137	2	3
March	454	118	.....	35	18	6	2	.....	5	2	.....	10	88	164	4	2
April	497	109	.....	41	10	8	2	1	5	2	.....	29	93	189	6	2
May	539	117	.....	36	13	8	2	1	5	2	.....	29	101	216	6	3
June	531	114	.....	38	4	10	2	1	5	2	.....	30	102	212	8	3
July	573	124	.....	43	17	11	2	1	5	2	.....	30	94	230	11	3
August	599	143	.....	41	16	13	2	1	5	2	.....	34	98	228	12	4
September	598	143	.....	46	18	14	2	1	5	2	.....	31	99	224	9	4
October	570	141	.....	48	16	13	2	2	5	2	.....	23	93	211	10	4
November	542	147	.....	45	16	13	2	2	5	2	.....	15	96	190	8	1
December	511	141	.....	46	12	11	2	2	5	2	.....	13	93	174	6	4

[1] Includes operators distributed as follows: Connecticut, 1; Kentucky, 3; Massachusetts, 1; Montana, 3; New Mexico, 1; North Carolina, 3; Texas, 1; Utah, 4; Vermont, 1; West Virginia, 1.

These statistics show practically steady employment in such states as Alabama, Georgia, Tennessee, and Virginia, where the climatic conditions do not interfere with mining operations; and even in the states of Minnesota, Michigan, and Wisconsin, the variation in the number employed was less than generally presumed to be the case. This was undoubtedly due to the fact that the demand for ore encouraged a considerable amount of "dead work" and underground exploitation during the winter months. It is probable that figures for the year 1903 would show considerably greater variation between the seasons than those for 1902.

While the states of Minnesota and Michigan produced 76.7 per cent of the iron ore mined in the United States in 1902, the average number of wage-earners in those states represented only 58.5 per cent of the total for the country, and a calculation shows that for each wage-earner in those states 1,156 tons of iron ore were produced. Similar estimates for important producing states and for the country appear in the following table, to which the figures for 1889 have been added for the purpose of comparison:

TABLE 5.—*Tons of iron ore produced per wage-earner, by states: 1902 and 1889.*

STATE.	1902			1889		
	Quantity produced (long tons).	Number of wage-earners.	Tons of ore per wage-earner.	Quantity produced (long tons).	Number of wage-earners.	Tons of ore per wage-earner.
United States	35,567,410	38,851	915	14,518,041	36,341	399
Minnesota	15,137,650	8,256	1,834	864,508	1,697	509
Michigan	11,135,215	14,456	770	5,856,169	12,496	469
Alabama	3,574,474	4,864	735	1,570,319	3,019	520
Virginia and West Virginia	[1] 978,301	[1] 2,686	362	511,255	2,307	222
Tennessee	874,542	1,299	673	473,294	1,478	320
Pennsylvania	822,932	1,140	722	1,560,234	4,219	370
Wisconsin	783,996	1,361	576	887,399	1,737	482
New York	555,321	965	575	1,247,537	3,011	414
New Jersey	441,879	1,660	266	415,510	1,780	233
Georgia and North Carolina	[2] 330,554	[2] 688	480	258,145	736	351
Colorado	306,572	418	733	109,136	366	298
Missouri	66,308	148	448	265,718	678	392
Ohio	22,657	111	204	254,294	1,565	162
All other states and territories	[3] 542,009	[3] 799	678	[4] 294,523	[4] 1,252	235

[1] Includes Virginia only.
[2] Includes Georgia only.
[3] Includes Connecticut, Kentucky, Maryland, Massachusetts, Montana, New Mexico, North Carolina, Texas, Utah, Vermont, West Virginia, and Wyoming.
[4] Includes Connecticut, Delaware, Idaho, Kentucky, Maine, Maryland, Massachusetts, Montana, New Mexico, Oregon, Texas, Utah, and Washington.

It should be pointed out, in connection with the foregoing table, that the increase in 1902 over 1889 in the productive capacity per wage-earner is probably considerably less than is indicated by the figures, owing to the difference in the method of computing the average number of wage-earners at the two censuses.

An analysis of the statistics of wage-earners presents some interesting features. In Table 14, showing the detailed statistics, it will be noted that out of a total of 38,851 wage-earners, 23,082 are reported as employed below ground. That is, of the total number of wage-earners engaged in the iron ore industry 59.4 per cent are employed below the surface, the remainder being engaged upon surface mining or upon the work above ground. It is also shown that out of a total of 38,851, those returned as miners and miners' helpers, number 20,849, which suggests that slightly over one-half of those engaged in the iron ore industry may be considered as actually digging the ore.

As already stated, exact comparisons between the number of wage-earners at the Eleventh and Twelfth censuses can not be made, by reason of the fact that in 1902 the number of employees was reduced to the basis of practically continuous work (300 days) during the year. However, out of a total of 37,707 employees reported in 1889, 19,708 were returned as working below ground. The miners and laborers below ground, who may be considered as representing miners and miners' helpers, showed a total of 18,911 in 1889. The miners engaged in large open-cut operations were classed as laborers, and if the number of these be added to the above total, and this again corrected for the employees who were not actually helpers, the resulting figure indicates that practically the same ratio held good in 1889 as in 1902, namely, that about one-half of the wage-earners at iron ore mines may be considered as having actually dug the ore.

Table 14 shows also that a number of the miners worked above ground, and that a large proportion of the unclassified labor was employed below the surface. The unclassified labor represented about 29.9 per cent of all those engaged in the iron ore industry. This is accounted for by the fact that in a number of the large open-cut mines, where the operations were carried on by steam shovel, the only skilled help was really those engaged in the handling of machinery, trains, etc.

Table 6 shows for 1902 the distribution of wage-earners according to daily rates of pay, by states.

TABLE 6.—DISTRIBUTION OF WAGE-EARNERS ACCORDING TO DAILY RATES OF PAY, BY STATES AND TERRITORIES: 1902.

[Each cumulative percentage shows the proportion of the total number receiving a wage as great as, or greater than, the lowest wage of the given wage group.]

RATE PER DAY (DOLLARS).	UNITED STATES.			ALABAMA.			MICHIGAN.			MINNESOTA.			NEW JERSEY.			NEW YORK.		
	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.
Total	[1]38,851	100.0	.....	4,864	100.0	.....	14,456	100.0	.....	8,256	100.0	.....	1,660	100.0	.....	965	100.0	.....
Less than 0.50	141	0.4	100.0	21	0.4	100.0	.....	.....	.....	1	(2)	100.0	.....	.....	.....	.....	.....	.....
0.50 to 0.74	279	0.7	99.6	87	1.8	99.6	1	(2)	100.0	.....	.....	99.9	6	0.4	100.0	.....	.....	.....
0.75 to 0.99	853	2.2	98.9	209	4.3	97.8	12	0.1	99.9	.....	.....	99.9	3	0.2	99.6	2	0.2	100.0
1.00 to 1.24	4,618	11.9	96.7	1,239	25.5	93.5	50	0.4	99.9	11	0.1	99.9	47	2.8	99.4	170	17.6	99.8
1.25 to 1.49	2,874	7.4	84.8	743	15.3	68.0	148	1.0	99.5	17	0.2	99.9	391	23.6	96.6	219	22.7	82.2
1.50 to 1.74	5,468	14.1	77.4	1,504	30.9	52.7	1,622	11.2	98.5	211	2.6	99.7	693	41.7	73.0	448	46.4	59.5
1.75 to 1.99	7,344	18.9	63.3	858	17.6	21.8	3,614	25.0	87.3	1,763	21.4	97.1	433	26.1	31.3	64	6.7	13.1
2.00 to 2.24	8,535	22.0	44.4	169	3.5	4.2	4,132	28.6	62.3	3,404	41.2	75.7	57	3.4	5.2	36	3.7	6.4
2.25 to 2.49	4,862	12.5	22.4	5	0.1	0.7	3,156	21.8	33.7	1,361	16.5	34.5	25	1.5	1.8	14	1.5	2.7
2.50 to 2.74	2,511	6.4	9.9	23	0.5	0.6	1,421	9.8	11.9	867	10.5	18.0	5	0.3	0.3	5	0.5	1.2
2.75 to 2.99	630	1.6	3.5	1	(2)	0.1	184	1.3	2.1	390	4.7	7.5	.....	.....	.....	3	0.3	0.7
3.00 to 3.24	454	1.2	1.9	5	0.1	0.1	74	0.5	0.8	93	1.1	2.8	.....	.....	.....	3	0.3	0.4
3.25 to 3.49	77	0.2	0.7	.....	.....	.....	13	0.1	0.3	44	0.5	1.7	.....	.....	.....	.....	.....	0.1
3.50 to 3.74	125	0.3	0.5	.....	.....	.....	18	0.1	0.2	54	0.7	1.2	.....	.....	.....	.....	.....	0.1
3.75 to 3.99	7	(2)	0.2	.....	.....	.....	2	(2)	0.1	4	(2)	0.5	.....	.....	.....	.....	.....	0.1
4.00 to 4.24	30	0.1	0.2	.....	.....	.....	7	0.1	0.1	7	0.1	0.5	.....	.....	.....	1	0.1	0.1
4.25 and over	43	0.1	0.1	.....	.....	.....	2	(2)	(2)	29	0.4	0.4	.....	.....	.....	.....	.....	.....

RATE PER DAY (DOLLARS).	PENNSYLVANIA.			TENNESSEE.			VIRGINIA.			WISCONSIN.			ALL OTHER STATES AND TERRITORIES.[3]		
	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.
Total	1,140	100.0	.....	1,299	100.0	.....	2,686	100.0	.....	1,361	100.0	.....	2,164	100.0	.....
Less than 0.50	8	0.7	100.0	2	0.2	100.0	96	3.6	100.0	.....	.....	.....	13	0.6	100.0
0.50 to 0.74	10	0.9	99.3	48	3.7	99.8	80	3.0	96.4	.....	.....	.....	47	2.2	99.4
0.75 to 0.99	57	5.0	98.4	258	19.9	96.1	146	5.4	93.4	4	0.3	100.0	162	7.5	97.2
1.00 to 1.24	411	36.1	93.4	440	33.9	76.2	1,593	59.3	88.0	4	0.3	99.7	653	30.2	89.7
1.25 to 1.49	336	29.5	57.3	113	8.7	42.3	579	21.6	28.7	14	1.0	99.4	314	14.5	59.5
1.50 to 1.74	240	21.0	27.8	244	18.8	33.6	123	4.6	7.1	105	7.7	98.4	278	12.8	45.0
1.75 to 1.99	28	2.4	6.8	11	0.8	14.8	22	0.8	2.5	451	33.1	90.7	100	4.6	32.2
2.00 to 2.24	23	2.0	4.4	20	1.5	14.0	28	1.0	1.7	582	42.8	57.6	84	3.9	27.6
2.25 to 2.49	8	0.7	2.4	121	9.3	12.5	6	0.2	0.7	153	11.2	14.8	13	0.6	23.7
2.50 to 2.74	2	0.2	1.7	39	3.0	3.2	8	0.3	0.5	39	2.9	3.6	102	4.7	23.1
2.75 to 2.99	17	1.5	1.5	.....	.....	0.2	4	0.2	0.2	6	0.4	0.7	25	1.1	18.4
3.00 to 3.24	.....	.....	.....	3	0.2	0.2	1	(2)	(2)	.....	.....	0.3	275	12.7	17.3
3.25 to 3.49	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	0.1	0.3	19	0.9	4.6
3.50 to 3.74	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.2	53	2.5	3.7
3.75 to 3.99	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	0.1	0.2	.....	.....	1.2
4.00 to 4.24	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	0.1	0.1	14	0.6	1.2
4.25 and over	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	0.6	0.6

[1] Includes 8,105 wage-earners, paid by the ton, for whom average daily earnings are shown.
[2] Less than one-tenth of 1 per cent.
[3] Includes Colorado, Connecticut, Georgia, Kentucky, Maryland, Massachusetts, Missouri, Montana, New Mexico, North Carolina, Ohio, Texas, Utah, Vermont, West Virginia, and Wyoming.

PLATE II.—AUBURN MINE, MILLING PIT, MESABI RANGE, MINNESOTA.

In the preceding table the distribution of wage-earners, according to daily rates of pay, is shown separately for the 8 states which reported more than 1,000 wage-earners, and also for New York, which is the only other state in which the number of wage-earners approximated 1,000. These 9 states gave employment to 36,687 wage-earners, or 94.4 per cent of the total number employed in this industry in the United States. Of the states for which statistics are presented separately, Minnesota shows the highest rates of pay, 97.1 per cent of the wage-earners having received at least $1.75 per day, and 34.5 per cent of these $2.25 per day or over. The rates of pay were only slightly lower in Michigan and Wisconsin. In the former state 11.2 per cent received between $1.50 and $1.74, while in Wisconsin the proportion with rates of $2.25 or over was considerably smaller than in Minnesota. Michigan, Minnesota, and Wisconsin constitute the Lake Superior district, and the rates in these 3 states were materially higher than those in the other states. In each of the 3 states of the Lake Superior district the bulk of the wage-earners received $2 per day or over, while in each of the other states for which statistics are shown separately, practically all the wage-earners received less than $2 per day.

The state in which the daily rates of pay approached most nearly those of the Lake Superior district is New Jersey, where the range of wages for 91.4 per cent of the employees was from $1.25 to $1.99. New York, Alabama, Pennsylvania, and Wisconsin follow in the order named. New York shows a considerable number with rates of less than $1.25 per day and a comparatively small number who received as much as $1.75. In Alabama the bulk of the wage-earners, 89.3 per cent, received between $1 and $1.99. There was very little difference on the whole between the rates paid in Pennsylvania and those paid in Tennessee. The proportion receiving $1.75 or over was greater in Tennessee, but the number who received less than $1 was so large as to offset this. Rates were lower on the whole in Virginia than in any other state which reported a large number of wage-earners, only 7.1 per cent of the total number having been paid as much as $1.50 to $1.74 per day.

Table 7 shows the distribution of the wage-earners employed in 1902 in the mining of iron ore among the several occupations and according to daily rates of pay. For each occupation the average number employed during the year at specified rates, and the percentages which these numbers form of the total number, are given. In an additional column these percentages are accumulated, thus rendering it possible to determine what proportion of the total number received as much as, or more than, a given rate.

TABLE 7.—DISTRIBUTION OF WAGE-EARNERS ACCORDING TO DAILY RATES OF PAY: 1902.

[Each cumulative percentage shows the proportion of the total number receiving a wage as great as, or greater than, the lowest wage of the given wage group.]

RATE PER DAY (DOLLARS).	ALL CLASSES.			ENGINEERS.			FIREMEN.			MACHINISTS, BLACKSMITHS, CARPENTERS, AND OTHER MECHANICS.			MINERS.		
	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.
Total	[1] 38,851	100.0	.....	1,102	100.0	.....	812	100.0	.....	1,842	100.0	.....	18,556	100.0	.....
Less than 0.50	141	0.4	100.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.50 to 0.74	279	0.7	99.6	.....	.....	.....	1	0.1	100.0	.....	.....	.....	13	0.1	100.0
0.75 to 0.99	853	2.2	98.9	.....	.....	.....	3	0.4	99.9	3	0.2	100.0	296	1.6	99.9
1.00 to 1.24	4,618	11.9	96.7	21	1.9	100.0	49	6.0	99.5	36	2.0	99.8	3,001	16.2	98.3
1.25 to 1.49	2,874	7.4	84.8	91	8.3	98.1	135	16.6	93.5	108	5.9	97.8	1,057	5.7	82.1
1.50 to 1.74	5,468	14.1	77.4	168	15.3	89.8	76	9.4	76.9	206	11.2	91.9	2,478	13.4	76.4
1.75 to 1.99	7,344	18.9	63.3	239	21.7	74.5	312	38.4	67.5	341	18.5	80.7	1,585	8.5	63.0
2.00 to 2.24	8,535	22.0	44.4	378	34.3	52.8	183	22.5	29.1	502	27.2	62.2	3,926	21.2	54.5
2.25 to 2.49	4,862	12.5	22.4	84	7.6	18.5	37	4.5	6.6	290	15.7	35.0	3,642	19.6	33.3
2.50 to 2.74	2,511	6.4	9.9	23	2.1	10.9	9	1.1	2.1	186	10.1	19.3	1,687	9.1	13.7
2.75 to 2.99	630	1.6	3.5	7	0.6	8.8	.....	.....	1.0	68	3.4	9.2	481	2.6	4.6
3.00 to 3.24	454	1.2	1.9	25	2.3	8.2	3	0.4	1.0	52	2.8	5.8	304	1.6	2.0
3.25 to 3.49	77	0.2	0.7	9	0.8	5.9	2	0.3	0.6	12	0.7	3.0	24	0.1	0.4
3.50 to 3.74	125	0.3	0.5	17	1.5	5.1	2	0.3	0.3	27	1.5	2.3	55	0.3	0.3
3.75 to 3.99	7	(2)	0.2	1	0.1	3.6	.....	.....	.....	2	0.1	0.8	2	(2)	(2)
4.00 to 4.24	30	0.1	0.2	10	0.9	3.5	.....	.....	.....	10	0.5	0.7	.....	.....	.....
4.25 and over	43	0.1	0.1	29	2.6	2.6	.....	.....	.....	4	0.2	0.2	5	(2)	(2)

RATE PER DAY (DOLLARS).	MINERS' HELPERS.			TIMBERMEN AND TRACK LAYERS.			BOYS UNDER 16 YEARS.			ALL OTHER WAGE-EARNERS.		
	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.
Total	2,293	100.0	.....	2,099	100.0	.....	518	100.0	.....	11,629	100.0	.....
Less than 0.50	.....	.....	.....	.....	.....	.....	141	27.2	100.0	.....	.....	.....
0.50 to 0.74	.....	.....	.....	.....	.....	.....	250	48.3	72.8	15	0.1	100.0
0.75 to 0.99	13	0.6	100.0	5	0.2	100.0	99	19.1	24.5	434	3.7	99.9
1.00 to 1.24	151	6.6	99.4	29	1.4	99.8	17	3.3	5.4	1,314	11.3	96.2
1.25 to 1.49	194	8.5	92.8	86	4.1	98.4	8	1.5	2.1	1,195	10.3	84.9
1.50 to 1.74	503	21.9	84.3	121	5.7	94.3	3	0.6	0.6	1,913	16.5	74.6
1.75 to 1.99	618	26.9	62.4	667	31.8	88.6	.....	.....	.....	3,582	30.8	58.1
2.00 to 2.24	645	28.1	35.5	607	28.9	56.8	.....	.....	.....	2,294	19.7	27.3
2.25 to 2.49	105	4.6	7.4	245	11.7	27.9	.....	.....	.....	459	3.9	7.6
2.50 to 2.74	38	1.7	2.8	317	15.1	16.2	.....	.....	.....	251	2.2	3.7
2.75 to 2.99	10	0.4	1.1	4	0.2	1.1	.....	.....	.....	65	0.6	1.5
3.00 to 3.24	16	0.7	0.7	2	0.1	0.9	.....	.....	.....	52	0.5	0.9
3.25 to 3.49	.....	.....	.....	2	0.1	0.8	.....	.....	.....	28	0.2	0.4
3.50 to 3.74	.....	.....	.....	14	0.7	0.7	.....	.....	.....	10	0.1	0.2
3.75 to 3.99	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	(2)	0.1
4.00 to 4.24	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	0.1	0.1
4.25 and over	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	(2)	(2)

[1] Includes 8,105 wage-earners paid by the ton, for whom average daily earnings are shown.

[2] Less than one-tenth of 1 per cent.

More than half, 52.8 per cent, of the total number of engineers received $2 or over. Most of the engineers are, however, concentrated in the $2 group, and the two groups below, 71.3 per cent, receiving between $1.50 and $2.24. The wages for firemen are seen to be somewhat lower than those for engineers. For firemen the lower-limit median rate group is $1.75, while for engineers it is $2; in each case a greater number of employees is included in the median group than in any other.

The range of wages for over 82 per cent of machinists was from $1.50 to $2.74. The median rate lies between $2 and $2.24, and the distribution both above and below that rate is comparatively regular. In this occupation, also, the median group comprises a greater number of men than is found at any other rate.

The table shows a very wide range in the rates paid to miners. The wages for the bulk of the employees ranged from $1 to $2.74, with the median at $2. By far the greater portion of miners' helpers are concentrated in three wage groups, the range for 76.9 per cent being from $1.50 to $2.24.

The median wage for timbermen and track layers was between $2 and $2.24, and the bulk of the employees received from $1.50 to $2.74.

Almost half of the boys employed, 48.3 per cent, received between 50 cents and 75 cents; 27.2 per cent received less than 50 cents, and 19.1 per cent received between 75 cents and $1. The median rate for all other wage-earners was between $1.75 and $1.99. The wages for 92.3 per cent of the total number ranged from 75 cents to $2.24.

In the year 1889, also, data in regard to the wages paid the different classes of labor, both above and below ground, were obtained. The returns were in the form of average daily wages and may be summarized as follows:

OCCUPATION.	Average wages per day above ground.	OCCUPATION.	Average wages per day below ground.
Foremen and overseers	$2.40	Foremen and overseers	$2.46
Mechanics	1.90	Miners	1.91
Laborers	1.29	Laborers	1.60
Boys under 16 years	0.62	Boys under 16 years	0.82

Mechanical power.—The detailed summary shows that 119,558 horsepower was used at iron ore mines in the various operations requiring power. This power was applied chiefly through 1,132 steam engines, with a horsepower of 102,878, or 86 per cent of the total. There were also 11 gas or gasoline engines with a horsepower of 86, 11 water wheels having a horsepower of 1,010, and 260 miscellaneous appliances with a horsepower of 15,444. In addition to this primary power 35 electric motors were used, their total horsepower being 937; 140 horsepower was rented to other establishments.

At the census of 1889, 1,109 steam boilers, with a total horsepower capacity of 57,976, were reported by iron ore mines. It was stated in the report on iron ore at that census that these boilers furnished steam to 1,093 steam engines, including air compressors, hoisting machinery, and engines for driving washeries, etc. In 1902 the mechanical power was applied for the purposes for which power is commonly employed in mining work, namely, for hoisting the ore from the shaft, for subsequent beneficiating treatment, for operating steam shovels and dredges in open-cut mining, pumping and ventilating machinery, mechanical haulage, air compressors, electric lighting, drills, etc.

Table 14 shows also the distribution of the power among the several states; Michigan led in the horsepower employed, having 47,395 horsepower, or 39.6 per cent of the total; Minnesota had 25,332 horsepower, or 21.2 per cent of the total; Alabama, 10,370 horsepower, or 8.7 per cent; New Jersey, 6,684 horsepower, or 5.6 per cent; and New York, 6,015, or 5 per cent. In the other states the amount of mechanical power used was smaller, but on the whole proportionate to the extent of their operations.

Production.—At the Eighth and Ninth censuses the statistics of production were not collected in the same manner as in subsequent census years. In 1860 the number of tons of iron ore mined by the owners of blast furnaces was reported separately from the production of what were considered strictly mining companies. The report shows that the blast furnace establishments used 2,309,975 short tons in 1860, and that in addition 908,300 short tons were produced by mining companies, a total of 3,218,275 short tons, equivalent to 2,873,460 long tons.

In 1870 the total amount of iron ore produced by the mines reporting was 3,395,718 short tons, equivalent to 3,031,891 long tons; in addition some ore was produced by the owners of blast furnaces which the Bureau of the Census estimated at from 800,000 to 900,000 long tons, so that, taking the first named figure, at least 3,831,891 long tons of iron ore were mined in 1870. At the Tenth, Eleventh, and Twelfth censuses the data were obtained from all mines irrespective of their ownership or their relation to blast furnaces. The following statement gives a comparison of the figures for these censuses:

Production of iron ore: 1860 to 1902.

CENSUS YEAR.	Quantity (long tons).
1860	2,873,460
1870	3,831,891
1880	7,120,862
1889	14,518,041
1902	35,567,410

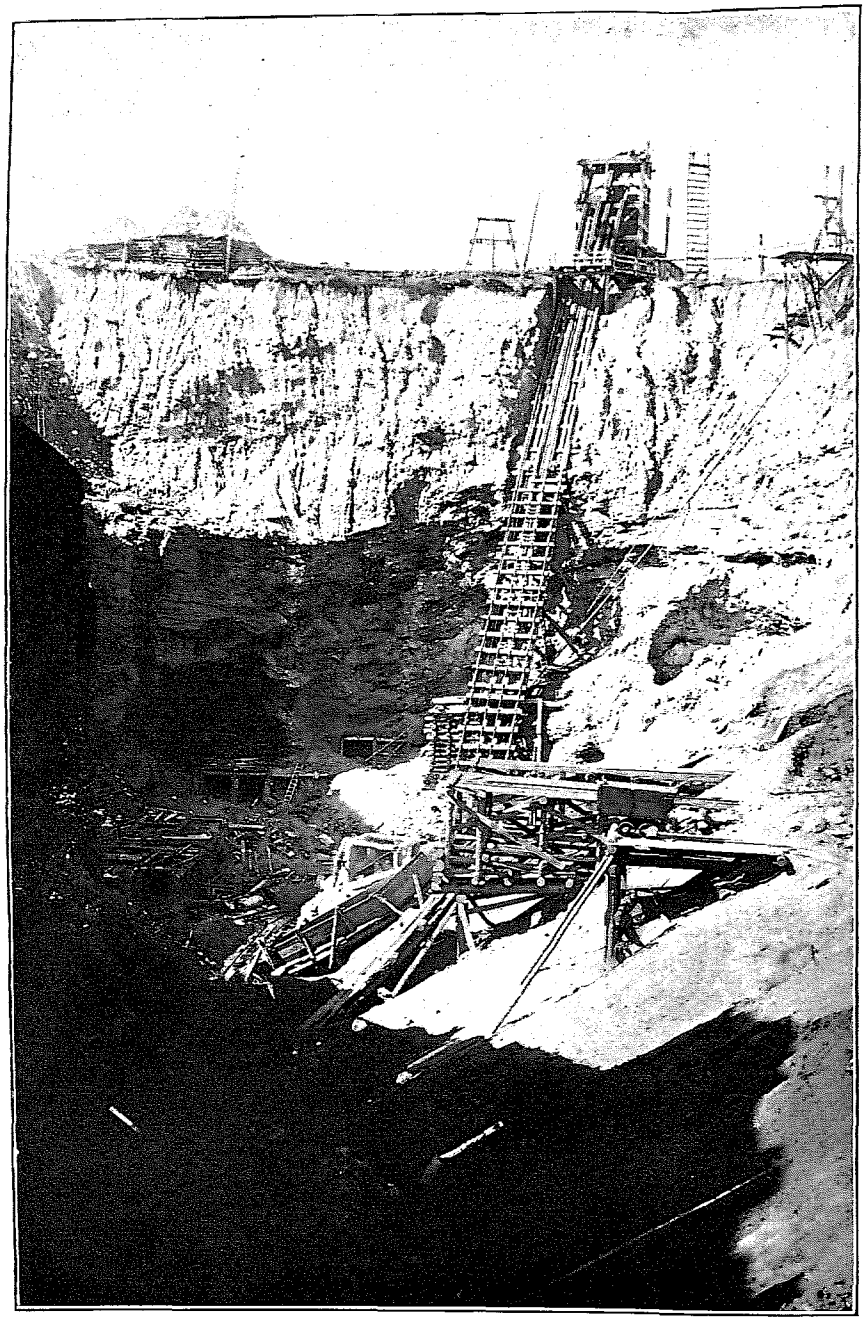


PLATE III.—NO. 2 PIT, ADAMS MINE, EVELETH, MINNESOTA.

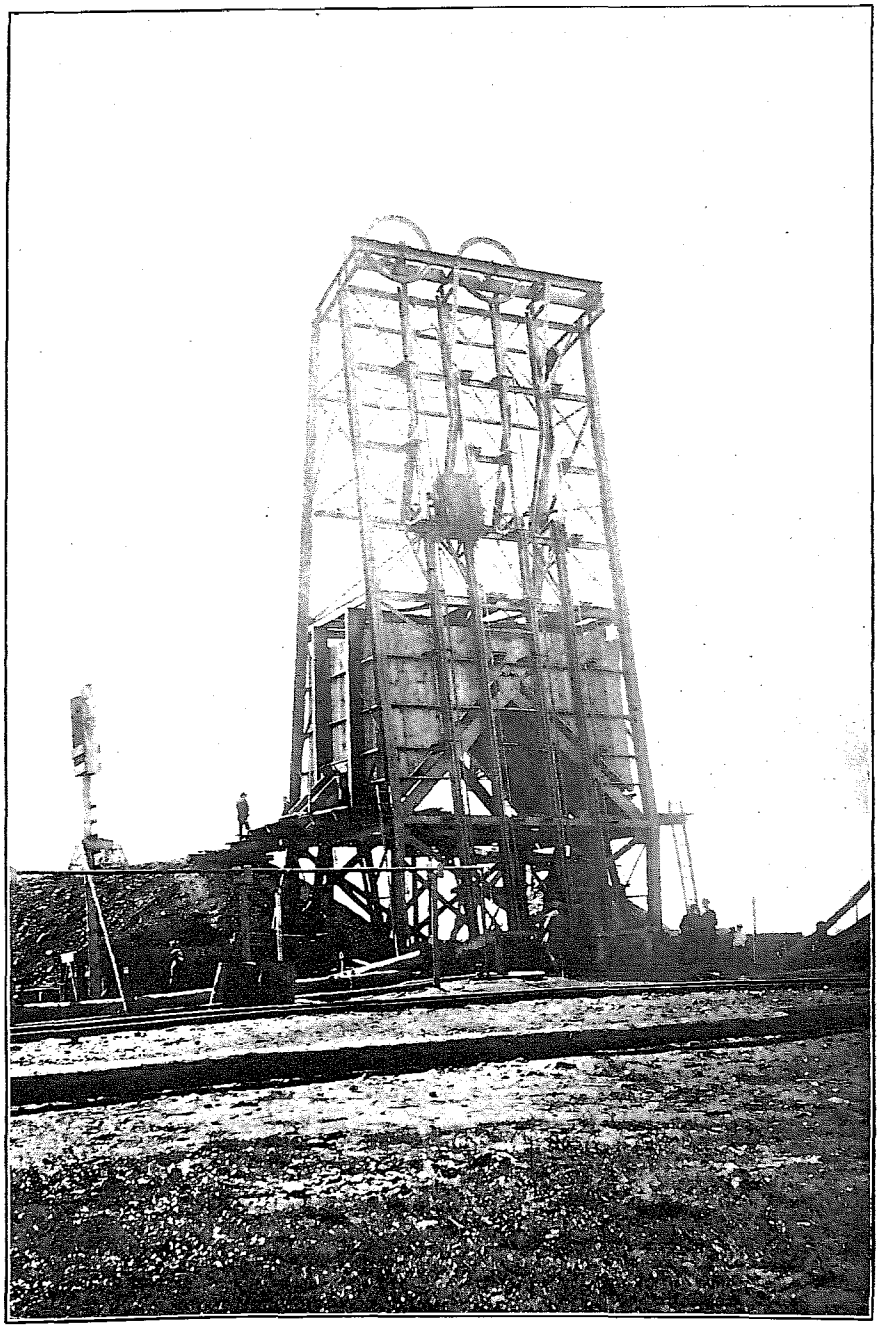


PLATE IV.—STEEL SHAFT HOUSE, ADAMS MINE, FIRST ON THE MESABI RANGE.

There is, as mentioned, some uncertainty in regard to the production of iron ore at the Eighth and Ninth censuses, but in comparing the statistics of the various censuses it will be noted that the production in 1880 was nearly double that of 1870, while in 1889 the output was twice that of 1880. In 1900, according to the figures of the United States Geological Survey (the census of 1902 was taken at a time thirteen years removed from 1889), the proportion over 1889 was almost identical. Thus, in every decade since 1870 the production of iron ore in the United States has practically been doubled.

The following table presents for each class of iron ore the amount produced in the census years 1902, 1889, and 1880, together with the percentages which these amounts formed of the total for all classes:

TABLE 8.—*Production of iron ores by varieties, with per cent of total: 1902, 1889, and 1880.*

VARIETY.	1902		1889		1880	
	Quantity (long tons).	Per cent of total.	Quantity (long tons).	Per cent of total.	Quantity (long tons).	Per cent of total.
Total	35,567,410	100.0	14,518,041	100.0	7,120,362	100.0
Red hematite	30,532,149	85.9	9,056,288	62.4	2,243,993	31.5
Brown hematite	[1]3,318,759	9.3	2,523,087	17.4	1,918,622	26.9
Magnetite	1,688,860	4.7	2,506,415	17.2	2,134,276	30.0
Carbonate	27,642	0.1	432,251	3.0	823,471	11.6

[1] Includes 13,275 tons of manganiferous ore.

There has been an increasing preference for rich and easily smelted iron ores, and considering the different varieties of ore, it will be found that the amount of red hematite reported in 1880 was but 31.5 per cent; in 1889, 62.4 per cent; and in 1902, 85.9 per cent of the total output. The brown hematite, although augmenting in the amounts mined, indicates a decided decrease in percentages of the total; from 1,918,622 long tons in 1880 this class of ore increased to 2,523,087 long tons in 1889 and 3,305,484 long tons in 1902, the percentages at the three censuses being respectively 26.9, 17.4, and 9.3 per cent. On the other hand, the magnetites and carbonates have shown a decline, not only in total production, but also in percentage. The former contributed 30 per cent (2,134,276 tons) of the total in 1880, 17.2 per cent (2,506,415) in 1889, and 4.7 per cent (1,688,860) in 1902. The carbonate ore has fallen from 823,471 long tons, 11.6 per cent, in 1880 to but 27,642 tons, one-tenth of 1 per cent, of the total in 1902.

The production of iron ore of the different varieties, by states, in the year 1902 was as follows:

TABLE 9.—*Production of iron ore, by states and territories and varieties: 1902.*

[Long tons.]

STATE OR TERRITORY.	Total.	Red hematite.	Brown hematite.	Magnetite.	Carbonate.
United States	35,567,410	30,532,149	[1]3,318,759	1,688,860	27,642
Minnesota	15,137,650	15,137,650	.....	.....	.....
Michigan	11,135,215	11,079,124	.....	56,091	.....
Alabama	3,574,474	2,565,635	1,008,839	.....	.....
Virginia and West Virginia	987,958	31,677	953,128	3,153	.....
Tennessee	874,542	370,643	503,899	.....	.....
Pennsylvania	822,992	20,441	185,846	616,645	.....
Wisconsin	783,996	758,316	25,680	.....	.....
New York	555,321	91,075	12,676	451,570	.....
New Jersey	441,879	.....	.....	441,879	.....
Georgia and North Carolina	364,890	117,812	216,242	30,836	.....
Montana, New Mexico, Utah, and Wyoming	362,034	255,269	18,079	88,686	.....
Colorado	306,572	4,375	[1]302,197	.....	.....
Kentucky	71,006	42,195	28,811	.....	.....
Missouri	66,308	57,037	8,371	.....	.....
Connecticut, Massachusetts, and Vermont	29,093	.....	29,093	.....	.....
Maryland	24,367	.....	19,382	.....	4,985
Ohio	22,657	.....	.....	.....	22,657
Texas	6,516	.....	6,516	.....	.....

[1] Includes 13,275 tons of manganiferous iron ore used in the manufacture of spiegeleisen.

Considering the individual states it is evident that those located in the Lake Superior region and in the Southern and Western states have shown an almost constant increase. In the Middle Atlantic and New England states, however, the bog, brown hematite, fossil, and magnetite ores, which formerly were the chief reliance of the local blast furnaces, have been replaced by the richer Lake Superior ores, and therefore show a marked falling off. The states will be considered in the order of their prominence in 1902.

Minnesota.—This state in 1902 contributed 15,137,650 long tons of iron ore, a greater amount than was produced by the entire country in 1889. This shows the unprecedented increase in thirteen years of eighteen times the amount contributed in 1889, viz, 864,508 long tons, when Minnesota occupied fifth position, while in the previous census year, 1880, no iron ore was mined in the state, the first production being in the year 1884. Since the year last mentioned the state has shown a phenomenal and practically an uninterrupted advance in the yearly output. The ore is obtained from the Vermilion and Mesabi ranges, that secured from the former being a hard specular or red hematite ore, while in the latter the red and brown hematites are much softer and in many localities quite finely comminuted. No true limonite ore is shipped from Minnesota, but the degree of hydration of some of the red hematites and the prevailing color encouraged the trade recognition of part of the state's product as brown hematite.

A comparison of the production and value of Minnesota iron ores at the last two census years is as follows:

Production and value of Minnesota iron ore: 1889 and 1902.

YEAR.	Quantity (long tons).	Value.
1889	864,508	$2,478,041
1902	15,137,660	23,989,227

Michigan.—In the year 1880 the amount of iron ore mined in Michigan was 1,640,814 long tons, giving the state second rank, Pennsylvania being first. The output increased in 1889 to 5,856,169 long tons, Michigan ranking first and continuing to hold that position until 1901. In 1902 the production was 11,135,215 long tons, nearly double that at the previous census. The greater portion of this ore was of high grade, although in late years some siliceous ores comparatively low in iron content and also low in phosphorus have been won for use as a mixture in the furnaces with richer ores low in silica. The three ranges from which this ore was mined, the Marquette, Menominee, and Gogebic ranges, are all located closer to shipping ports and to the principal pig iron manufacturing centers than the Minnesota ranges, and the ores therefore command a higher relative value at the mine than those of Minnesota, as will be seen from the following statement:

Production and value of Michigan iron ore: 1880 to 1902.

YEAR.	Quantity (long tons).	Value.
1880	1,640,814	$6,034,648
1889	5,856,169	15,800,521
1902	11,135,215	26,695,860

Alabama.—In 1880 Alabama was a comparatively unimportant iron ore producer, the quantity obtained being 171,139 long tons, giving the state seventh position. The extensive deposits of fossil ores, particularly in the Birmingham district, located close to supplies of fuel and flux, were, however, the foundation of an important pig iron industry, and the amount of ore mined increased in 1889 to 1,570,319 long tons, which was more than doubled in the year 1902, when 3,574,474 long tons were won, as shown in the statement below. These ores, however, are not of so high a grade, nor are their values so great, as those of the Lake Superior district. In addition to the red hematite ores referred to, important deposits of brown hematite have been developed, and this class of mineral represents about one-third of the iron ore supply of the state. Some exploitation has also been carried on for the purpose of utilizing magnetites which occur in apparently moderate quantities.

Production and value of Alabama iron ore: 1880 to 1902.

YEAR.	Quantity (long tons).	Value.
1880	171,139	$201,865
1889	1,570,319	1,511,611
1902	3,574,474	3,936,812

Virginia and West Virginia.—The iron industry in Virginia was established early in the seventeenth century, but as charcoal was the fuel used in the old furnaces, the amount of ore consumed, which was usually mined within convenient reach of the furnaces, was small. The production for 1880 in Virginia and West Virginia was 217,448 long tons. The output in 1889 was 511,255 long tons, and in 1902, 987,958 long tons. The iron ore supply of the Virginias has been supplemented in late years by the importation of iron ores from the Lake Superior region. Most of the iron ores now obtained in the Virginias are of the brown hematite variety, but some red hematites and magnetites are also mined. The production and value for the last three census years are given as follows:

Production and value of Virginia and West Virginia iron ore: 1880 to 1902.

YEAR.	Quantity (long tons).	Value.
1880	217,448	$530,943
1889	511,255	935,299
1902	987,958	1,667,456

Tennessee.—Tennessee occupied tenth position as a producer of iron ore in 1880, eighth in 1889, and fifth in 1902, its output consisting of brown and red hematites, the amounts and values being as follows:

Production and value of Tennessee iron ore: 1880 to 1902.

YEAR.	Quantity (long tons).	Value.
1880	93,272	$147,181
1889	473,294	606,476
1902	874,542	1,123,527

Pennsylvania.—Pennsylvania, which produced practically half of the total pig iron manufactured in the United States in 1902, might be supposed to be the largest iron ore producing state, and prior to improved transportation facilities this was the case. In the year 1880 it occupied first position, with a total of 1,951,496 long tons, declining to third in 1889, the output being 1,560,234 long tons, and to sixth place in 1902, produc-

PLATE V.—MOUNT IRON MINE, MESABI RANGE, LOOKING EAST ACROSS PIT, SHOWING TWO STRIPPING AND THREE ORE LEVELS.

ing only 822,932 long tons, due to the use by Pennsylvania furnaces of rich ores from other sections of the country. Magnetites predominated, brown hematite being second and red hematite least in importance. A statement of the quantity and value at each of the last three census years follows:

Production and value of Pennsylvania iron ore: 1880 to 1902.

YEAR.	Quantity (long tons).	Value.
1880	1,951,496	$5,517,079
1889	1,560,234	3,063,534
1902	822,932	1,225,453

Wisconsin.—The bulk of the iron ore obtained in Wisconsin is secured from the Gogebic and Menominee ranges, which extend from the state of Michigan into Wisconsin. Most of the ore is red hematite, a small proportion being brown hematite. This state contributed 37,000 long tons of iron ore in 1880, 837,399 long tons in 1889, and 783,996 long tons in 1902, the quantities and values being as follows:

Production and value of Wisconsin iron ore: 1880 to 1902.

YEAR.	Quantity (long tons).	Value.
1880	37,000	$73,000
1889	837,399	1,840,908
1902	783,996	1,800,864

New York.—In earlier years large amounts of iron ore of all four classes were obtained from various deposits in New York, the total for 1880 being 1,126,899 long tons, giving the state third position. The output had risen in the year 1889 to 1,247,537 long tons, but in 1902 there was a decline to 555,321 long tons. The bulk of New York ores mined are magnetites, but some red and brown hematites are found. A statement for the last three census years follows:

Production and value of New York iron ore: 1880 to 1902.

YEAR.	Quantity (long tons).	Value.
1880	1,126,899	$3,654,872
1889	1,247,537	3,100,216
1902	555,321	1,362,987

Other states and territories.—None of the other states or territories contributed over one-half million tons in 1902, and they will not, therefore, be considered individually. In the following table the production of these remaining states and territories in 1902, 1889, and 1880, is given, together with the total value of the iron ore mined:

TABLE 10.—*Quantity and value of iron ore, by states and territories: 1880 to 1902.*

STATE OR TERRITORY.	1902		1889		1880	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
Colorado	[1] 306,572	$1,084,424	109,136	$487,433	.....	.....
Connecticut, Maine, and Massachusetts	[2] 29,093	81,374	88,251	265,901	92,549	$382,929
Delaware and Maryland	[3] 24,367	46,911	29,380	68,240	127,102	428,244
Georgia and North Carolina	364,890	505,488	258,145	334,025	84,584	148,907
Idaho and Montana	[4] 3,090	19,642	24,072	158,974	.....	.....
Kentucky	71,006	86,169	77,487	195,559	57,865	165,905
Missouri	66,308	106,379	265,718	561,041	344,819	1,674,875
New Jersey	441,879	1,228,664	415,510	1,341,543	676,225	2,910,442
New Mexico and Utah	[5] 358,944	455,674	36,050	70,956	.....	.....
Ohio	22,657	41,976	254,294	532,725	488,753	1,269,530
Oregon and Washington	.....	.....	26,283	39,234	[6] 6,225	4,669
Texas	6,516	6,434	13,000	19,750	3,214	8,100

[1] Includes 13,275 tons of manganiferous iron ore, valued at $52,371.
[2] Includes Vermont; no production from Maine.
[3] Maryland only.
[4] Montana only.
[5] Also Wyoming.
[6] Oregon only.

The predominating ores obtained from these states are brown hematite from New England, Delaware, Maryland, Georgia, Colorado, Oregon, Washington, and Texas; magnetites from New Jersey, North Carolina, and New Mexico; red hematites from Missouri and Wyoming; and carbonates from Ohio.

Table 11 shows in a general way the status of the iron ore industry in the United States by important districts.

TABLE 11.—*Summary, by districts: 1902.*

	Lake Superior district.[1]	Southern district.[2]	New York, New Jersey, and Pennsylvania.	Virginia and West Virginia.	Rocky Mountain district.[3]
Number of mines	151	100	77	63	43
Number of operators	79	57	64	26	28
Salaried officials, clerks, etc.:					
Number	1,358	393	291	260	50
Salaries	$1,288,380	$302,337	$241,889	$175,484	$65,304
Wage-earners:					
Average number	23,999	6,851	3,765	2,699	713
Wages	$15,308,242	$2,771,647	$1,641,532	$893,254	$617,207
Contract work	$398,376	$500	$11,998	$6,730	$3,940
Miscellaneous expenses	$7,385,070	$276,484	$291,077	$121,356	$160,081
Cost of supplies and materials	$6,725,609	$801,758	$889,603	$201,726	$272,425
Product:					
Quantity, long tons	26,977,404	4,779,570	1,820,132	987,958	668,606
Value	$52,422,685	$5,513,056	$3,817,104	$1,667,456	$1,559,740
Mechanical power:					
Horsepower	79,094	15,916	17,233	4,786	1,095

[1] Includes Michigan, Minnesota, and part of Wisconsin.
[2] Includes Alabama, Georgia, and Tennessee.
[3] Includes Colorado, Montana, New Mexico, Utah, and Wyoming.

No attempt was made to include in Table 11 the statistics for the entire country, as such data are presented in other tables, but the states of Michigan, Minnesota, and Wisconsin are grouped in the Lake Superior region,

while the southern district includes the iron ore mines of Alabama, Georgia, and Tennessee. Other important groups of states, such as New York and New Jersey combined with Pennsylvania, and Virginia combined with West Virginia, are also shown, and the Rocky Mountain region is presented as a whole to indicate the extent of iron ore production in that section of the country. The comparisons suggested by the table will be understood as covering the districts generally, and not as applicable to the individual mines.

It will be noted that 151 mines in the Lake Superior region produced 26,977,404 long tons, equivalent to 178,658 long tons per mine, while in the Southern district 100 mines produced 4,779,570 long tons, an average of 47,796 long tons per mine, mainly attributable to the difference in the character of the deposits of the two regions. The Lake Superior ores occur in large beds or lenses, making the local development extensive, and encouraging the introduction of labor-saving appliances. The high grade of ore mined, as compared with that in other parts of the country, is also responsible in part for the extensive development. In the Southern district the ore deposits are either in stratified beds or in pockets, and the local developments while important are not so large, nor is the ore as rich as in the Lake Superior region; therefore, the application of labor-saving appliances is not justified to the extent it is in the Lake Superior district.

Imports.—While enormous quantities of rich iron ores are produced in the United States, large amounts of iron ores are imported, principally from Cuba (where all of the mines are operated by American capital), and used in blast furnaces located in the eastern portion of the United States. Small quantities are also brought in to supply the charcoal furnace located at Port Townsend, Wash., and for other uses than smelting.

The following table shows the quantity and value of the iron ore imported during the years 1889 to 1902:

TABLE 12.—*Quantity and value of iron ore imported: 1889 to 1902.*

YEAR.	Quantity (long tons).	Value.	YEAR.	Quantity (long tons).	Value.
1889	853,573	$1,852,392	1896	682,806	$1,036,917
1890	1,246,830	2,854,118	1897	489,970	678,912
1891	912,864	2,456,521	1898	187,208	255,548
1892	806,585	1,795,644	1899	674,082	1,082,847
1893	526,951	906,687	1900	897,831	1,303,196
1894	167,807	267,241	1901	966,950	1,659,273
1895	524,153	786,207	1902	1,165,470	2,583,077

The values given are those placed on the iron ore at the point of shipment and do not include any allowance for freight or import duty.

Previous to 1892 Spain ranked first as a contributor, supplying in 1890 over half a million tons, the ores coming from the Bilbao district, in the northern portion of the country, or from mines located near the Mediterranean sea, in southern Spain. In 1892, however, Cuba took first rank, which position it still holds. In the earlier years Algeria and Italy were also important contributors, but lately the amount received from these countries has been small, and in some years none has been imported.

In 1889 and 1890 Greece forwarded a comparatively small amount of iron ore, some of which contained a small percentage of manganese. Newfoundland and Labrador contributed ore in 1889, 1890, and 1896.

In the year 1902 the imports of iron ore, 1,165,470 long tons, were the largest since 1890, when 1,246,830 long tons were brought to this country. Cuba was the principal contributor in 1902, supplying 696,375 long tons; the provinces of Quebec and Ontario, Canada, sent 203,824 tons; Spain, 153,527 tons; and Newfoundland and Labrador (principally Newfoundland), 81,920 tons. Smaller amounts were imported from Algeria, Belgium, British Columbia, France, Germany, and Great Britain.

Table 14 is a detailed summary of the statistics for active mines, by states and territories. Where one or two operations only were active in a state, the statistics have been combined in order not to disclose individual operations, and are presented under the head "all other states and territories." This table, in connection with Table 9, presents a synopsis of the entire iron ore industry of the United States.

DESCRIPTIVE.

The phenomenal record made in producing pig iron in the United States is illustrated by the following statement from the annual statistical report of the American Iron and Steel Association. This shows the growth in the manufacture of pig iron in the past nine years, until in the year 1902 the maximum production approximated 18,000,000 tons.

Production of pig iron: 1894 to 1902.

YEAR.	Long tons.	YEAR.	Long tons.
1894	6,657,388	1899	13,620,703
1895	9,446,308	1900	13,789,242
1896	8,623,127	1901	15,878,354
1897	9,652,680	1902	17,821,307
1898	11,773,934		

This record naturally invites attention to the materials entering into the manufacture of pig metal, the character of these materials, and the sources from which they are obtained. Fuels, iron ores, and fluxes, components of commercial pig iron, in passing through blast furnaces, produce either pig iron in merchantable form or liquid metal, to be carried to Bessemer converters or open-hearth furnaces. In 1902 an effort was made on behalf of the Canadian government in equating bonuses to iron industries, to discriminate against liquid metal being classed as pig iron, but the contention was not sustained, and commercially the entire product of blast furnaces smelting iron ore is considered and reported for statistical purposes as pig iron.

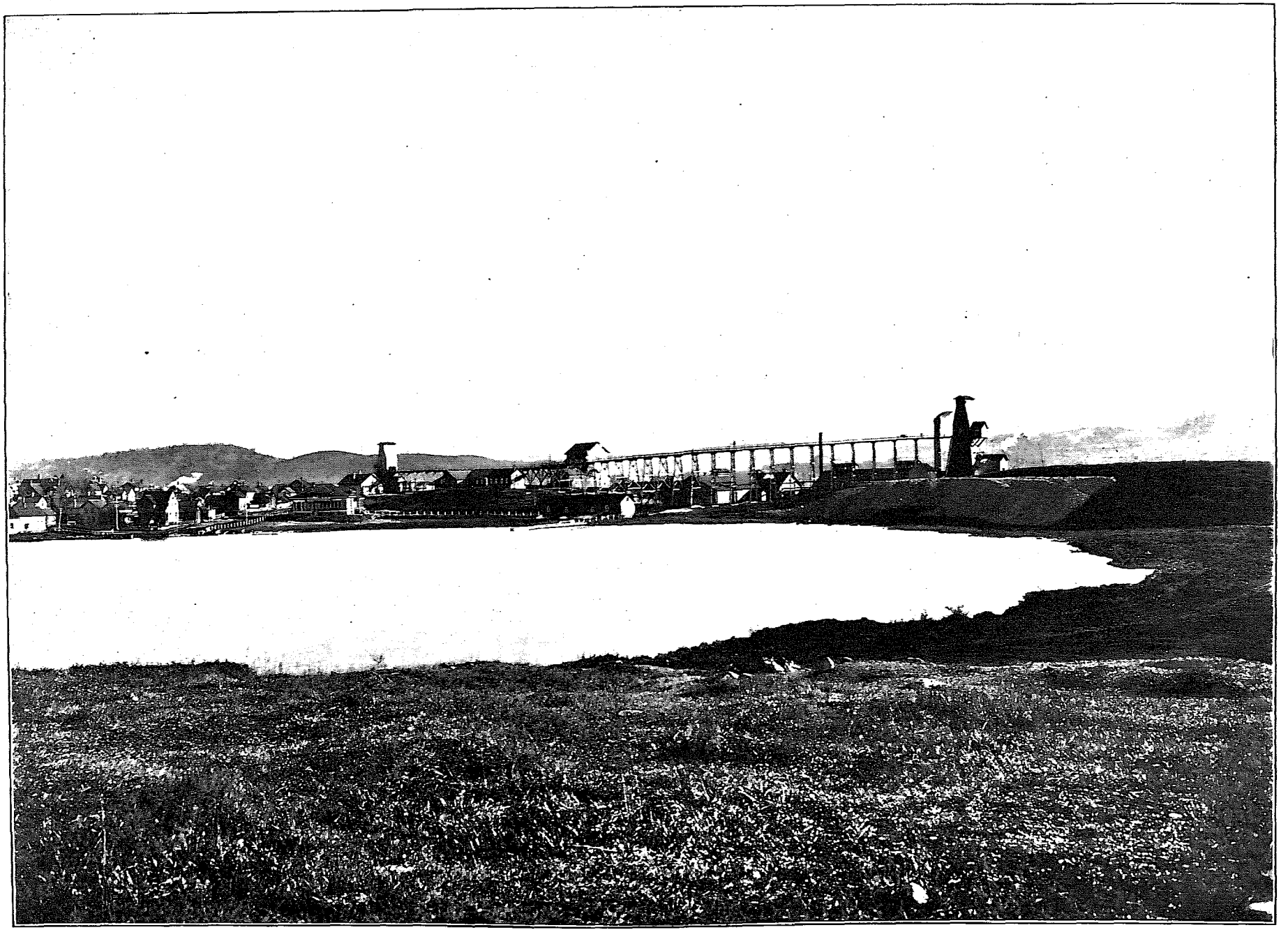


PLATE VI.—GROUP OF MINE BUILDINGS AND DWELLINGS, CLIFFS SHAFT MINE, LAKE BANCROFT, MICHIGAN.

For the production of the quantity of pig metal credited to the United States in the year 1902 there were required about 30,000,000 tons of bituminous coal (the larger portion of which was converted into coke) and about one million and a half tons of anthracite coal. In addition to mineral fuel probably 350,000 tons, or 38,000,000 bushels of charcoal were consumed in blast furnaces. About 33,000,000 tons of iron ore were fed to the furnaces, and the flux necessary to carry away the impurities of the ores is estimated at about eight and a half million tons. Therefore, to supply the blast furnaces of the United States in 1902, which produced nearly 18,000,000 tons of pig iron, there were required about 73,000,000 tons of raw materials.

In the manufacture of pig iron a considerable quantity of rolling mill cinder, roll scale, etc., is produced which is also employed practically as ore. Some "blue billy" or "purple ore," resulting from the calcination of pyrites and the residuum from roasting ferriferous and manganiferous zinc ores, are also utilized. The total amount of iron ore and of materials used as ore made available in the United States in 1902 may be approximated as follows:

	Tons.
Domestic iron ores	35,567,410
Foreign iron ores	1,165,470
Roll scale, mill cinder, blue billy, etc	1,900,000
Total	38,632,880

Some iron ore is employed for other purposes than for the manufacture of pig iron. It forms an important part of the charge of many open-hearth steel furnaces, and is used also for fix in puddling and other furnaces, for flux in silver smelting, and in making metallic paints. After making allowance for the other materials that are used as ore and deducting the quantity of ore which is applied to purposes other than iron production, the actual quantity of iron ore and materials used as ore entering into the manufacture of pig iron in 1902 is found to be, approximately, 33,000,000 long tons.

The active demand for iron ore to maintain in operation the blast furnaces of the United States, and the expectation that this demand would continue, was responsible to a great extent for the phenomenally large output of the iron ore mines in the year 1902. Large stocks of ore accumulated at or near blast furnace plants aided in swelling the total iron ore supply to figures never before reached and which may not be exceeded in the near future.

CLASSIFICATION OF IRON ORE.

Iron ore may be considered in four general commercial classes, as follows:

(1) Red hematite, including all anhydrous hematites, known by various names, such as red hematite, specular, micaceous, fossil or slate iron ore, martite, blue hematite, etc.

(2) Brown hematite, including the varieties of hydrated sesquioxide of iron, recognized as limonite, goethite, turgite, bog ores, pipe ores, etc.

(3) Magnetite, an ore in which the iron occurs as magnetic oxide and which includes some martite, mined with the magnetite. Martite is a red hematite ore which preserves to a varying extent the crystalline form of magnetite, but which is nonmagnetic or nearly so.

(4) Carbonates comprise those ores which contain a considerable amount of carbonic acid, such as spathic ore, blackband, siderite, clay ironstone, etc.

This classification is to be considered as general, the ores having various local or trade names. Thus the prevailing color or general physical appearance is used to indicate an ore, as blue, black, red, or brown, micaceous or glistening hematite. The term "specular," although more properly applied to a glistening ore, is by custom given to many dull red hematites. Other hematites receive designations according to their topographical or geographical occurrence, as "fossil," "mountain," or "valley" ore, or to the structure, as "flaxseed" ore, "slate" ore, etc. In the brown hematite class "limonite," "turgite," etc., are mineralogical terms referring to the degree of hydration, but the physical structure and appearance of some of the ores are described by the term "lump" ore, "pipe" ore, "botryoidal" ore, "needle" ore, etc. The beneficiating of brown hematites has given rise to the terms "wash" ore, "sand" ore, etc. The carbonate ores are known as spathic ore, limestone ore, blackband ore, kidney ore, etc.

The association of other substances with iron also furnishes names to certain ores, such as pyrite, pyrrhotite, ilmenite, chromite, etc., but in this discussion it is not essential that either the chemical, mineralogical, or physical features of the various ores should be considered in detail.

The early iron industry of the United States was based largely upon bog ores, limonites, or other forms of brown hematites, obtained at points convenient to the Atlantic seaboard. Magnetites also were employed at first by means of a direct process whereby, in Catalan forges, the ores were reduced and the resulting metal forged into blooms or billets without passing through the casting process; subsequently magnetites as well as hematites were smelted in blast furnaces. But the later development of the iron industry and present great importance are due largely to the use of red hematite ore.

The brown hematites and red hematites are of the same chemical composition in so far as iron oxide is the basis of the ore, the primary differences being structural and the lower percentages of combined and hygroscopic water in the red hematites. Red hematite, if free from other impurities, will yield 70 per cent of iron, and pure brown hematite, if thoroughly dried out

and calcined to eliminate all water, will also yield the same proportion of iron. But if the ores are merely dried to drive off the moisture, which differs under varying conditions, the amount of metallic iron possible in a pure red hematite is about 70 per cent, and in a pure brown hematite 60 per cent. However, iron ores seldom occur practically pure, the amounts of silica, alumina, lime, magnesia, and of such elements as manganese, chromium, sulphur, phosphorus, titanium, etc., reducing the actual percentage of metallic iron obtainable from ores.

Magnetic ores are capable of yielding in the pure state more metal than any other ores, and pure magnetite would show 72.48 per cent of metallic iron, but magnetites, like the hematites, are subject to deterioration from other elements which are present.

The fourth form of iron ore is the carbonate or spathic, in which the oxide of iron is associated with carbonic acid and generally with lime. If this carbonic acid is driven off by heat carbonate ores become practically brown hematites, but in the natural state the purest carbonate would not yield over 46.7 per cent of iron. Considerable of the early iron industry, particularly in western Pennsylvania, eastern and southern Ohio, Kentucky, and Maryland, and also to a certain extent in eastern New York, was based upon the use of carbonate ores, but because of the facts that these ores in their natural state are "lean," that they usually occur in veins that must be worked underground, often deteriorating as workings are extended, and that the ore must be roasted, the quantity of carbonate iron ores employed has been greatly reduced, until in the year 1902 only 27,642 tons were used.

In late years the quantity of magnetic iron ores utilized annually in producing pig iron has increased but slightly, although some remarkable deposits of these ores are available. But magnetites are not as readily reduced as the hematites, are often dense and hard, are liable to have an excess of sulphur, phosphorus, or titanium, or are so closely associated with the gangue matter as to make them lean, demanding that roasting or some method of concentration, either by hydraulic or magnetic separators, should be employed.

Brown hematites occur mostly in pockets or lenses, but are occasionally found in strata, often associated closely with limestone, and also more or less intimately mixed with clays and siliceous matter. Consequently, many brown hematites require washing to separate the clay and sand, and in some cases this washed ore is subsequently roasted to drive off the excess of moisture.

All methods of beneficiating ores, such as roasting, washing, and separating, add to the expense of production, and it is therefore not surprising that red hematites, which seldom require preliminary treatment, have met with general favor. This preference can also be explained by the fact that the ores are usually readily reducible, and most of those mined yield satisfactory percentages of iron. Another feature of material advantage is that many red hematites occur in large and well-defined lenses or bodies, permitting the exploiting of the deposits on a large scale by utilizing labor-saving appliances. The use of such appliances may extend from the winning of the ore at the mine to its delivery at the blast furnaces. Thus a large proportion of the red hematite ore from the Lake Superior region is never touched by manual labor. That which is obtained from open cut workings is in many cases dug by steam shovels which load the ore into standard railroad cars. In some underground mines manual labor is confined practically to directing the ore into "mills" and chutes, which discharge into mine cars, these cars being elevated and automatically dumped into bins from which standard railroad cars are loaded. In other underground operations it is necessary to shovel the ore by hand into mine cars, but thereafter labor-saving appliances are available.

Most of the ore mined in the Lake Superior region is carried in standard railroad dump cars to shipping docks, where it is dropped into bins, from which chutes convey it into the holds of vessels brought to the side of the docks. These vessels are unloaded by mechanical appliances, which deliver the ore either onto stock piles or into standard railroad cars, which carry it to the blast furnaces. At the blast furnace plants there are equally satisfactory mechanical appliances, such as car dumpers, which empty a 100,000-pound car by reversing it, or traveling bridges, fitted with large buckets, which transfer to bins or to stock piles the ore dumped from the cars. These devices are so perfected that only a small amount of ore is touched by hand from the time it leaves its native bed until it passes into the blast furnace, and while they are most in evidence in the Lake Superior region they are in use in connection with important iron ore mines in other portions of the country.

DISTRIBUTION OF ORE DEPOSITS.

The distribution of iron ore throughout the United States is general; there is no state in which iron ores of some kind are not found in considerable quantities, but all are not available for use.

In some cases the ores are too lean, that is, carry too small a percentage of iron; in others deleterious elements, such as phosphorus, sulphur, silica, and titanium, are in excess. Some deposits are too far from desirable fuel, or too inconvenient to blast furnaces, to make their immediate utilization practicable; others are in small bodies or veins, or are scattered over too large areas to make their exploitation profitable. It is probable that some of the undeveloped deposits may be exploited in

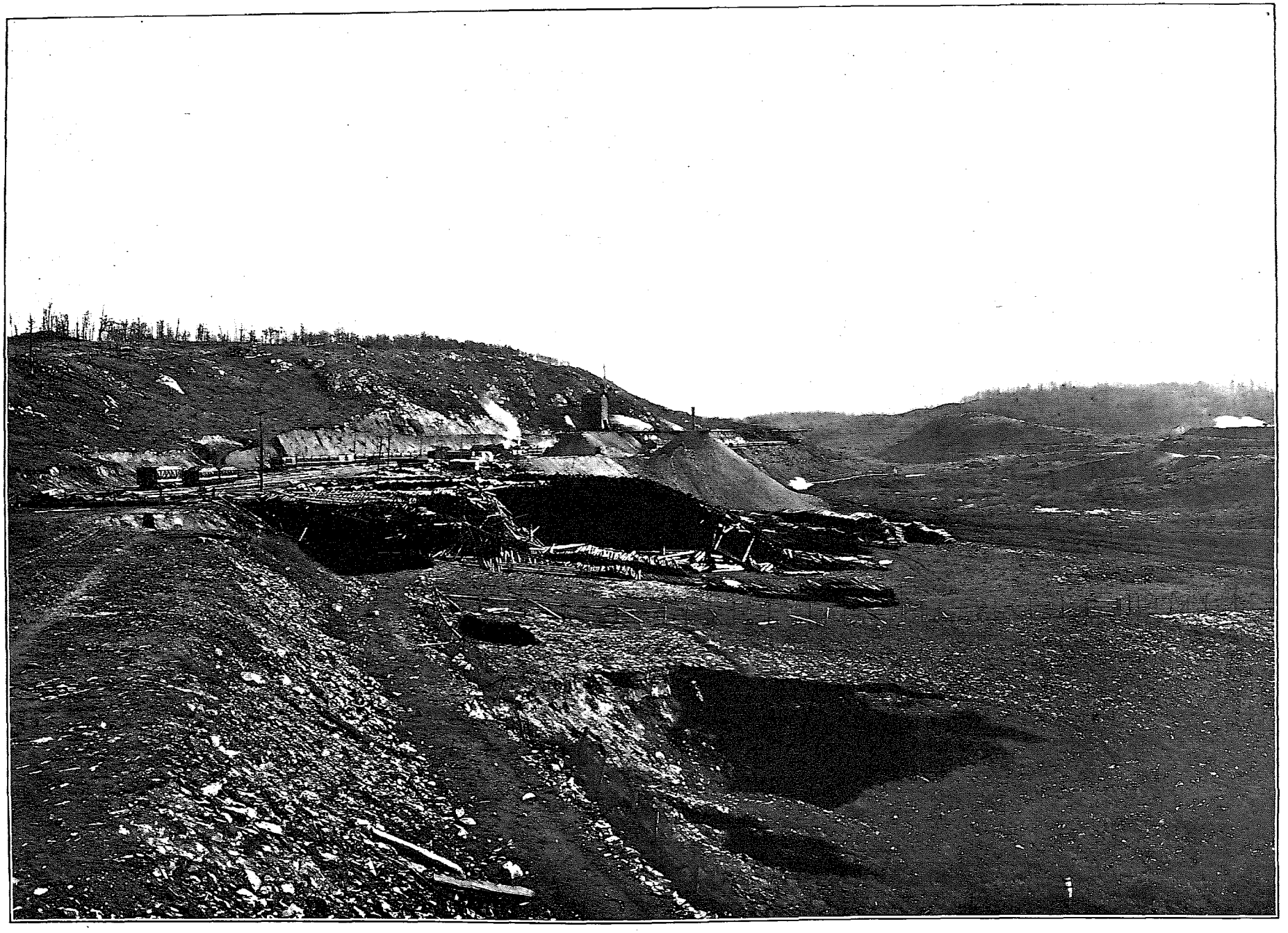


PLATE VII.—CLEVELAND LAKE MINE, MARQUETTE RANGE, MICHIGAN, LOOKING EAST.

the near future as the development of newer sections of the country makes fresh demands for iron, or as the extension of railroad facilities and water transportation brings the ores and fuel into convenient association. Improvements in smelting and fluxing ores, which are now considered undesirable because of the presence of some of the elements mentioned above, may also make the production of satisfactory metal from these ores a commercial possibility. While the manager of a smelting plant can obtain ores high in iron, or those which need no beneficiating treatment, at prices which permit him to produce metal at a satisfactory profit, he can not be expected to consider favorably supplying the blast furnaces under his direction with inferior raw material. But the rapid increase in the output of the blast furnaces to meet the growing demands of a developing country may in the near future encourage the utilization of ores which are now considered undesirable.

While the statistical data is reported by states, except in such cases as would disclose individual statistics, a presentation of the industry according to prominent districts is offered as of interest, for the lines dividing states are lost in anything affecting the industry of the nation. The statistics for these districts are presented in summarized form in Table 11.

The Lake Superior region.—The greatest development of iron ore deposits in the world is in the Lake Superior region, which in 1902 produced 26,977,404 long tons, or 76 per cent of the total output for the United States. No other section of the United States, and no other district in the world, has shown such marvelous development or produced so much iron ore as the region embracing parts of northern Michigan and Wisconsin and the eastern portion of Minnesota. Whether in the same extent of territory elsewhere there may or may not be larger deposits of iron ore of equally desirable composition can not be asserted, for it is by development that these great properties have become known and their reserves approximately determined. But to-day the Lake Superior region stands in a unique position by reason of the large quantity and generally superior character of iron ores won from the five ranges or subdistricts which it embraces. Some of these mines have been in operation for fifty years, a number of them for half that time, but the largest annual producers are later developments.

The initial shipment of iron ore from the Lake Superior region is credited to the year 1856; the development has advanced almost constantly, and about two-thirds of the total product since 1856 has been taken from its mines in the last ten years.

The production of iron ore in the Lake Superior region in the past decade and the quantity previously shipped are as follows:

Production of Lake Superior iron ore, 1893 to 1902, with previous shipments.

YEAR.	Long tons.
1893	6,594,620
1894	7,682,548
1895	10,268,978
1896	10,566,359
1897	12,205,522
1898	13,779,308
1899	17,802,955
1900	20,561,238
1901	21,445,903
1902	26,977,404
Total for 10 years	147,887,835
Previously shipped	73,440,647
Aggregate	221,328,482

The mines of this region are located at an elevation of from 1,000 to 1,500 feet above Lake Superior, the distance from the lake varying from a few to a hundred miles. The output finds cheap transportation for the rail haul to the lakes, has grades favorable to the traffic, and on the lake shores expensive and well-equipped docks have been constructed at seven different ports, where the ore coming in train loads is received into bins, and delivered from the bins by gravity into the holds of vessels. The vessels take the ore from the shipping docks and carry it through two or more of the Great Lakes to receiving docks where equal facilities for unloading by mechanical appliances have been provided. In this way enormous quantities of ore are handled cheaply and expeditiously.

The Lake Superior region is also unique in that its location is such that ore can be delivered at furnaces, in a populous section of the country, and there meet a cheap fuel supply; in other words, its market facilities are unexcelled. It has been this which has chiefly encouraged the phenomenal development.

The quantities of iron ore obtained from the five ranges embraced in the Lake Superior region, taking these in the order of their initial shipment, are as follows:

The Marquette range, in the northern peninsula of Michigan, has contributed since 1854 a total of 66,915,217 long tons, or 30 per cent of the entire production of the Lake Superior region.

The Menominee range, south of the Marquette range and extending from the northern peninsula of Michigan across into northern Wisconsin, has shipped, since 1877, 42,406,228 long tons, or 19 per cent of the entire production.

The Gogebic range, west of the Menominee and Marquette, partly in the northern peninsula of Michigan and partly in Wisconsin, has supplied, since 1884, 38,288,761 long tons, or 17 per cent of the entire production.

The Vermilion range, in the eastern portion of the

state of Minnesota, has, since 1884, sent forward 19,074,424 long tons, or 9 per cent of the entire production.

The Mesabi range, in Minnesota, south of the Vermilion range, in the brief interval since its opening in 1892, has furnished 54,641,532 tons, or 25 per cent of the entire production of the region.

The total production of these five ranges since their opening is 221,326,162 tons, and adding 2,320 tons not credited to any particular range, the grand total for the Lake Superior region is 221,328,482 tons. This far exceeds the quantity of iron ore won from any other mining district in the world, and the amount obtained in the year 1902 from these five ranges, which represents their maximum production, is in excess of the entire production in one year of any foreign country. The quantity of ore won from the state of Minnesota in 1902 has only been exceeded by the yearly production of Great Britain in thirteen years and of Germany in six years. None of the other foreign countries has as yet reached a total approximating this state's 1902 output.

The Vermilion range, in Minnesota, was opened in the year 1884. The ore which is there produced is a hard specular, high in iron, and usually of Bessemer grade. This range is the farthest removed from the principal pig iron producing centers, and the high esteem in which the ore is held is shown by the fact that much of it traverses a distance of over 1,000 miles to points of consumption. The two principal producing mines in this range are known as the Pioneer and the Chandler. Plate I is a surface view of these mines, showing the shafts and various buildings connected with the mining operations, the large open cut, and the extent to which timber has been denuded for mine supports and fuel.

Plate II shows the Auburn mine, on the Mesabi range, in Minnesota. The ore in this deposit is won by the "milling" system, in which the surface earth is removed and the ore drawn through "raises" into drifts located some distance below the top of the ore, making in this way large sinks or craters. This system requires that the cover be stripped, and is especially adapted to shallow deposits of soft ore. The plate gives an excellent view of the crater which is formed by the mining. A steam shovel is at work loading ore cars, which are taken through the tunnel shown to the shaft, through which it is elevated to the surface.

Plate III is a view of the No. 2 pit of the Adams mine, where red hematite is obtained; it is located at Eveleth, Minn. The incline plane is shown bottomed in ore, while in the left of the illustration are seen the tunnels which are run back in the ore. Operations have been carried on at this mine both in open pits and underground.

In some of the newer mines modern apparatus has been installed. Plate IV shows a view of a steel shaft frame at the Adams mine. It is provided with hoppers in which to receive ore from skip cars, and was one of the first of this class to be erected in the country.

Plate V, a view on the Mesabi range, in Minnesota, shows large deposits of ore. These are usually of a comparatively soft character, lying in nearly horizontal strata and with covering of such slight depth that they can be easily stripped. The ore is won by means of steam shovels which place it directly on iron ore cars, in which it is hauled to the docks. In this way immense quantities of ore are cheaply and easily obtained. It is owing principally to these mines that Minnesota shows a larger production per employee than any of the other states.

The view presented herewith shows the Mountain Iron mine, located at Mountain Iron, Minn., in which three steam shovels are shown, one being at work, as seen at the top of the picture, stripping the ore, while in the foreground another shovel is engaged in loading the cars, and on the right-hand side a third shovel is at work.

Around some of the more important mines in the Lake Superior region towns have sprung up, which are dependent entirely upon the iron ore industry. Plate VI shows a group of mine buildings, crusher house, A and B shafts, and some of the dwelling houses located at the Cliffs Shaft mine on Lake Bancroft, Mich., and gives a good idea of the general surface appearance of a well conducted Lake Superior iron ore mine.

The earliest mining in the Lake Superior district was on the Marquette range and one of the oldest operations is the Cleveland mine, which has been supplying ore constantly for a period of over fifty years. Plate VII shows a general view of the Cleveland Lake mine of the Cleveland Cliffs Company, looking from the east. The shaft houses, ore piles, and dumps are shown, together with the ore cars. In the foreground are immense piles of lumber. The lake bed, drained for the purpose of extending mining operations, may also be seen.

Most of the iron ore won in Michigan is taken from underground mines; the only views obtainable of these are such as are taken by flash light. Plate VIII illustrates the Cliffs Shaft mine, one of the more prominent on the Marquette range in Michigan. A mine car running along a track placed at the bottom of the drift is loaded with ore which has been broken down by means of explosives. A power drill in operation is shown in the right of the picture.

Plate IX is a view of part of the open cut of the Salisbury red hematite mine, on the Marquette range, in Michigan.

In the summer of 1903 the Lake Superior Iron Mining Company, a pioneer of the region, celebrated the fiftieth year of its activity, and the following statement,

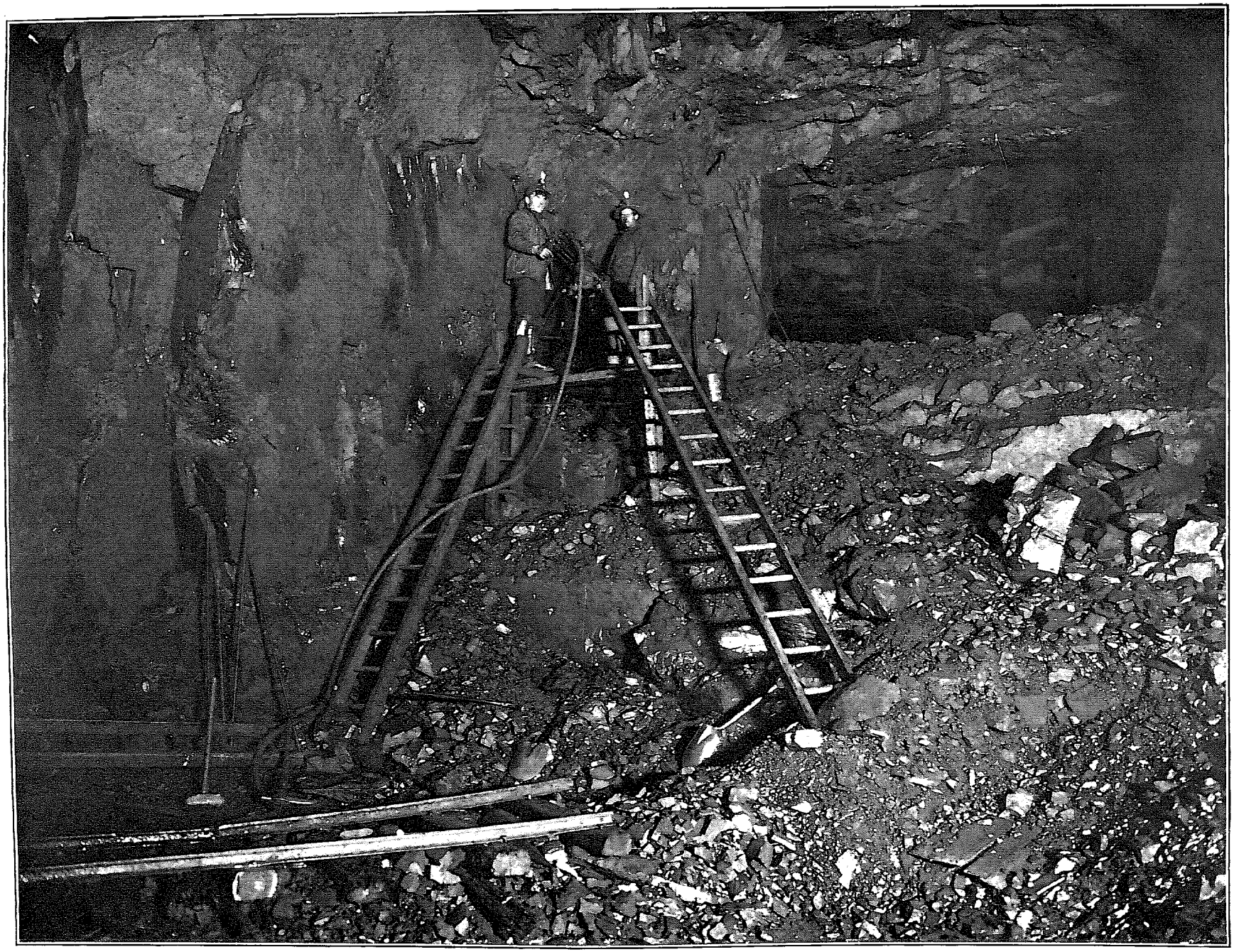


PLATE VIII.—CLIFFS SHAFT MINE, MARQUETTE RANGE, MICHIGAN.

which embraces the salient points of a contribution for the occasion by the author of this report, emphasizes the development referred to:

Neither the records of the production of the Lake Superior region nor the annual reports of the American Iron and Steel Association go back beyond 1854; therefore no data earlier than this will be exact.

In 1854 there was one mine reported as operating in the Marquette range, the shipments amounting to 3,000 tons. In 1902 the shipments of the Marquette range were 3,868,025 tons, the lake shipments from all ranges in that year reaching a total of 27,039,169 tons.

The production or consumption of iron ore in the United States in 1854 can only be estimated from the quantity of pig iron made. According to the census statistics of 1850 there would have been in the neighborhood of 1,500,000 tons of iron ore consumed during that year, for there was made in the country 563,775 tons of pig iron. In 1854, according to the reports of the American Iron and Steel Association, 736,218 net tons, equivalent to 657,337 gross tons, of pig iron required about 1,750,000 tons of iron ore, whereas in 1902 the country produced 17,821,307 gross tons of pig iron, and the domestic output of all the iron ore mines in the country for 1902 was 35,567,410 long tons.

At least 137 producing mines are now active in the Lake Superior region, a number having exceeded annual outputs of 1,000,000 tons, and one mine has approximated 2,000,000 tons in a year. The estimated iron ore production of the country in 1854 approximated 1,750,000 tons, based upon the reported pig iron production, and the yield of ores did not exceed an average of 40 per cent of metallic iron. Therefore, it is doubtful if in 1854 the United States produced as much iron ore as the Fayal mine in Minnesota did in 1902, which in that year shipped 1,919,172 tons. Considered on the basis of metallic contents, however, this output of the Fayal mine probably produced as much pig iron as was made in the United States in any year up to 1866.

In order to indicate the chemical composition of the iron ores obtained from the Lake Superior district the following statements have been prepared. The first shows what may be considered as representative compositions of standard ores of each of the ranges; and in the second the analyses are for the lower grade ores, which are employed largely because of high silica and low phosphorous contents. These analyses are of ores in their natural condition, and represent cargo lots. Determinations of ores obtained from individual mines in each of the ranges will vary from those given in the statements.

Typical analyses of Lake Superior iron ores.

CONTENT.	Marquette range (per cent).	Menominee range (per cent).	Gogebic range (per cent).	Vermilion range (per cent).	Mesabi range (per cent).
Iron	56.5	55.2423	56.308	61.36	56.9996
Phosphorus	0.0353	0.0594	0.0338	0.0373	0.0365
Silica	4.584	6.7693	3.5961	4.2545	3.4867
Sulphur	0.0089	.....	.....	.....	.....
Moisture	11.85	6.525	10.828	4.5649	12.8158

Analyses of siliceous ores.

CONTENT.	Marquette range (per cent).	Menominee range (per cent).	Vermilion range (per cent).
Iron	42.27	42.129	51.1938
Phosphorus	0.0316	0.0244	0.0498
Silica	35.834	34.141	22.3642
Sulphur	0.0099	.....	.....
Moisture	1.23	2.2	3.21

Alabama-Tennessee, or Southern district.—Next to the Lake Superior district in order of present importance, basing such importance on the quantity of iron ore produced, is the district of which Birmingham, Ala., may be considered the business center, embracing northern Alabama, part of northern Georgia, and part of southern Tennessee. In 1902 Alabama supplied 3,574,474 tons, Georgia 330,554 tons, and Tennessee 874,542 tons, making a total for this district of 4,779,570 tons of iron ore. The bulk of the Alabama ores are red hematites, these ores being largely mined convenient to Birmingham. There is, however, a considerable quantity of brown hematite mined in Alabama and also in Georgia and Tennessee. A statement covering the classification of ores in these three states for the year 1902 may be summarized as follows:

Production of iron ores, Southern district, by states and varieties: 1902.

STATE.	Total (long tons).	Red hematite (long tons).	Brown hematite (long tons).
Southern district	4,779,570	3,054,090	1,725,480
Alabama	3,574,474	2,565,635	1,008,839
Georgia	330,554	117,812	212,742
Tennessee	874,542	370,643	503,899

Apparently the largest development of the hematite ores flanking the Allegheny mountains exists in Alabama, where the red hematite (known locally as Red mountain ores), obtained in large quantities close to deposits of coal suitable for the manufacture of coke, have encouraged the growth of the iron industry. The red hematites are locally recognized as soft and hard ores, the former, being at or near the surface, are partially decomposed; the latter are mined by underground workings and may be subdivided into siliceous ores, in which silica is present in quantity, and "limey" ores, in which the proportion of lime may be such as to make the ore approximately self-fluxing. Nearly parallel with the Red mountain deposits are important beds of brown hematite and limonite ore, occurring in isolated deposits, some of large extent. In fact, the exploited brown hematite deposits of this region are of greater average extent than those found in other portions of the country. Occasional deposits of magnetite are also found in the Alabama-Tennessee district, but few have been worked. Some carbonate ore has also been won and used in the manufacture of special irons.

Plate X illustrates the openings at one of the Red mountain mines near Birmingham. Plate XI is a view of a limonite bank near Tecumseh, Cherokee county, Ala.; the ore is broken down, loaded onto tram cars, as shown, and taken to washers, from which it goes to the railroad cars.

New York and New England.—Magnetite iron ores are produced chiefly in New York, New Jersey, and Pennsylvania, but some are won from North Carolina, Michigan, New Mexico, and Utah. The deposits of

this class of mineral in New York state are phenomenally large, and so far as metallic contents are concerned, unusually rich; but many carry phosphorus, sulphur, or titanium in excess, some of the most extensive deposits having so much titanium that they have not been brought into commercial use. High phosphorous ores, however, have been and are mined to a large extent, and beneficiated by magnetic concentration. Some ores in the vicinity of Port Henry, N. Y., carry as high as 3 per cent of phosphorus, as apatite, mixed with the magnetic crystals, which, after the ore is comminuted, can be readily separated, either by magnetic separators or by jigs. Other ores of the Port Henry mines district are of Bessemer grade, and from one opening 30,000 tons of very high grade magnetic ore were obtained. This ore approached chemical purity, was of Bessemer grade as to phosphorus contents, and was practically a mass of well-defined octahedral crystalline forms, some an inch and a quarter on the face, many having practically perfect proportions. Still larger sized crystals have been found, but these were more or less imperfect, and masses of crystals affected by pressure had some faces flattened.

The localities which have been worked in the Lake Champlain district are the mines at Chateaugay, west of Plattsburg; the mines at Moriah, west of Port Henry; and those west of Crown Point. These deposits are at elevations of from 600 to 1,000 feet above the level of Lake Champlain, and while some explorations originally developed beds of considerable size by an open cut, most of the mining is now underground, and much of it at a depth of 500 feet or more. Some mines which have been exploited are adjacent to the shore of the lake, others are close to the Adirondack mountains, and some are on the western side of the range. Prominent among the titaniferous ore deposits are the Split Rock mine, on Lake Champlain, and the Adirondack Village mine, close to the main Adirondack range. These titaniferous ores were utilized in former years by the Catalan or direct process, in which the ore was converted into metal by charcoal in open hearths.

The Port Henry mines, located at Mineville, near Lake Champlain, in Essex county, have long been famous as a source of iron ore supply; it is claimed that the first ore was taken out in 1804. The ore is a dense magnetite, and Plate XII is a view of No. 21 mine of the Port Henry Iron Ore Company. It shows the large pillars of pure ore left to support the roof of the mine, the operations now being practically all underground. It is estimated that there are in the pillars of this mine and of the mines adjoining, belonging to Witherbee, Sherman & Co., at least 800,000 tons of ore. The deposit is very large, having a thickness in some places of 400 feet. The ore bodies are divided into two parts by a horse of rock, and at the lower depth diamond drillings have indicated the existence of two underlying veins of ore high in iron and phosphorus and low in silica. The ore which is sold in the market is high in iron, but also contains phosphorus in the form of apatite, making it all of non-Bessemer quality.

Other deposits of magnetite occur in the Hudson river district, the most pronounced exposures and veins being south of West Point on the Highlands east of the Hudson river, extending as far as Croton Falls, but some magnetite is also found west of the river, and this line of deposits can be traced from New York into New Jersey. The southern New York magnetites are, as a rule, lean, and contain either an excess of phosphorus or, more frequently, of sulphur. There has been considerable exploitation of these deposits, but outside of the Tilly Foster mine none has been a large producer, and all are inactive. The Tilly Foster appeared to be a large lens, which was worked first as an open bed, then the ore body was followed by shafting, the rooms being filled with concrete arches to permit the removal of pillars, and finally the working was restored to an open pit by the removal of 600,000 cubic yards of overlying rock. Large expenditures were also made on the Theall mine, near Brewster, which was worked by an extensive tunnel with stopes, shafts, and galleries. A concentrating plant was erected at this mine, but subsequently dismantled. The Benson mine in northern New York, west of the Adirondack mountains, has also installed a separating plant, and has produced merchantable concentrates in considerable quantity from lean magnetites. The Lake Champlain district has been prominent in the efforts to beneficiate ores by concentration by the use of jigs, and also by magnetic separators. At the Port Henry mines is the largest separator plant in the country.

New York is one of the few states where, in addition to the magnetites, the three other varieties of iron ore are found. Red hematite is mined from the north central portion of the state, in Jefferson, Clinton, and Oneida counties; brown hematites are won in the southern portion, east of the Hudson river, in Dutchess and Columbia counties, and in the same district carbonate ore has been found to a considerable extent, and a large plant for roasting these ores has been constructed near Catskill Landing.

Some of the brown hematite mines along the Harlem Railroad have been worked for many years, and have been, and are still, the main reliance of the charcoal iron industry along the Connecticut and New York boundary. This same class of ores extends into Litchfield county, Conn., and Berkshire county, Mass., the district being generally recognized as the Salisbury region. The rapid denudation of available timber, and the necessity of operating small blast furnace plants producing a special grade of pig iron, has reduced the number of furnaces, so that now only a few are making iron with charcoal; these smelt brown hematite and some carbonate ores.

In addition to the brown hematite ores mentioned as

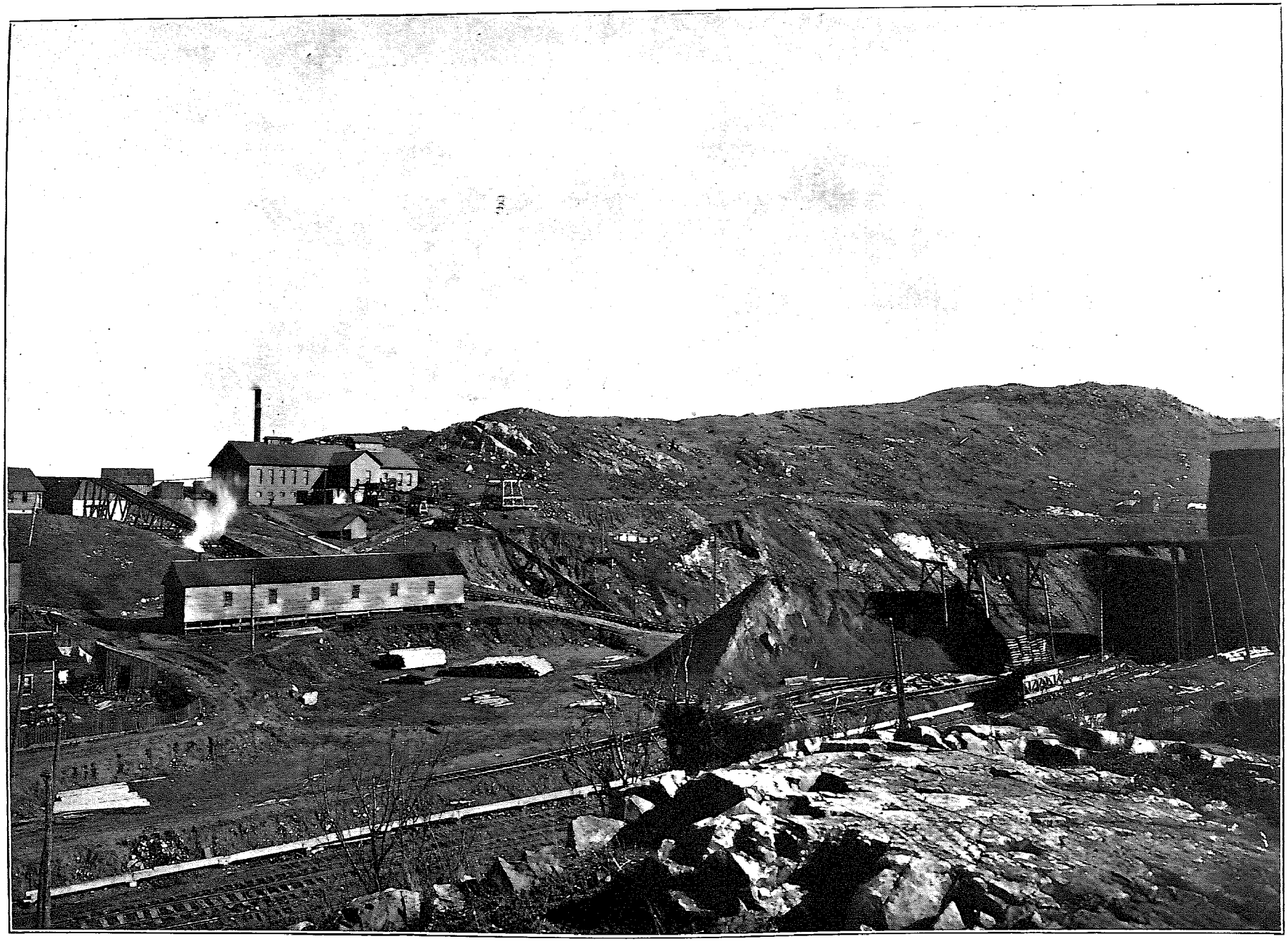


PLATE IX.—THE SALISBURY MINE, MARQUETTE RANGE, MICHIGAN.

occurring in southwestern Massachusetts and northwestern Connecticut, bog ores are found in eastern Massachusetts, and were the foundation upon which the first practical development of the iron industry in the United States was based. Magnetic ore occurs in Rhode Island, and magnetites and brown hematites have been mined in Maine and Vermont.

New Jersey.—The magnetite ores extending from New York across northern New Jersey into Pennsylvania, have been liberally developed in a number of locations in New Jersey. The importance of the industry, however, has declined in late years, the bulk of the product being confined to a few of the more important mines. As a rule, the ores of New Jersey are lean, and some of them carry sulphur or phosphorus in excess, but others are of Bessemer grade. In western New Jersey magnetites also occur in a decomposed condition, and carry considerable manganese. Brown hematites are found in western New Jersey, in the vicinity of Belvidere, but have not been extensively developed. The early iron industry of New Jersey was based upon the use of bog ores, which came from the district close to the ocean front; these are no longer used, and all of the ore won in New Jersey is of the magnetite class. The beneficiation of magnetic ores by washing and by separation has reached a development in New Jersey approximating that of the state of New York. The failure of some of the more pretentious magnetic separating plants, which comminuted ore finely, has encouraged magnetic cobbing and the treatment of ore as coarse grains by separators. The roasting of dense ores is also a feature of New Jersey blast furnace practice.

Pennsylvania.—Pennsylvania, although not the pioneer in American iron industry (its initial enterprise having been established about 1716), rapidly advanced to first place, and by reason of the wide distribution of all classes of iron ore and abundance of fuel, became the largest producer of iron, and still holds that rank, although the bulk of the iron ore used in the manufacture of its iron and steel products is mined outside of the state.

The most important iron mining operation in Pennsylvania is that carried on in the Cornwall ore deposit in Lebanon county, which has produced about three-fourths of a million tons annually, and, since the year 1740, has contributed a total approximating eighteen million tons to supply Pennsylvania iron works. This ore as mined yields on the average about 46 per cent of iron, carries about three-fourths of 1 per cent of copper, and about 2½ per cent of sulphur. It must, therefore, be roasted, and ore-roasting kilns have here obtained their largest development. Furnaces of the Gjers cylindrical form, using solid fuel, are used at some plants, and at others there are circular or rectangular kilns heated by producer gas after the Davis-Colby patents.

The Cornwall ore bank, at Cornwall, Lebanon county, is a large deposit of magnetite from which immense quantities of ore have been won. Most of the ore is obtained above water level, cars being run in on a series of terraces. The ore is broken down and loaded onto cars by means of barrows, and thus transported to the furnaces.

Plate XIII shows two terraces in solid ore, with the workmen engaged in filling the ore cars. In the background of the picture a stripping which covers the ore can be seen.

Along the South mountain, from the Delaware river to and beyond the Susquehanna river, deposits of magnetic iron ores are found and have been worked. In Lehigh and Lancaster counties at present they are mined chiefly for concentration, as the ore is lean. In Berks county a large underground development was made at Boyertown, some shafts extending over 600 feet in depth, the ore being, as a rule, low in phosphorus but high in sulphur, and requiring roasting. These mines are being unwatered to make it possible to obtain ore. Between Boyertown and Cornwall a number of magnetic deposits have been worked spasmodically, and beyond the Susquehanna, in Adams and York counties, similar mines have been in operation. In Lancaster county a magnetic concentrating plant has lately been installed, operating on a large mass of lean magnetite, which is crushed, sized, and separated, the object being to form the concentrates into briquettes for use in blast furnaces.

Along the northern and western faces of the South mountain, and in the valley between the South and North mountain ranges, brown hematite ore has been mined in many localities, some of the deposits having been worked on a liberal scale, and others, producing but little, have a history approximating a century of time. As a rule, these brown hematites require washing to make them desirable for blast furnace purposes, and they yield, after such treatment, about 45 per cent of iron, some with 2 to 5 per cent of manganese, and all with phosphorus above the Bessemer limit. Other brown hematites of nearly similar composition occur in central Pennsylvania, along the eastern flank of the foothills of the Allegheny mountains, in Bedford, Center, Huntingdon, and other counties. In the same region fossil and red hematites are won by underground operations, and this is true also of deposits in northeastern Pennsylvania, along the Blue mountain range, and in the vicinity of Danville and Bloomsburg. Practically all of the brown hematites have been won from open cut workings, the ore occurring with clay and limestone, and requiring washing. Much of the red hematite was mined from small underground drifts.

In the bituminous coal belt, which extends across Pennsylvania from northeast to southwest, with the Allegheny mountains as an axis, the carbonate ores obtained were formerly an important base of supply. The location of many of these ores in small veins, the

exploitation of which is expensive, the necessity of roasting them, and their generally high phosphorus content have much limited their use.

Delaware and Maryland.—In Delaware there are several isolated deposits of brown hematite which have been worked but are now inactive. In eastern Maryland carbonates which occur mixed with clay are mined in a desultory way by farmers and used near the city of Washington to produce a special grade of pig metal with charcoal. In western Maryland there are brown hematites in considerable quantities, also indications of red hematites, and some lean magnetites, which, while appearing to occur in large proportions, would have to be concentrated to be merchantable.

The Virginias and Carolinas.—In Virginia the bulk of the iron ores mined are of the brown hematite class, some occurring in beds of clay, others in a form approaching veins embedded in rock strata. Minor deposits of red hematite also exist, and in southwestern Virginia and in western North Carolina there are large bodies of magnetites. Titaniferous magnetites and brown hematites occur in central North Carolina and extend into South Carolina, Georgia, Tennessee, and Alabama.

The Appalachian mountain chain is bordered by iron ore deposits from northern New York through New Jersey, Pennsylvania, Maryland, the Virginias, North Carolina, Tennessee, Georgia, and Alabama. These deposits are mostly magnetites and brown hematites, the latter generally showing in the valleys, the former often in foothills or on the slopes of the mountains. Some red hematites are also found on the mountain slopes. Nearly paralleling the Appalachian range, and occupying positions in the foothills of the Allegheny mountains, are deposits of brown hematite, also of carbonates. The carbonates are more abundant in the coal bearing regions, and occur on both flanks of the Allegheny mountains.

Still farther west carbonate ores and some brown hematites are found in the coal measures of western Pennsylvania, West Virginia, Ohio, Kentucky, and eastern Tennessee; red and brown hematite are abundant in Kentucky and Tennessee.

Ohio.—The ores obtained from Ohio and from the portion of Kentucky adjacent to the Ohio river are either carbonates or hematites, resulting from the weathering of carbonates; these have sustained a considerable iron industry for many years in southern Ohio and in Kentucky, in a locality known as the Hanging Rock region, with Ironton, Ohio, and Ashland, Ky., as business centers. The original installations were all charcoal furnaces, some of which are still active; for a time some furnaces used raw bituminous coal, but the larger plants are now dependent on coke, local ores being used, supplemented by other ores from the Lake Superior region.

There are also in Kentucky excellent deposits of limonite, and these extend into Tennessee, some quite important mines existing in the central and western portions of the state. There are also carbonates in the southwestern section which extend into Mississippi. Carbonate ore also exists in northern Florida.

Wisconsin and Iowa.—The liberal exploitation of the iron ores in the Lake Superior region has directed attention to deposits in adjacent states. In central Wisconsin brown hematite exists in pockets or lenses. In southern Wisconsin there is a unique deposit of high phosphorus red hematite ore, which, owing to its physical structure, is known as flaxseed ore, and an apparently large quantity of red hematite of excellent composition has also lately been discovered by drilling and shafting in the vicinity of North Freedom, Sauk county, Wis. This deposit is expected to be a factor in the iron ore supply of Chicago and vicinity. In northeastern Iowa brown hematites have been wrought, and carbonates are found in the western section of the state.

Missouri and Arkansas.—Missouri attained prominence as an iron producing state several decades ago through the Iron Mountain and Pilot Knob deposits, which gave promise of being large producers, but as development proceeded these ore beds were practically exhausted, although it is possible there may be undiscovered extensions of them. In central, eastern, and southern Missouri red hematite and brown hematite ores are obtained in quantities, and these ores also extend into Arkansas, although there has been no development in that state.

Texas.—The exploitations for iron ore in Texas have been chiefly in the northeastern section, where brown hematites have been won from near the surface, and the fact that these lie in nearly horizontal layers, covered but slightly with a ferruginous sandstone and sand, suggests that they are bog ores forming the bottom of an extinct lake. They extend over a large territory, except where the plateaus are cut by water courses. In central Texas an important deposit of red hematite ore, claimed to be of excellent quality, has been opened up, but in the absence of demand for this mineral exploitation has not been prosecuted.

Rocky Mountain region.—The section of the country which may be considered as the Rocky Mountain region has a number of important deposits of iron ores and all the general classes of ores are found. In what might be called the distinctively mountainous section, on the western slopes, magnetites are obtained, and some deposits of apparent magnitude are known to exist, but owing to the high elevation of the deposits and the amount of snow encountered, they have not been exploited. It is possible that the increasing demand for iron ores may encourage development.

The iron ore deposits at Sunrise, Laramie county, Wyo., are quite extensive; until late years, however, but little ore had been produced from them. The ore is a red hematite occurring in carboniferous lime-

PLATE X.—RED HEMATITE MINE, RED MOUNTAIN, NEAR BIRMINGHAM, ALABAMA.

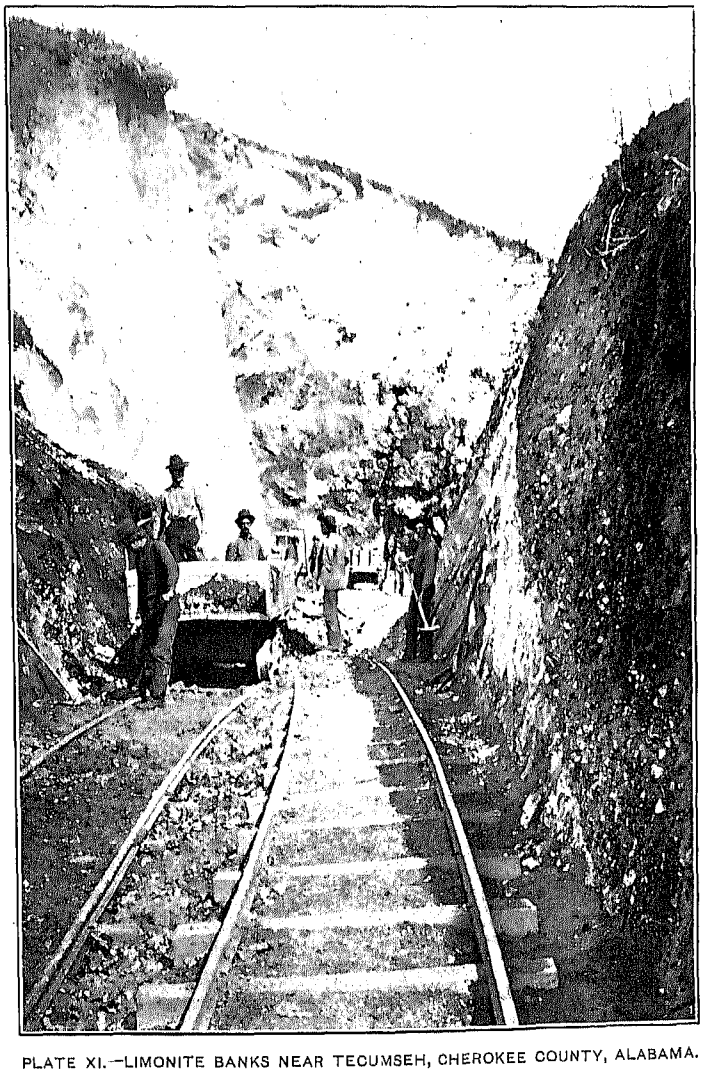


PLATE XI.—LIMONITE BANKS NEAR TECUMSEH, CHEROKEE COUNTY, ALABAMA.

stone; covers, as it is claimed, a superficial area of about 20 square miles; contains from 60 to 67 per cent of iron from 2.5 to 5 per cent of silica, and is low in phosphorus. It is won by open cut working, as shown in the illustration, the steam shovels loading onto cars on which it is taken to the furnaces at Pueblo, Colo. The view (Plate XIV) shows the ore *in situ* together with the covering of limestone and earth.

In New Mexico there is a deposit where red hematite and magnetite ores are obtained. The Fierro, or Union Hill, and Jim Fair mines are located in the territory of New Mexico, near Hanover. Mr. D. M. Barringer, M. E., states that the ore generally, but not always, occurs with eruptive granite and limestone, probably carboniferous, the vein being vertical or dipping at a steep angle. The ore of the Union Hill mine is a mixture of approximately 75 per cent magnetite and 25 per cent hematite, and is quite hard.

The ore of the Jim Fair mine is of practically the reverse composition to that of the Union Hill, the greater portion being of the hematite variety, and is also quite hard. Both here and at the Union Hill mine the ore stands in dikes, and is quarried out in open cuts. Mr. Barringer states that at one place there is a large deposit of brown hematite ore, and at one point there is also a considerable amount of specular ore. The ore carries satisfactory percentages of iron, and is of Bessemer quality. The permanency of this deposit does not seem assured from the results of mining operations to date.

In the San Luis valley of Colorado, which may be said to be in the heart of the Rocky mountains, brown hematite ores are mined, and one mine has been phenomenal not only for the quantity taken from it, but also for the low percentage of phosphorus in the ore. In fact, the product has been persistently a Bessemer ore, and it is probable that no other deposit of brown hematite has produced as much low phosphorus ore as the Orient mine. This mine is located in the eastern part of Saguache county, Colo., about eight miles from Villa Grove, and was opened in 1882. The ore body is from 30 to 150 feet in width and is worked by means of tunnels, from which stopes are run. Over 1,000,000 tons of ore have been obtained from this deposit, but unfortunately it shows signs of exhaustion. It may be, however, that deposits of similar character will be found in the same district.

Plate XV is a view of the Orient mine, showing one of the inclines from which the ore is loaded onto cars for transportation to the blast furnace.

Between the Pacific coast and the Rocky mountains there are a number of deposits of iron ore, but few have been exploited, because there has been little or no market for the mineral. Blast furnaces which were located at Ogden, Utah, at Clipper Gap, Cal., and at Salem, Oreg., have ceased operations, and the only enterprise now active is near Port Townsend, on Puget sound, in the state of Washington. This plant has drawn its supply in part from local hematites (bog ores), but is largely dependent upon magnetic ores imported from British Columbia. The plants now idle relied, when in operation, mostly on brown hematite ores mined near the furnaces, with the exception of the plant in Utah which received as part of its supply red hematites from Wyoming. In northern and southern California magnetites and red hematites are reported, but nothing beyond exploratory work has been done upon them. When satisfactory supplies of metallurgical fuel become available it is possible that some of these Pacific coast deposits may be exploited. Magnetite has also been mined near Lovelocks, Nevada.

VALUE OF IRON ORE DEPOSITS.

The determination of the value of iron ore deposits is difficult, for they are only serviceable in so far as the material of which they are composed may be utilized. Thus, a mountain of excellent iron ore remote from blast furnaces or other means of utilization, without transportation facilities to carry the mineral to points where markets exist, would stand practically useless until these conditions were modified.

The quality of the iron ore obtainable has a decided influence upon the value of the product, and therefore upon that of the deposit. Ores low in phosphorus, although with moderate iron content, command premiums over those carrying this element in excess, and in the present state of metallurgical development ores carrying titanium are considered undesirable, although in the near future they may possibly be sought after. A sulphurous ore requiring roasting is less desirable than one free from sulphur, and ores which require washing or beneficiating, either by jigs or magnetic separators, have less value than those which can be used in their native state. Therefore, the apparent quantity and average quality of an ore in a deposit and its accessibility to markets or prospective points of consumption affect its value. Where a mine is producing and where the tests made to determine the apparent extent of the deposit are satisfactory, its value may be gauged by capitalization based upon a royalty charge for ore mined, for in an ore deposit the material taken out is not reproduced, and therefore some allowance covering a value for the ore won is proper.

The difficulties of determining the value of iron ore deposits are increased by the fact that in some instances mere mining rights are granted, while in others a proprietor may allow a mining company to take ore at a fixed rate per ton, or upon a sliding scale. In still other cases the ownership is in a state which grants mining leases at tonnage rates; these leased properties after having been explored or developed are sublet, and thus two or more royalties may be cumulative. A deposit of ore has no definite value to the lessee or sublessee, other than what he gets out of it during the

term of his lease, for he has no interest in its future and the owner can practically base no estimate of value except by capitalizing its earning capacity, providing that earning capacity can be maintained. Another feature which has caused trouble in an attempt to determine approximate valuations for the iron ore deposits of the United States has been that a company may own or lease a considerable tract of land only a small part of which has been explored or exploited. It would be manifestly unfair to base an estimate of the value of the entire property upon results obtained from a limited area.

During July, 1902, an interesting suit in chancery developed the estimate which the officers of the United States Steel Corporation placed upon its iron ore properties. Practically this estimate claimed that the corporation had in reserve, in deposits which had been tested, over 700,000,000 tons of iron ore, upon which the company placed a value to itself of $1 per ton. This was not merely a royalty estimate, but represented what the officers of the corporation considered the ore was worth as a material for conversion into merchantable products, taking into consideration the location of the deposits in relation to its furnaces and mills, and the fact that as far as known this supply could not be duplicated elsewhere, certainly not within any limit of transportation to the corporation's existing plants. This valuation was questioned because an official of the corporation had stated that it had reserves of ore and fuel sufficient for sixty years, the assumption being that the value of a supply of mineral which would not be exhausted before sixty years would be strongly affected by the interest which the money invested should earn in that time. In a case such as indicated, an iron ore deposit which produces a quantity of ore desirable in quality, so as to be of material service to the industry, undoubtedly possesses a value to the owners which is not fully measured by a mere royalty charge, for it acts as a basis for supplying raw material and gives the owner not only a possible profit on the mining, but a protection in cases of fluctuations in prices of ore, a value difficult to estimate in money.

COMMERCIAL VALUE OF THE PRODUCT.

The determination of the value of iron ores is contingent upon the character of each ore, its chemical components, its texture, its location in relation to blast furnaces where it can be used, and transportation facilities. The custom heretofore followed in census reports of ascertaining as closely as possible what commercial value the various ores represent at the mines, including any royalty or allowance for royalty, and excluding all transportation charges has been followed in this report. In discussing the output by states, the value of the ore delivered at points of consumption is not taken into consideration, but comparisons are based upon what the ores are commercially worth at the mine ready for market. The value, however, should and does include the cost of beneficiating ores when they receive such treatment, so as to make the record show the total value of the iron ore produced in each state.

The prices of the Lake Superior ores of Bessemer quality are based on a standard ore yielding 63 per cent of iron when dried at 212° F., with 0.045 per cent phosphorus and 10 per cent moisture, equivalent to 56.7 per cent of metallic iron in the natural condition. The standard for non-Bessemer ores yields 60 per cent of iron when dried at 212° F., with 12 per cent moisture, equivalent to 52.8 per cent metallic iron in the natural condition. The calculation to determine the selling price is made on ores having the above hypothetical analysis, delivered f. o. b. cars at blast furnaces. If the ores yield above or below the chemical standard the price is adjusted accordingly by premium or discount. The scale for Bessemer ores takes into account the percentage of both iron and phosphorus. The price of non-Bessemer ores is determined in the same way, but usually only metallic iron is taken into consideration unless other constituents are excessive.

The physical condition of iron ores—that is, whether they are coarse or fine, dense or open in structure—also affects their commercial value. The Mesabi range ores are divided into three classes, according to their degrees of fineness, as determined by sieve tests; the second class is 10 cents, and the third class 25 cents below the price placed upon the first class.

All of the ore mined in the United States is not utilized in the production of metal for steel manufacture, for in this freedom from phosphorus is generally necessary; an excess of this element, however, is admissible in iron treated by the basic Bessemer process.

For use in foundries, for treatment in puddling furnaces, and for other purposes which, taken together, consume approximately one-quarter of the pig iron produced, the limitations as to phosphorus are less rigid. For these purposes many ores may be smelted which are not considered desirable in manufacturing pig iron for conversion into steel. However, other elements than phosphorus demand consideration, and in the selection of ores their chemical composition determines their availability for specific use. The percentage of iron which an ore yields is the first consideration, for upon this the economy of smelting primarily depends, but objectionable elements or oxides may encourage the selection of an ore containing less metallic iron, but freer from objectionable constituents than an ore with high iron contents associated with deleterious ingredients.

Seeking for large outputs of metal of a particular composition, and for low fuel consumption, blast furnace managers may refuse nearby ores lean in iron or carrying undesirable constituents, and bring from a

PLATE XII.—VIEW OF NO. 21 MINE, PORT HENRY IRON COMPANY, MINEVILLE, NEAR PORT HENRY, NEW YORK.

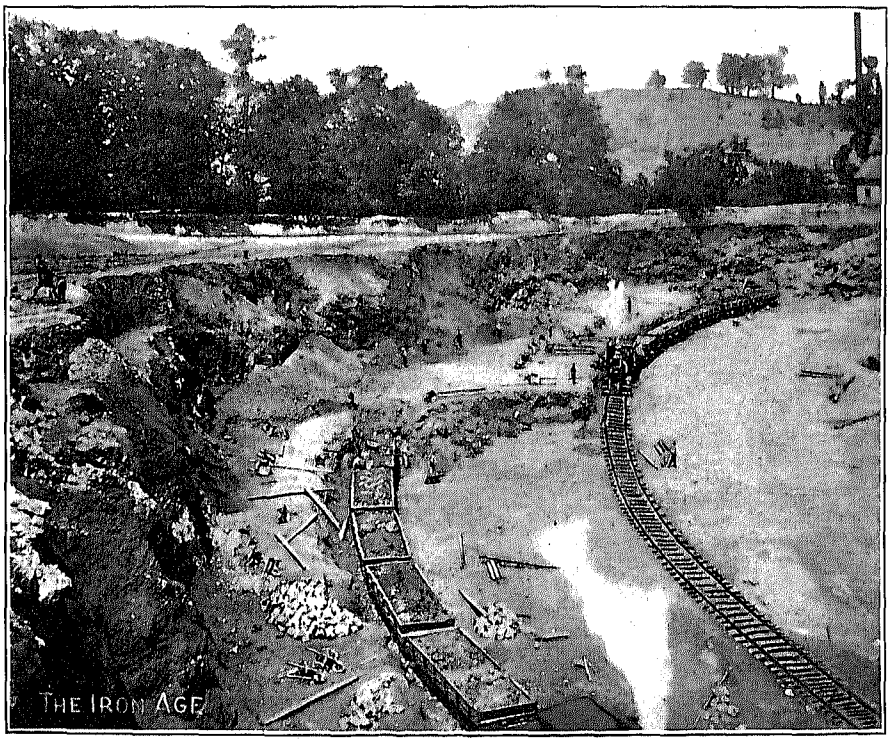


PLATE XIII.—CUT IN MIDDLE HILL, CORNWALL ORE BANKS, CORNWALL, LEBANON COUNTY, PENNSYLVANIA.

distance ores with larger percentages of metal or with very little of phosphorus, sulphur, titanium, etc.

The following table shows the quantity of iron ore produced in each state and territory in the United States, its value, and the average value per ton, for each year from 1899 to 1902:

TABLE 13.—QUANTITY, VALUE, AND AVERAGE VALUE PER TON OF IRON ORE, BY STATES AND TERRITORIES: 1899 TO 1902.

STATE OR TERRITORY.	1902			1901			1900			1899		
	Quantity (long tons).	Value.	Average value per ton.	Quantity (long tons).	Value.	Average value per ton.	Quantity (long tons).	Value.	Average value per ton.	Quantity (long tons).	Value.	Average value per ton.
United States	35,567,410	$65,465,321	$1.84	28,887,479	$49,256,245	$1.71	27,553,161	$66,590,504	$2.42	24,683,173	$34,999,077	$1.42
Minnesota	15,137,650	23,989,227	1.58	11,109,537	15,335,513	1.38	9,834,399	24,384,393	2.48	8,161,289	9,924,853	1.22
Michigan	11,135,215	26,695,860	2.40	9,654,067	21,735,592	2.25	9,926,727	28,859,650	2.91	9,146,157	13,707,899	1.50
Alabama	3,574,474	3,936,812	1.10	2,801,732	2,587,719	0.92	2,759,247	2,629,068	0.95	2,662,943	2,601,609	0.98
Virginia and West Virginia	987,958	1,667,456	1.69	925,394	1,466,423	1.58	921,821	1,489,318	1.62	986,476	1,766,410	1.79
Tennessee	874,542	1,123,527	1.28	789,494	912,849	1.16	594,171	669,087	1.13	632,046	694,372	1.10
Pennsylvania	822,932	1,225,453	1.49	1,040,684	1,561,620	1.50	877,684	1,890,100	2.15	1,009,327	1,991,772	1.97
Wisconsin	783,996	1,800,864	2.30	738,868	1,564,173	2.12	746,105	2,081,272	2.79	579,798	837,766	1.44
New York	555,321	1,362,987	2.45	420,218	1,006,231	2.39	441,485	1,103,817	2.50	443,790	1,241,985	2.80
New Jersey	441,879	1,228,664	2.78	401,989	918,011	2.28	344,247	956,711	2.78	256,185	814,920	3.18
Georgia and North Carolina	364,890	505,488	1.39	[1]215,599	258,227	1.20	336,186	446,354	1.33	284,364	307,965	1.08
Nevada, New Mexico, Utah, and Wyoming	[2]362,034	475,316	1.31	[3]234,514	367,864	1.57	[4]132,277	202,480	1.53	54,148	108,720	2.01
Colorado	306,572	1,084,424	3.54	404,037	1,284,255	3.18	407,084	1,510,831	3.71	307,557	749,734	2.44
Kentucky	71,006	86,169	1.21	[5]46,499	48,938	1.05	[5]55,057	60,886	1.11	35,384	35,384	1.00
Missouri	66,308	106,379	1.60	14,230	33,742	2.37	41,366	62,745	1.52	22,720	42,203	1.86
Connecticut and Massachusetts	[6]29,093	81,374	2.80	25,214	73,487	2.91	31,185	75,702	2.43	29,611	77,989	2.63
Maryland	24,367	46,911	1.93	21,218	33,825	1.59	26,223	55,735	2.13	3,428	4,628	1.35
Ohio	22,657	41,976	1.85	44,185	67,776	1.53	61,016	98,563	1.62	53,221	77,606	1.46
Texas	6,516	6,434	0.99	(7)	(7)	(7)	16,881	13,792	0.82	14,729	13,262	0.90

[1] Includes South Carolina.
[2] Includes Montana. No product reported for Nevada.
[3] Includes Texas and Montana.
[4] Includes Montana.
[5] Includes Iowa.
[6] Includes Vermont.
[7] Included with Nevada, New Mexico, Utah, and Wyoming.

The values at different mines vary greatly and only the averages are presented in the above table. In considering these values it must be remembered that they represent the labor employed and the expenses of operating, royalties, or sinking fund, but no transportation charges. These values are not the selling prices of the ores, which are gauged when delivered either at the furnace or at receiving points where they are handled for distribution.

MINING METHODS.

Iron ore deposits in the United States vary materially in character, size, and occurrence, and the geological and physical conditions of the several varieties generally known as magnetite, red hematite, brown hematite, and carbonate ores require different methods of exploitation which also vary greatly. The known character, the apparent dimensions, the general form, and the position of an iron ore deposit, with reference to the surface and water, the physical structure or chemical composition of the material to be extracted, the character of the earth or rock inclosing or occurring in the ore body, the stratification, dip, and strike, the simplicity or complexity of the ore body, the convenience of the deposit to an available market for its product, and the capital at command of those who attempt the exploitation all influence the methods followed in mining iron ore.

Where the ore body projects above or lies close to the surface, or where in a large apparently well defined deposit the cover can be stripped to advantage, the exploitation may be carried on by open cut work, from which the ore is taken out either by train or, after digging, lifted by steampower applied to inclines or to vertical hoists.

In the Mesabi range of Minnesota, in the Sunrise district of Wyoming, and in a number of brown hematite deposits of the South, large open cuts are worked by the use of the steam shovel, these appliances removing the ore in successive benches after large areas have been stripped by the same method.

Where the body of ore is under considerable cover, if the roof is firm, or if the vein matter is comparatively narrow and the dip steep, it is removed through shafts, either vertical or inclined, and through tunnels or adits. In a number of instances open cut work has, after reaching a considerable depth, been supplemented by underground exploitation, while in a few cases this method has been reversed and a large open cut has supplanted underground work. The shafts or adits, which are generally expected to serve as long as the deposit yields ore, are necessarily costly and need to be planned and located with care, for through these the miners have access to the underground workings, and the ore and water are carried to the natural surface.

Except when the strata penetrated are exceptionally compact and hard, the shafts or adits must be substantially timbered, so that they can be maintained until the deposit is exhausted; they are excavated either in the ore or in inclosing rock, and if in the ore large

bodies are left adjacent to these avenues of approach as a safeguard against accident. From these main arteries drifts are opened either parallel or at different angles in wide or shallow deposits, or at determined depths in narrow and deep deposits, and from these in turn supplementary drifts are run and rooms or stopes excavated.

In deposits dipping considerably from the horizon one prevailing method of exploitation is to open a series of drifts at different levels, from which mining is carried on simultaneously; the upper levels are farther advanced than those below, the ore being taken out in horizontal sections or slices, known in mining parlance as stopes. When the ore is worked above a given level and allowed to fall by gravity, through chutes or otherwise, to vehicles which deliver it to the main arteries, the method is called "overhand stoping." Where the material is attacked below a level and the ore raised to this level, the method is recognized as "underhand stoping." The overhand system is, under most circumstances, the cheaper and more advantageous, but the underhand stoping is necessary in taking up floors, removing pillars, and in some open cut work.

In underground operations the space made void as the ore is removed must be protected, at least in part, either by timbering or by filling in rock or other waste material. In some instances the ore, if hard and if left in pillars alternating with rooms or stopes, will safely support the roof, but often the proportion of ore sacrificed is too great to make this method desirable.

After shafts or adits have been sunk and main drifts run the ore is taken out by various systems, which may be briefly designated as follows:

"Milling," in which the surface earth is removed and the ore drawn through "raises" into drifts located some distance below the top of the ore, thus making large sinks or craters. This system requires that the cover be stripped, and is especially adapted to moderately shallow deposits of soft ore covering a large area.

In "caving" a series of levels connecting with the main shaft or with several shafts are simultaneously worked, the ore being taken out from the upper levels and delivered through winzes to lower levels which are protected by the ore *in situ*. As the ore is removed from the portion of one level the superincumbent rock or earth is allowed to cave upon the ore below, and frequently the settling of the material is facilitated by the use of explosives. By this method but little ore need be left in a deposit, and if care is exercised the risks are not great and but little waste becomes mixed with the ore. This method is applied more to soft or moderately soft ores than to those which are harder, but it is used in some hard ore mines where the roof or hanging wall is insecure.

"Drifting" is employed in all underground mining, but where a series of parallel drifts, one advanced more than another, are employed to slice off the deposit the method is specifically known as the "drifting or slicing system."

"Room mining" may be considered either as digging out cavities which alternate with pillars, or as opening cavities of considerable length, width, and height, usually from foot wall to hanging wall, and supporting the last named and the roof by an elaborate arrangement of timbers known as square sets, in which the timbers are so placed as to form the outlines of a series of cubes resting upon one another by carefully fitted joints. This method is largely employed in removing soft hematite, and some of the cavities thus made and protected are of enormous size.

"Filling" is not so much a method of mining as a means of protecting the workings by depositing in the cavities waste rock, sand, and other refuse. This method is often more economical than timber support, and is adapted to hard ore mines.

The magnetites, as a rule, are found in fairly well-defined veins, inclosed between walls and dipping at steep angles from the horizon. Some of these veins are of enormous size, as in the Lake Champlain district of New York, where the texture and hardness of the ore permit of its use as pillars in the mines. Other veins are narrow and tortuous, although persistent, and each of these characteristics demands different methods of exploitation.

Where magnetic iron ore is obtained from underground operations the ore left as pillars generally furnishes sufficient support for the roof. There have been instances where the proportion of the total ore in the deposits which these pillars represented was so large, or the tendency of the mineral to break from the pillars in large masses was so great, as to cause their abandonment.

FINE ORES.

During late years there have been interesting discussions in the technical press concerning disturbances in blast furnaces, which are attributed largely to the increasing use of finely comminuted iron ores. The troubles have been emphasized by the contemporaneous development of the Mesabi range in Minnesota, where a majority of the ores occur finely comminuted, some practically as powder, by the use of concentrated ores, and by the increase in the dimensions and power of blast furnaces. As a result, fine ores have been discredited, and explosions, slips, and losses in the blast furnaces have been attributed to the use of these ores. Fine ore is undoubtedly more troublesome in the blast furnace than ore which is of moderate size, as the comminuted material is liable to sift down through the charge and accumulate in portions of the furnace, increasing the resistance of the blast, and a portion as flocculent material is carried over with the furnace gases. In some blast furnaces the latter represents so large a proportion of the ore charged that the material

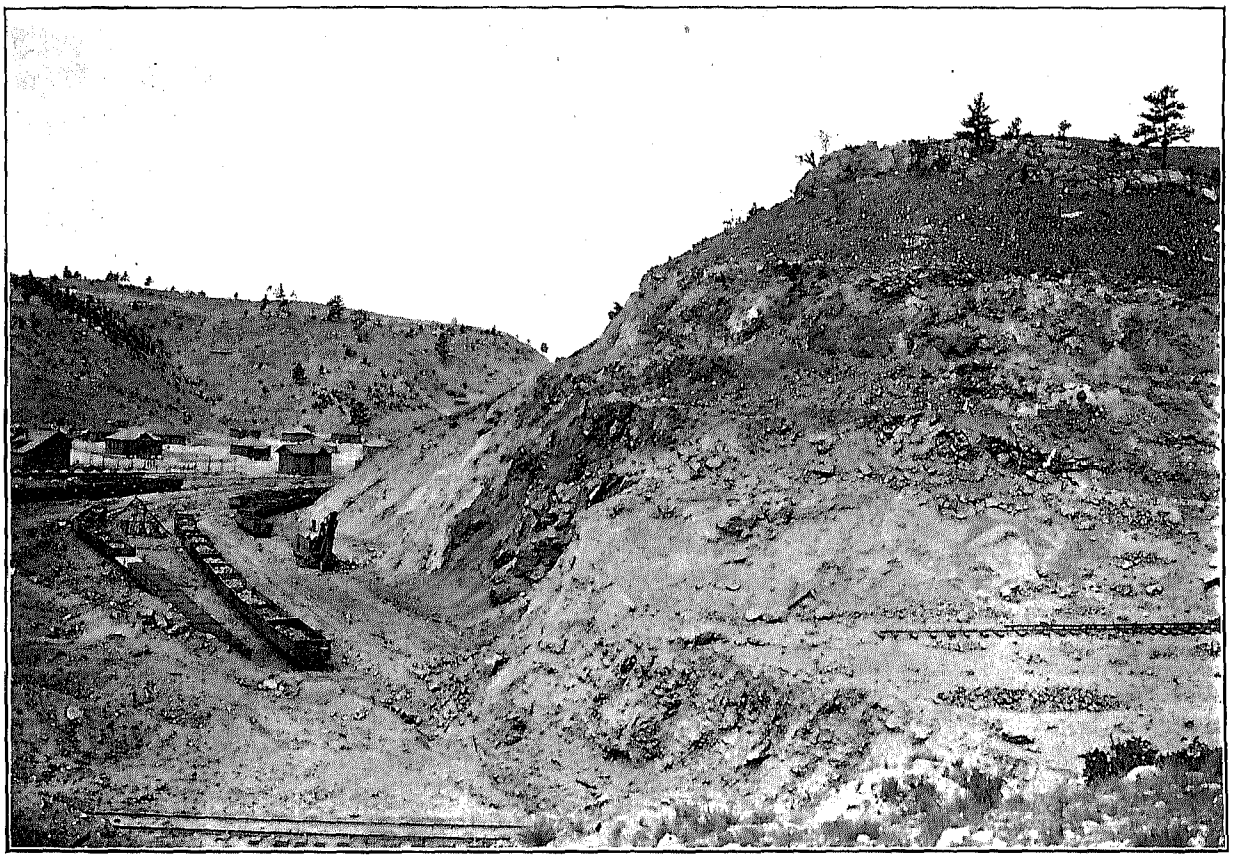


PLATE XIV.—SUNRISE PIT FROM THE EAST, AT SUNRISE, LARAMIE COUNTY, WYOMING.

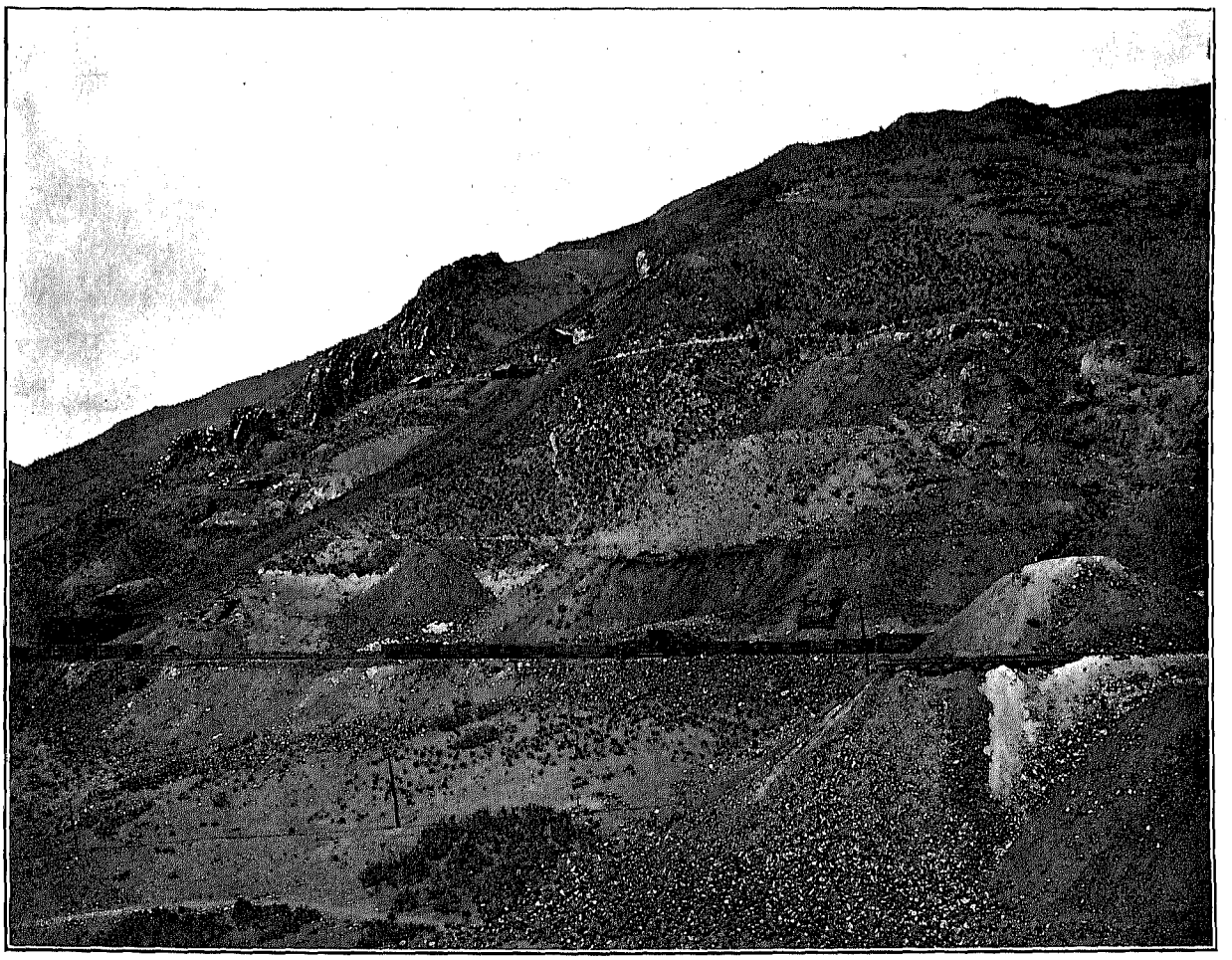


PLATE XV.—NOS. 3 AND 4 TRAMS AND RAILROAD TRACKS, ORIENT MINE, NEAR SALIDA, SAGUACHE COUNTY, COLORADO.

is recovered and formed into briquettes, or made into mud with water, to be returned into the furnace.

There is no intention to question the desirability of using relatively coarse ores in blast furnaces, but it is probable that fine ores are blamed for some disturbances for which they are only partially responsible. The accumulation of fine material of any kind in a portion of a blast furnace may cause unequal settlements, slips, or irregular operation, and, while the fine ore is subject to this, the same results may come from an accumulation of comminuted coke and fluxes. In the enlargement of blast furnaces the system of feeding materials has been radically changed. Where thousands of tons are fed daily into the throat of a blast furnace, the handling of this becomes an important matter, and labor-saving appliances are demanded. A few years ago the general practice of blast furnaces, of what was then large size but would now be considered of moderate dimensions, was to discharge the raw material from cars running upon trestles, shovel or fork this into charging buggies which were elevated to the top of the furnace and discharged upon the bell, which closed the throat by fitting against the hopper. But where large quantities are daily handled bins have been introduced which take the place of trestles, and the material, instead of being shoveled or forked into the discharging buggies, drops from railroad cars into bins and from bins through chutes into scale or weigh cars, thence into skip cars, which are lifted considerably above the top of the furnace and dumped into the receiving hopper, thence through a bell and chamber to the main furnace bell.

Bins have been erected to considerable height, and in dumping the material, particularly coke, into the bins, or in passing it through them, it becomes more or less broken. At some furnaces the coke bin discharges immediately into the skip car running to the top of the furnace, but in a majority of cases the weigh car intervenes. As a consequence, a large percentage of coke is ground to powder, for it may have an aggregate drop of from 30 to 50 feet from the time it leaves the car in which it is transported until it touches the main bell of the furnace.

In the smelting operation there is no opportunity for coke to be consumed until it approaches the tuyeres of the blast furnace, for it is here that the combustion of the fuel is made possible by the admission of heated air. An excess of free oxygen would carry this combustion to a point which would result in imperfect and irregular furnace operation, consequently the fine material which may accumulate in the shaft or upper portion of the furnace may be added to until it is in such volume and position as to cause a disturbance by slipping, resulting in increased pressure of blast, and an irregular working of the blast furnace. While the same may be true of the fine ore, this has the advantage of being reduced by the gases resulting from the combustion of the fuel. Investigations of some of the larger furnaces blown out for repair seldom show unreduced ore, although the proportion of fine ore fed may have been large, but indicate volumes of coke dust adjacent to the walls or accumulated in different portions of the blast furnace. The combination of fine ore and fine coke may therefore be considered largely responsible for many slips and irregularities, but it is possible that explosions which have been so severe at a number of furnaces are attributable primarily to flocculent incandescent carbonaceous matter (resulting from the grinding of the coke), meeting oxygen under conditions similar to those in coal mines, flour mills, and grain elevators.

The quantity and chemical character of the fine ores which are available demonstrate the necessity of their use, and it is the duty of those designing or operating blast furnaces to provide for such utilization, and where satisfactory operation is secured under disadvantage the manager of a plant is entitled to proper credit for overcoming difficulties. The constructor must take into consideration the handling and distribution of this material, and also design and equip the furnace to meet the excessive pressure or unequal settlement which may be traceable to the fine ores, whether associated with fine coke or not. The latter condition will exist to some extent in any furnace, although for the reasons given above the quantity of fine coke is undoubtedly greatly magnified in the recent method of handling the materials. Ores which cost at the furnace 5, 6, or more cents per unit of metal can not be wasted with impunity, and where it is found impracticable to control the loss of fine ore through the gas flues, the collection of these, and their preparation for subsequent treatment, demand attention. The briquetting of fine ores, whether in their natural state or after beneficiation, is also commanding attention. Whenever an iron ore is handled and rehandled, passed through any mechanical apparatus, or heated, there is additional cost placed against it, and this cost will naturally affect the price of pig iron. However, it may be assumed as an axiom that the treatment of ores preliminary to their being fed into the blast furnace can generally be considered as more economical than depending on the furnace to do the work.

Methods of cheaply beneficiating and briquetting fine ores so as to introduce them into the blast furnace, and permit of their being carried down into the zone of reduction before changing form, seem to present a possible feature of advance, to which those interested in the smelting of iron can well afford to give attention.

While fine ores are considered by many managers undesirable, there is also objection to the mineral being of large size, especially in dense magnetites or red hematites. Preliminary crushing to approximately uniform size is therefore desirable, and to meet furnace requirements large crushing plants are in use at

some important mines, the purpose being to reduce the hard ores to sizes convenient for handling and adapted to quick reduction.

CONCENTRATION OF IRON ORES.

In various parts of the country there are deposits of iron ores of considerable magnitude in which the amount of metallic iron is insufficient to justify the mining of the mineral and its use in blast furnaces. Some of these deposits are located so that the ore can be cheaply mined, and are also convenient to transportation facilities to market.

To reduce the percentage of gangue and to produce material carrying iron sufficient for economical smelting, these ores need to be beneficiated, and usually they are comminuted by crushing or grinding if they are not naturally of a size suitable for the purpose. After reduction in size the ore is either passed through jigs, where in connection with water the iron oxide separates from the gangue by specific gravity or the fine material is delivered to magnetic separators. The separation in jigs is effected when the specific gravity of the iron oxide and the gangue differ sufficiently to permit of a good separation. In magnetic separation the magnetic particles are attracted to belts, drums, or to stationary magnets and the gangue or such portion as is feebly magnetic is rejected. In either process time and the degree of comminution are elements in securing satisfactory results. Magnetic separation is confined to the treatment of lean magnetic ores or to hematites which are made magnetic by preliminary roasting, although some of the apparatus used discriminates satisfactorily between minerals of moderately different magnetic quality.

The size of the grains of ore intermixed with the gangue determines the possibility of perfection being approached by either system of concentration. But in many ores these grains are so small that the comminution required adds greatly to the cost, and also produces material whose desirability for smelting purposes is limited. Consequently, most of the concentrating plants do not attempt to attain perfection in separation, but produce a concentrate which, while below the possible standard of purity obtainable, is acceptable to the blast furnace managers because of the size of the grains. It is found to be advantageous to lose a portion of the mineral in the tailings rather than to attempt perfection with the separators. In some cases the tailings, when practically free from iron, are re-treated because of the value of these by-products. The sand resulting from a siliceous ore finds a ready sale, and the apatite separated from high phosphorus magnetite is in demand for fertilizing.

The magnetic separators in use in the United States in 1902 produced 192,285 long tons of commercial ore. Most of this was magnetite ore. In addition a cobbing method was used, wherein ore of considerable size was treated by magnetic separators. The possibilities of producing an ore rich enough for smelting purposes from some of the large deposits of lean magnetite have encouraged the introduction of a number of forms of separators, only a few of which, however, have proved of sufficient economic importance to be used.

ROASTING IRON ORES.

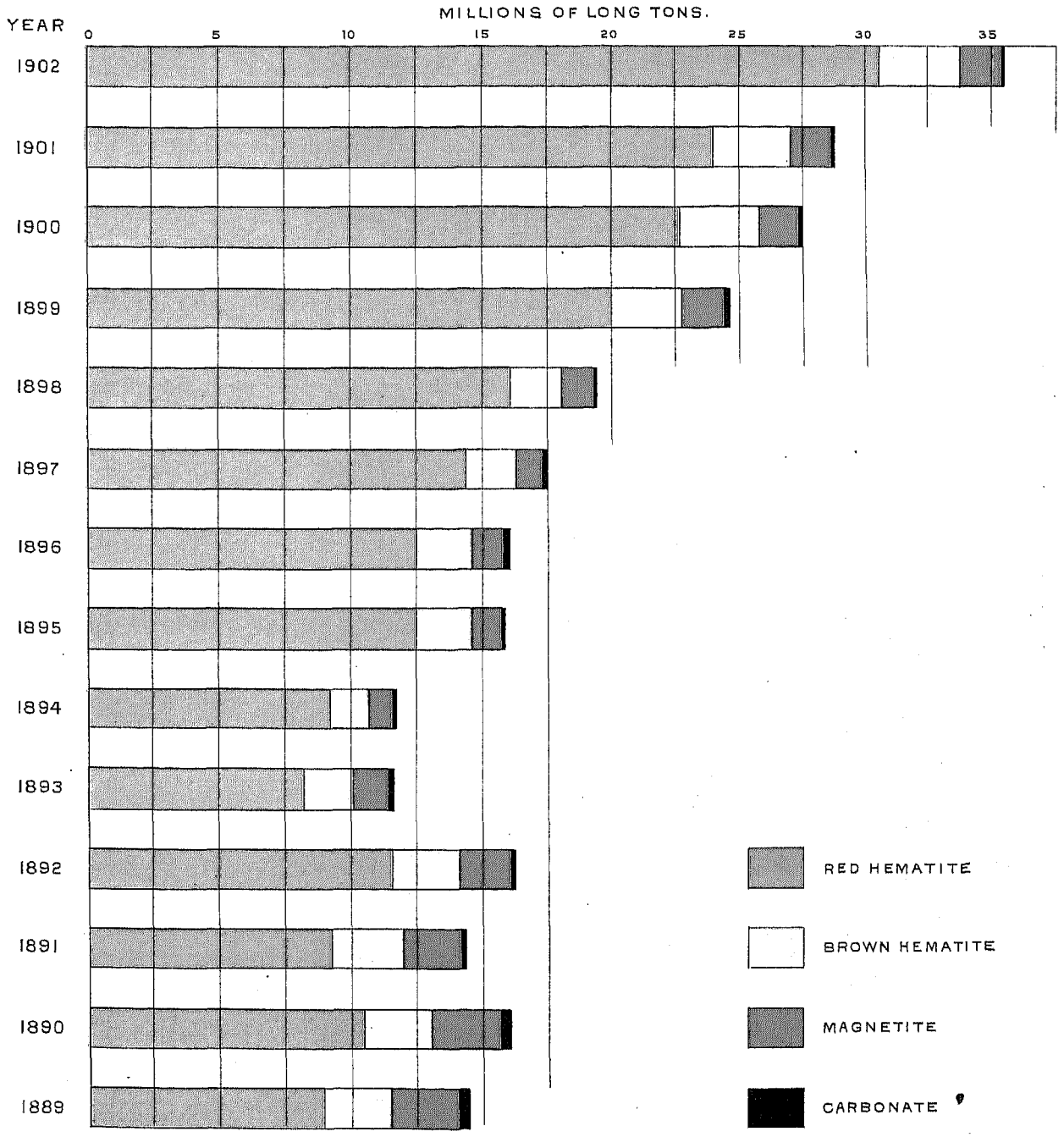
Among the methods used to beneficiate iron ores—that is, to improve their natural condition—is roasting, which may be applied for several purposes:

1. To drive off moisture.
2. While driving off moisture, to bake so as to separate the earthy matter which adheres to some ores and which often carries a large proportion of silica.
3. To eliminate carbonic acid, as in the case of the treatment of carbonate ores, thereby practically converting carbonate into brown hematite.
4. To reduce the percentage of sulphur carried in many ores, particularly magnetites.
5. To break up dense ores or make changes in the degree of oxidation and thus increase their reducibility.

Roasting was formerly done entirely in open heaps, formed of layers of wood (in some cases charcoal or fine bituminous coal supplementing the wood), alternating with layers of ore. These piles, when fire was applied to them, burned for months, and, in fact, the pile after being completed at one end was extended, while the end first finished was being roasted and the roasted ore taken from it to the furnace. An improvement in roasting was the introduction of cylindrical or rectangular masonry or metal kilns, in which fuel is mixed with the ore. In this way a more economical handling of the material is possible, and the results are under better control. In later years improvements in the roasting of ore have been practically confined to feeding kilns with gas, derived directly from the gas furnaces or obtained from gas producers. In the drying of brown hematites advanced progress is illustrated at the Shelby Iron Works, Alabama, where the Davis-Colby kiln using gas, roasts brown hematite ores. A statement by Mr. Charles J. Christian shows that taking green ore as it came from the washer, the yield was 43 per cent, and to flux this ore 23 per cent of limestone was required, while to smelt it 135 bushels of charcoal were necessary. When roasted in heaps, the moisture driven off, and the reduction of silica, which was obtained by screening, showed a yield of 50 per cent of iron, the requirements for smelting being 20 per cent of limestone and 105 bushels of charcoal. When gas kilns were introduced the yield of the ore was increased to 52 per cent, the proportion of flux was reduced to 18 per cent and the fuel consumption to 102 bushels of charcoal.

An experiment was also made in taking from a stock pile ore which had been roasted in heaps and reroast-

DIAGRAM I.— CLASSIFICATION OF IRON ORE PRODUCTION: 1889 TO 1902.



ing it. When the yield was increased to 56 per cent, the flux was reduced to 15 per cent of the ore burden, and the fuel consumption fell to 95 bushels of charcoal per ton of iron. In ordinary practice, Mr. Christian states, that the shrinkage of ore due to roasting and screening is about 23 per cent, water to the extent of 15 to 18 per cent being driven off; the balance is tailings in which there is some iron, but this loss is more than compensated for by the reduction in silica. The richer ore not only requires less flux and fuel, but also increases the product from a given furnace and reduces the cost of production correspondingly.

In roasting for the elimination of carbonic acid, most of the ores have been treated in piles, although some have been subjected to the roasting process in large kilns, some of these being 16 feet in diameter and 60 feet high; it is probable, however, that better results would be obtained in lower kilns. This treatment of the roasted ore is primarily to convert the carbonate into sesquioxide of iron by driving off the carbonic acid gas, and practically converting the clay ironstone ore into a brown hematite ore.

A number of years ago efforts were made in Scotland to use the upper portion of a blast furnace for this purpose, and one plant was erected in this country, the expectation being not only to drive off the carbonic acid gas from the ore, but to coke the raw coal as it passed down the furnace. This departure need not be further considered, as practically all the roasting is now done prior to feeding the ore to the furnace, and the results obtained encourage the continuance of this practice.

When sulphur is to be eliminated, the old practice of feeding solid fuel with the ore to heaps or kilns is less perfect than the new, as in the newer kilns using gas the ore is maintained at a high temperature, so as to oxidize more of the sulphur than would otherwise be the case. The most extensive use of ore roasting kilns is in the neighborhood of the Cornwall ore mines, Pennsylvania, where the average amount of sulphur in the ore as mined is 2.5 per cent. In kilns operated by fuel fed in alternate layers with the ore the sulphur is reduced about one-half; but in the kilns where gas is applied and the incandescent ore subsequently subjected to currents of air, the percentage of sulphur is reduced below 1 per cent. In addition to reducing the sulphur, the ore is improved in texture, and results obtained at the Wharton furnace in New Jersey show a very decided improvement independent of the elimination of sulphur. The roasting undoubtedly affects the physical character of the ore, making it more porous; it is, therefore, more readily attacked by the blast furnace gases. Where a component is to be eliminated in whole or in part, the driving off of this, whether it be water, carbonic acid, or sulphur, affects the texture of the mineral and makes it more readily reducible. It may be that the combined water in a magnetic ore, or the proportion which is hygroscopic, removed in the process of roasting, improves the texture of the ore; but this is not a matter upon which enough experiment has been made to speak with definiteness.

Mr. Edward Kelly, manager of the Wharton blast furnaces in New Jersey, states that the base of the ore mixture used in these furnaces is Hibernia magnetic ore, a close grained refractory ore, which is roasted to secure lower fuel consumption than is necessary when using it in the raw state. One furnace using 75 per cent Hibernia roasted ore, 12.5 per cent Hibernia raw ore, and 12.5 per cent soft Lake Superior hematite (the yield of this mixture approximating 50 per cent of iron) produced a ton of pig iron on a fuel consumption of 2,050 pounds. Another furnace, using 75 per cent Hibernia unroasted ore and 25 per cent of hematites, required 2,500 pounds of fuel to make 1 ton of metal. Therefore, the apparent saving at the furnace using Hibernia ore roasted is 450 pounds of fuel per ton of metal. With fuel at $4 per ton, this represents a saving of 90 cents per ton of pig iron, which the management attributed entirely to the roasting of Hibernia ore.

It may be considered as an established principle that whenever the metallic yield of an ore can be improved and the cinder making constituents reduced and yet left in sufficient quantity to permit satisfactory smelting, such a treatment is more economically done before charging the ore into the furnace than after it reaches the tunnel head, and it may be asserted that the beneficiating of ores in a blast furnace is the most expensive method to follow.

To determine the results to be obtained from roasting an iron ore a practical demonstration is essential. A laboratory test will be of value, but not nearly so satisfactory as a practical trial in a blast furnace. However, as such a trial is expensive, the laboratory experiment must be relied upon where there is no roasting appliance. Thus, by taking a sample of unroasted ore, crushing it fine, and similarly treating a sample of the same ore roasted, exposing this in tubes to the action of furnace gases, or of a current of carbon monoxide gas at a low red heat, the amount of oxygen in each case removed could be compared. Such a test would indicate whether a saving in fuel to offset the expense of roasting is probable. Blast furnaces using raw Lake Champlain magnetic ores require from 2,600 to 2,800 pounds of fuel per ton of metal, and in similar furnaces using Lake Superior ores 2,000 to 2,200 pounds per ton are required. With coke at $2.25 per ton the fuel saving of 600 pounds represents a decreased cost of 67.5 cents per ton of pig iron. When magnetites are roasted the smelting conditions approximate those prevailing with red hematites.

Another feature which has attracted attention in the Lake Superior region is the amount of moisture in the ore, and the proposition has been made to experiment

on a large scale with the idea of reducing this, as it limits the yield of the ore in the furnace and means additional freight by vessels to the lower lake and from the receiving docks to the blast furnaces.

ADVANTAGES OF MIXING IRON ORES.

The circumstances surrounding the mining, handling, and transporting of ores from the Lake Superior iron region seem to have a decidedly beneficial influence in securing the delivery to the blast furnaces of ores of nearly uniform composition. Similar conditions prevail elsewhere, but not to the same extent as in the Lake Superior region, because of the size of the deposits in that district, their liberal exploitation, their distance from points of consumption, and climatic conditions which limit the water transportation of ores.

All iron deposits vary more or less in different portions. This variation may be in the percentage of iron, silica, phosphorus, or other ingredients, and where a furnace depends on local mines, drawing upon them from day to day, receiving its stock practically as mined, greater irregularities are to be expected in the ore delivered than where ore passes through various handlings.

In the Lake Superior region the practice of the larger mines, although the mineral may nominally be of uniform character, is to win ore from several portions of the deposit simultaneously. The ores so won may be mixed in trains going to the ore docks, or trains may be made up entirely of ore from certain portions of the mines. Unless the chemical composition of this ore varies notably in the percentages of iron and phosphorus no segregation is necessary, and a number of bins in the shipping dock are filled with ore as it comes down in the railroad trains. A vessel brought to the side of the dock receives ore simultaneously, or nearly so, from a number of alternate pocket spouts, and is then moved to intermediate spouts. As the bins or pockets hold several carloads each there is a mixture in these and a further mixture in the hold of the vessel.

When the vessel reaches the receiving dock the ore is taken out by mechanical appliances, seldom by hand, the buckets delivering the ore either to stock piles on the receiving docks or directly into cars which convey it to the blast furnace.

As the shipping season on the Great Lakes covers usually about seven months in each year the blast furnaces must either carry stocks of ore at the plants or have them held at the receiving docks. Such accumulations of stocks result in securing a general mixture of ores from each mine which supplies the plant. Where work is prosecuted in the winter in the Lake Superior region, it is confined principally to dead work or exploration, largely to opening up drifts or chambers to facilitate mining during the next season. This ore taken out in the winter becomes thoroughly mixed in the stock pile and is subject to the same handling as above described. Even if the ore is delivered from vessels directly to cars, and these cars are dumped into the bins at the blast furnace, there is the admixture of ore from different parts of the mine, resulting from handling at the shipping and receiving docks, a mixture which it is not possible to secure from ores which are mined and sent directly to the furnace. The result is that the Lake Superior ores from different mines naturally have greater uniformity than those from other sections which may have ores of equal desirability. This may seem an unimportant matter when the average of the ores charged determine the basis on which to use them, but it exerts an effect on the operation of the furnace because there may be constant changes which affect the fluxing. For if at one time of a day the ore is low in silica, and at another time comparatively high, although the ore comes from the same bin, the fluxing will not be as perfectly equated as desired. As a consequence, the interior lining of a blast furnace is attacked, or the pig iron produced is more irregular than if the same relation between the gangue material in the ore and the fluxing medium was maintained steadily.

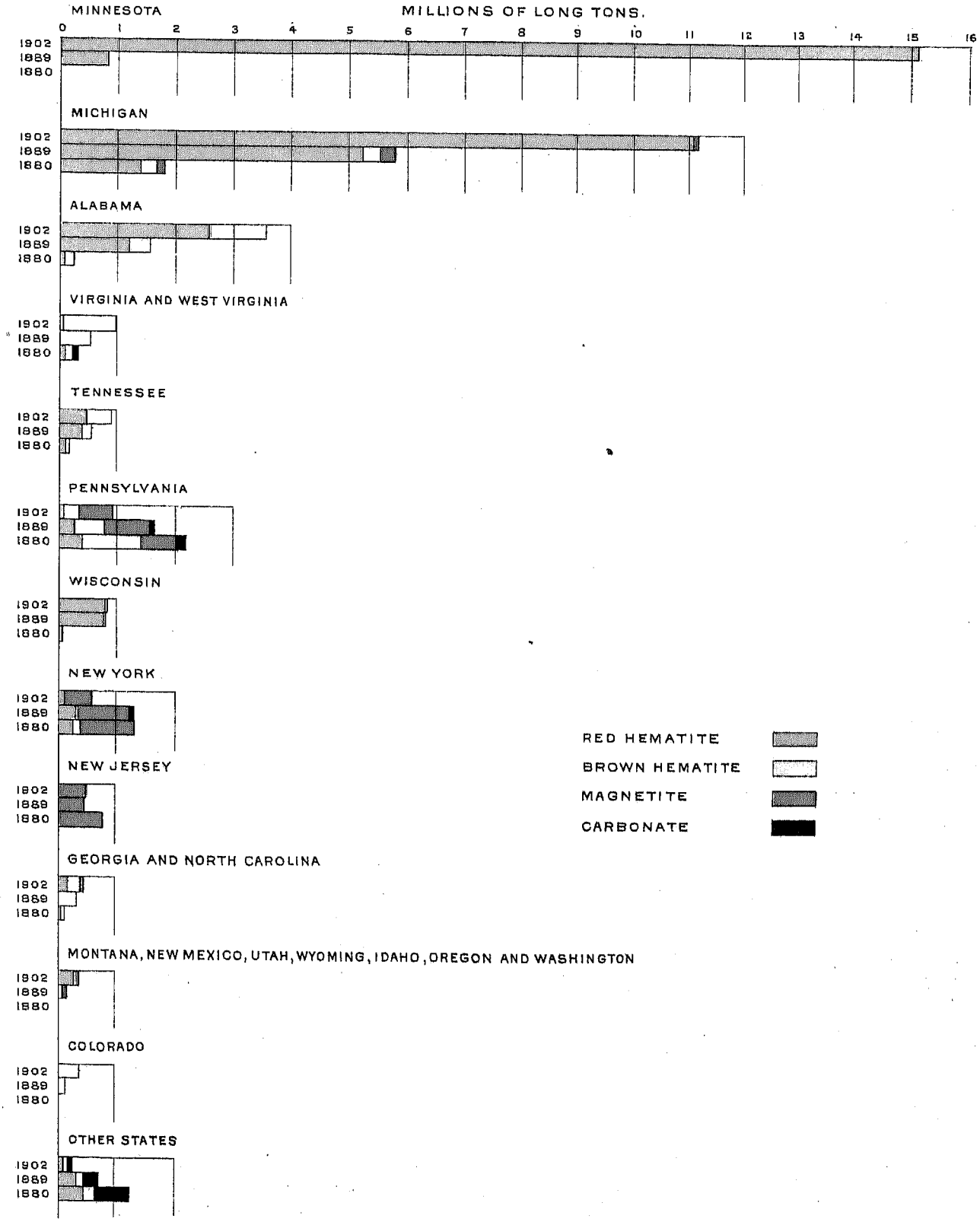
CLASSIFICATION OF IRON ORE PRODUCTION.

The rapid growth in production, both absolutely and proportionately, of red hematite in the United States is illustrated by Diagram I, which shows proportionately the quantity of red hematite, brown hematite, magnetite, and carbonate iron ores produced in 1889 (the classification being that of the Eleventh Census), and from 1890 to 1902, inclusive. While there has been a decided increase in red hematite, there has also been an advance, absolutely but not proportionately, in brown hematite, and a decline in the proportion of magnetite, although in late years this has been nearly stationary. The quantity of carbonate ore has constantly decreased.

Diagram II gives the relative quantities of each class of ore supplied by the more important producing states for the three census years 1880, 1889, and 1902. The illustration does not embrace the states producing small quantities. Even if the year 1900 had been selected for the comparison, the growth over 1889 would have been shown to be almost as great as that of 1889 over 1880. The increase of 1902 over 1889 is greater.

The plate shows that the entire production of Minnesota, and nearly all of the output of Alabama, Michigan, and Wisconsin, is classed as red hematite. It also shows the advance made in thirteen years, which is most notable in Alabama, Michigan, and Minnesota. The majority of the brown hematites are indicated as being mined in Alabama, Colorado, Georgia, Pennsylvania, Tennessee, and the Virginias, while the magnetites come principally from New Jersey, New York, and Pennsylvania. The production has

DIAGRAM II.– PRODUCTION OF IRON ORES IN THE UNITED STATES: 1902, 1889, AND 1880.



declined in New Jersey, New York, Pennsylvania, and in the group of states which includes "all others" not specially designated. Necessarily where the quantity of any one kind of ore has been too small to be shown on the plate it has been omitted. The legend of colors and the system of single and double cross hatching illustrate the different varieties of ores for the three census years covered by the diagram.

PRODUCTION OF IRON ORE IN LARGE MINES.

The proportion of the output of the United States contributed by large mines is a matter to which attention has been drawn, and Diagram III is presented to illustrate this. Data are not at hand showing the number of large mines and their total output, except for the years beginning with 1892, but the total production is given for the census years 1850, 1860, 1870, 1880, and 1889. The full lines of the column illustrate the total production of the ore, while the shaded portions show the quantity contributed by mines supplying over 50,000 tons. The total number of the larger mines in each year since 1891 appears in numerals at the sides of the respective columns. This showing demonstrates that while there has been an increase in the output of the smaller mines the bulk of the augmented product is due to the larger mines.

CONTEMPORANEOUS PRODUCTION OF IRON ORE IN THE UNITED STATES, GREAT BRITAIN, AND GERMANY.

Diagram IV shows for the years 1889 to 1902, inclusive, the relative quantities of iron ore produced in Great Britain, Germany, and the United States, and the proportion of the production of the United States supplied by the Lake Superior region. It will be noted that with the exception of 1894 the United States was a larger producer than either Great Britain or Germany. The strides by which these competitors have been distanced is illustrated by the showing for the interval from 1896 to 1902. A varying and practically decreasing tendency of the iron ore trade is illustrated for Great Britain, while a general advance is shown for Germany. The plate indicates the relation to the iron ore industry of the United States borne by the production of the Lake Superior region, which, since 1899, has been greater than the annual output of the mines of Great Britain, and since 1900 considerably in advance of the total product of the German mines.

DIAGRAM III.—ANNUAL PRODUCTION OF IRON ORE IN THE UNITED STATES.

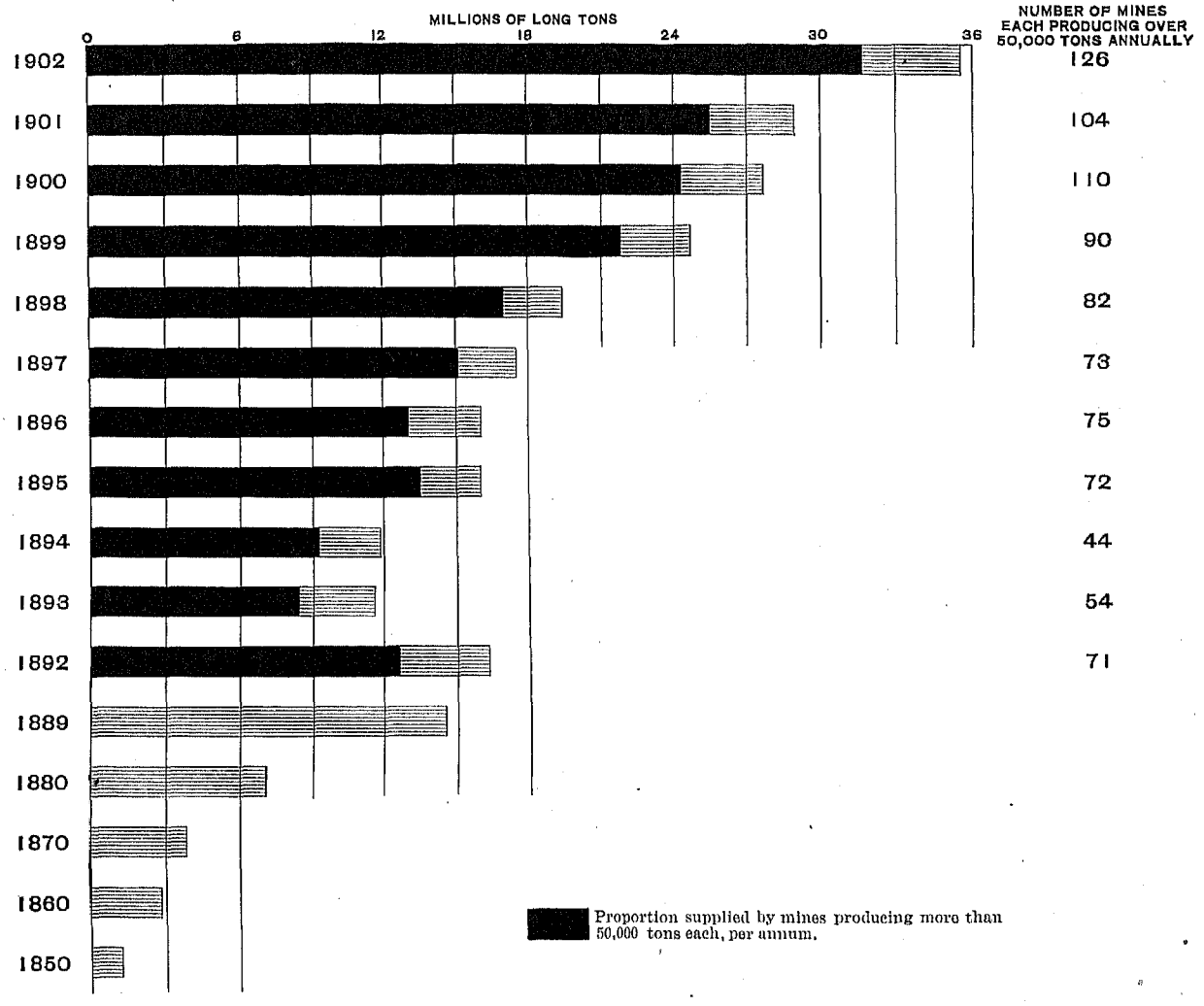
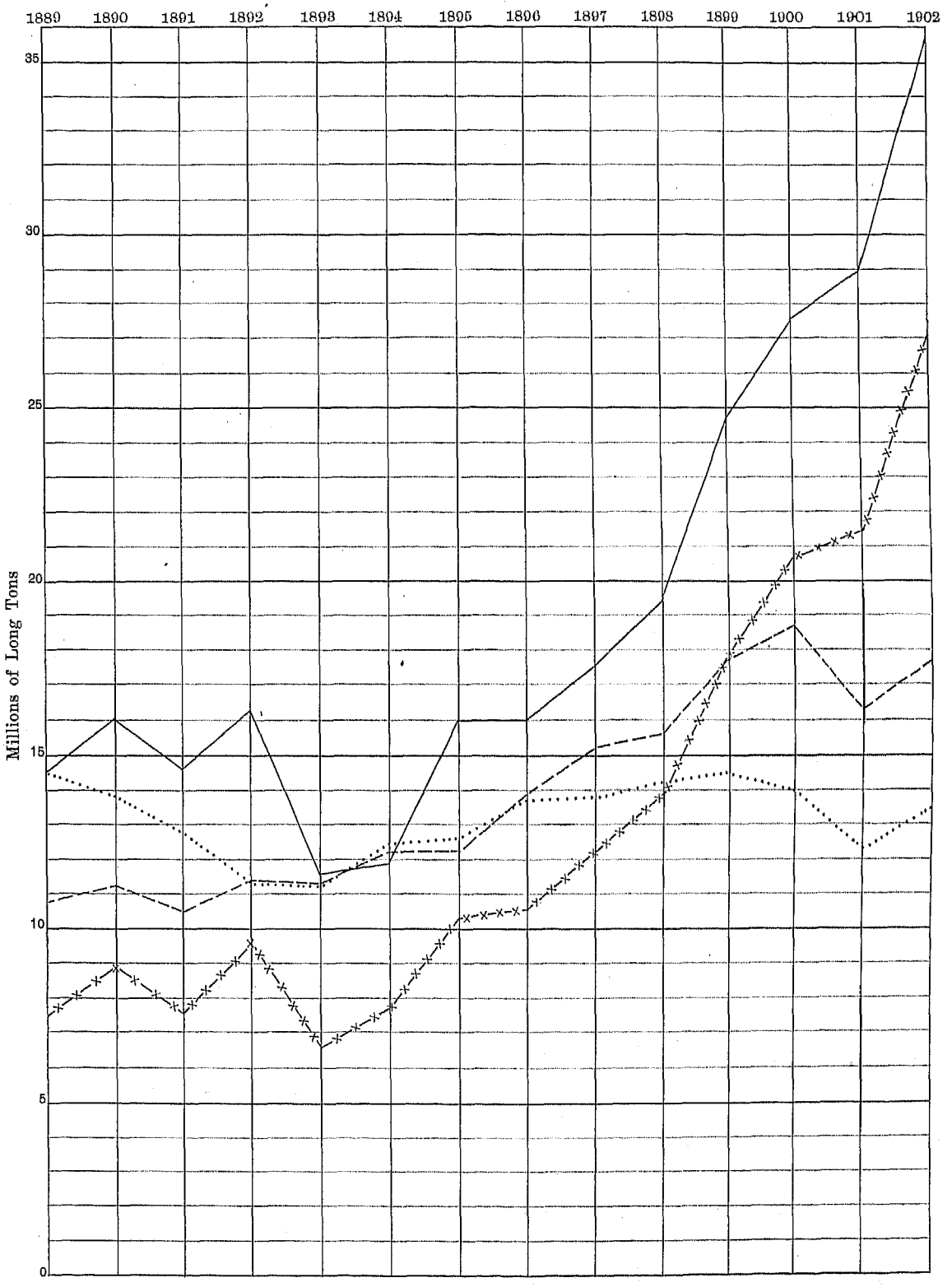


DIAGRAM IV.—CONTEMPORANEOUS PRODUCTION OF IRON ORES IN THE UNITED STATES, GREAT BRITAIN, AND GERMANY; ALSO RELATIVE PROPORTION SUPPLIED FROM THE LAKE SUPERIOR REGION: 1889 TO 1902.



Total production of the United States ———— Production of Germany — — — — —

Production of the Lake Superior Region —x—x—x—x— Production of Great Britain .....

TABLE 14.—DETAILED

		United States.	Alabama.	Colorado.	Georgia.	Maryland.	Michigan.
1	Number of mines	525	59	33	19	29	80
2	Number of operators	332	31	20	13	28	41
	Character of organization:						
3	Individual	83	3	1	3	25	.....
4	Firm	33	1	1	1	2	.....
5	Incorporated company	214	27	18	9	1	41
6	Cooperative association	2	.....	.....	.....	.....	.....
	Salaried officials, clerks, etc.:						
7	Total number	2,405	227	33	60	5	750
8	Total salaries	$2,113,230	$188,441	$42,577	$42,361	$1,910	$775,914
	General officers—						
9	Number	129	11	5	9	1	33
10	Salaries	$298,076	$35,100	$6,550	$13,855	$600	$102,237
	Superintendents, managers, foremen, surveyors, etc.—						
11	Number	846	107	9	30	3	195
12	Salaries	$797,807	$91,351	$14,600	$17,728	$910	$256,157
	Foremen below ground—						
13	Number	782	26	10	8	.....	307
14	Salaries	$627,178	$18,540	$14,297	$4,118	.....	$274,098
	Clerks—						
15	Number	648	83	9	13	1	215
16	Salaries	$390,169	$43,450	$7,130	$6,660	$400	$143,422
	Wage-earners:						
17	Aggregate average number	38,851	4,864	418	688	76	14,456
18	Aggregate wages	$21,531,792	$2,029,807	$417,162	$229,138	$22,349	$9,132,763
	Above ground—						
19	Total average number	15,769	3,133	56	536	76	3,494
20	Total wages	$7,444,435	$1,213,629	$61,189	$170,318	$22,349	$2,075,167
	Engineers, firemen, and other mechanics—						
21	Average number	3,756	364	30	59	5	1,401
22	Wages	$2,309,527	$182,305	$35,413	$27,327	$1,955	$912,013
	Miners—						
23	Average number	4,813	1,417	.....	365	59	39
24	Wages	$1,781,983	$570,526	.....	$112,357	$18,249	$23,185
	Boys under 16 years—						
25	Average number	469	116	.....	35	12	2
26	Wages	$77,265	$18,376	.....	$4,712	$2,145	$107
	All other wage-earners—						
27	Average number	6,731	1,236	26	77	.....	2,052
28	Wages	$3,275,660	$442,422	$25,776	$25,922	.....	$1,139,562
	Below ground—						
29	Total average number	23,082	1,731	362	152	.....	10,962
30	Total wages	$14,087,357	$816,178	$355,973	$58,820	.....	$7,057,596
	Miners—						
31	Average number	13,743	1,110	282	106	.....	6,217
32	Wages	$8,868,687	$577,989	$287,428	$43,446	.....	$4,252,230
	Miners' helpers—						
33	Average number	2,293	355	53	28	.....	1,005
34	Wages	$1,252,772	$136,210	$35,647	$10,545	.....	$630,919
	Boys under 16 years—						
35	Average number	49	10	.....	6	.....	8
36	Wages	$11,709	$2,000	.....	$1,080	.....	$3,086
	All other wage-earners—						
37	Average number	6,997	256	27	12	.....	3,732
38	Wages	$3,954,189	$99,979	$32,898	$3,749	.....	$2,171,361
	Average number of wage-earners at specified daily rates of pay:						
	Engineers—						
39	$1.00 to $1.24	21	1	.....	1	1	.....
40	$1.25 to $1.49	91	13	.....	7	1	.....
41	$1.50 to $1.74	168	61	.....	3	1	.....
42	$1.75 to $1.99	239	10	.....	5	.....	111
43	$2.00 to $2.24	378	16	.....	8	.....	219
44	$2.25 to $2.49	84	4	.....	1	.....	16
45	$2.50 to $2.74	23	2	.....	.....	.....	4
46	$2.75 to $2.99	7	1	.....	.....	.....	1
47	$3.00 to $3.24	25	1	2	.....	.....	1
48	$3.25 to $3.49	9	.....	.....	.....	.....	.....
49	$3.50 to $3.74	17	.....	4	.....	.....	.....
50	$3.75 to $3.99	1	.....	.....	.....	.....	.....
51	$4.00 to $4.24	10	.....	9	.....	.....	.....
52	$4.25 and over	29	.....	.....	.....	.....	.....
	Firemen—						
53	$0.50 to $0.74	1	.....	.....	.....	.....	.....
54	$0.75 to $0.99	3	.....	.....	1	.....	.....
55	$1.00 to $1.24	49	7	.....	4	1	.....
56	$1.25 to $1.49	135	55	.....	6	.....	.....
57	$1.50 to $1.74	76	8	.....	1	.....	8
58	$1.75 to $1.99	312	.....	.....	.....	.....	225
59	$2.00 to $2.24	183	.....	.....	5	.....	70
60	$2.25 to $2.49	37	.....	.....	.....	.....	4
61	$2.50 to $2.74	9	.....	2	.....	.....	.....
62	$3.00 to $3.24	3	.....	.....	.....	.....	.....
63	$3.25 to $3.49	2	.....	.....	.....	.....	.....
64	$3.50 to $3.74	2	.....	2	.....	.....	.....
	Machinists, blacksmiths, carpenters, and other mechanics—						
65	$0.75 to $0.99	3	.....	.....	.....	.....	.....
66	$1.00 to $1.24	36	14	.....	1	.....	2
67	$1.25 to $1.49	108	22	.....	5	1	9
68	$1.50 to $1.74	206	50	.....	3	.....	45
69	$1.75 to $1.99	341	24	.....	1	.....	152
70	$2.00 to $2.24	502	54	.....	5	.....	233
71	$2.25 to $2.49	290	1	.....	.....	.....	168
72	$2.50 to $2.74	186	16	.....	1	.....	73
73	$2.75 to $2.99	63	.....	.....	.....	.....	21
74	$3.00 to $3.24	52	4	1	1	.....	17
75	$3.25 to $3.49	12	.....	2	.....	.....	3
76	$3.50 to $3.74	27	.....	2	.....	.....	12
77	$3.75 to $3.99	2	.....	.....	.....	.....	1
78	$4.00 to $4.24	10	.....	4	.....	.....	4
79	$4.25 and over	4	.....	2	.....	.....	2

SUMMARY: 1902.

Minnesota.	Missouri.	New Jersey.	New York.	Ohio.	Pennsylvania.	Tennessee.	Virginia.	Wisconsin.	All other states and territories.[1]	
59	34	15	15	12	47	22	62	16	23	1
31	27	9	13	9	42	13	25	10	20	2
.....	12	2	2	2	20	4	2	2	5	3
.....	9	.....	1	2	9	.....	5	1	1	4
31	5	7	10	5	12	9	18	7	14	5
.....	1	.....	.....	.....	1	.....	.....	.....	.....	6
529	15	138	62	5	91	106	257	83	44	7
$430,994	$14,766	$101,870	$65,231	$2,037	$74,788	$71,535	$174,034	$85,262	$41,510	8
24	5	8	5	.....	9	7	8	2	2	9
$34,378	$9,500	$16,770	$14,750	.....	$19,500	$9,200	$29,200	$4,036	$2,400	10
139	8	21	17	1	54	60	146	23	33	11
$134,979	$4,705	$19,457	$25,336	$770	$41,353	$37,846	$87,184	$8,971	$33,460	12
200	1	90	29	1	15	14	44	34	3	13
$172,827	$240	$53,100	$18,485	$257	$6,848	$10,084	$22,262	$29,975	$2,047	14
166	1	19	11	3	13	25	59	24	6	15
$88,810	$321	$12,543	$6,660	$1,010	$7,087	$14,405	$35,388	$19,280	$3,603	16
8,256	148	1,660	965	111	1,140	1,299	2,686	1,361	723	17
$5,376,933	$57,475	$773,286	$432,039	$38,901	$436,207	$512,702	$888,958	$837,661	$346,411	18
2,668	147	636	352	24	873	845	2,002	384	543	19
$1,656,501	$56,675	$277,522	$162,258	$10,661	$329,450	$276,937	$641,286	$216,118	$274,375	20
834	11	212	148	2	121	132	219	158	65	21
$580,891	$6,850	$117,792	$77,190	$900	$65,759	$63,709	$96,987	$98,462	$41,974	22
103	54	.....	72	22	480	398	1,413	62	329	23
$59,820	$20,155	.....	$24,541	$9,761	$180,290	$128,399	$447,518	$33,832	$153,350	24
2	1	5	2	.....	21	90	176	4	3	25
$443	$170	$1,074	$450	.....	$2,806	$16,509	$29,351	$600	$222	26
1,729	81	419	130	.....	251	225	194	165	146	27
$1,015,347	$29,500	$158,656	$60,077	.....	$80,595	$68,320	$67,430	$83,224	$78,829	28
5,588	1	1,024	613	87	267	454	684	977	180	29
$3,720,432	$800	$495,764	$269,781	$28,240	$106,757	$235,765	$247,672	$621,543	$72,036	30
3,463	1	261	365	80	152	326	640	645	95	31
$2,432,487	$800	$133,156	$170,691	$25,900	$61,679	$177,039	$236,040	$421,929	$47,873	32
393	.....	206	54	.....	86	85	8	8	12	33
$233,182	.....	$95,143	$25,038	.....	$33,365	$43,096	$2,272	$4,471	$2,884	34
.....	.....	.....	.....	.....	1	4	17	3	.....	35
.....	.....	.....	.....	.....	$106	$900	$2,870	$1,667	.....	36
1,732	.....	557	194	7	28	39	19	321	73	37
$1,054,763	.....	$267,465	$74,052	$2,340	$11,607	$14,739	$6,490	$193,476	$21,279	38
.....	.....	.....	10	.....	4	.....	2	.....	2	39
1	1	3	8	.....	25	8	23	.....	1	40
1	.....	30	11	.....	14	18	22	.....	7	41
13	2	42	14	1	1	5	4	29	2	42
82	1	4	9	.....	6	13	6	14	.....	43
52	.....	.....	.....	.....	2	8	5	.....	1	44
9	.....	.....	1	.....	2	.....	5	.....	.....	45
.....	.....	.....	1	.....	3	.....	1	.....	.....	46
19	.....	.....	.....	.....	.....	2	.....	.....	.....	47
9	.....	.....	.....	.....	.....	.....	.....	.....	.....	48
13	.....	.....	.....	.....	.....	.....	.....	.....	.....	49
1	.....	.....	.....	.....	.....	.....	.....	.....	.....	50
1	.....	.....	.....	.....	.....	.....	.....	.....	.....	51
27	.....	.....	.....	.....	.....	.....	.....	.....	2	52
.....	.....	.....	.....	.....	.....	.....	1	.....	.....	53
.....	.....	.....	.....	.....	.....	.....	2	.....	.....	54
.....	.....	.....	1	.....	1	9	24	.....	2	55
.....	.....	3	26	.....	10	13	19	.....	3	56
1	1	29	.....	.....	7	9	9	.....	3	57
47	.....	14	4	.....	.....	.....	.....	22	.....	58
86	.....	.....	2	.....	5	.....	.....	15	.....	59
31	.....	.....	.....	.....	.....	.....	.....	.....	2	60
5	.....	.....	.....	.....	.....	1	.....	.....	1	61
3	.....	.....	.....	.....	.....	.....	.....	.....	.....	62
.....	.....	.....	.....	.....	.....	.....	.....	.....	2	63
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	64
.....	.....	.....	.....	.....	.....	.....	1	.....	2	65
.....	.....	2	3	.....	4	.....	8	.....	2	66
2	1	13	8	.....	3	11	25	1	7	67
6	.....	16	19	1	5	26	31	3	1	68
78	.....	30	5	.....	5	5	9	29	3	69
130	4	9	13	.....	7	7	19	14	7	70
82	.....	13	4	.....	3	1	1	16	1	71
78	1	4	4	.....	.....	.....	1	6	2	72
22	.....	.....	2	.....	14	.....	.....	3	1	73
21	.....	.....	2	.....	.....	1	1	.....	4	74
6	.....	.....	.....	.....	.....	.....	.....	.....	1	75
7	.....	.....	.....	.....	.....	.....	.....	.....	6	76
.....	.....	.....	.....	.....	.....	.....	.....	1	.....	77
1	.....	.....	1	.....	.....	.....	.....	.....	.....	78
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	79

[1] Includes operators distributed as follows: Connecticut, 1 (2 mines); Kentucky, 3; Massachusetts, 1; Montana, 3; New Mexico, 1 (2 mines); North Carolina, 3; Texas, 1 (2 mines); Utah, 4; Vermont, 1; West Virginia, 1; Wyoming, 1.

TABLE 14.—DETAILED

		United States.	Alabama.	Colorado.	Georgia.	Maryland.	Michigan.
	Average number of wage-earners at specified daily rates of pay—Con.						
	Miners—						
80	$0.50 to $0.74	13					
81	$0.75 to $0.99	296	80		38	3	
82	$1.00 to $1.24	3,001	372		297	53	
83	$1.25 to $1.49	1,057	167		64	2	
84	$1.50 to $1.74	2,478	1,058		72	1	463
85	$1.75 to $1.99	1,585	762				126
86	$2.00 to $2.24	3,926	88				2,056
87	$2.25 to $2.49	3,642		2			2,516
88	$2.50 to $2.74	1,687		20			907
89	$2.75 to $2.99	481		14			135
90	$3.00 to $3.24	304		228			40
91	$3.25 to $3.49	24		14			8
92	$3.50 to $3.74	55					5
93	$3.75 to $3.99	2					
94	$4.25 and over	5		4			
	Miners' helpers—						
95	$0.75 to $0.99	13					
96	$1.00 to $1.24	151	108		13		
97	$1.25 to $1.49	194	77		15		
98	$1.50 to $1.74	503	170				2
99	$1.75 to $1.99	618					364
100	$2.00 to $2.24	645					526
101	$2.25 to $2.49	105					102
102	$2.50 to $2.74	38		37			1
103	$2.75 to $2.99	10					10
104	$3.00 to $3.24	16		16			
	Timbermen and track layers—						
105	$0.75 to $0.99	5	5				
106	$1.00 to $1.24	29	14		3		
107	$1.25 to $1.49	86	52				
108	$1.50 to $1.74	121	49				9
109	$1.75 to $1.99	667	1				411
110	$2.00 to $2.24	607	10				129
111	$2.25 to $2.49	245					147
112	$2.50 to $2.74	317	5				295
113	$2.75 to $2.99	4					
114	$3.00 to $3.24	2					
115	$3.25 to $3.49	2					1
116	$3.50 to $3.74	14		14			
	Boys under 16 years—						
117	Less than $0.50	141	21		11		
118	$0.50 to $0.74	250	87		30	12	1
119	$0.75 to $0.99	99	18				
120	$1.00 to $1.24	17					1
121	$1.25 to $1.49	8					8
122	$1.50 to $1.74	3					
	All other wage-earners—						
123	$0.50 to $0.74	15					
124	$0.75 to $0.99	434	109		3		12
125	$1.00 to $1.24	1,314	723		64		47
126	$1.25 to $1.49	1,195	357				131
127	$1.50 to $1.74	1,913	108		18		1,095
128	$1.75 to $1.99	3,582	61				2,225
129	$2.00 to $2.24	2,294	1				899
130	$2.25 to $2.49	459					203
131	$2.50 to $2.74	251		15	1		141
132	$2.75 to $2.99	65					17
133	$3.00 to $3.24	52		15			16
134	$3.25 to $3.49	28					1
135	$3.50 to $3.74	10		8			1
136	$3.75 to $3.99	2					1
137	$4.00 to $4.24	10		1			3
138	$4.25 and over	5					
	Average number of wage-earners during each month:						
	Men 16 years and over—						
139	January	33,854	4,358	437	562	30	13,415
140	February	33,195	4,403	428	559	30	12,858
141	March	34,714	4,616	425	644	80	13,373
142	April	36,829	4,655	433	659	75	13,946
143	May	39,291	4,693	409	670	83	14,803
144	June	39,311	4,715	418	673	47	14,399
145	July	40,594	4,850	390	661	92	14,977
146	August	41,426	4,887	406	664	85	15,340
147	September	41,259	4,861	412	647	83	15,441
148	October	40,958	4,987	407	630	72	15,449
149	November	39,859	4,939	437	705	50	14,911
150	December	38,706	4,892	419	690	41	14,440
	Boys under 16 years—						
151	January	405	113		33	2	7
152	February	397	102		40	2	6
153	March	454	118		35	18	6
154	April	497	109		41	10	8
155	May	539	117		36	13	8
156	June	531	114		38	4	10
157	July	573	124		43	17	11
158	August	599	143		41	16	13
159	September	598	143		46	18	14
160	October	570	141		48	16	13
161	November	542	147		45	16	13
162	December	511	141		46	12	11
	Contract work:						
163	Amount paid	$425,292	$500				$57,382
164	Number of employees	1,079	7				96
	Miscellaneous expenses:						
165	Total	$8,257,714	$88,008	$114,540	$76,622	$12,314	$3,004,384
166	Royalties and rent of mine and mining plant	$6,503,908	$37,938	$87,094	$8,351	$2,271	$2,254,864
167	Rent of offices, taxes, insurance, interest, and all other sundries	$1,753,806	$50,070	$27,446	$68,271	$10,043	$749,520
168	Cost of supplies and materials	$9,005,608	$592,286	$137,450	$64,932	$2,639	$3,661,194
	Product:						
169	Quantity, long tons	35,567,410	3,574,474	[1] 306,572	330,554	24,367	11,135,215
170	Value	$65,465,321	$3,936,812	[1] $1,084,424	$452,717	$46,911	$26,095,860

[1] Includes 13,275 tons of manganiferous iron ore valued at $52,871, used in the manufacture of spiegeleisen. The high average value per ton of the product in Colorado is due to the silver content, and to its availability for use as a fluxing medium when mixed with other gold and silver ores in the smelter.

SUMMARY: 1902—Continued.

Minnesota.	Missouri.	New Jersey.	New York.	Ohio.	Pennsylvania.	Tennessee.	Virginia.	Wisconsin.	All other states and territories.	
							13			80
				24	23		113		15	81
1	17		70	49	213	402	1,414		113	82
1	36	10	14		192	61	408		42	83
16	2	62	301	23	180	106	34	42	118	84
367		176	31	6	16	1	5	50	45	85
1,265		2	11		5		2	452	45	86
852		11	10		3	116		130	2	87
677						38	1	29	15	88
317							3	3	9	89
34									2	90
1								1		91
33									17	92
2										93
									1	94
		1							12	95
			12		10		8			96
		31			71					97
48		151	42		5	85				98
231		23								99
111								8		100
3										101
										102
										103
										104
										105
2		6			1		1		2	106
		2			4	20	8			107
		3	25				23		12	108
94		105						56		109
420		14	1					33		110
90		1				1		6		111
12		1					1	2	1	112
4										113
1			1							114
1										115
										116
1					8	2	96		2	117
	1	3			9	44	62		1	118
			2		4	48	23	4		119
1		2			1		12			120
										121
								3		122
		3			1	4	4		3	123
		2			30	210	7		64	124
7	1	37	74	7	177	29	124	4	20	125
13	72	329	163		31		36	13	50	126
139	7	402	50		29		4	57	4	127
933		43	10		6		4	265	35	128
1,310	1	28					1	46	8	129
251								1	4	130
86								2	6	131
47									1	132
15									6	133
27										134
1										135
1										136
5								1		137
2									3	138
6,210	108	1,453	965	34	1,074	1,126	2,136	1,393	553	139
6,198	113	1,535	862	69	1,021	1,113	2,104	1,372	530	140
6,416	113	1,580	928	112	990	1,134	2,337	1,355	611	141
7,370	134	1,684	1,007	115	1,076	1,208	2,396	1,393	678	142
8,449	147	1,732	959	125	1,102	1,250	2,664	1,429	776	143
8,759	153	1,769	989	158	1,100	1,271	2,682	1,403	780	144
9,102	182	1,775	894	141	1,229	1,257	2,845	1,392	807	145
9,456	182	1,762	978	137	1,179	1,271	2,846	1,421	812	146
9,659	164	1,694	946	104	1,184	1,217	2,718	1,336	793	147
9,440	156	1,647	1,019	121	1,153	1,225	2,577	1,346	720	148
9,308	156	1,617	996	127	1,158	1,195	2,318	1,227	715	149
8,672	156	1,612	1,013	89	1,150	1,193	2,293	1,181	865	150
2		5	2		10	85	141	2	3	151
2		5	2		10	86	137	2	3	152
2		5	2		10	88	164	4	2	153
2	1	5	2		29	93	189	6	2	154
2	1	5	2		29	101	216	6	3	155
2	1	5	2		30	102	212	8	3	156
2	1	5	2		30	94	230	11	3	157
2	1	5	2		34	98	228	12	4	158
2	1	5	2		31	99	224	9	4	159
2	2	5	2		23	93	211	10	4	160
2	2	5	2		15	96	190	8	1	161
2	2	5	2		13	93	174	6	4	162
$338,244	$500	$10,770			$1,228		$6,730	$2,750	$7,188	163
728	50	113			4		53	10	23	164
$4,134,526	$3,373	$30,114	$199,587	$1,556	$61,376	$111,854	$120,563	$247,149	$51,748	165
$3,648,750	$2,538	$7,915	$12,385	$1,503	$26,343	$93,672	$93,429	$181,243	$45,612	166
$485,776	$835	$22,199	$187,202	$53	$35,033	$18,182	$27,134	$65,906	$6,136	167
$2,699,115	$26,052	$429,231	$293,950	$345	$166,422	$144,540	$201,426	$375,959	$210,067	168
15,137,650	66,308	441,879	555,321	22,657	822,932	874,542	973,301	783,996	517,642	169
$23,989,227	$106,379	$1,228,664	$1,362,987	$41,976	$1,225,453	$1,123,527	$1,652,799	$1,800,864	$716,721	170

TABLE 14.—DETAILED

		United States.	Alabama.	Colorado.	Georgia.	Maryland.	Michigan.
	Power:						
171	Total horsepower	119,558	10,370	865	2,681	315	47,395
	Owned—						
	Engines—						
	Steam—						
172	Number	1,132	105	14	40	6	324
173	Horsepower	102,878	7,440	785	2,512	315	38,351
	Gas or gasoline—						
174	Number	11			2		
175	Horsepower	86			9		
	Water wheels—						
176	Number	11					7
177	Horsepower	1,010					750
	Other power—						
178	Number	260	62	1	3		86
179	Horsepower	15,444	2,930	80	160		8,294
	Rented—						
180	Steam, horsepower	140					
	Electric motors owned—						
181	Number	35					13
182	Horsepower	937					388
183	Supplied to other establishments, horsepower	140					

SUMMARY: 1902—Continued.

Minnesota.	Missouri.	New Jersey.	New York.	Ohio.	Pennsylvania.	Tennessee.	Virginia.	Wisconsin.	All other states and territories.	
25,332	535	6,684	6,015	50	4,480	2,865	4,686	5,894	1,391	171
206	10	78	38	1	87	38	87	75	23	172
23,928	525	6,584	5,820	50	3,722	1,770	4,217	5,834	1,026	173
1	1	.....	4	.....	1	.....	1	.....	1	174
10	10	.....	10	.....	38	.....	6	.....	3	175
.....	.....	.....	1	.....	.....	.....	2	.....	1	176
.....	.....	.....	100	.....	.....	.....	155	.....	5	177
39	.....	6	2	.....	10	26	12	6	7	178
1,254	.....	100	85	.....	720	1,095	308	60	358	179
140	.....	.....	.....	.....	.....	.....	.....	.....	.....	180
13	.....	.....	2	.....	2	.....	.....	.....	5	181
375	.....	.....	4	.....	50	.....	.....	.....	120	182
140	.....	.....	.....	.....	.....	.....	.....	.....	.....	183

MANGANESE ORE

MANGANESE ORE.

By John Birkinbine.

Although manganese occupies an important position among metals, and is necessary in the manufacture of steel, of glass, and in the chemical industry, the production in the United States is small; and in 1902 may properly be discounted to the extent of 9,000 long tons reported as mined in Montana, which was not immediately available for consumption.

Table 1 is a comparative summary of the statistics for the industry as reported for the years 1902, 1889, and 1880.

Table 1.—*Comparative summary: 1880 to 1902.*

	1902	1889	1880
Number of mines	19	(1)	(1)
Number of operators	19	(1)	6
Salaried officials, clerks, etc.:			
Number	18	(2)	10
Salaries	$9,395	(2)	(2)
Wage-earners:			
Average number	194	432	222
Wages	$74,924	$123,958	[3] $46,610
Miscellaneous expenses	$3,845	(1)	(1)
Cost of supplies and materials	$17,728	(1)	$16,164
Product:			
Quantity, long tons	16,477	24,197	[4] 11,350
Value	$177,911	$240,559	[4] $102,700

[1] Not reported.
[2] Not reported separately.
[3] Includes salaries, not separable, of 10 salaried employees.
[4] Includes 637 tons, with an estimated value of $5,765, for which statistics of wage-earners, wages, and other expenses, etc., were not obtainable.

In the year 1902 the data are given in full, but for the previous census years some details are unobtainable, and in the year 1880 there was 1 mine from which no information was secured except the production of ore and its estimated value.

Of the 19 mines reported in 1902, 3 were in California, 6 each in Georgia and Virginia, 2 in Arkansas, and 1 each in Montana and South Carolina. The entire number was controlled by 19 operators, of whom 8 were individuals; 5, firms; and 6, incorporated companies.

Capital stock of incorporated companies.—Table 2, which follows, presents the statistics of capitalization of incorporated companies.

Table 2.—*Capitalization of incorporated companies: 1902.*

	United States.	California.	Georgia.	Virginia.
Number of incorporated companies	6	1	3	2
Number reporting capitalization	4	1	1	2
Capital stock:				
Total authorized—				
Number of shares	523,280	500,000	30	23,250
Par value	$2,855,000	$500,000	$30,000	$2,325,000
Total issued—				
Number of shares	123,330	100,050	30	23,250
Par value	$2,455,050	$100,050	$30,000	$2,325,000
Common—				
Authorized—				
Number of shares	517,280	500,000	30	17,250
Par value	$2,255,000	$500,000	$30,000	$1,725,000
Issued—				
Number of shares	117,330	100,050	30	17,250
Par value	$1,855,050	$100,050	$30,000	$1,725,000
Preferred—				
Authorized—				
Number of shares	6,000	.....	.....	6,000
Par value	$600,000	.....	.....	$600,000
Issued—				
Number of shares	6,000	.....	.....	6,000
Par value	$600,000	.....	.....	$600,000

Table 2 shows that the capital stock issued amounted to $2,455,050.

In 1889 the inquiries in regard to capital were different from 1902, the capital invested in lands, buildings and fixtures, machinery, tools and implements, live stock, cash, and stock of ore on hand being asked for at that census; therefore no comparison of any value can be made. According to the reports made in 1889 the total amount of capital invested was $2,188,950, divided as follows: Land, $1,618,650; buildings and fixtures, $98,700; machinery, tools, etc., $233,750; other items, including cash, $237,850.

Employees and wages.—In Table 10 the statistics of employees and wages are presented in detail by states. The different classes of salaried officials and wage-earners are given.

Of the total amount, $84,319, reported as paid for salaries and wages in the production of manganese ore, $74,924, or 88.9 per cent, was paid to wage-earners, and $9,395, or 11.1 per cent, to the salaried officials, clerks, etc.

Table 10 shows also the average number of wage-earners at specified daily rates of pay by occupations. Miners constituted 49.5 per cent of the total number of wage-earners, and of all miners 80.2 per cent were employed at rates from $1 to $1.24 per day. This low wage rate was due to the fact that most of the employees were unskilled, and the wages paid in the Southern states were lower, as a rule, than those prevailing in the Lake Superior region, where the climatic conditions are more severe. Of the 15 engineers, 3 received $2 or more per day. Miners' helpers formed a small class, constituting 1.5 per cent of the total wage-earners. The class of "all other wage-earners" numbered 56, composed chiefly of ordinary laborers. Of these workmen 92.9 per cent received from $1 to $1.24 per day, the same general rate as that of many of the miners, while 7.1 per cent received $1.25 or more.

The average number of wage-earners, men and boys, employed during each month of the year, is also shown in Table 10. With the exception of the mines in Georgia, where employment was practically constant, the average number of wage-earners varied considerably. It will be noted that during the summer and fall months the average number of wage-earners in Virginia was considerably augmented, falling off during the winter and early spring months. In California the operations practically closed in August and remained in this condition until the end of the year.

For the various mechanical operations requiring power at the mines there were 11 steam engines of 354 horsepower.

Production.—To show the relative production of manganese ores in 1902 and in each of the nine years preceding, Table 3 is presented. It gives the production, total value, and average value per ton of ore at the mines.

TABLE 3.—*Production of manganese ores: 1893 to 1902.*

[United States Geological Survey, "Mineral Resources of the United States."]

YEAR.	Quantity (long tons).	Value.	Average value per ton.
1893	7,718	$66,614	$8.63
1894	6,308	53,635	8.50
1895	9,547	71,769	7.52
1896	10,088	90,727	8.99
1897	11,108	95,505	8.60
1898	15,957	129,185	8.10
1899	9,935	82,278	8.28
1900	11,771	100,289	8.52
1901	11,995	116,722	9.73
1902	16,477	177,911	10.80

The following table shows the quantity, total value, and average value per ton of the manganese ore produced by states in the year 1902. The production of South Carolina was a sample shipment, the value of which was estimated:

TABLE 4.—*Production and value, and average value per ton, of manganese ores, by states: 1902.*

STATE.	Quantity (long tons).	Value.	Average value per ton.
United States	16,477	$177,911	$10.80
Arkansas	(1)	(1)	5.15
California	846	10,175	12.03
Georgia	3,500	20,830	5.95
Montana	(1)	(1)	13.00
South Carolina	(1)	(1)	5.00
Virginia	3,041	29,444	9.68
Arkansas, Montana, and South Carolina	9,090	117,462	.....

[1] Not given separately, in order to avoid disclosing operations of individual establishments.

In producing the total for 1902, 16,477 tons, valued at $177,911, 6 states contributed, viz: Montana, Georgia, Virginia, California, Arkansas, and South Carolina, in the order named.

The following table gives the production by states for the census years 1889 and 1902, and for each of the twelve years intervening. The figures for the years between 1889 and 1902 were obtained from the statistical reports of the United States Geological Survey.

TABLE 5.—*Production of manganese ores, by states: 1889 to 1902.*

[United States Geological Survey, "Mineral Resources of the United States."]

YEAR.	United States (long tons).	Virginia (long tons).	Georgia (long tons).	Arkansas (long tons).	All other states (long tons).
Total	197,814	90,001	44,431	33,167	30,215
1889	24,197	14,616	5,208	2,528	1,845
1890	25,684	12,699	749	5,339	6,897
1891	23,416	16,248	3,575	1,650	1,943
1892	13,613	6,079	826	6,708	.....
1893	7,718	4,092	724	2,020	882
1894	6,308	1,797	1,277	1,934	1,300
1895	9,547	1,715	3,856	2,991	985
1896	10,088	2,018	4,085	3,421	564
1897	11,108	3,650	3,332	3,240	886
1898	15,957	5,662	6,689	2,662	944
1899	9,935	6,228	3,089	356	262
1900	11,771	7,881	3,447	145	298
1901	11,995	4,275	4,074	91	3,555
1902	16,477	3,041	3,500	82	9,854

The output of the three states producing the greatest quantities, viz, Virginia, Georgia, and Arkansas, as well as the total for the United States, shows a marked falling off since the year 1889, when the total mined in Virginia was 14,616 long tons; in Georgia, 5,208 long tons; in Arkansas, 2,528 long tons; and in other states, 1,845 long tons; a total of 24,197 long tons, valued at $240,559.

In the year 1902 the production of manganese ore per wage-earner was greater than in either 1889 or 1880, being 85 tons, as against 56 tons in 1889 and 49 tons in 1880. But for the census year 1889 the total number of persons employed is given for the time during which the mines were operated, whereas for the census year 1902 the average number is the number that would be required at continuous employment throughout the year.

Imports of manganese ore.—The United States is the largest manufacturer of steel in the world. In the processes of the conversion of iron into steel spiegeleisen or ferromanganese obtained from manganese or manganiferous ore is a necessity. Consequently, owing to the insufficient supply of this mineral obtained in the United States, large quantities are imported.

Through the courtesy of the Bureau of Statistics of the Department of Commerce and Labor, the following table has been prepared showing the importation of manganese ore into the United States during the calendar year 1902, by countries:

TABLE 6.—*Imports of manganese ore, by countries: 1902.*

COUNTRY.	Quantity (long tons).	Value.
Total	235,576	$1,931,282
Belgium	165	1,962
Brazil	102,550	1,006,969
British East Indies	64,170	352,487
Colombia	700	3,385
Cuba	36,294	285,571
Germany	2,155	68,241
Japan	2,481	37,064
Nova Scotia, New Brunswick, etc	59	2,311
Quebec, Ontario, etc	140	820
Russia	3,338	24,581
Spain	10,464	48,098
Turkey in Europe	12,609	88,979
United Kingdom	451	10,814

Table 6 shows that in the census year 1902, 235,576 long tons were imported, valued at $1,931,282, an average of $8.20 per ton. The valuations placed on this ore are as invoiced at the point of shipment, and do not include the cost of ocean freight to the United States or rail charges to points of consumption. The principal contributor was Brazil, with a total of 102,550 long tons, valued at $1,006,969. The other contributing countries were India, Cuba, Turkey, Spain, Russia, Japan, Germany, Colombia, United Kingdom, Canada, and Belgium, in the order named.

The following table gives the quantity and value of manganese ore imported into the United States from 1889 to 1902, inclusive:

TABLE 7.—*Imports of manganese ore: 1889 to 1902.*

YEAR.	Quantity (long tons).	Value.
Total	1,436,950	$13,028,432
1889	4,286	78,391
1890	34,154	516,900
1891	28,825	380,618
1892	58,572	840,811
1893	68,113	880,238
1894	44,655	432,561
1895	86,111	747,910
1896	31,489	250,468
1897	119,961	1,023,824
1898	114,885	831,967
1899	188,349	1,584,528
1900	256,252	2,042,361
1901	165,722	1,486,573
1902	235,576	1,931,282

Table 7 shows that, with the exception of the year 1900, the largest quantity imported was in the year 1902. It will be of interest to note that in the year 1889, 24,197 long tons of domestic manganese ore were produced and 4,286 long tons of manganese ore imported; whereas, in the year 1902, 16,477 long tons of domestic manganese ore were mined and 235,576 long tons imported. In the fourteen years under consideration the manganese mines of the United States have contributed 197,814 long tons, while the importations have amounted to 1,436,950 long tons; therefore, 87.9 per cent of the manganese ore used in the United States during these fourteen years came from foreign countries. In the year 1902 the quantity of imported manganese ore represented 93.5 per cent of the total consumption. In 1902 the greater portion, 200,434 long tons, of the manganese ore brought to this country was received at the port of Baltimore, Maryland.

World's production.—As the greater portion of the manganese ore consumed in this country is obtained from foreign nations, Table 8 is presented showing the production of the more important manganese producing countries. For each country the latest reliable statistics obtainable have been used, the years to which the figures relate being indicated in the table.

TABLE 8.—*World's production of manganese ores.*

COUNTRY.	Year.	Production (long tons).	COUNTRY.	Year.	Production (long tons).
North America:			Europe—Continued.		
United States	1902	16,477	Italy	1902	2,438
Canada[1]	1902	154	Portugal	1901	[2] 904
Cuba[1]	1902	39,628	Russia	1900	884,200
South America:			Spain[1]	1902	61,949
Brazil[1]	1902	156,269	Sweden	1902	2,805
Chile[1]	1901	31,477	Turkey[1]	1902	49,210
Europe:			Asia:		
Austria	1902	5,557	India	1902	157,780
Bosnia and Herzegovina	1902	5,669	Japan	1901	15,858
France	1901	21,948	Java[1]	1899	1,888
Germany	1901	49,025	Oceania:		
Greece	1901	18,945	New Zealand	1901	208
Hungary	1902	7,281	Queensland	1901	278
			South Australia	1901	192

[1] Exports. [2] Metric tons.

Russia has for years been the largest producer, the bulk of the ore coming from the Caucasus region, the mines being located in the Secharopan district of the government of Kutais, not far from the extreme eastern shore of the Black Sea, near Poti. India has important deposits which have been actively exploited in late years, most of those from which shipments are made being located in the presidency of Madras. In the year 1902 Brazil, where the manganese industry has been lately developed, took third position; most of the ore mined being obtained in the Minas Geraes and Nazareth districts, located in the states of Minas Geraes and Bahia, respectively, in the eastern central portion of the country. Spain, Turkey, Cuba, and Chile have

important deposits of manganese ores, and small quantities are obtained in the Austrian Empire, France, Germany, Greece, Italy, Portugal, Sweden, Japan, Canada, New Zealand, and in Australia. Failure to appreciate the necessity of careful preparation of ores has restricted the quantities shipped from some of these countries.

In the United States the manganese deposits exploited are either of comparatively small extent, or the mineral contains phosphorus or silica in such proportions as to limit the transportation value of the ore, or the deposits are too far removed from markets where the ore would be consumed to make their development at present desirable. Manganese, however, either in the form of an ore or associated with iron or silver, has been supplied in large quantities. The bulk of this, being applied to the manufacture of steel, is sold under limitations, wherein the modicum of phosphorus and the percentage of silica, calculated on sliding scales, affect the prices paid for the ore, thus seriously interfering with the development of some properties where the quantity is apparently sufficient, but the quality is not desirable.

Value of manganese ores.—Manganese ores are valued from a sliding scale for the ore delivered f. o. b. cars at the large steel works, the prices being based on ores containing not more than 8 per cent of silica or more than one-tenth of 1 per cent of phosphorus. To illustrate, the following may be taken as the prices for manganese ores delivered in the Pittsburg (Pa.) district, they being subject to change without notice unless otherwise agreed:

Prices paid for manganese ore delivered in the Pittsburg (Pa.) district.

MANGANESE.	PRICE PER UNIT.	
	Iron (cents).	Manganese (cents).
Ore containing—		
Above 49 per cent	6	28
46 to 49 per cent	6	27
43 to 46 per cent	6	26
40 to 43 per cent	6	25
37 to 40 per cent	6	24
34 to 37 per cent	6	23
31 to 34 per cent	6	22

These prices are subject to deductions as follows: For each 1 per cent of silica in excess of 8 per cent, 15 cents per ton, and for each two-hundredths of 1 per cent of phosphorus in excess of one-tenth of 1 per cent, 1 cent per unit of manganese. Settlements are based on analyses of the ores dried at 212° F., the percentage of moisture in samples when taken being deducted from the weight.

The value of ore at the mines would be practically the price obtained for the ore delivered in the Pittsburg district, as above, less transportation charges.

In the manufacture of steel for various purposes and by different methods, the metallic manganese required ranges from about 9 to 40 pounds per ton of ingots produced, the average for the entire steel industry approximating 20 pounds of metallic manganese, or about 25 pounds of high-grade ferromanganese per ton of ingots made.

Manganiferous iron ores.—In addition to the true manganese ore produced, considerable quantities of manganiferous iron ore are obtained in the United States, the statistics of which are included in the report on iron ores. In the year 1902 there was obtained in the state of Colorado 13,275 long tons of this class of ore, in which the percentage of manganese varied from 18 to 32 per cent, having a total reported value at the mines of $52,371. This ore was all used in the production of spiegeleisen at steel works and should properly be classed as manganese ore, but owing to the impossibility of segregating the proportion of wage-earners, wages, and other expenses chargeable in the different mines from which this ore was obtained, the data were included in the statistics of iron ore. In the Lake Superior region, also, considerable amounts of iron ore are won which carry small percentages of manganese, but, as a rule, this does not exceed 1 per cent. In Virginia, too, a small quantity of manganiferous iron ore has been secured while mining true manganese ore.

The following statement shows the quantity, percentage of manganese, value at the mine, and average value per ton of manganiferous iron ores mined in the United States during the year 1902:

Production of manganiferous iron ores: 1902.

LOCALITY.	Quantity (long tons).	Per cent of manganese.	Value.	Average value per ton.
Total	901,214	1 to 32	$2,001,626	$2.22
Colorado	13,275	18 to 32	52,371	3.95
Lake Superior region	884,939	1 to 10	1,946,255	2.20
Virginia	3,000	(1)	3,000	1.00

[1] Not given.

The following table presents the production, total value at the mine, and average value per ton of the manganiferous iron ores obtained in the United States from 1889 to 1902, inclusive, the statistics for the years between the two censuses being obtained from the reports of the United States Geological Survey.

TABLE 9.—*Production of manganiferous iron ores: 1889 to 1902.*

[United States Geological Survey, "Mineral Resources of the United States."]

YEAR.	Quantity (long tons).	Value.	Average value per ton.
1889	83,434	$271,680	$3.26
1890	61,863	231,655	3.74
1891	132,511	314,099	2.37
1892	153,373	354,664	2.31
1893	117,782	283,228	2.40
1894	205,488	408,597	1.99
1895	125,729	233,998	1.86
1896	338,712	726,413	2.14
1897	202,304	343,784	1.70
1898	287,810	429,302	1.49
1899	761,845	1,147,047	1.51
1900	377,577	1,037,314	2.75
1901	574,489	1,475,084	2.57
1902	901,214	2,001,626	2.22

In the year 1889 the total production of manganiferous iron ores in the United States was 83,434 long tons, valued at $271,680. In 1902 the production was 901,214 long tons, an increase of 817,780 long tons, or nearly tenfold.

Argentiferous manganiferous iron ores.—In the state of Colorado argentiferous manganiferous iron ore is obtained from precious metal mines. This ore, containing an insufficient quantity of silver to make it valuable on that account, finds a ready market as a flux for use in smelters. The ores which are mined chiefly in the vicinity of Leadville, Colo., are classed usually as carbonates, sulphides, oxides, and siliceous ores. The first two classes are dependent for their value upon the carbonates and sulphides of lead and silver, but the oxides and siliceous ores may or may not be dependent on the precious metal content, and unless the value of the ores for smelting purposes was greater than the charge for the extraction of the precious metal (approximating $12 per ton) they have been considered as iron ores and included in the report on that mineral. The total quantity of these ores (which contain varying percentages of manganese) mined in the year 1902 was 194,132 long tons, valued at $908,098, an average of $4.68 per ton. In 1889, 64,987 long tons of argentiferous manganiferous ores valued at $227,455, were mined in the United States, the average value being $3.50 per ton. This shows an increase in 1902 of 129,145 tons, or nearly twofold, while the average value per ton rose to $4.68.

Manganiferous zinc ores.—The franklinite mines, located in northern New Jersey, produce ores which carry, in addition to the zinc content, iron and manganese. The clinker resulting from treatment for the removal of zinc is utilized in the production of spiegeleisen. The quantity of this class of material produced in 1902 was 65,246 long tons, valued nominally at $1 per ton. The production in 1889 was 43,648 long tons, valued at $54,560, or an average value of $1.25 per ton.

A résumé of the useful minerals produced in the United States in 1902, which contained manganese in notable proportions, is given in the following statement, in which the figures for the year 1889 have been included for purposes of comparison:

Useful minerals produced containing manganese in notable proportions: 1902 and 1889.

	1902			1889		
	Quantity (long tons).	Value.	Average value per ton.	Quantity (long tons).	Value.	Average value per ton.
Total	1,177,069	$3,152,881	$2.68	216,266	$794,254	$3.67
Manganese ores	16,477	177,911	10.80	24,197	240,559	9.94
Manganiferous iron ores	901,214	2,001,626	2.22	83,434	271,680	3.26
Manganiferous silver ores	194,132	908,098	4.68	64,987	227,455	3.50
Manganiferous zinc residuum	65,246	65,246	1.00	43,648	54,560	1.25

The total quantity of manganese and manganiferous ores mined in the United States in 1889 was 216,266 long tons, valued at $794,254, whereas in 1902 it had risen to 1,177,069 long tons, valued at $3,152,881, the increase being confined entirely to manganiferous ores, the production of true manganese ores having decreased.

REVIEW OF THE INDUSTRY BY STATES.

The conditions surrounding and affecting the production of manganese ores in different states are summarized as follows:

Arkansas.—Manganese ores occur chiefly in two districts of Arkansas—(a) the Batesville district, in Independence and Izard counties, in the northeastern part of the state; and (b) in the southwestern section, extending from Pulaski county on the east to Pope county and Indian Territory on the west. The mining in the latter district has been limited and practically all of the ores mined have come from the Batesville region, where they occur in residuary clays, derived from the decay of limestone.

Ore was discovered near Batesville about 1840, and in 1850 small quantities were sent to Boston, New York, Philadelphia, and Chicago. The maximum output was in the year 1892, when 6,708 long tons were produced. Lately, however, there has been a marked decline, for although some of the ores of Arkansas carry satisfactory percentages of manganese, their high phosphorus content, in addition to the distances from points of con-

sumption and the expense of mining, has rendered the winning of many of them unprofitable.

In 1902, 82 tons of manganese ore were secured. According to the Eleventh Census the amount of manganese ore mined in Arkansas in 1889 was 2,528 tons. The total production of the district from 1850 to 1902, inclusive—some of the figures being estimates—was 49,974 tons.

California.—California contains a number of deposits of manganese ore, some of which are reported as of high quality, and have been largely employed in chlorination works for the reduction of gold ores. In 1902 deposits in Alameda, San Joaquin, Santa Clara, and Stanislaus counties were operated, the amount produced being 846 tons. The quantity mined in 1889 was 53 tons. The total production of manganese ore in California from 1874 to 1902, inclusive, as near as can be ascertained, amounts to 11,358 tons, the production in 1902 being the maximum.

Colorado.—A large amount of iron ore, which contains a mixture of iron, manganese, and the precious metals, is produced in Colorado. The greater portion of this ore, which carries an insufficient amount of the precious metals to make it valuable on that account, is used as a flux in smelters, while some of that which is higher in manganese content is forwarded to steel works, where it is utilized in the manufacture of spiegeleisen. The figures for the production of these classes of ores, which have been included in the census report on iron ores, are inserted here as an item of interest. The comparison of the production in the year 1902 with that of the census year 1889 is shown in the following statement:

Production of manganiferous ores in Colorado: 1902 and 1889.

ORE.	1902 (long tons).	1889 (long tons).
Total	207,407	67,062
Manganiferous iron ores used for producing spiegeleisen	13,275	2,075
Manganiferous silver ores	194,132	64,987

Georgia.—The manganese ores of Georgia are won from two districts—the Cartersville district, located near the town of that name in Bartow county, and the Cave Springs district, in Floyd and Polk counties. The deposits in the latter district have been but little worked, nearly the entire production coming from the Cartersville district. The mines which were active in the year 1902 were all located there. Some of these manganese ores are of good quality, but others contain comparatively high percentages of phosphorus and are lower in manganese. The total amount of manganese ore obtained in Georgia in 1902 was 3,500 long tons, while in 1889 it was 5,208 long tons, showing a decrease of 1,708 tons, or 32.8 per cent. The total production of this district from 1866 to 1902, inclusive—the output for some of the years being estimated—was 91,594 long tons, the maximum production being 9,024 long tons, in 1887.

Montana.—In previous years Montana has been an unimportant contributor of manganese ore, but in 1902 a large quantity of ore was reported as mined, but not shipped, from two deposits in this state. Although most of this will not be immediately available for use, the reported product is included in the statistical data. The deposits are located at a considerable distance from steel works, which are the largest consumers of this ore, and unless satisfactory rail rates are secured it is doubtful whether this state will become an important producer in the immediate future.

South Carolina.—As has been stated, the 8 tons of manganese ore which were secured near Greenwood, in this state, were shipped as a sample; no systematic mining has been reported.

Virginia.—Virginia was the most important producer of manganese ore in the United States in 1889, a total of 14,616 long tons being secured. Nearly all of this came from the Crimora mine, located in Augusta county, but after a few years this mine showed signs of exhaustion and mining operations were suspended. It has, however, been reopened in the hope of encountering new reserves of ore, and if these expectations are realized the state may again become an important contributor. The 1902 output was only 3,041 tons. The aggregate production from 1880 to 1902, inclusive, was 191,067 tons, the output of the year 1886, when 20,567 long tons were mined, being the maximum.

Table 10 is a detailed summary of the statistics of the manganese industry for the United States, by states, in 1902.

DESCRIPTIVE.

Manganese is not found in a metallic state in nature, but usually occurs as an oxide, carbonate, or silicate in combination with one or more of the other elements. The oxides are the most common of manganese minerals, but rhodonite and rhodochrosite—the silicate and the carbonate—are frequently met. The commercially important ores are the oxides—pyrolusite, psilomelane, braunite, manganite, hausmannite, and wad—brief descriptions of which follow:

Pyrolusite, a peroxide or binoxide of manganese (MnO_2), is of an iron-black color, giving a black streak on a test plate, with a hardness of 2 to 2.5 and a specific gravity of 4.8 to 5. If pure, it would yield 63.2 per cent of manganese and 36.8 per cent of oxygen. It is used in the manufacture of ferromanganese, in the production of chlorine, and in freeing glass from the brown or green color.

Psilomelane, one of the common ores of manganese, usually occurs associated with pyrolusite. It is also a binoxide or peroxide of manganese, but contains varying amounts of combined water, and often potassium, barium, and iron. It is generally massive (i. e., not crystallized), has a hardness of 5 to 6 (much harder than pyrolusite), and a specific gravity from 4 to 4.4. It is black, steel-blue, or greenish-black in color. Its uses are the same as those of pyrolusite, and by some it is considered a hydrated variety of this mineral. The manganese contents range, when the ore is pure, from 45 to 60 per cent.

Braunite is an anhydrous oxide of manganese (Mn_2O_3), usually containing silica. It is a black or brownish-black ore, generally crystalline, giving the same streak as pyrolusite on the test plate and having a submetallic luster. It has a hardness of 6 to 6.5 and a specific gravity of 4.8. When pure, which is rarely the case, it contains 69 per cent of metallic manganese.

Manganite, a hydrous sesquioxide of manganese ($Mn_2O_3H_2O$), is of a steel-black or iron-black color, with a hardness of 4 to 4.5 and a specific gravity of 4.3 to 4.4. When the water is removed from manganite it changes to pyrolusite, hausmannite, or braunite; in some cases the latter minerals are supposed to be altered manganite, this being especially true of pyrolusite.

Hausmannite, a double protobinoxide of manganese (Mn_3O_4), is of a brownish-black color and of a submetallic luster, with a hardness of from 5 to 5.5 and a specific gravity of 4.7. It is a rare mineral, which, if pure, would contain 72.1 per cent of manganese and 29.9 per cent of oxygen.

Wad, or bog manganese, is an impure peroxide of manganese, with peroxide of iron carrying from 10 to over 25 per cent of water, often several per cent of oxide of cobalt or copper, and sometimes nickel. Its hardness is from 1 to 6 and its specific gravity 3 to 4. The color varies from brown to black. It occurs in irregular masses in clay as solid beds several feet thick, but on account of its impurities is seldom used as a source of manganese, but is occasionally employed as the base for black or brown paint.

Both manganese and manganiferous ores are applied to the industrial arts, their uses being summarized as follows: As an alloy with iron in the production of ferromanganese and spiegeleisen manganese is employed in the conversion of iron into steel. It is also alloyed with copper, either with or without iron in manganese bronze, and with aluminum, zinc, copper, and silicon in silver bronze, and with aluminum, zinc, tin, lead, and magnesium.

Manganese ore is employed as a flux in smelting precious metals; it is utilized as an oxidizer in chemical works in the manufacture of chlorine and bromine; as a decolorizer of glass and also for coloring it; as a drier for varnishes and paints; for Leclanche batteries in the preparation of oxygen in a small way; in the manufacture of disinfecting permanganates, etc. It is also used as coloring material in printing, in pottery and brick, and for green and violet paints. Some varieties of manganese ore are also utilized in a limited way in medicine, in chemical laboratories, and in jewelry manufacture.

Most of the manganiferous ores are applied either to the production of spiegeleisen or as an integral part of the charge of an iron producing plant, or are fed to silver smelters as a flux.

TABLE 10.—DETAILED SUMMARY: 1902.

	United States.	California.	Georgia.	Virginia.	All other states.[1]
Number of mines	19	3	6	6	4
Number of operators	19	3	6	6	4
Character of organization:					
Individual	8	2	2	1	3
Firm	5	.....	1	3	1
Incorporated company	6	1	3	2	.....
Salaried officials, clerks, etc.:					
Total number	18	.....	7	10	1
Total salaries	$9,395	.....	$2,964	$4,241	$2,190
Superintendents, managers, foremen, surveyors, etc.—					
Number	11	.....	5	5	1
Salaries	$7,354	.....	$2,174	$2,990	$2,190
Foremen below ground—					
Number	5	.....	1	4	.....
Salaries	$1,560	.....	$450	$1,110	.....
Clerks—					
Number	2	.....	1	1	.....
Salaries	$481	.....	$340	$141	.....
Wage-earners:					
Aggregate average number	194	7	62	113	12
Aggregate wages	$74,924	$4,740	$21,161	$33,903	$15,120
Above ground—					
Total average number	125	2	50	73	.....
Total wages	$41,479	$1,500	$17,561	$22,418	.....
Engineers, firemen, and other mechanics—					
Average number	26	.....	9	17	.....
Wages	$10,986	.....	$5,255	$5,731	.....
Miners—					
Average number	33	2	25	6	.....
Wages	$12,245	$1,500	$8,760	$1,985	.....
Boys under 16 years—					
Average number	13	.....	9	4	.....
Wages	$1,394	.....	$954	$440	.....
All other wage-earners—					
Average number	53	.....	7	46	.....
Wages	$16,854	.....	$2,592	$14,262	.....
Below ground—					
Total average number	69	5	12	40	12
Total wages	$33,445	$3,240	$3,600	$11,485	$15,120
Miners—					
Average number	63	3	12	36	12
Wages	$31,310	$2,700	$3,600	$9,890	$15,120
Miners' helpers—					
Average number	3	2	.....	1	.....
Wages	$884	$540	.....	$344	.....
All other wage-earners—					
Average number	3	.....	.....	3	.....
Wages	$1,251	.....	.....	$1,251	.....
Average number of wage-earners at specified daily rates of pay:					
Engineers—					
$1.00 to $1.24	8	.....	2	6	.....
$1.25 to $1.49	4	.....	.....	4	.....
$2.00 to $2.24	3	.....	3	.....	.....
Firemen—					
$1.00 to $1.24	4	.....	.....	4	.....
$2.00 to $2.24	3	.....	3	.....	.....
Machinists, blacksmiths, carpenters, and other mechanics—					
$1.00 to $1.24	2	.....	.....	2	.....
$2.00 to $2.24	2	.....	1	1	.....
Average number of wage-earners at specified daily rates of pay—Cont'd.					
Miners—					
$1.00 to $1.24	77	.....	37	40	.....
$1.25 to $1.49	1	.....	.....	1	.....
$1.50 to $1.74	1	.....	.....	1	.....
$2.50 to $2.74	5	5	.....	.....	.....
$3.50 to $3.74	12	.....	.....	.....	12
Miners' helpers—					
$1.00 to $1.24	1	.....	.....	1	.....
$1.25 to $1.49	2	2	.....	.....	.....
Boys under 16 years—					
Less than $0.50	11	.....	9	2	.....
$0.50 to $0.74	2	.....	.....	2	.....
All other wage-earners—					
$1.00 to $1.24	52	.....	4	48	.....
$1.25 to $1.49	3	.....	3	.....	.....
$1.50 to $1.74	1	.....	.....	1	.....
Average number of wage-earners employed during each month:					
Men 16 years and over—					
January	165	15	53	85	12
February	144	15	53	64	12
March	172	15	53	92	12
April	178	15	53	98	12
May	167	6	53	96	12
June	185	6	53	114	12
July	180	6	53	109	12
August	184	6	53	113	12
September	167	.....	53	102	12
October	196	.....	53	131	12
November	206	.....	53	141	12
December	228	.....	53	163	12
Boys under 16 years—					
January	13	.....	9	4	.....
February	13	.....	9	4	.....
March	13	.....	9	4	.....
April	13	.....	9	4	.....
May	13	.....	9	4	.....
June	13	.....	9	4	.....
July	13	.....	9	4	.....
August	13	.....	9	4	.....
September	13	.....	9	4	.....
October	13	.....	9	4	.....
November	13	.....	9	4	.....
December	13	.....	9	4	.....
Miscellaneous expenses:					
Total	$3,845	$50	$2,915	$600	$280
Royalties and rent of mine and mining plant	$1,996	.....	$1,575	$421	.....
Rent of offices, taxes, insurance, interest, and all other sundries	$1,849	$50	$1,340	$179	$280
Cost of supplies and materials	$17,228	$461	$6,866	$8,691	$1,210
Product:					
Quantity, long tons	16,477	846	3,500	3,041	9,090
Value	$177,911	$10,175	$20,830	$29,444	$117,462
Power, owned:					
Engines, steam—					
Number	11	.....	4	7	.....
Horsepower	354	.....	162	192	.....

[1] Includes operators distributed as follows: Arkansas, 2; Montana, 1; South Carolina, 1.

LEAD AND ZINC ORE

LEAD AND ZINC ORE.

By Isaac A. Hourwich, Ph. D.

The present report deals only with mines producing nonargentiferous lead and zinc ores. The statistics relative to the production of lead and zinc incidental to mining for gold and silver are treated in the report on gold and silver.

The combination of the mining and smelting of lead in early times precluded separate statistics for each process. The census data relating specifically to lead mining were first presented in 1870. The earliest mention of zinc ore in census reports was in 1860, when 2 mines were reported with 52 employees and a value of product aggregating $72,600. Lead and zinc mining was reported at the census of 1870, and at the two subsequent censuses. Differences in the scope of the inquiry, and in the method of presenting the results, materially impair the value of the statistics of all these years for comparative purposes. At the Eleventh Census no statistics of wages, or of other expenditures, were shown for the zinc mines of southwestern Missouri; only the output, amounting to 186,262,308 pounds, valued at $2,024,057, was reported for that district. The statistics of the Eleventh Census are, therefore, omitted from the comparative summary given in the following table:

Table 1.—*Comparative summary: 1902, 1880, and 1870.*

	1902	1880	1870
Number of mines	559	206	[1] 127
Number of operators	557	(2)	(2)
Salaried officials, clerks, etc.:			
Number	910	420	(2)
Salaries	$826,327	(3)	(2)
Wage-earners:			
Average number	7,881	7,063	1,714
Wages	$4,329,271	[3] $2,640,265	$600,628
Contract work	$108,607	(2)	(2)
Miscellaneous expenses	$2,092,001	(2)	(2)
Cost of supplies and materials	$2,511,675	$331,970	$78,687
Value of product	[4] $14,600,177	$3,837,161	$1,524,884

[1] Establishments.
[2] Not reported.
[3] Salaries included in wages.
[4] Includes $83,781, value of product of custom mills, and $1,913,810, for which the number of mines was not reported.

In order to make the data of the Eleventh Census comparable with those of the Twelfth, a summary of all mines, exclusive of the zinc mines of Missouri, is presented for the two years in the following table:

Table 2.—*Comparative summary, exclusive of zinc mines in Missouri: 1902 and 1889.*

	1902	1889
Number of mines	238	(1)
Salaries	$404,836	[2] $21,033
Wages	$2,042,821	$1,220,766
Contract work	$32,701	$34,511
Miscellaneous expenses	$495,388	$242,649
Cost of supplies and materials	$1,153,129	$407,938
Value of product	$5,713,601	$2,780,122

[1] Not reported.
[2] Salaries of foremen included in wages.

The total number of lead and zinc mines reported for the United States in 1902 is 559, and the total number of operators 557; the difference represents 2 incorporated companies in Virginia that operated iron mines in connection with zinc mines and are included in the report on iron mines; the statistics for the zinc mines, however, except those of capitalization, were segregated and are shown in this report.

Because of the prevalence of the leasing system in the operation of the lead and zinc mines, the terms "mine" and "operator" are indefinite in their meaning. The unit of these tables represents every operation for which a separate return was made. If the land was operated by its owner, the owner's report was included in the tables. Leasing companies whose business was confined to distributing land in small lots among operators and to drawing royalties, were not included in the general tables, unless some hired labor was employed by them in developing the mines. If the land was operated by a lessee with the help of hired labor, the lessee's report was tabulated. The numerous small sublessees, personally working in the mines, as a rule did not report; only 56 operators of that class made returns, and the

statistics for these are included in the tables. The share contributed by this class of small operators to the lead and zinc production of Kansas and Missouri is shown in the following table:

TABLE 3.—DISTRIBUTION OF THE VALUE OF THE LEAD AND ZINC PRODUCTION OF KANSAS AND MISSOURI BY CLASS OF OPERATORS: 1902.[1]

CLASS OF OPERATOR.	KANSAS.				MISSOURI.			
	Total.	Per cent of total.	Lead ore.	Zinc ore.	Total.	Per cent of total.	Lead ore.	Zinc ore.
Total	$707,026	100.0	$163,084	$543,942	$12,513,021	100.0	$5,520,211	$6,992,810
Operators reporting	342,943	48.5	67,144	275,799	10,496,884	83.9	5,073,363	5,423,521
Sublessees not reporting	364,083	51.5	95,940	268,143	2,016,137	16.1	446,848	1,569,289

[1] Exclusive of the production of custom mills valued at $73,189.

Of the 557 operators reporting, only 90 owned the mines they operated, 461 were first lessees or sublessees, and 6 failed to report as to ownership. The Missouri lead and zinc mine inspector's list of mines enumerates 151 landowners; according to census returns for Missouri, 61 operators were owners of the lands they operated, which leaves 90 landowners whose mines were operated under the leasing system. The above number of lessees and sublessees does not include the numerous class of small sublessees who do the work themselves with pick and shovel. The number of such sublessees reported by landowners was 638, of whom 632 were reported from Missouri. This number, however, is very far from complete, an accurate count being precluded by the shifting character of this class of miners.

The unincorporated form of business organization was the prevailing form among operators. There were in all 398 unincorporated concerns and 161 corporations directly engaged in operating the mines. Judged by the volume of production, the corporations held a place of greater prominence in the lead-zinc mining industry than that held by unincorporated operators.

The share of each class of operators in the total production and the average output per mine are shown in the following table:

TABLE 4.—*Classification of lead and zinc mines, by character of ownership: 1902.*

CHARACTER OF OWNERSHIP.	Number of mines.	PRODUCT.		
		Value.	Per cent of total.	Average per mine.
Total	559	$14,600,177	100.0	[1] $22,695
Incorporated company	161	8,823,159	60.4	54,802
Firm	328	3,073,822	21.1	9,516
Individual	66	670,201	4.6	10,155
Other form	9	119,185	0.8	13,243
Form not reported	.....	1,913,810	13.1	.....

[1] Exclusive of those for which character of organization was not reported.

A summary for incorporated and unincorporated operators is presented in the following table:

TABLE 5.—*Summary for incorporated and unincorporated operators: 1902.*

	Total.	Incorporated.	Unincorporated.
Number of mines	[1] 559	[1] 161	398
Salaries	$826,327	$634,177	$192,150
Wages	$4,329,271	$2,928,788	$1,400,483
Contract work	$108,607	$49,903	$58,704
Miscellaneous expenses, exclusive of royalties	$566,633	$512,319	$54,314
Royalties	$1,525,368	$584,149	$941,219
Work on share of product	$234,461	$189,597	$44,864
Cost of supplies and materials	$2,511,657	$1,771,672	$739,985
Value of product, total	[2] $14,600,177	[3] $8,823,159	[4] $5,777,018
Lead—			
Quantity, short tons	[5] 132,330	[5] 105,409	26,921
Value	$5,850,721	$4,530,281	$1,320,440
Zinc—			
Quantity, short tons	[6] 491,332	[6] 326,576	164,756
Value	$8,665,675	$4,277,660	$4,388,015

[1] Includes 2 corporations whose capitalization is reported under iron ore.
[2] Includes $83,781, value of product from custom mills.
[3] Includes $15,218, value of product from custom mills.
[4] Includes $68,563, value of product from custom mills.
[5] Includes 16,023 tons, valued at $432,231, product of small operators not reporting.
[6] Includes 60,685 tons, valued at $1,533,548, product of small operators not reporting.

From the preceding table the average value per ton of lead ore is computed to be $44 for the product of all mines, $43 for incorporated and $49 for unincorporated operators. Average values of zinc ore drawn from the preceding statement would be misleading, inasmuch as the quantity and the value of zinc ore for incorporated companies and, consequently, for all mines in the United States, are affected by the returns of 3 large eastern mines—1 in New Jersey and 2 in Virginia—that produce low grade ore. In the following statement these mines are eliminated, and the average values, relating only to western ores, which are approximately of the same grade, disclose no substantial difference between incorporated and unincorporated forms of ownership:

Quantity and value of high grade zinc ore, mined by incorporated and unincorporated operators: 1902.

CHARACTER OF OWNERSHIP.	Short tons.	Value.	Average per ton.
Total	289,800	$8,022,522	$27.68
Incorporated	125,044	3,634,507	29.07
Unincorporated	*164,756*	*4,388,015*	*26.63*

Capital stock of incorporated companies.—The capitalization of the incorporated companies is shown in the following table:

TABLE 6.—CAPITALIZATION OF INCORPORATED COMPANIES: 1902.

	United States.[1]	Colorado.	Illinois.	Kansas.	Missouri.	Wisconsin.	All other states.[2]
Number of incorporated companies	159	1	4	8	129	15	2
Capital stock and bonds issued	$51,326,891	$600,000	$330,000	$825,000	$34,958,891	$263,000	$14,350,000
Capital stock:							
Total authorized—							
Number of shares	8,612,792	1,000,000	250,300	531,500	6,495,822	231,670	103,500
Par value	$59,423,200	$1,000,000	$330,000	$725,000	$46,666,200	$352,000	$10,350,000
Total issued—							
Number of shares	6,198,299	600,000	250,300	516,500	4,585,329	142,670	103,500
Par value	$45,923,641	$600,000	$330,000	$710,000	$33,670,641	$263,000	$10,350,000
Dividends paid	$2,500,015	.....	.....	$3,015	$879,500	$17,500	$1,600,000
Common—							
Authorized—							
Number of shares	8,341,992	1,000,000	250,300	531,500	6,225,022	231,670	103,500
Par value	$56,380,200	$1,000,000	$330,000	$725,000	$43,623,200	$352,000	$10,350,000
Issued—							
Number of shares	5,973,526	600,000	250,300	516,500	4,360,556	142,670	103,500
Par value	$43,551,286	$600,000	$330,000	$710,000	$31,298,286	$263,000	$10,350,000
Dividends paid	$2,446,475	.....	.....	$3,015	$825,960	$17,500	$1,600,000
Preferred—							
Authorized—							
Number of shares	270,800	.....	.....	.....	270,800	.....	.....
Par value	$3,043,000	.....	.....	.....	$3,043,000	.....	.....
Issued—							
Number of shares	224,773	.....	.....	.....	224,773	.....	.....
Par value	$2,372,355	.....	.....	.....	$2,372,355	.....	.....
Dividends paid	$53,540	.....	.....	.....	$53,540	.....	.....
Bonds:							
Authorized—							
Number	15,265	.....	.....	340	4,925	.....	10,000
Par value	$12,575,000	.....	.....	$115,000	$2,460,000	.....	$10,000,000
Issued—							
Number	6,845	.....	.....	340	2,505	.....	4,000
Par value	$5,403,250	.....	.....	$115,000	$1,288,250	.....	$4,000,000
Interest paid	$226,200	.....	.....	$6,900	$59,300	.....	$160,000
Assessments levied	$79,531	.....	.....	.....	$64,531	$15,000	.....

[1] In addition there were 2 incorporated companies owning 2 mines in Virginia, and also owning and operating iron ore mines in West Virginia. The capitalization of these companies is reported under iron ore, since the capitalization for each industry can not be segregated.
[2] Includes 1 in New Jersey and 1 in New York.

The division of the capital stock into common and preferred is not in general use among the lead and zinc mining corporations. In the following statement the 159 operating companies are grouped in accordance with the class of stock reported by them:

Incorporated companies grouped by class of stock: 1902.

CLASS OF STOCK.	Number of incorporated companies.	AMOUNT ISSUED.		
		Total.	Common.	Preferred.
Total	159	$45,923,641	$43,551,286	$2,372,355
Both common and preferred	14	8,760,661	6,388,306	2,372,355
Common only	145	37,162,980	37,162,980	.....

The total bonded indebtedness reported was: Authorized, $12,575,000; issued, $5,403,250; the interest paid was $226,200. Among the companies for which a bonded indebtedness was reported were 2 companies whose capital stock and bonds represented manufacturing plants in addition to mining property. With these companies eliminated, there were in all 7 mining companies with an authorized bonded indebtedness aggregating $2,525,000, of which bonds to the value of $1,353,250 had been issued. One of these companies reported $200,000 as authorized but none issued; 4 reported an authorized indebtedness of $1,265,000, of which $1,220,000 was issued. The interest paid amounted to $63,200, the average rate being 5.2 per cent; 2 companies paid no interest on outstanding bonds during the year.

Few companies in the lead-zinc mining industry levied assessments. In 1902, 12 companies, 11 in Missouri and 1 in Wisconsin, reported total assessments since organization amounting to $79,531.

Of the 159 incorporated companies, only 45 declared dividends in 1902. Of this number, 3 companies operated smelting and other manufacturing establishments in connection with their mines, and their reported capitalization and dividends embraced their entire operations. The following table shows the capitalization and dividends of the 42 mining companies by which dividends were paid in 1902, exclusive of the 3 engaged in other business beside mining, and also the capitalization of the 114 companies by which no dividends were declared in 1902.

TABLE 7.—INCORPORATED COMPANIES, DIVIDEND AND NONDIVIDEND PAYING, BY KIND OF STOCK: 1902.[1]

CLASS.	AUTHORIZED.			ISSUED.			Dividends or interest paid.
	Number of shares or bonds.	Par value.		Number of shares or bonds.	Par value.		
		Total.	Average per share or bond.		Total	Average per share or bond.	
Dividend paying companies:							
Total	.....	$17,257,000	.....	.....	$11,458,550	.....	$672,515
Common stock	2,447,350	14,757,000	$6.03	1,490,955	9,808,400	$6.58	618,975
Preferred stock	89,000	2,300,000	25.84	63,768	1,650,150	25.88	53,540
Bonds	400	200,000	500.00	.....	.....	.....	.....
Companies paying no dividends in 1902:							
Total	.....	28,191,200	.....	.....	21,568,341	.....	63,200
Common stock	5,684,642	25,123,200	4.42	4,497,571	19,492,886	4.33	.....
Preferred stock	181,800	743,000	4.09	161,005	722,205	4.49	.....
Bonds	4,690	2,325,000	495.74	2,670	1,353,250	506.84	63,200

[1] Exclusive of 3 companies engaged in manufacturing as well as mining.

Of the 42 dividend paying companies whose dividends are shown in the preceding table, there were only 5 with both preferred and common stock; of these only 1 company declared dividends on both classes of stock, while 4 paid dividends on preferred stock alone. The average rate of dividends on preferred stock was 3.2 per cent. The 38 companies which declared dividends on common stock had an authorized capitalization of $11,957,000, divided into $10,957,000 common, and $1,000,000 preferred; of this the amount outstanding was $6,008,400 common and $425,550 preferred. The average rate of dividends paid by these companies on their common stock was 10.3 per cent.

The census returns furnish no data for determining the net profits earned in mining, since the excess of the value of the product over the expenses reported is not an indication of actual profit; yet some data bearing indirectly on the subject are found in the returns of the dividend paying companies. The payment of dividends by a company may ordinarily be taken as a proof of successful operation. Certainly it must not be assumed that the dividends paid during one year are derived from the profits of the same year, nor that the failure to declare a dividend during a certain year is an evidence of unprofitable mining. In the first case, the dividends may represent the accumulated earnings of former years, while in the second, the surplus may have been invested in the acquisition of new property, in the erection of new plants, etc. With these qualifications, the following comparative summary is presented:

TABLE 8.—*Summary for dividend paying and nondividend paying companies: 1902.*

	Incorporated companies.[1]	Dividend paying companies.	Nondividend paying companies.
Number of companies	156	42	114
Salaries	$594,016	$233,181	$360,835
Wages	$2,713,993	$951,865	$1,762,128
Contract work	$49,103	$21,377	$27,726
Work on share of product	$189,597	$189,597	.....
Royalties	$507,954	$273,119	$234,835
Miscellaneous expenses, exclusive of royalties	$495,809	$87,489	$408,320
Cost of supplies and materials	$1,612,098	$731,348	$880,750
Value of product	[2]$8,174,181	$3,502,890	[2]$4,671,291
Average value per company	$52,399	$83,402	$40,976
Lead:			
Quantity, short tons	105,085	33,949	71,136
Value	$4,525,081	$1,475,889	$3,049,192
Average value per ton	$43.06	$43.47	$42.86
Zinc:			
Quantity, short tons	124,919	69,453	55,466
Value	$3,633,882	$2,027,001	$1,606,881
Average value per ton	$29.09	$29.19	$28.97

[1] Exclusive of 3 companies engaged in manufacturing as well as mining.
[2] Includes product of custom mills.

It appears from the preceding table that the dividend paying companies enjoyed no advantage either in the grade of their ore or in the marketing of the same, since the average prices received by them did not perceptibly differ from those generally prevailing in 1902. But the two classes differed in the volume of production; the average for dividend paying companies was twice as large as that for the nondividend paying companies, the average being $83,402 and $40,976, respectively.

Employees and wages.—The following table shows the average number of wage-earners employed during each month, by states and territories:

TABLE 9.—*Average number of wage-earners employed during each month, by states and territories: 1902.*

	United States.	Colorado.	Illinois.	Iowa.	Kansas.	Missouri.	Wisconsin.	All other states and territories.[1]
Men 16 years and over:								
January	7,325	.....	97	12	175	6,195	445	461
February	7,266	.....	94	16	167	6,153	415	421
March	7,465	.....	96	16	187	6,277	427	462
April	7,608	.....	111	13	209	6,415	393	467
May	7,965	20	115	16	207	6,726	364	517
June	7,996	20	124	9	197	6,750	388	508
July	8,008	20	82	7	227	6,766	390	516
August	8,181	.....	98	9	238	6,890	407	539
September	8,067	.....	114	16	258	6,689	437	553
October	8,125	.....	92	12	270	6,729	463	559
November	8,034	.....	82	13	273	6,710	431	525
December	8,172	.....	131	17	268	6,768	432	556
Boys under 16 years:								
January	27	.....	2	.....	.....	25	.....	.....
February	27	.....	2	.....	.....	25	.....	.....
March	28	.....	2	.....	.....	26	.....	.....
April	28	.....	2	.....	.....	26	.....	.....
May	31	.....	2	.....	.....	26	3	.....
June	32	.....	2	.....	.....	27	3	.....
July	35	.....	.....	.....	.....	32	3	.....
August	31	.....	.....	.....	.....	30	1	.....
September	32	.....	.....	.....	.....	31	1	.....
October	32	.....	.....	.....	.....	31	1	.....
November	27	.....	.....	.....	.....	27	.....	.....
December	30	.....	.....	.....	.....	30	.....	.....

[1] Includes operators as follows: Arizona, 1; Kentucky, 1; New Jersey, 1; New Mexico, 1; New York, 1; Virginia (2 mines; operators reported under iron ore).

The number of salaried officials, clerks, etc., for the 559 mines reporting was 910, or an average of 1.6 to a mine. Of these 76 were salaried officials of corporations. Since the total number of corporations was 161, it appears that more than one-half of them had no salaried officials.

The average number of wage-earners was 7,881, or 14 to a mine. The aggregate wages paid amounted to $4,329,271. Miners working in the mines on shares are not included in the general tables.

In any analysis of these figures it must be borne in mind that the above number of wage-earners is an average computed on the basis of 300 working days, and is not identical with the actual number of persons who earned the amount of wages reported. The average per wage-earner accordingly represents the cost of one man's labor power to the employer, and this cost is not identical with the average annual earnings. For the purpose of estimating the earning capacity of wage-earners, average daily rates should be consulted.

In the following table the distribution of the wage-earners according to daily rates of pay is shown for the various occupations:

TABLE 10.—DISTRIBUTION OF WAGE-EARNERS ACCORDING TO DAILY RATES OF PAY, BY OCCUPATIONS: 1902.

RATE PER DAY (DOLLARS).	ALL OCCUPATIONS.		ENGINEERS.		FIREMEN.		MACHINISTS, BLACKSMITHS, CARPENTERS, AND OTHER MECHANICS.		MINERS.		MINERS' HELPERS.		TIMBERMEN AND TRACK LAYERS.		BOYS UNDER 16 YEARS.		ALL OTHER WAGE-EARNERS.	
	Average number.	Per cent of total.	Average number.	Per cent of total.	Average number.	Per cent of total.	Average number.	Per cent of total.	Average number.	Per cent of total.	Average number.	Per cent of total.	Average number.	Per cent of total.	Average number.	Per cent of total.	Average number.	Per cent of total.
Total	[1]7,881	100.0	528	100.0	224	100.0	397	100.0	3,300	100.0	658	100.0	36	100.0	30	100.0	2,708	100.0
Less than 0.50	5	0.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	16.7	.....	.....
0.50 to 0.74	14	0.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	40.0	2	0.1
0.75 to 0.99	7	0.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	16.7	2	0.1
1.00 to 1.24	165	2.1	.....	.....	.....	.....	1	0.3	47	1.4	4	0.6	.....	.....	5	16.7	108	4.0
1.25 to 1.49	1,371	17.4	2	0.4	53	23.7	11	2.8	300	9.1	302	45.9	11	30.6	1	3.3	691	25.5
1.50 to 1.74	2,053	26.0	44	8.3	104	46.4	54	13.6	909	27.5	183	27.8	7	19.4	2	6.6	750	27.7
1.75 to 1.99	683	8.7	73	13.8	7	3.1	51	12.8	308	9.3	21	3.2	3	8.3	.....	.....	220	8.1
2.00 to 2.24	2,301	29.2	176	33.3	41	18.3	159	40.0	1,217	36.9	124	18.8	13	36.1	.....	.....	571	21.1
2.25 to 2.49	788	10.0	85	16.1	8	3.6	49	12.3	414	12.6	24	3.7	1	2.8	.....	.....	207	7.7
2.50 to 2.74	309	3.9	117	22.2	10	4.5	42	10.6	93	2.8	.....	.....	.....	.....	.....	.....	47	1.7
2.75 to 2.99	26	0.3	5	0.9	.....	.....	7	1.7	2	0.1	.....	.....	.....	.....	.....	.....	12	0.4
3.00 to 3.24	143	1.8	24	4.6	1	0.4	17	4.3	8	0.3	.....	.....	1	2.8	.....	.....	92	3.4
3.25 to 3.49	10	0.1	.....	.....	.....	.....	3	0.8	1	(2)	.....	.....	.....	.....	.....	.....	6	0.2
3.50 to 3.74	4	0.1	1	0.2	.....	.....	2	0.5	1	(2)	.....	.....	.....	.....	.....	.....	.....	.....
3.75 to 3.99	1	(2)	.....	.....	.....	.....	1	0.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4.00 to 4.24	1	(2)	1	0.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

[1] Includes 2 wage-earners paid by the ton, for whom average daily wages are shown.
[2] Less than one-tenth of 1 per cent.

In the above table 6,008 wage-earners, or 76.2 per cent of the total number, are included under the two heads "miners" and "all other wage-earners." It will be noticed also that there is comparatively little difference in the range of wages for the several classes of employees.

Of the total number of wage-earners, 7,196, or 91.3 per cent, received between $1.25 and $2.49 per day. Of those classed as miners the proportion included between those rates was even greater, constituting 95.4 per cent of all the miners. The number of miners who received $1.50 per day was evidently very large, as was also that

of those who were paid $2 per day, for 27.5 per cent are included in the group $1.50 to $1.74 and 36.9 per cent in the group $2 to $2.24.

There were 658 men reported as miners' helpers. The daily rates of pay for 485 of them, 73.7 per cent of the total number, were between $1.25 and $1.74. Only 36 men were reported as timbermen and track layers; the rates of pay for 34 of these men ranged from $1.25 to $2.24. Most of the men employed as firemen received between $1.24 and $2.24 per day; 91.5 per cent of the total number was included between those rates. The rate at which the greatest number were employed was probably $1.50, since 46.4 per cent are included in the group $1.50 to $1.74. For engineers, machinists, and other mechanics wages were somewhat higher. Of the engineers, 93.7 per cent, and of the machinists and other mechanics, 89.3 per cent, were paid between $1.50 and $2.74 per day.

There were 30 boys under 16 years reported as employed in lead and zinc mines, 28 of them from Missouri. Of these boys, 12 were paid between 50 and 74 cents per day, 5 were paid less than 50 cents, while 5 received between 75 and 99 cents, and 8 received $1 or over.

The proportion of the employees included under the head of "all other wage-earners" is very large, but the range of wages differed very little from that for the balance of the wage-earners, 94.1 per cent of the total number having received between $1 and $2.49 per day.

Contract mining, i. e., working at a stated rate per ton, is exceptional in lead-zinc mining; according to the reports a total of $266 was paid for such work during the year, and this amount has been included in the general tables. In those mines, however, where the landowner or first lessee is also the buyer of all ore mined by the sublessees, the latter are virtually wage-earners paid by the ton. The total number of such sublessees reported was 638 and the total amount paid to them was $234,461; out of this amount they were required to furnish their own supplies.

The total number of men engaged in mining can not be ascertained with accuracy. The lead and zinc mine inspector of Missouri reported 11,358 men employed in all capacities at the lead and zinc mines; he explained, however, that "it must not be understood that this number is employed continuously, as quite a number of farmers mine in many counties when not engaged in farm work."[1] The census returns from the lead and zinc mines of Missouri show an average of 6,612 wage-earners and 777 salaried employees, in all 7,389 persons. The average number of the census is the number that would be required at continuous employment for 300 days in the year to produce the quantity of ore reported. The two numbers are incommensurate; the difference between them, 3,969 persons, would be much in excess of the average number of miners working on shares, as well as of the actual number of such miners who at one time or another during the year perform some work in the mines. Taking the value of ore produced as a basis, the average number of such miners could be estimated for Missouri at about 1,300 men.

The following table shows lead and zinc mines classified by the length of time in operation during the year, so far as reports were made in this particular:

[1] Sixteenth Annual Report of the State Lead and Zinc Mine Inspector of Missouri, page 16.

TABLE 11.—LEAD AND ZINC MINES, CLASSIFIED BY NUMBER OF DAYS IN OPERATION, BY STATES AND TERRITORIES: 1902.

STATE OR TERRITORY.	Total.	DAYS IN OPERATION.												
		30 or less.	31 to 60.	61 to 90.	91 to 120.	121 to 150.	151 to 180.	181 to 210.	211 to 240.	241 to 270.	271 to 300.	301 to 330.	331 to 365.	Not reported.
United States	559	25	44	40	55	42	31	50	50	58	109	26	4	5
Colorado	3			1										2
Illinois	14	1		1			1	1	1	1	5	3		
Iowa	14			2	1		1	3	4	2	1			
Kansas	57	3	4	5	7	7	4	7	4	2	11	1	2	
Missouri	374	19	36	26	36	27	23	29	31	45	69	11	2	
New Jersey	1											1		
New York	1		1											
Virginia	2					1					1			
Wisconsin	90	2	3	5	11	7	2	10	10	8	22	10		
All other states and territories[1]	3													3

[1] Includes Arizona, 1; Kentucky, 1; New Mexico, 1.

Mechanical power.—Steam was the prevailing kind of power in 1902. There were 1,060 steam engines, 45 electric motors, 32 gas or gasoline engines, 8 water wheels, and 39 other power generators in use during the year. Renting of power was practically unknown; the total number of horsepower supplied to other establishments by the operators reporting was 91, and the total supplied to the mines by other establishments was 199, while a total of 41,901 horsepower was owned. The progress in this respect within the last three decades is shown in the following table, by states and territories:

TABLE 12.—*Steam engines, by states and territories: 1902, 1880, and 1870.*

STATE OR TERRITORY.	1902		1880		1870	
	Number.	Horsepower.	Number.	Horsepower.	Number.	Horsepower.
United States	1,060	38,616	167	6,739	21	953
Illinois	14	364	3	240	1	20
Iowa	.....	.....	1	25	1	40
Kansas	92	2,512	14	268	.....	.....
Missouri	904	32,953	118	2,805	2	72
Wisconsin	25	617	3	37	4	85
All other states and territories[1]	25	2,170	28	3,364	13	736

[1] Includes the following states and territories: 1902: Arizona, Colorado, New Jersey, New York, and Virginia. 1880: New Jersey, Pennsylvania, and Tennessee. 1870: North Carolina and Pennsylvania.

Production.—In 1902 the dressing of the ore was done at the mine in nearly every case. Of the 559 concerns reporting, 525 were equipped with concentrating plants or hand jigs, 16 were custom mills, and 18 made no report as to equipment for treating the ore, presumably having no facilities for dressing their ore at the mine.

The total reported value of the product of the lead and zinc mines and mills in 1902 was $14,600,177. This amount was made up as shown in the following statement:

Value of the lead and zinc product: 1902.

Production of mines:		
Lead ore	$5,850,721	
Zinc ore	8,665,675	
Total		$14,516,396
Production of custom mills:		
Earned for custom work	34,309	
Ore sold	122,646	
Total	156,955	
Deduct cost of ore purchased	73,174	
Net value		83,781
Total, mines and mills		$14,600,177

While the production of custom mills adds to the value of the ore treated, it can not, theoretically at least, add anything to the quantity of the product; it would therefore be a duplication to add the product of the mills to that of the mines. In actual practice a portion of the product of the custom mills was recovered from "sludge," i. e., mill refuse purchased from the neighboring mines equipped with mills. The reports of the latter are assumed to include the value realized from the sale of sludge; it is, however, by no means certain that these values are included in all cases. The sludge is considered of little value; it is usually sold for a lump sum, without much regard to quantity. It is possible, therefore, that by deducting the value of purchased ore from the total value of the product the value of the lead and zinc product may have been underrated. Likewise, by omitting from the quantity of the product shown in Table 13, the output of custom mills, the total production may have been underrated. Still, as the gross value of all the ore sold by the mills amounted to only $122,646, or less than 1 per cent of the total production of the lead-zinc mines, the error may be treated as a negligible quantity.

The quantity, total value, and average value per ton of lead and zinc ore produced in 1902 are shown by states and territories in the following table:

TABLE 13.—QUANTITY, TOTAL VALUE, AND AVERAGE VALUE PER TON OF LEAD AND ZINC ORE, BY STATES AND TERRITORIES: 1902.

STATE OR TERRITORY.	TOTAL.		LEAD ORE.			ZINC ORE.		
	Value.	Per cent of total.	Short tons.	Value.	Average value per ton.	Short tons.	Value.	Average value per ton.
United States[1]	$14,526,988	100.0	132,330	$5,861,313	$44.29	491,332	$8,665,675	$17.64
Illinois	90,619	0.6	792	30,936	39.06	2,778	59,683	21.48
Iowa	13,358	0.1	186	9,106	48.96	376	4,252	11.31
Kansas	707,026	4.9	3,468	163,084	47.03	21,642	543,942	25.13
Missouri	12,513,021	86.1	124,537	5,520,211	44.33	240,057	6,992,810	29.13
Wisconsin	473,652	3.3	2,623	122,184	46.58	19,376	351,468	18.14
All other states and territories[2]	729,312	5.0	724	15,792	21.81	207,103	713,520	3.45

[1] Does not include the production of custom mills in Kansas and Missouri.
[2] Includes the following states and territories: Arizona, Colorado, Kentucky, New Jersey, New Mexico, New York, and Virginia.

The value of the lead and zinc ores shown in the preceding table is $14,526,988, or $73,189 less than the value of product shown in Table 1, and in the detailed summary. This difference is accounted for by the absence of the net value of the production of custom mills in Kansas and Missouri. According to the preceding table, six-sevenths of the lead and zinc production of the United States was furnished by the state of Missouri.

The progress made by the lead-zinc mining industry

since the Eleventh Census appears from the following comparative summaries:

TABLE 14.—*Comparative summary, quantity and value of lead ore, by states and territories: 1902 and 1889.*

STATE OR TERRITORY.	SHORT TONS.			VALUE.		
	1902	1889	Per cent of increase.	1902	1889	Per cent of increase.
United States[1]	132,330	50,238	163.4	$5,861,313	$1,754,380	234.1
Missouri	124,537	44,482	180.0	5,520,211	1,571,161	251.4
Kansas	3,468	3,617	[2]4.1	163,084	103,236	58.0
Wisconsin	2,623	1,678	56.3	122,184	64,063	90.7
Illinois	792	173	357.8	30,936	4,800	544.5
Iowa	186	.....	.....	9,106	.....	.....
All other states and territories	[3]724	[4]288	151.4	[3]15,792	[4]11,120	42.0

[1] Does not include the production of custom mills in Kansas and Missouri in 1902.
[2] Decrease.
[3] Includes Arizona, Colorado, Kentucky, New Jersey, New Mexico, New York, and Virginia.
[4] Southern states.

TABLE 15.—*Comparative summary, quantity and value of zinc ore, by states and territories: 1902 and 1889.*

STATE OR TERRITORY.	SHORT TONS.			VALUE.		
	1902	1889	Per cent of increase.	1902	1889	Per cent of increase.
United States[1]	491,332	234,503	109.5	$8,665,675	$3,049,799	184.1
Missouri	240,057	93,131	157.8	6,992,810	2,024,057	245.5
Kansas	21,642	39,575	[2]45.3	543,942	299,192	81.8
Wisconsin	19,376	24,832	[2]22.0	351,468	400,568	[2]12.3
Illinois	2,778	.....	.....	59,683	.....	.....
Iowa	375	450	[2]16.7	4,252	3,600	18.1
Eastern states	[3]201,532	[4]63,339	218.2	[3]643,153	[4]175,052	267.4
All other states and territories	[5]5,572	[6]13,176	[2]57.7	[5]70,367	[6]147,330	[2]52.2

[1] Does not include the production of custom mills in Kansas and Missouri in 1902.
[2] Decrease.
[3] Includes New Jersey and Virginia.
[4] Includes New Jersey and Pennsylvania. Number not reported.
[5] Includes Colorado, Kentucky, and New Mexico.
[6] Includes Arkansas, New Mexico, and the Southern states.

In the following statement the census returns for Missouri are compared with the report of the lead and zinc mine inspector of that state:

Quantity and value of lead and zinc ore, Census and Missouri mine inspector's returns: 1902.

SOURCE OF INFORMATION.	Total value.	LEAD ORE.			ZINC ORE.		
		Short tons.	Value.	Average value per ton.	Short tons.	Value.	Average value per ton.
Census returns[1]	$12,513,021	124,537	$5,520,211	$44.33	240,057	$6,992,810	$29.13
State mine inspector's returns	12,370,985	126,831	5,318,157	41.93	234,903	7,052,828	30.02
Difference:							
More (+) or less (−)	−142,036	+2,294	−202,054	−2.40	−5,154	+60,018	+0.89
Per cent	−1.1	+1.8	−3.7	−5.4	−2.1	+0.8	+3.0

[1] Exclusive of production of custom mills.

As evidenced by the preceding statement, the census returns on production are in substantial agreement with those of the state mine inspector. Small discrepancies of from 1 to 3 per cent are quite unavoidable in view of the nature of the information. In many cases the value reported by the operator was not the actual amount entered on his books, but an estimate based upon an assumed average value of the ore, which was the best information obtainable. Small operators only too often keep very imperfect books, if any, whereas the largest producers, who do not sell their ores but smelt them at their own plants and market the bullion, must put an assumed valuation upon the ore in order to answer the inquiries of the Bureau of the Census or of the state bureau of mines. Therefore, if the reports of such operators were made on different dates, the estimates for the same mining company might differ, and in more than one case this state of affairs was disclosed by a comparison of the confidential census returns with the figures published by the state mine inspector. That the discrepancy is on the whole within such narrow limits may be accepted as proof of the substantial accuracy of the returns.

The mining district comprising Kansas and a portion of Missouri is called the Joplin-Galena district. The average base prices of zinc and lead ores in this district, computed from monthly averages for 1902, were reported by the United States Geological Survey as follows: Lead per 1,000 pounds, $23.05; zinc per short ton, $30.33. For 1902 the range of fluctuations of monthly base prices in the same district was as follows:

	Lead ore per 1,000 pounds.	Zinc ore per short ton.
Highest price	$25.00	$34.37
Lowest price	21.00	26.76
Variation	4.00	7.61

These averages are not strictly comparable with the average values by states and territories given in Table 13. The variations, however, are inconsiderable, viz:

Average value above (+) or below (−) base price.

	Lead ore per 1,000 pounds.	Zinc ore per short ton.
Kansas	−$0.46	+$5.20
Missouri	− 0.89	+ 1.20

It appears from these comparisons that the variations between the values reported to the Bureau of the Census and the average base prices for the year 1902 were within the ordinary range of market fluctuations. The quantity reported represents dressed ore of various grades, except in a few cases where the quantity of rough ore was reported and could not be reduced to terms of dressed ore.

Table 16 is a summary of the statistics for all lead and zinc mines in Missouri at the censuses of 1902, 1880, and 1870.

TABLE 16.—*Comparative summary, lead and zinc mines, Missouri: 1902, 1880, and 1870.*

	1902	1880	1870
Number of mines	374	71	42
Number of operators	374	71	42
Salaried officials, clerks, etc.:			
Number	777	342	(1)
Salaries	$727,021	(2)	(1)
Wage-earners:			
Average number	6,612	4,180	539
Wages	$3,691,923	[2] $2,034,254	$124,179
Contract work	$105,877	(1)	(1)
Miscellaneous expenses	$1,768,458	(1)	(1)
Cost of supplies and materials	$2,189,461	$194,532	$5,654
Value of product	$12,555,580	$2,077,944	$201,885

[1] Not reported. [2] Salaries included in wages.

As has been stated above, at the Eleventh Census the statistics of zinc mines of southern Missouri were confined to the quantity and value of the output. Mine expenses were reported only for lead mines. In the following table the data concerning these mines are collated with the expenses and production of the mines for which the product reported for 1902 was likewise only lead ore:

TABLE 17.—*Comparative summary of mines producing lead ore only, Missouri: 1902 and 1889.*

	1902	1889
Number of mines	59	(1)
Salaries	$308,290	(1)
Wages	$1,448,902	$401,431
Contract work	$30,031	$8,525
Miscellaneous expenses	$465,212	$142,153
Cost of supplies and materials	$842,945	$244,784
Product:		
Short tons	93,926	44,482
Value	$4,126,278	$1,571,161

[1] Not reported.

The following table, reproduced from the report of the state lead and zinc mine inspector of Missouri for 1902, shows the growth of the zinc production in that state, by years, from the beginning of zinc mining, in 1873, to the year 1902. The output of 1902, as reported by the state mine inspector, exceeds by eight-tenths of 1 per cent that reported to the Bureau of the Census. The reasons for this insignificant variance are discussed on a previous page.

TABLE 18.—*Quantity and value of zinc ore, Missouri: 1873 to 1902.*

[Sixteenth Annual Report of the Lead and Zinc Mine Inspector of Missouri, for the year ending December 31, 1902.]

YEAR.	Number of tons.	Amount received for output.	YEAR.	Number of tons.	Amount received for output.
1873	960	$8,640.00	1890	100,248	$2,256,583.00
1874	5,100	51,000.00	1891	123,752	2,673,063.36
1875	3,600	36,000.00	1892	131,488	2,862,475.08
1876	11,300	148,000.00	1893	108,591	2,245,028.80
1877	10,000	140,000.00	1894	89,150	1,337,910.36
1878	12,000	198,000.00	1895	101,294	1,707,665.40
1879	20,000	340,000.00	1896	92,754	1,831,856.45
1880	27,500	440,000.00	1897	93,148	1,706,947.53
1881	35,500	579,150.00	1898	139,668	2,927,321.00
1882	34,900	589,100.00	1899	181,430	5,974,624.00
1883	35,700	624,750.00	1900	186,293	5,711,631.00
1884	43,200	777,600.00	1900[1]	105,150	2,835,895.00
1885	42,200	738,500.00	1901	224,074	5,308,671.00
1886	48,400	895,400.00	1902	234,903	7,052,819.00
1887	57,300	1,088,700.00			
1888	61,550	1,292,550.00	Total	2,443,510	56,145,615.06
1889	82,357	1,765,734.08			

[1] For ten years prior to 1901 the above figures covered a fiscal year ending June 30. The six months accounted for above are the last six months of 1900, making full years for the period.

LEAD CONTENTS OF LEAD AND ZINC ORES.

The lead contents of the ore can be estimated by comparison with the returns from lead smelters. The returns from 5 leading mining and smelting companies of Missouri show a total of 103,428 tons of their own and purchased ore treated, from which 70,491 tons of lead were recovered, or an average of 68.2 per cent. The quantity of nonargentiferous lead ore treated by those companies is equal to 78 per cent of the total quantity mined during the year. A glance at the price column of Table 13 shows that the ore was brought by concentration to about the same grade throughout the nonargentiferous lead region. The only exception is found in the group of "all other states," where the quantity reported apparently represented crude ore. The quantity, however, being only somewhat over two-tenths of 1 per cent, the effect of this variation upon the average for the United States could not exceed a few cents per ton. The average percentage of recovery reported by the above-mentioned 5 smelting companies—viz, 68 per cent—may therefore be taken as representative of the results generally obtained in the United States.[1] The metal yield of all nonargentiferous ores may be estimated on this basis, in round figures, at 90,000 tons. According to reports from the same companies, lead bullion of the value of $2,534,683 was produced from concentrates valued at $2,045,978—i. e., 24 per cent was added to the value of concentrates by smelting. The total reported value of the lead concentrates produced in the United States was $5,850,721. By an addition of 24 per cent of this amount $7,255,000 is obtained as the estimated value of the 90,000 tons of metallic lead

[1] The relation of the product to lead ores consumed in 1880 was represented by the following percentages: Illinois, 68.6; Iowa, 70.2; Wisconsin, 66.6; Kansas, 69.3; and Missouri, 72.4.

recoverable from nonargentiferous ores. The average value is 4.03 cents per pound of refined lead, which is within the range of the prices of lead at New York city in 1902 as reported by the United States Geological Survey—viz, highest, 4.10 cents; lowest, 4 cents. The reports made by smelters to the United States Geological Survey show 79,445 tons of pig lead produced from nonargentiferous ores of Missouri, Kansas, Wisconsin, Illinois, Iowa, Virginia, and Kentucky. The difference is accounted for by the fact that "a considerable quantity of the ore is converted into a pigment."[1]

ZINC CONTENTS OF LEAD AND ZINC ORES.

The zinc ores of Missouri and Kansas are usually sold upon an assay basis of 60 per cent of metallic zinc in the concentrates, with a deduction of $1 for every unit or percentage below that standard, and a similar allowance for higher grades of concentrates. Sixty per cent is thought to be, approximately, the average for the entire district.

The price of ore shipped from mines in Wisconsin is determined by the price of ore in Missouri. The average value per ton of zinc ore in Missouri was $29.13, and in Wisconsin $18.14; the difference, $10.99, may be taken as reflecting the difference in the grade of the concentrates, and would show an average assay of 49 per cent for Wisconsin ore (dressed). The three states named furnished 278,727 tons out of a total of 283,680 tons for the Western states, or 98.3 per cent of the total output of western mines. The eastern and southern ores are of a much lower grade. The average zinc contents of New Jersey concentrates was about 25 per cent; the chemical composition of the ore, according to Mr. Ingalls, is 23.58 per cent zinc. The concentrates of Virginia assay 38.08 zinc.[2] From these data the zinc contents of the ores mined are estimated for the principal producing states as follows:

[1] United States Geological Survey, "Mineral Resources of the United States," 1902, page 209.

[2] Production and Properties of Zinc, by Walter Renton Ingalls, pages 193 and 201.

TABLE 19.—*Zinc contents of ores mined in the principal producing states: 1902.*

STATE.	Short tons of concentrates.	Average assay (per cent).	Zinc contents (short tons).
Total	482,607	.....	217,726
Missouri	240,057	60	144,034
Kansas	21,642	60	12,985
Wisconsin	19,376	49	9,494
New Jersey[1]	201,532	25	51,213
Virginia[1]		38	

[1] The computation is made separately for New Jersey and Virginia, but the returns can not be shown separately without disclosing individual operations.

This leaves 8,725 tons of ore, or about 2 per cent, the zinc contents of which are a matter of conjecture.

GENERAL SUMMARY OF LEAD AND ZINC MINES, BY STATES AND CHARACTER OF MINE.

A table for all lead and zinc mines is presented by states. Small mines from which no individual reports were received are not included in this statement. The royalties shown in the detailed summary at the close of this report include those paid by these sublessees; therefore royalties are omitted also. The rate of royalty is fixed by custom and does not, as a rule, vary in individual cases. Custom mills which merely rework ore mined elsewhere or mill refuse ("sludge") are not included in the following table which is intended to present the facts relating to mines only:

TABLE 20.—SUMMARY OF LEAD AND ZINC MINES, BY STATES: 1902.

STATE.	Number of mines.	Salaries.	Wages.	Contract work.	Work on share of product.	Miscellaneous expenses, exclusive of royalties.	Cost of supplies and materials.	Value of product.
United States[1]	541	$818,451	$4,244,256	$108,607	$244,661	$543,172	$2,058,933	$12,550,617
Illinois	14	9,120	51,565	.....	.....	1,226	20,464	90,619
Iowa	14	280	5,766	.....	.....	556	919	13,358
Kansas	54	20,783	129,584	922	.....	10,226	72,453	342,943
Missouri	362	721,905	3,650,237	105,877	228,664	512,996	1,748,749	10,963,294
Wisconsin	90	26,202	192,209	1,008	.....	1,658	56,774	473,652
All other states[2]	7	40,161	214,795	800	15,997	16,510	159,574	666,751

[1] Custom mills and small mines not included.
[2] Includes operators distributed as follows: Colorado, 3; New Jersey, 1; New York, 1; Virginia, 2.

In analyzing the figures of the preceding table, the prevalence of mining on a small scale in Iowa and Wisconsin should be taken into consideration. In a mine worked on a small scale the operator gives his personal attention to many details of business which on a larger scale of operation require the services of salaried employees; furthermore, the absence of steampower in the great majority of these mines reduced the expense for supplies.

Where the same mine produces both lead and zinc ore, it is impossible to segregate the expenses incident to each of these products. There were a number of mines, however, which reported but one product, either lead or zinc ore.

The following is a comparative summary of all mines, classified according to the character of their product, the division showing those producing lead ore only, those producing zinc ore only, and those producing both lead and zinc ore:

TABLE 21.—SUMMARY OF MINES, BY CHARACTER OF PRODUCT: 1902.

CHARACTER OF PRODUCT.	Number of mines.	Salaries.	Wages.	Contract work.	Work on share of product.	Miscellaneous expenses, exclusive of royalties.	Cost of supplies and materials.	Value of product.	LEAD.			ZINC.		
									Short tons.	Value.	Value per ton.	Short tons.	Value.	Value per ton.
United States[1]	541	$818,451	$4,244,256	$108,607	$244,661	$543,172	$2,058,933	$12,550,617	122,307	$5,418,490	$44.30	430,647	$7,132,127	$16.56
Lead ore	108	314,875	1,493,068	30,031	27,139	384,715	855,514	4,209,174	95,790	4,209,174	43.94	.....	.....	.....
Zinc ore	144	171,792	844,233	12,792	.....	67,014	590,756	2,467,623	.....	.....	.....	263,985	2,467,623	9.35
Lead and zinc ore	289	331,784	1,906,955	65,784	217,522	91,443	612,663	5,873,820	26,517	1,209,316	45.61	166,662	4,664,504	27.99

[1] Custom mills and small mines not included.

The average value realized per ton of lead ore shows no marked difference for either class of lead mines. The average values per ton of zinc ore, shown in the preceding table, are misleading because they include the low grade zinc ores of New Jersey and Virginia. When those ores are eliminated, the total output of distinctively zinc mines is reduced to 62,453 tons, valued at $1,824,470, which corresponds to an average value of $29 per ton. Thus there is no perceptible difference in the average value of zinc ore of the same class.

The following is a comparative summary of zinc mines by districts, viz, Kansas and Missouri, which is the main zinc producing region; the upper Mississippi valley, extending over Wisconsin, Illinois, and Iowa; and the Eastern states, embracing New Jersey and Virginia:

TABLE 22.—SUMMARY FOR MINES PRODUCING ZINC ORE EXCLUSIVELY, BY DISTRICTS: 1902.

DISTRICT.	Number of mines.	Salaries.	Wages.	Contract work.	Miscellaneous expenses, exclusive of royalties.	Cost of supplies and materials.	PRODUCT.		
							Short tons.	Value.	Average per ton.
United States	144	$171,792	$844,233	$12,792	$67,014	$590,756	263,985	$2,467,623	.....
Kansas and Missouri	113	125,544	572,652	11,965	50,287	414,216	56,236	1,702,829	$30.28
Upper Mississippi valley[1]	28	8,312	62,821	827	747	19,966	6,217	121,641	19.57
Eastern states[2]	3	37,936	208,760	.....	15,980	156,574	201,532	643,153	3.19

[1] Includes mines as follows: Illinois, 3; Iowa, 2; Wisconsin, 23.

[2] Includes mines as follows: New Jersey, 1; Virginia, 2.

The following table is a summary for lead mines yielding no zinc by product, by districts:

TABLE 23.—SUMMARY FOR MINES PRODUCING LEAD ORE EXCLUSIVELY, BY DISTRICTS: 1902.

DISTRICT.	Number of mines.	Salaries.	Wages.	Contract work and work on share of product.	Miscellaneous expenses, exclusive of royalties.	Cost of supplies and materials.	PRODUCT.		
							Short tons.	Value.	Average per ton.
United States	108	$314,875	$1,493,068	$57,170	$384,715	$855,514	95,790	$4,209,174	$43.94
Missouri	59	308,290	1,448,902	57,170	383,380	842,945	93,926	4,126,278	43.93
Upper Mississippi valley[1]	49	6,585	44,166	.....	1,335	12,569	1,864	82,896	44.47

[1] Includes mines distributed as follows: Illinois, 10; Iowa, 12; Wisconsin, 27.

A detailed summary of the lead and zinc ore industry for 1902 is given in Table 34.

AURIFEROUS AND ARGENTIFEROUS LEAD AND ZINC ORES.

The statistics of mines producing auriferous and argentiferous lead and zinc ores are given in the report on gold and silver. Still, as these ores furnish a not inconsiderable share of the materials from which lead and zinc are produced in this country, a proper comparison of the production of the mines with the consumption of the lead and zinc ores must embrace all classes of these ores. The production of lead and zinc from all sources, as returned by the census of mines and quarries for the year 1902, is collated in the following statement:

Value of lead and zinc in all ores, by sources of production: 1902.

	Lead.	Zinc.
Total	$18,181,013	$9,006,361
In nonargentiferous lead and zinc ores	5,850,721	8,665,675
In gold and silver ore	12,311,239	340,686
In copper ore	19,053	.....

Mr. Harry A. Lee, commissioner of mines of Colorado, in his report for 1901–2, wrote as follows of zinc mining in that state:

Zinc is practically a new product that occurs intimately associated with iron and lead sulphides in bodies of great magnitude. Until within the past few years these ore bodies were worthless on account of the zinc sulphides present, and were, therefore, as far as possible, left intact in the mines. The extraction of the more valuable ores has, nevertheless, developed large bodies of zinciferous ores that are now a valuable asset.[1]

Zinc associated with gold, silver, and lead was reported from Colorado, where, according to census returns, 51,996,073 pounds of zinc were contained in 245,555 tons of gold and silver bearing lead ore, showing an average assay of 10.6 per cent of zinc in the ore. In addition to this, the reports from nonargentiferous lead and zinc mines included in the preceding statements show a product of 1,536 tons of zinc concentrates. The commissioner of mines estimated the production for 1902 at 52,582,510 pounds of zinc. This leaves 586,437 pounds for the contents of 1,536 tons of nonargentiferous lead and zinc ore included in previous statements, which would correspond to 19.5 per cent of zinc in the dressed ore. The estimate is apparently too low.

The value reported to the Bureau of the Census is $335,436 for the zinc contents of argentiferous ore and $18,398 for the lead and zinc ores; in all, $353,834. The value reported by the commissioner of mines was computed at the average price for spelter, 4.84 cents per pound, which amounts to $2,544,993. The price realized by the mine operator was about 13.9 per cent of the value of metallic zinc contained in the ore.

The mineralogical character of the zinc bearing ores of Colorado is shown in the following statement:

[1] Report of the State Bureau of Mines of Colorado for the years 1901–2, page 105.

Assay contents of the zinc ores of Colorado: 1902.

CLASS OF ORE.	Number of mines reporting.	Gold value.	Silver value.	LEAD.		ZINC.	
				Pounds.	Value.	Pounds.	Value.
Total	12	$139,619	$633,064	11,316,284	$260,412	51,996,072	$335,436
Associated with gold and silver	2	540	1,937	.....	.....	574,753	5,260
Associated with gold, silver, and lead	7	139,079	616,875	9,290,784	230,206	47,395,139	295,796
Associated with silver and lead	3	.....	14,252	2,025,500	30,206	4,026,180	34,380

A classification of these zinc bearing ores by the commercial value of the principal metal is presented in the following statement:

Classification of zinc bearing ores of Colorado by the commercial value of the principal metals: 1902.

COMPOSITION OF THE ORE.		Value of zinc contents.
Metals of chief value.	Other metals.	
Total		$335,436
Gold and silver	Lead	150,734
Lead	Gold and silver	45,562
Zinc	Lead, gold, and silver	139,140

As appears from the preceding statement, most of the Colorado zinc was a by-product of auriferous and argentiferous lead ore. Lead smelters very reluctantly handle this class of ore; they make no allowance for the zinc, and even charge a penalty in case the assay shows zinc in excess of a certain percentage. According to Census reports, concentration and magnetic separation of zinc ore have been introduced at some mines. Shipments of zinc ore were made to Kansas zinc smelters and to New York for export. Under the stimulus of the growing supply of zinc ore, zinc works have been recently erected in Colorado.

Reports from Utah show 19,582,443 pounds of zinc among the contents of argentiferous lead ore. With the exception of a small shipment assaying 105,000 pounds of zinc, no returns were brought by the zinc, although the rough ore assayed 4.2 per cent zinc. The ore was bought by lead smelters for its gold, silver, and lead contents. In Utah as well as in Colorado there were other mines which produced zinciferous ores; but since the operators received no returns for their zinc, they kept no records of the same, and failed to report it to the Bureau of the Census.

Consumption of zinc ore.—The zinc contents of lead and zinc ore were estimated above at 217,726 tons, exclusive of the contents of 8,725 tons, which could not be estimated with any degree of accuracy. The zinc contents of auriferous and argentiferous ores were given in Census reports from Colorado as 25,998 tons. The reports from Utah showed one shipment of ore assaying 52 tons of zinc, for which payment was received. This makes a total of 243,776 tons of zinc and 8,725 tons of zinc ore. No account is taken of zinciferous ore shipped to lead smelters, there being no positive information to show how the zinc contents of such ores were utilized, or even that they were utilized at all.

The production of spelter for 1902 was reported by the United States Geological Survey as 156,927 tons. Allowing 15 per cent for the loss in smelting, the zinc contents of the ores from which this output was extracted, may be estimated at 184,600 tons. To this must be added the output of zinc oxide, which is manufactured in the United States directly from the ore. The production of zinc oxide for 1902 is estimated[1] at 52,730 tons. The zinc contents of this product, figured at the rate of 80.3 per cent of zinc in the oxide, were equal to 42,342 tons. The total output of zinc in all

[1] The Mineral Industry, Vol. XI, page 600.

forms for 1902 may be estimated therefore at 226,942 tons, or in round numbers at 227,000 tons.

The exports of zinc ore for the calendar year 1902 were 49,762 long tons,[1] or 55,733 short tons. Of this quantity, 20,883 long tons were exported through New York; the rest, with the exception of a small quantity, was exported through Galveston. The New York exports represented New Jersey ores which contained, at an assay rate of about 25 per cent, 5,221 long tons or 5,847 short tons of zinc. The estimated production and consumption would thus compare as follows:

Production and consumption of zinc: 1902.

	Zinc (short tons).	Ore (short tons).
Total production	243,776	8,725
Domestic consumption in the manufacture of spelter and oxides	227,000	.....
Exports:		
New Jersey ores	5,847	.....
Other ores[1]	.....	32,344
Total consumption	232,847	32,344
Excess (+) or deficiency (−) of production over consumption	+10,929	−23,619

[1] 28,879 long tons.

The deficiency of 23,619 tons of ore in the preceding calculation is covered by the excess of 10,929 tons of zinc, which corresponds to an average tenor of 46 per cent zinc in western ores. No account is taken here of the increase or decrease of the stock of ore. It must be understood that these are only rough estimates, allowing a wide range for error.

Tendency toward centralization.—The lead-zinc mining industry has not escaped the general trend of modern business toward centralization. In this respect a marked difference in degree exists between those mines which may be classed as zinc mines, lead being mined only as a by-product, and those which may properly be classed as lead mines, zinc occurring, if at all, as a by-product.

The following table shows the distribution of lead mines by value of production in 1902:

[1] United States Geological Survey, "Mineral Resources of the United States," 1902, page 225.

TABLE 24.—*Classification of lead mines by value of product: 1902.*[1]

PRODUCT PER MINE.	Number of mines.	VALUE OF PRODUCT.			
		Total.	Per cent of total.	Lead.	Zinc.
Total[2]	176	$4,963,625	100.0	$4,743,264	$220,361
Less than $500	45	9,335	0.2	8,777	558
$500 to $999	23	17,784	0.4	15,848	1,936
$1,000 to $9,999	66	210,540	4.2	181,378	29,162
$10,000 to $49,999	29	595,892	12.0	484,236	111,656
$50,000 to $99,999	5	381,737	7.7	304,688	77,049
$100,000 to $499,999	5	1,250,719	25.2	1,250,719	.....
$500,000 and over	3	2,497,618	50.3	2,497,618	.....

[1] A classification by states is impossible without disclosing the identity of some individual establishments.
[2] Custom mills and small mines not included.

The following table shows the zinc mines classified by value of production:

TABLE 25.—*Classification of zinc mines by value of product: 1902.*[1]

PRODUCT PER MINE.	Number of mines.	VALUE OF PRODUCT.			
		Total.	Per cent of total.	Zinc.	Lead.
Total[2]	365	$7,586,992	100.0	$6,912,030	$674,962
Less than $500	26	6,305	0.1	6,020	285
$500 to $999	28	19,586	0.2	17,908	1,678
$1,000 to $9,999	150	629,497	8.3	552,228	77,269
$10,000 to $49,999	118	3,050,173	40.2	2,751,249	298,924
$50,000 to $99,999	36	2,372,151	31.3	2,177,674	194,477
$100,000 and over[3]	7	1,509,280	19.9	1,406,951	102,329

[1] A classification by states is impossible without disclosing the identity of some individual establishments.
[2] Custom mills and small mines not included.
[3] Includes 1 establishment reporting a product of over $250,000 but less than $500,000, and 1 reporting a product of over $500,000.

Missouri.—The state lead and zinc mine inspector of Missouri, in his report for 1902, noted the decrease within recent years of the number of individual operators, who were giving place to large and strong companies.[2] As the mines of Missouri furnish the bulk of the zinc and soft lead production of the United States, the tendencies observed in Missouri may be said to be representative of the industry in general.

In soft lead mining the progress of centralization is far in advance of that manifested by the zinc mining industry. The degree of centralization reached in each branch appears from Tables 26 and 27, which show the distribution of all operators by value of production. This classification does not include the great number of sublessees employing no hired labor.

[2] Sixteenth Annual Report of the State Lead and Zinc Mine Inspector of Missouri, pages 10 and 11.

TABLE 26.—*Classification of lead mines, Missouri, by value of product: 1902.*[1]

PRODUCT PER MINE.	Number of mines.	VALUE OF PRODUCT.			
		Total.	Percentage of total.	Lead.	Zinc.
Total	108	$4,788,799	100.0	$4,596,606	$192,193
Less than $500	20	3,643	0.1	3,190	453
$500 to $999	15	11,248	0.2	9,888	1,360
$1,000 to $9,999	37	127,020	2.6	104,039	22,981
$10,000 to $49,999	23	516,814	10.8	426,464	90,350
$50,000 to $99,999	5	381,737	8.0	304,688	77,049
$100,000 to $499,999	5	1,250,719	26.1	1,250,719	.....
$500,000 and over	3	2,497,618	52.2	2,497,618	.....

[1] Exclusive of the production of sublessees who employ no hired labor.

TABLE 27.—*Classification of zinc mines, Missouri, by value of product: 1902.*[1]

PRODUCT PER MINE.	Number of mines.	VALUE OF PRODUCT.			
		Total.	Per cent of total.	Zinc.	Lead.
Total	254	$6,174,495	100.0	$5,587,181	$587,314
Less than $500	19	4,486	0.1	4,222	264
$500 to $999	15	11,197	0.2	10,523	674
$1,000 to $9,999	82	366,072	5.9	326,533	39,539
$10,000 to $49,999	98	2,600,174	42.1	2,343,122	257,052
$50,000 to $99,999	34	2,266,991	36.7	2,079,535	187,456
$100,000 and over[2]	6	925,575	15.0	823,246	102,329

[1] Exclusive of the production of sublessees who employ no hired labor.
[2] Includes 1 establishment reporting a product of over $250,000.

It is apparent from the preceding tables that the bulk of the zinc mine output of Missouri is the result of production on a middle scale, or from $10,000 to $100,000; very large producers, as well as the very small, falling far behind, while over three-quarters of the output of soft lead is furnished by 8 mines, with a production of more than $100,000 each. Three operators, each with an output exceeding $500,000, produced over one-half of the lead output of the state.

Tables 28 and 29, showing the correlation between the value of production and ownership of mineral lands, have been compiled in this office from the individual reports of mining companies published in the annual report of the lead and zinc mine inspector of the state of Missouri for the year 1902.

TABLE 28.—LEAD MINES OF MISSOURI, ACREAGE OWNED, AND VALUE OF PRODUCT: 1902.

[Compiled from 16th Annual Report of the State Lead and Zinc Mine Inspector of Missouri.]

SIZE OF PROPERTY.	Number of owners.	ACREAGE.		VALUE OF PRODUCT.				
		Total.	Per cent of total.	Total.	Per cent of total.	Per acre.	Lead.	Zinc.
Total[1]	46	90,519	100.0	$4,409,044	100.0	$49	$4,216,692	$192,352
Less than 10 acres	4	19	(2)	11,927	0.3	628	10,064	1,863
10 to 99 acres	18	800	0.9	399,048	9.0	499	253,699	145,349
100 to 999 acres	11	4,282	4.7	504,308	11.4	118	459,168	45,140
1,000 acres and over	12	85,418	94.4	3,493,761	79.3	41	3,493,761	.....

[1] Exclusive of lead valued at $117,374 and zinc at $420, produced by operators who did not report acreage.
[2] Less than one-tenth of 1 per cent.

As appears from the preceding table, the title to all lead bearing lands in Missouri were concentrated in the hands of 45 owners, 94 per cent of all the lands being held by 12 owners in tracts of over 1,000 acres. The same properties furnished over three-fourths (77.74 per cent) of the total production. The production per acre decreased with the increase of the acreage, the range being from $628 per acre for the small properties to $41 per acre for the larger ones; this points to the fact that the larger properties are as yet undeveloped.

TABLE 29.—ZINC MINES OF MISSOURI, ACREAGE OWNED, AND VALUE OF PRODUCT: 1902.

[Compiled from 16th Annual Report of the State Lead and Zinc Mine Inspector of Missouri.]

SIZE OF PROPERTY.	Number of owners.	ACREAGE.		VALUE OF PRODUCT.				
		Total.	Per cent of total.	Total.	Per cent of total.	Per acre.	Zinc.	Lead.
Total[1]	147	35,248	100.0	$7,630,402	100.0	$216	$6,685,875	$944,527
Less than 10 acres	17	85	0.2	230,415	3.0	2,711	215,885	14,530
10 to 99 acres	99	4,148	11.8	3,415,367	44.8	823	3,067,548	347,819
100 to 999 acres	25	6,191	17.6	2,625,250	34.4	424	2,271,784	353,466
1,000 acres and over	6	24,824	70.4	1,359,370	17.8	55	1,130,658	228,712

[1] Exclusive of zinc valued at $174,181 and lead valued at $39,564, produced by operators who did not report acreage.

As appears from the above table, over two-thirds of all the zinc bearing lands were owned by 6 companies. The output, however, did not keep pace with the area owned, since only one-sixth of the total output was produced by these 6 companies. With the increase in the size of the property there was a decrease in the production per acre; while the small properties yielded $2,711 per acre, the largest yielded only $55 per acre. This indicates that the greater part of the extensive zinc bearing fields owned by the larger companies is still awaiting development, whereas the small properties are under active operation.

Local observers have noted the connection between the growth of centralization and the progress of deep mining. Shallow mining, which was universal in the past, has given way to deep mining, as shown in the following table compiled from the Report of the State Lead and Zinc Mine Inspector of Missouri:

TABLE 30.—*Depth of shaft and value of product in Missouri: 1902.*

[Compiled from 16th Annual Report of the State Lead and Zinc Mine Inspector of Missouri.]

AVERAGE DEPTH OF SHAFT.	Number of operators or lessees.	VALUE OF PRODUCT.		
		Total.	Per cent of total.	Average per operator.
Total[1]	189	$11,937,186	100.0	$66,688
Less than 100 feet	35	428,520	3.6	12,243
100 to 199 feet	124	6,812,629	57.1	54,940
200 feet and over	30	4,696,037	39.3	156,535

[1] Exclusive of lead and zinc valued at $433,799, produced from mines that did not report the depth of shaft.

It appears from this table that the bulk of the product was obtained from mines over 100 feet in depth; about two-fifths of the production came from mines over 200 feet in depth. The average value per operator increased with the depth of the mine.

Production on a small scale.—There were in 1902 a number of mines operated by means of animal or hand power only. The Report of the State Mine Inspector of Missouri shows that there were in that state 857 shafts equipped with 639 steam hoisters and 265 horse hoisters. Of the 559 mines and mills reported to the Bureau of the Census, 170 were without mechanical power, 355 possessed mechanical power, 16 were custom mills, and 18 failed to report as to their equipment.

Table 31 shows the average production for all mines and for those using hand and animal power only, by states.

TABLE 31.—*Average production for all mines and for those using hand and animal power only, by states: 1902.*

STATE.	AVERAGE VALUE OF PRODUCT PER MINE.	
	All mines.	With hand and animal power only.
United States	$23,199	$2,852
Illinois	6,473	3,897
Iowa	954	1,726
Kansas	6,351	2,557
Missouri	30,285	2,476
Wisconsin	5,263	3,375

The following table shows the distribution of the mines using only hand and animal power, by value of production, and by states:

TABLE 32.—*Number and value of production of mines without mechanical power, by states: 1902.*

PRODUCT PER MINE.	NUMBER OF MINES.				
	United States.	Kansas.	Missouri.	Wisconsin.	All other states.[1]
Total	170	20	58	73	19
Less than $500	48	4	20	17	7
$500 to $999	28	4	12	10	2
$1,000 to $9,999	82	11	21	42	8
$10,000 to $49,999	12	1	5	4	2

[1] Includes Illinois and Iowa.

Table 33 is a summary showing expenses and product, by states, for mines using hand and animal power only.

TABLE 33.—SUMMARY FOR MINES OPERATED WITHOUT MECHANICAL POWER, BY STATES: 1902.

STATE.	Number of mines.	Number of owners working.	Salaries.	Wages.	Contract work and work on share of product.	Miscellaneous expenses, exclusive of royalties.	Cost of supplies and materials.	PRODUCT.				
								Total value.	Lead.		Zinc.	
									Short tons.	Value.	Short tons.	Value.
United States	170	170	$19,484	$170,354	$29,365	$4,202	$44,087	$484,800	5,015	$236,911	13,543	$247,889
Illinois	5	.....	.....	10,520	.....	.....	1,041	19,486	110	5,406	700	14,080
Iowa	14	14	280	5,766	.....	556	919	24,158	186	9,106	375	15,052
Kansas	20	64	125	9,289	.....	.....	6,609	51,140	543	23,949	903	27,191
Missouri	58	68	9,363	47,104	28,867	2,752	17,183	143,631	2,375	115,603	1,491	28,028
Wisconsin	73	24	9,716	97,675	498	894	18,335	246,385	1,801	82,847	10,074	163,538

A computation from the figures presented shows an average value of about $47 per ton of lead ore. The average computed for all mines of the same states was about $44. The value per ton of zinc ore realized by the operators using only hand and animal power averaged about $18, and the average computed for all mines of the same states was likewise about $18. This shows that in marketing their ores the small operators enjoyed the same facilities as all other competitors in the lead and zinc market.

The detailed statistics of lead and zinc mining for 1902 are given in Table 34.

DESCRIPTIVE.

The earliest discovery of lead on the American continent is recorded fourteen years after the landing of the first English settlers in Virginia. In 1621 lead deposits were found in the vicinity of Falling creek, near Jamestown. The steady tide of European immigration in the seventeenth and eighteenth centuries caused a growing demand for bullets and stimulated further discoveries wherever the settlements of the colonists extended. The French acquainted the northwestern Indians with firearms, inducing them to hunt

fur bearing animals on a large scale; consequently lead assumed a value in the eyes of the Indians, both for use in making bullets for their own weapons and as an article of traffic. Toward the close of the seventeenth century the Indians living in the region comprising portions of the present states of Wisconsin, Illinois, and Iowa, were smelting lead and bartering it with the French traders. In the second half of the eighteenth century lead had become of such importance in the trade of the upper Mississippi country that it served as currency, the rate of exchange being a peck of corn for a peck of ore. In 1810 Nicholas Boilvin, United States Indian agent at Prairie du Chien, went on foot from Rock Island to the mouth of the Wisconsin, and reported that the Indians of the region had "mostly abandoned the chase, except to furnish themselves with meat, and turned their attention to the manufacture of lead."[1]

Previous to the Louisiana purchase nearly all the valuable lead mining lands were within the domains of France and Spain. Soon after these lands had passed under the jurisdiction of the United States, Congress, by the act of March 3, 1807, reserved all Government lands bearing lead ores, and authorized leases of these lands. The first leases provided for a 10 per cent royalty on the lead produced; the rate was afterwards reduced to 6 per cent. No leases were issued until 1822, when crowds of prospectors began to enter this region. A few years later the mines gave employment to over 2,000 men, many of them farmers, who with their slaves spent only their spare time in the mines. The royalties were paid with some regularity for a short time only; after 1834, as a consequence of the immense number of illegal entries of mineral land at the Wisconsin land office, the smelters and miners refused to make any further payments, and the Government was unable to collect any royalty from them. After much trouble and expense, it was, in 1847, finally concluded to sell the mineral lands.[2]

The chief lead mining districts, which to-day furnish the bulk of the lead production of the United States, were not developed until much later. The lead deposits of the Joplin-Galena district, embracing southwestern Missouri and part of Kansas, were discovered in 1848, but attracted little attention before the Civil War. The great western deposits of argentiferous galena were discovered in 1864, but could not be worked profitably until the extension of the railroads through that region.

Methods of mining and smelting.—The early methods of lead mining on this continent were extremely crude. The Indians, who during the time of the French dominion were the chief producers, only skimmed the surface, although occasionally they would drift for some distance into the sidehills, and when they reached rock would build a fire under it and crack it by dashing cold water on the heated surface. Their tools, in the earliest times, were buckhorns, many of which were found in abandoned drifts by the first white settlers, but in the eighteenth century they obtained iron implements from the traders to whom they sold their lead. The Indians loaded their ore in the shafts into tough deerskins, the bundle being hoisted to the surface or dragged up inclined planes by long thongs of hide. Many of these leads, abandoned by the Indians when the work of developing them became too great for their simple tools, were found at a later epoch to be among the most profitable in the region.

Improvement in the method of working the mines was very slow for a long time after the advent of white miners. The first shaft in a lead mine in Missouri was sunk about the beginning of the nineteenth century. Schoolcraft, who visited the lead mining district in 1819, found about 40 mines, 4 or 5 of which had regular shafts. There was not an engine of any kind—horse, steam, or water power—for removing water from the mines, several of which, with the richest prospects in view, had been abandoned on this account.

The reduction of lead ore to the metallic state was in the earliest times not differentiated from mining. Any man who found a vein could mine and smelt the ore roughly himself. The methods of smelting were crude in the extreme. A hole was dug in the ground and lined with rocks. This was usually located on a hillside for the purpose of getting a strong air draft. Hollow log heaps were reared; the centers were filled with mineral; then as much wood as possible was piled on top of and around the heaps, and the mass was fired, with the result that a portion of the ore was smelted and ran into trenches in the ground. Sometimes this operation had to be repeated three times. Rough pigs run into a scooped-out hollow in the earth itself, and weighing about 75 pounds, were usually made by the Indian squaws. This method of smelting was wasteful, but since the supply of ore was apparently unlimited the same practice was followed as late as the first quarter of the nineteenth century by white miners, as well as by operators who worked their mines with slave labor. About that time smelting began to be specialized by ore buyers as a separate occupation. The methods of reduction practiced in those days are thus described by Schoolcraft:

> Having raised a sufficient quantity of ore for smelting, the next process consists in cleaning the ore from all extraneous matter. This is done by small picks, tapered down to such a point that a careful hand may detach the smallest particle of adhering spar. It is necessary that the ore should be well cleaned, for it would otherwise prove refractory in smelting. If there be any lumps of uncommon size, these are beaten smaller. The object is to bring the lumps as near as may be to a uniform size, so that the heat may operate equally in desulphurating the ore. It is desirable that the lumps should be about the bigness of a man's two fists, or about 15 pounds in weight; if too small, a difficulty and a waste is experi-

[1] Early Lead Mining in Illinois and Wisconsin, by Reuben Gold Thwaites, in Report of American Historical Association, 1893, page 191ff.

[2] Metallic Wealth of the United States, by J. D. Whitney, page 405.

enced in smelting. In this state the ore is conveyed to the furnace and piled on the logs prepared for its reception. When the charge is put in, which may in a common way be about 5,000 pounds, it is surrounded by logs of wood and covered over at the top and the fire is lit up at the mouth below. A gentle warmth is given at first, which is raised very gradually and kept at this point for about twelve hours to allow the sulphur to dissipate; the heat is then increased for the purpose of smelting the ore, and in twelve hours more the operation is completed and the lead obtained. Wood is occasionally added as the process goes on, and there is a practical nicety required in keeping the furnace in proper order, regulating the draft of air, etc., so that some smelters are much more expert, and thereby extract a greater quantity of lead from a like body of ore than others. This furnace is called the log furnace, and so far as I know, is peculiar to this country. It is of very simple construction, consisting of an inclined hearth, surrounded by walls on three sides, open at top, and with an arch for the admission of air below, and upon the whole it appears well adapted to the present situation and circumstances of the people. It is cheap, simple, may be built at almost any place, and answers the purpose very well. A good furnace of this kind may be built at an expense of from $50 to $60, every expense considered.[1]

It does not seem from this description that the white miners and smelters had by that time made much improvement upon the primitive methods of the Indians. It was not before 1836 that the log furnace was superseded by the blast furnace.

Ignorance of scientific methods caused the early miners to throw away the lead carbonate, or cerussite, which they called "dry bone" and considered worthless. It accumulated in great heaps until the arrival, in 1838, of a German named Hagen, who knew the value of "dry bone," and erected furnaces for its reduction. The result of the utilization of the cerussite was a largely increased production.

Utilization of zinc ore.—The ignorance of the practical miner likewise retarded the utilization of zinc ores, which are associated with lead ores and now constitute the chief value of the output of the zinc-lead mines. The presence of zinc in the lead mines of the Mississippi valley was noted by Schoolcraft, who wrote as early as 1819:

Considering the rarity of this metal in America, and its extensive usefulness, which is yearly increasing, I have no doubt it will shortly attract the attention of some capitalist and become a source of much profit.[2]

It took, however, more than half a century before the prediction was fulfilled. Whitney, writing thirty-five years later, gave expression to the following view:

No one acquainted with the manufacture of zinc ores into metal or oxide would recommend the establishment of works for this purpose in the western lead region, as the business can not be made profitable against the competition of the Belgian and Prussian manufactories, except under the most favorable circumstances of situation and an abundant supply of ore which can be obtained without any considerable mining cost. The zinc deposits of the West do not satisfy these conditions either as regards quantity or quality of the ore or of the proximity of fuel.[3]

[1] View of the Lead Mines, by Henry Rowe Schoolcraft, pages 93 and 94.
[2] Ibid., page 56.
[3] Metallic Wealth of the United States, page 352.

These words of one who was an expert in his own time have a peculiar sound to-day, when it is considered that over $8,000,000 was won from the western zinc deposits in 1902.

For over half a century zinc ore was taken out of the mines of the southwestern part of Missouri, in connection with lead ore, and thrown upon the dump pile as worthless. Mines were deserted because of the prevalence of this refuse or "tiff," as it was called by the miners. In the early seventies this peculiar looking substance, which was causing the lead miners so much trouble, was examined by a geologist and pronounced to be zinc ore. A carload of it was shipped to Lasalle, Ill., for treatment. The smelter returned $15 for the carload, telling the shippers that it was a high grade of zinc ore. This led to further shipments of the ore. Abandoned mines were gradually reopened because of the zinc ore they contained, and in 1902 the zinc product of Missouri was more than eleven times the value of all the zinc ore mined in the Eastern states, where zinc mining dates back to 1848, and where the mines were the main source of the domestic zinc supply previous to the development of the Joplin-Galena district.

Business organization.—The last twenty years in the history of the lead-zinc mining industry have been a period of change. A contemporaneous description of the business methods of twenty years ago is given in the following excerpts:

When a good prospect is discovered in new ground the land around it is leased from the original owners on royalties ranging from 10 to 25 per cent by a number of individuals, who organize various mining, or, as they would more properly be called, land companies. These companies have the land divided up into lots 200 feet square, and a plat of it made; select certain lots for themselves, and throw the others open to miners. They usually start a shaft on one of their own lots, and put in a pump. If the indications continue good, many of the lots, particularly those near the pump shaft, are quickly taken up by parties of miners who sink shafts upon them, timber the ground, put up hoisting contrivances, furnish all supplies, and bear all expenses.

When ore is struck it is drifted on and followed in all directions up to the boundaries of the lot in question. The ore is raised to the surface and crushed and washed by the miners, and is sold to one of the zinc or mineral buyers. It is weighed over the company's scales, and paid for to the company, which deducts a royalty of 25 per cent on zinc blends and 50 per cent on "mineral" (galena); and if it has pumps running, a pump rent of $1 a ton on zinc ore and $2 on 1,000 pounds of galena; and pays over the balance to the miners. The royalties, of course, vary with circumstances, but the above are general.[4]

With a few exceptions all the mining was done by small companies, mostly unchartered associations of persons living in the immediate neighborhood. Some storekeeper, farmer, or local capitalist furnished the small amount of money needed for tools; and the men who worked in the ground in winter usually engaged in farm work during the summer. The ore was generally raised to the surface by a windlass, and cleaned by hand

[4] United States Geological Survey, "Mineral Resources of the United States," 1882, pages 369 and 370.

with a "pickawee" hammer, or crushed with a "bucking iron" on a flat stone, or by an itinerant horsepower crusher, and was concentrated by sluicing and hand jigging. The holders of lots sometimes put up crushing and washing machinery on their lots.

The machinery is usually of the simplest description—a farm or small stationary engine, covered by a shed of rough boards, a small-sized Blake's breaker, set over a pair of rolls, and a horse whim or a whip. The jigs are ordinary hand jigs, with an overhead breakstaff, working a sieve 2 by 3½ feet up and down in a box of water. The jigging is usually done by contract, and is paid for by the ton of cleaned ore. It is common to see from 10 to 20 of these jigs grouped together under a shed of poles, covered with branches of trees or rough boards.[1]

The smelting companies which drew their ore supply from this district had their resident or traveling purchasing agents. Most of the miners were poor and unable to work their diggings to good advantage, or to hold their ore long after it was cleaned.

The labor was to a considerable extent performed by miners working upon their own account. Men with no capital but their picks and shovels would lease small mining lots and try their luck. The advantages of the leasing system to the landowner and mine operator, as compared with the regular wage system, are further explained in the same article. The miners, working on their own account, with hopes of large ultimate gains, have every inducement to work hard and cheaply, and to follow every clew that working prospectors, who, during the season wander from place to place, and follow every real or supposed indication of ore, may find.

How else, it may be asked, could prospecting be so well or so cheaply done? And there is a class of enterprising, skillful, well-to-do miners, naturally associated as partners, who have made one or more good strikes, and are always ready to take hold of any new venture that promises well, either in working a lot or in forming a land company to open new mines. Where else could be found capitalists so willing to risk their money in a speculative venture? Men of this sort are always ready and able to work themselves, or to direct the work above or below ground. How else could be obtained as willing and as watchful superintendents, foremen, and clerks?[2]

The leasing system has maintained itself up to the present day in zinc mining. A comprehensive description of this system is given in a recent pamphlet by a local expert, Mr. Frank Eberle:

The methods of mining and handling zinc ore are * * * unlike those used in mining for other minerals. The first step necessary is to secure the land upon which to begin operations. Zinc mining lands are seldom sold, their owners preferring to lease them on royalty. Virgin lands, or those on which no mineral has been found, or which have never been prospected for mineral, are leased at 10 per cent royalty, that is to say, the landowner leases the land and agrees to take as payment one-tenth of all the ore obtained from his land. The company or individual who secures the lease then divides the tract up into 1-acre mining lots and prospects the land with a steam drill in several places to ascertain whether the land contains mineral, and where the best bodies of ore are located, their depth, thickness, and the force of water that the miners will have to contend with. When the land has been sufficiently prospected, lots are then subleased to miners at 20 per cent royalty, which means that the miners must give 20 per cent, or one-fifth, of the ore to the company or individual holding the original lease. Out of this 20 per cent the original lessee must pay the landowners 10 per cent, and generally he must also undertake to put in pumping plants, to keep the tract drained, where the water is so strong as to interfere with mining. The miners lease one or more lots from the lessee of the tract, and begin operation by sinking a shaft. * * *

The zinc ore, or "jack," is purchased at the mines by "jack" buyers representing American and European smelters. These buyers * * * bid on the week's output of zinc ore. They make an offer of so much a ton for all of the ore to be taken out of the mine during the week. If the offer is accepted, the "jack" buyer sends his wagons to the mines, and hauls the ore to the cars for shipment to the smelters for which he buys. Every Saturday evening is settling-up time. Then the mine owners, miners, and ore buyers assemble in the various towns in the district, and the ore buyer draws a check for the ore purchased from each mine. The check is made payable to the landowner upon whose property the ore was mined. He takes out his 10 per cent royalty, and passes the balance to the original lease holder, who takes out his 10 per cent royalty and gives the balance to the mine operator, who pays his operating expenses out of the share he receives.[3]

The larger companies which have their own smelters buy all the ore from their lessees at a stipulated price, deducting from the same their royalties.

Mining in a small way.—It is of great theoretical and practical interest to note the special conditions which have permitted of the survival of zinc-lead mining on a small scale, and often with primitive methods, amid concentration of ownership in mineral lands.

The subject is treated from a technical point of view in the Twenty-second Annual Report of the United States Geological Survey, from which the following is quoted:

The individual ore bodies are rarely large. The mines must accordingly be short lived, and the plants must be built to meet that condition. In a district where it is cheaper to sink a new shaft than to tram ore 600 or 700 feet underground, central shafts of large capacity are out of place. Large central mills to which the ore of a whole tract is brought are not considered a good investment. In hauling 100 tons of 10 per cent ore 90 tons of waste drift are moved, and when simple and effective mills of small capacity are so easily and cheaply built and run, individual mills are to be preferred, even though the larger mill be able to make a slight saving per ton in mill charges. It is difficult to supply dirt steadily enough to keep a large mill running, and loss of time is more costly with a large than a small plant. The mills of the district * * * are very simple, and are developed on the principle of using a rougher jig before cleaning, instead of attempting close sizing. The result is a very great capacity at small cost. The saving is not so close as in a well-run sizing mill, but the extra ore saved by the latter is not in this district worth the added cost

[1] United States Geological Survey, "Mineral Resources of the United States," 1882, page 370.
[2] Ibid., page 371.
[3] Frank Eberle, Zinc Mining, pages 8 and 20.

of saving it. * * * A hundred-ton mill can be built in the district at a general price of $6,500 to $7,000, and the opening and equipping of a mine costs ordinarily, approximately, $10,000. The mill can be run by four men. To that number must be added a hoisterman and an underground force. * * * The mill and plant are of such style as to be readily torn down and moved when the particular ore body is worked out, and the whole plant is designed for rapid work. Economy is sought in first cost rather than in refinements of efficiency. * * * The whole style of equipment and the methods of mining and milling are designed to meet the conditions of short-lived individual deposits of low-grade ore.[1]

The higher cost of running small plants, as compared with mines operated on a large scale, comes from the expensive methods of generating and distributing power, but it is the opinion of Mr. Bain that, with modern methods of power transmission, this difficulty can be overcome by the development of central power plants.

[1] Twenty-second Annual Report of the United States Geological Survey, Part II, 1900–1901. Preliminary report on the lead and zinc deposits of the Ozark region, by H. F. Bain, page 227.

Though the actual operation of the mines is to some extent still conducted on a small scale, the tendency toward combination has not been without effect upon the zinc-lead mining industry.

Both the productive capacity and the consumptive demand for spelter have been centralized in a striking manner. Upward of 50 per cent of the consumption of spelter in the United States is for the purpose of galvanizing iron, which business is now chiefly in the hands of the constituent companies of the United States Steel Corporation. The manufacture of sheet zinc is in the hands of four companies. The manufacture of brass in Connecticut, which is the principal center of that industry, is controlled by one company. The consumption of spelter for use in the desilverization of lead is also chiefly in the hands of one corporation. It is safe to say, therefore, that 75 or 80 per cent of the demand for American spelter now comes from seven corporations. On the other hand, the production of spelter has also been centralized, practically the whole of the active smelting capacity being now divided among seven concerns.[2]

[2] Production and Properties of Zinc, pages 46 and 47.

TABLE 34.—DETAILED SUMMARY: 1902.

	United States.	Colorado.	Illinois.	Iowa.	Kansas.	Missouri.	Wisconsin.	All other states and territories.[1]
Number of mines	559	3	14	14	57	374	90	7
Number of operators	557	3	14	14	57	374	90	5
Character of ownership:								
Individual	66	.....	4	2	4	48	5	3
Firm	323	2	6	12	44	189	70	.....
Incorporated company	159	1	4	.....	8	129	15	2
Other form	9	.....	.....	.....	1	8	.....	.....
Salaried officials, clerks, etc.:								
Total number	910	3	12	1	35	777	50	32
Total salaries	$826,327	$2,025	$9,120	$280	$21,143	$727,021	$26,202	$40,536
General officers—								
Number	76	1	2	.....	.....	65	.....	8
Salaries	$195,910	$500	$1,000	.....	.....	$176,650	.....	$17,760
Superintendents, managers, foremen, surveyors, etc.—								
Number	363	2	7	1	14	289	33	17
Salaries	$365,089	$1,525	$6,870	$280	$11,746	$307,470	$19,294	$17,904
Foremen below ground—								
Number	366	.....	1	.....	19	329	17	.....
Salaries	$209,808	.....	$500	.....	$8,827	$193,573	$6,908	.....
Clerks—								
Number	105	.....	2	.....	2	94	.....	7
Salaries	$55,520	.....	$750	.....	$570	$49,328	.....	$4,872
Wage-earners:								
Aggregate average number	7,881	5	104	13	223	6,612	417	507
Aggregate wages	$4,329,271	$5,475	$51,565	$5,766	$140,249	$3,691,923	$192,209	$242,084
Above ground—								
Total average number	3,443	1	28	6	120	2,845	122	321
Total wages	$1,948,180	$1,125	$14,967	$2,544	$80,203	$1,638,482	$56,924	$153,935
Engineers, firemen, and other mechanics—								
Average number	1,149	1	11	.....	36	1,007	27	67
Wages	$727,232	$1,125	$6,310	.....	$23,253	$642,665	$13,850	$40,029
Miners—								
Average number	290	.....	10	6	7	155	82	30
Wages	$146,373	.....	$4,556	$2,544	$4,000	$87,310	$37,064	$10,899
Boys under 16 years—								
Average number	23	.....	1	.....	.....	21	1	.....
Wages	$5,644	.....	$175	.....	.....	$5,203	$266	.....
All other wage-earners—								
Average number	1,981	.....	6	.....	77	1,662	12	224
Wages	$1,068,931	.....	$3,926	.....	$52,950	$903,304	$5,744	$103,007
Below ground—								
Total average number	4,438	4	76	7	103	3,767	295	186
Total wages	$2,381,091	$4,350	$36,598	$3,222	$60,046	$2,053,441	$135,285	$88,149
Miners—								
Average number	3,010	4	74	7	98	2,471	282	74
Wages	$1,679,325	$4,350	$35,758	$3,222	$56,771	$1,413,280	$129,465	$36,484
Miners' helpers—								
Average number	658	.....	2	.....	5	544	.....	107
Wages	$317,050	.....	$845	.....	$3,275	$264,064	.....	$48,866
Boys under 16 years—								
Average number	7	.....	.....	.....	.....	7	.....	.....
Wages	$947	.....	.....	.....	.....	$947	.....	.....
All other wage-earners[2]—								
Average number	763	.....	.....	.....	.....	745	13	5
Wages	$383,769	.....	.....	.....	.....	$375,150	$5,820	$2,799

[1] Includes operators distributed as follows: Arizona, 1; Kentucky, 1; New Jersey, 1; New Mexico, 1; New York, 1; Virginia (2 mines; operator reported under iron ore).

[2] Includes timbermen and track layers.

TABLE 34.—DETAILED SUMMARY: 1902—Continued.

	United States.	Colorado.	Illinois.	Iowa.	Kansas.	Missouri.	Wisconsin.	All other states and territories.
Average number of wage-earners at specified daily rates of pay:								
Engineers—								
$1.25 to $1.49	2						2	
$1.50 to $1.74	44		5			24	9	6
$1.75 to $1.99	73				2	61	6	4
$2.00 to $2.24	176		3		17	149	5	2
$2.25 to $2.49	85		1		6	78		
$2.50 to $2.74	117				4	111		2
$2.75 to $2.99	5					5		
$3.00 to $3.24	24					24		
$3.50 to $3.74	1							1
$4.00 to $4.24	1	1						
Firemen—								
$1.25 to $1.49	53					53		
$1.50 to $1.74	104		1			100	1	2
$1.75 to $1.99	7					7		
$2.00 to $2.24	41				1	36		4
$2.25 to $2.49	8					8		
$2.50 to $2.74	10					10		
$3.00 to $3.24	1					1		
Machinists, blacksmiths, carpenters, and other mechanics—								
$1.00 to $1.24	1					1		
$1.25 to $1.49	11					11		
$1.50 to $1.74	54		1			37	2	14
$1.75 to $1.99	51				1	41		9
$2.00 to $2.24	159				3	142	2	12
$2.25 to $2.49	49				1	46		2
$2.50 to $2.74	42				1	38		3
$2.75 to $2.99	7					5		2
$3.00 to $3.24	17					16		1
$3.25 to $3.49	3					1		2
$3.50 to $3.74	2					1		1
$3.75 to $3.99	1					1		
Miners—								
$1.00 to $1.24	47					19	2	26
$1.25 to $1.49	300					209	91	
$1.50 to $1.74	909		72	13		529	256	39
$1.75 to $1.99	308				29	227	13	39
$2.00 to $2.24	1,217		11		73	1,131	2	
$2.25 to $2.49	414		1			413		
$2.50 to $2.74	93				3	90		
$2.75 to $2.99	2					2		
$3.00 to $3.24	8	3				5		
$3.25 to $3.49	1					1		
$3.50 to $3.74	1	1						
Miners' helpers—								
$1.00 to $1.24	4					4		
$1.25 to $1.49	302		2			300		
$1.50 to $1.74	183					76		107
$1.75 to $1.99	21				1	20		
$2.00 to $2.24	124				4	120		
$2.25 to $2.49	24					24		
Timbermen and track layers—								
$1.25 to $1.49	11					11		
$1.50 to $1.74	7					5		2
$1.75 to $1.99	3							3
$2.00 to $2.24	13					13		
$2.25 to $2.49	1					1		
$3.00 to $3.24	1					1		
Boys under 16 years—								
Less than $0.50	5					5		
$0.50 to $0.74	12					11	1	
$0.75 to $0.99	5					5		
$1.00 to $1.24	5		1			4		
$1.25 to $1.49	1					1		
$1.50 to $1.74	2					2		
All other wage-earners—								
$0.50 to $0.74	2							2
$0.75 to $0.99	2							2
$1.00 to $1.24	108					78		30
$1.25 to $1.49	691				1	589	4	97
$1.50 to $1.74	750				2	680	15	53
$1.75 to $1.99	220		5		10	201	4	
$2.00 to $2.24	571				39	490	2	40
$2.25 to $2.49	207					207		
$2.50 to $2.74	47				4	43		
$2.75 to $2.99	12					12		
$3.00 to $3.24	92		1		18	73		
$3.25 to $3.49	6				3	3		
Average number of wage-earners employed during each month:								
Men 16 years and over—								
January	7,325		97	12	175	6,135	445	461
February	7,266		94	16	167	6,153	415	421
March	7,465		96	16	187	6,277	427	462
April	7,608		111	13	209	6,415	393	467
May	7,965	20	115	16	207	6,726	364	517
June	7,996	20	124	9	197	6,750	388	508
July	8,008	20	82	7	227	6,766	390	516
August	8,181		98	9	238	6,890	407	539
September	8,067		114	16	258	6,689	437	553
October	8,125		92	12	270	6,729	463	559
November	8,034		82	13	273	6,710	431	525
December	8,172		131	17	268	6,768	432	556
Boys under 16 years—								
January	27		2			25		
February	27		2			25		
March	28		2			26		
April	28		2			26		
May	31		2			26	3	
June	32		2			27	3	
July	35					32	3	
August	31					30	1	
September	32					31	1	
October	32					31	1	
November	27					27		
December	30					30		

TABLE 34.—DETAILED SUMMARY: 1902—Continued.

	United States.	Colorado.	Illinois.	Iowa.	Kansas.	Missouri.	Wisconsin.	All other states and territories.
Contract work:								
Amount paid	$108,607	$800	.....	.....	$922	$105,877	$1,008	.....
Number of employees	223	4	.....	.....	11	198	10	.....
Miscellaneous expenses:								
Total	$2,092,001	$190	$11,079	$2,511	$151,279	$1,768,458	$54,534	$103,650
Royalties and rent of mine and mining plant	$1,525,368	.....	$9,853	$1,955	$140,736	$1,235,753	$52,876	$84,195
Rent of offices, taxes, insurance, and all other sundries	$566,633	$190	$1,226	$556	$10,543	$532,705	$1,658	$19,455
Cost of supplies and materials	$2,511,657	$3,000	$20,464	$919	$84,313	$2,189,461	$56,774	$156,726
Value of product	[1] $14,600,177	$22,398	$90,619	$13,358	$737,656	$12,555,580	$473,652	$706,914
Power:								
Total horsepower	41,901	70	412	.....	2,512	35,680	846	2,381
Owned—								
Engines—								
Steam—								
Number	1,060	1	14	.....	92	904	25	24
Horsepower	38,616	50	364	.....	2,512	32,953	617	2,120
Gas or gasoline—								
Number	32	1	4	.....	.....	6	17	4
Horsepower	431	20	48	.....	.....	113	229	21
Water wheels—								
Number	8	.....	.....	.....	.....	3	.....	5
Horsepower	320	.....	.....	.....	.....	80	.....	240
Other power—								
Number	39	.....	.....	.....	.....	39	.....	.....
Horsepower	2,335	.....	.....	.....	.....	2,335	.....	.....
Rented—								
Electric, horsepower	7	.....	.....	.....	.....	7	.....	.....
Other power, horsepower	192	.....	.....	.....	.....	192	.....	.....
Electric motors owned—								
Number	45	.....	4	.....	2	32	2	5
Horsepower	1,475	.....	39	.....	35	1,167	12	222
Supplied to other establishments, horsepower	91	.....	.....	.....	30	61	.....	.....

[1] Includes $1,965,779 for which no individual reports were received.

COPPER ORE

COPPER ORE.

By Isaac A. Hourwich, Ph. D.

The statistics for copper ore in this report are those of mines producing ores, the principal or only value of which is their copper contents. The statistics for ore dressing works (stamp mills and concentrating plants) connected with copper mines are included in the returns. Copper is recovered also as a by-product of the smelting of ores valued chiefly for their precious metal contents. All statistics relating to the mining of these ores are included in the returns for gold and silver mines. Smelters are regarded as manufacturing establishments and were included in the Report on Manufactures of the Census of 1900.

The following table is a comparative summary of the statistics of copper mines from 1860 to 1902:

Table 1.—COMPARATIVE SUMMARY: 1860 TO 1902.

	1902	1889 [1]	1880	1870	1860
Number of mines	144	(2)	42	[3] 40	[3] 47
Number of operators	144	(2)	(2)	(2)	(2)
Salaried officials, clerks, etc.:					
Number	1,208	[4] 70	219	(5)	(5)
Salaries	$1,768,456	$123,236	(6)	(5)	(5)
Wage-earners:					
Average number	26,007	[4] 9,750	6,039	5,404	5,153
Wages	$21,151,405	$6,610,781	[6] $3,214,031	$2,706,264	$1,816,160
Contract work	$188,768	$337,061	(2)	(2)	(2)
Miscellaneous expenses	$1,397,465	$1,852,758	(2)	(2)	(2)
Cost of supplies and materials	$11,083,175	$5,638,694	$1,391,826	$586,844	$506,814
Product:					
Quantity of ore mined, short tons	11,780,064	3,322,742	1,007,490	(2)	(2)
Copper contents of ore shipped and milled, pounds	625,004,529	220,569,438	56,115,454	(2)	(2)
Value at mine of ore shipped and milled	$51,178,036	(2)	[7] $8,856,869	$5,201,312	$3,361,222

[1] Detailed figures shown only for Michigan, Montana, Arizona, and New Mexico.
[2] Not reported.
[3] Establishments.
[4] Foremen included in wage-earners.
[5] Not reported separately.
[6] Salaries included in wages.
[7] Value of 5,410,546 pounds of copper for Western states and 153,880 pounds for Tennessee not reported.

During the forty-two years covered by the table the growth of copper mining has been very marked, the value of products having increased $47,816,814, or over fourteenfold. The increase in the total wages was $19,335,245, or nearly elevenfold.

It was found that in most of the active mines no separate account was kept for development work. The expenses of producing mines, therefore, include the cost of development work incidental to mining. Considerable development work was done in mines that reported no production. Most of them were located in the Western states, where the mineralogical character of the ore was described as auriferous and argentiferous copper, yet it would not be practicable to classify such mines as copper, or gold and silver mines, in accordance with the chief valuable element of the ore, before they have become regular producers. In most cases the work was prosecuted in the expectation of developing a gold and silver mine. All such mines were, therefore, classed as gold and silver mines. Distinctively copper mines in the development stage were reported from the following states: Michigan, 10 mines; Wisconsin, Maryland, Georgia, Tennessee, and Missouri, 1 mine each. The statistics for these mines are not included in the preceding summary for producing mines, but are presented separately in the following statement:

Development work: 1902.

Number of mines	15
Number of operators	15
Salaried officials, clerks, etc.:	
Number	55
Salaries	$64,208
Wage-earners:	
Average number	302
Wages	$184,424
Contract work	$200
Miscellaneous expenses	$38,530
Cost of supplies and materials	$135,847

Number of mines and operators.—The terms "mine" and "operator," as used in this report, require a word of explanation. In some cases certain properties were combined by the owner under one management and reported as one mine, while others were operated as separate mines and so reported. When a "group" of mines was included in one report, it was very largely a matter of opinion whether all or some of the properties constituting the group were to be considered as separate mines, or whether all properties had been merged into one mine. The only reliable unit of enumeration was the reporting corporation, firm, or individual. Among these were 2 corporations whose mines were operated by lessees and 1 holding company, the Amalgamated Copper Company. The capitalization of the first two was a distinct element of the capital invested in copper mining, quite independent of the capital invested by the lessee, and it was believed, therefore, that this ought to be included in the total capitalization reported for the copper mining industry. As regards the Amalgamated Copper Company, it is a matter of opinion whether it or the companies whose entire stock is owned by it should be regarded as the actual operators. It was therefore thought preferable to show in the tables the total number of companies reporting. If the holding company and the two lessors are excluded from the total number reporting, then the number of operators was 141. If, on the other hand, the constituent companies of the Amalgamated Copper Company are excluded, then the total number of operators was 136.

Character of ownership.—The corporate form of ownership was the predominating type in the copper mining industry. Of the 144 operators 100 were incorporated companies, 23 were firms or limited partnerships, 19 were individuals, 1 was a cooperative association, and 1 was an estate. In Michigan all copper mining operators were incorporated.

A summary of all copper mines, classified by character of ownership, is presented in Table 2.

TABLE 2.—*Summary, by character of ownership: 1902.*

	Total.	Individual.	Firms, etc.[1]	Incorporated companies.
Number of operators	144	19	25	100
Salaries	$1,768,456	$27,095	$23,395	$1,717,966
Wages	$21,151,405	$434,059	$138,048	$20,579,298
Contract work	$188,768	$1,100	$4,100	$183,568
Miscellaneous expenses	$1,397,465	$31,084	$7,620	$1,358,761
Cost of supplies and materials	$11,083,175	$202,516	$70,693	$10,809,966
Ore shipped and milled:				
Short tons	11,464,868	156,833	11,178	11,296,857
Value at mine	$51,178,036	$594,377	$161,822	$50,421,837
Bullion contents—				
Copper—				
Pounds	625,004,529	10,388,443	2,060,802	612,555,284
Value	$70,175,810	$919,094	$207,783	$69,048,933
Silver	$5,833,256	$333,932	$32,400	$5,466,924
Gold	$1,854,025	$67,823	$3,929	$1,782,273
Other metals	$19,075	$489	$600	$17,986
Total gross value	$77,882,166	$1,321,338	$244,712	$76,316,116
Crude ore sold	$5,791,928	$968,786	$227,554	$4,595,588
Dressed ore sold	$8,615,960	$315	$4,230	$8,611,415
Ore smelted	$63,474,278	$352,237	$12,928	$63,109,113

[1] Includes 2 mines classed under "other forms."

It appears from the preceding table that the share contributed by each class of operators to the output of the mines was as follows: Incorporated companies, $50,421,837, or 98.5 per cent; individuals, $594,377, or 1.2 per cent; firms, $161,822, or three-tenths of 1 per cent. About three-fourths of the copper ore mined by individuals and firms was sold in the crude state, the remaining one-fourth being dressed or smelted at the mine. The incorporated companies, on the contrary, sold only 6 per cent of their ore in the crude state, namely, a product valued at $4,595,588; the value of dressed ore sold by them was $8,611,415, or 11.3 per cent, and that of ore smelted at the mine or shipped to smelters operated by the same companies was $63,109,113, or 82.7 per cent.

Capital stock of incorporated companies.—The capitalization of the incorporated companies is shown in Table 3. In the consideration of the capitalization of the copper mining companies, it should be borne in mind that a portion of the capital stock of some of them represented the value of smelting plants owned and operated by the same companies.

TABLE 3.—CAPITALIZATION OF INCORPORATED COMPANIES: 1902.

	United States.	Arizona.	California.	Colorado.	Idaho.	Michigan.	Montana.	Nevada.
Number of incorporated companies	100	21	4	13	1	20	14	1
Capital stock and bonds issued	$378,815,800	$31,302,493	$9,416,597	$7,735,585	$2,000,000	$46,453,750	$253,548,400	$86,500
Capital stock:								
Total authorized—								
Number of shares	45,218,707	8,690,000	1,250,000	10,951,000	200,000	1,960,000	6,395,000	200,000
Par value	$441,788,125	$33,780,000	$10,633,125	$9,965,000	$2,500,000	$49,000,000	$299,625,000	$100,000
Total issued—								
Number of shares	32,390,560	6,911,026	1,000,020	8,086,500	150,000	1,908,150	5,704,194	173,000
Par value	$372,240,270	$28,302,963	$9,416,597	$7,735,585	$1,500,000	$46,453,750	$251,547,400	$86,500
Dividends paid	$14,116,002	$3,667,036	$291,990	$7,000	.....	$3,290,000	$6,325,976	.....
Common—								
Authorized—								
Number of shares	42,318,707	8,690,000	1,000,000	8,851,000	200,000	1,960,000	6,345,000	200,000
Par value	$429,321,625	$33,780,000	$5,766,625	$7,865,000	$2,500,000	$49,000,000	$294,625,000	$100,000
Issued—								
Number of shares	31,105,560	6,911,026	750,020	7,101,500	150,000	1,908,150	5,654,194	173,000
Par value	$361,388,770	$28,302,963	$4,550,097	$6,750,585	$1,500,000	$46,453,750	$246,547,400	$86,500
Dividends paid	$13,667,012	$3,667,036	.....	.....	.....	$3,290,000	$6,175,976	.....
Preferred—								
Authorized—								
Number of shares	2,900,000	.....	250,000	2,100,000	.....	.....	50,000	.....
Par value	$12,466,500	.....	$4,866,500	$2,100,000	.....	.....	$5,000,000	.....
Issued—								
Number of shares	1,285,000	.....	250,000	985,000	.....	.....	50,000	.....
Par value	$10,851,500	.....	$4,866,500	$985,000	.....	.....	$5,000,000	.....
Dividends paid	$448,990	.....	$291,990	$7,000	.....	.....	$150,000	.....
Bonds:								
Authorized—								
Number	303,950	300,000	.....	.....	500	.....	2,800	.....
Par value	$6,950,000	$3,000,000	.....	.....	$500,000	.....	$2,800,000	.....
Issued—								
Number	303,029	299,953	.....	.....	500	.....	2,001	.....
Par value	$6,075,530	$2,999,530	.....	.....	$500,000	.....	$2,001,000	.....
Interest paid	$174,500	.....	.....	.....	$30,000	.....	$132,000	.....
Assessments levied	$7,725,748	$132,400	.....	.....	.....	$7,368,348	.....	.....

	New Mexico.	North Carolina.	Oregon.	Tennessee.	Utah.	Virginia.	Washington.	Wisconsin.	Wyoming.
Number of incorporated companies	6	1	2	2	11	1	1	1	1
Capital stock and bonds issued	$8,924,960	$3,000,000	$2,500,000	$4,875,000	$6,822,515	$10,000	.....	$1,000,000	$640,000
Capital stock:									
Total authorized—									
Number of shares	6,800,000	300,000	30,007	200,000	3,702,500	200	3,500,000	40,000	1,000,000
Par value	$12,100,000	$3,000,000	$3,700,000	$5,000,000	$6,875,000	$10,000	$3,500,000	$1,000,000	$1,000,000
Total issued—									
Number of shares	3,639,960	300,000	18,007	175,000	3,644,503	200	.....	40,000	640,000
Par value	$8,849,960	$3,000,000	$2,500,000	$4,375,000	$6,822,515	$10,000	.....	$1,000,000	$640,000
Dividends paid	.....	.....	.....	.....	$534,000	.....	.....	.....	.....
Common—									
Authorized—									
Number of shares	6,800,000	300,000	30,007	200,000	3,702,500	200	3,000,000	40,000	1,000,000
Par value	$12,100,000	$3,000,000	$3,700,000	$5,000,000	$6,875,000	$10,000	$3,000,000	$1,000,000	$1,000,000
Issued—									
Number of shares	3,639,960	300,000	18,007	175,000	3,644,503	200	.....	40,000	640,000
Par value	$8,849,960	$3,000,000	$2,500,000	$4,375,000	$6,822,515	$10,000	.....	$1,000,000	$640,000
Dividends paid	.....	.....	.....	.....	$534,000	.....	.....	.....	.....
Preferred—									
Authorized—									
Number of shares	.....	.....	.....	.....	.....	.....	500,000	.....	.....
Par value	.....	.....	.....	.....	.....	.....	$500,000	.....	.....
Issued—									
Number of shares	.....	.....	.....	.....	.....	.....	.....	.....	.....
Par value	.....	.....	.....	.....	.....	.....	.....	.....	.....
Dividends paid	.....	.....	.....	.....	.....	.....	.....	.....	.....
Bonds:									
Authorized—									
Number	150	.....	.....	500	.....	.....	.....	.....	.....
Par value	$150,000	.....	.....	$500,000	.....	.....	.....	.....	.....
Issued—									
Number	75	.....	.....	500	.....	.....	.....	.....	.....
Par value	$75,000	.....	.....	$500,000	.....	.....	.....	.....	.....
Interest paid	.....	.....	.....	$12,500	.....	.....	.....	.....	.....
Assessments levied	.....	.....	.....	.....	$225,000	.....	.....	.....	.....

As shown in Table 3, the division of stock into common and preferred is not general with copper mining companies. There were only 6 companies reporting both common and preferred stock; up to the close of the year 1902, 1 of these had issued no stock of either kind. The issue of bonds was not favored generally by copper mining companies; there were only 6 companies having bonded indebtedness, and of the $6,950,000 of bonds authorized, $6,075,530 were issued. Assessments on stock were also unusual, the total amount levied by all companies since organization being only $7,725,748.

The following table shows each class of capital stock, authorized and issued, in detail:

TABLE 4.—INCORPORATED COMPANIES, GROUPED BY CLASS OF STOCK: 1902.

CLASS OF STOCK REPORTED.	Number of incorporated companies.	AUTHORIZED.			ISSUED.		
		Total.	Common.	Preferred.	Total.	Common.	Preferred.
Total	100	$441,788,125	$429,321,625	$12,466,500	$372,240,270	$361,388,770	$10,851,500
Both common and preferred	[1] 6	92,833,125	80,366,625	12,466,500	56,816,597	45,965,097	10,851,500
Common only	94	348,955,000	348,955,000	.....	315,423,673	315,423,673	.....

[1] One company had issued no common or preferred stock up to the close of 1902.

The capital stock shown in Table 3 includes a duplication since the capitalization of the Amalgamated Copper Company, as well as that of its constituent companies, is reported. Table 5 shows the capitalization of the Amalgamated Copper Company and each of its constituent copper mining companies. Neither the parent company nor any of its constituent companies has preferred stock. The Amalgamated Copper Company owns the entire capital stock of the Colorado Smelting and Mining Company, and of the Washoe Copper Company, and a controlling interest in the others.

TABLE 5.—CAPITALIZATION OF THE AMALGAMATED COPPER COMPANY AND ITS CONSTITUENT COMPANIES: 1902.

COMPANY.	COMMON STOCK.				BONDS.			
	Authorized.		Issued.		Authorized.		Issued.	
	Shares.	Par value.	Shares.	Par value.	Number.	Par value.	Number.	Par value.
Amalgamated Copper Company	1,550,000	$155,000,000	1,538,880	$153,888,000	.....	.....	.....	.....
Anaconda Copper Mining Company	1,200,000	30,000,000	1,200,000	30,000,000	.....	.....	.....	.....
Boston and Montana Consolidated Mining Company	150,000	3,750,000	150,000	3,750,000	1,300	$1,300,000	501	$501,000
Butte and Boston Consolidated Mining Company	200,000	2,000,000	200,000	2,000,000	1,500	1,500,000	1,500	1,500,000
Colorado Smelting and Mining Company	100,000	1,000,000	100,000	1,000,000	.....	.....	.....	.....
Parrot Silver and Copper Company	230,000	2,300,000	229,850	2,298,500	.....	.....	.....	.....
Washoe Copper Company	200,000	20,000,000	30,464	3,046,400	.....	.....	.....	.....

Dividends.—The total amount of dividends paid in 1902 was $14,116,002. Of this amount, $3,077,760 was paid by the Amalgamated Copper Company. These dividends were derived partly from the dividends declared by its constituent companies, and partly from the earnings of other properties of the Amalgamated Copper Company, such as coal mines, railways, etc. The following table shows the capitalization and dividends of all dividend paying companies, with the exception of the Amalgamated Copper Company, and also the capitalization of the companies that paid no dividends in 1902:

TABLE 6.—INCORPORATED COMPANIES, CLASSIFIED WITH RELATION TO DIVIDENDS, CAPITAL STOCK, AND BONDS: 1902.[1]

	CAPITAL STOCK AND BONDS.						
	Authorized.			Issued.			
	Number of shares or bonds.	Par value.		Number of shares or bonds.	Par value.		Dividends or interest paid.
		Total.	Average per share or bond.		Total.	Average per share or bond.	
Dividend paying companies:							
Total capitalization	6,963,800	$167,783,125	.....	5,403,431	$116,963,457	.....	$11,080,242
Common stock	5,202,500	152,516,625	$29.32	4,117,977	102,911,427	$24.99	10,589,252
Preferred stock	1,400,000	10,966,500	7.83	985,000	10,551,500	10.71	448,990
Bonds	361,300	4,300,000	11.90	300,454	3,500,530	11.65	42,000
Companies by which no dividends were paid in 1902:							
Total capitalization	37,068,857	125,955,000	3.10	25,751,278	107,464,343	4.17	132,500
Common stock	35,566,207	121,805,000	3.42	25,448,703	104,589,343	4.11	.....
Preferred stock	1,500,000	1,500,000	1.00	300,000	300,000	1.00	.....
Bonds	2,650	2,650,000	1,000.00	2,575	2,575,000	1,000.00	132,500

[1] Exclusive of the Amalgamated Copper Company.

There were 18 dividend paying companies, with capital stock issued to the value of $113,462,927; whereas 81 companies, with capital stock issued to the value of $104,889,343, declared no dividends. Dividends on $10,551,500 of preferred stock were declared by 4 companies; the rate of dividends averaged 4.3 per cent. No dividends were declared by these companies on their common stock, which was issued to the amount of $45,965,097. Two companies with preferred stock authorized declared no dividends; the authorized preferred stock of these companies was $1,500,000; the amount issued, $300,000.

Dividends on common stock were declared by 14 companies with an authorized capitalization of $75,150,000, of which $56,946,330 was outstanding; no preferred stock was authorized by these companies. The average rate of dividends on common stock was 18.6 per cent.

A comparison between the par values of dividend paying and nondividend paying stocks is not without interest. The average par value per share of dividend paying common stock was $21.07, whereas the average par value of a share of common stock on which no dividends were declared was only $4.11. Similarly, the par value per share of preferred stock was $10.71 for dividend paying and only $1 for nondividend paying companies. It is apparent that the type of mining enterprises, for which capital stock is issued at $1 and less per share, is more frequent among nondividend paying than among dividend paying companies. The latter are, for the most part, concerns the capital stock of which is issued at prevailing commercial values per share, viz, at $25 and over.

The following statement shows the stock and bonds on which dividends and interest were paid:

Classes of stock and bonds on which dividends and interest were paid: 1902.

CLASS.	Number of companies.	Authorized.	Issued.	Dividends or interest paid.	Per cent.
Common stock	14	$75,150,000	$56,946,330	$10,589,252	18.6
Preferred stock	4	10,966,500	10,551,500	448,990	4.3
Bonds	4	3,800,000	3,001,000	174,500	5.8

The total amount of interest paid on bonds was $174,500, of which $132,500 was paid by companies that declared no dividends in 1902. The rate of interest on bonds averaged 5.8 per cent.

A number of corporations operated both copper mines and smelters, and some were interested in other properties, such as coal or iron mines, railways, etc. The dividends reported for such companies were derived from all those sources and can not be segregated.

A comparative summary of dividend paying companies—with the exception of the Amalgamated Copper Company, which, being merely a holding company, is therefore excluded—and those which declared no dividends in 1902, is presented in Table 7.

TABLE 7.—*Comparative summary of dividend paying and nondividend paying companies: 1902.*[1]

	Total.	Dividend paying companies.	Nondividend paying companies.
Number of companies	99	18	81
Salaries	$1,712,306	$724,774	$987,532
Wages	$20,579,298	$10,357,693	$10,221,605
Contract work	$183,568	$92,384	$91,184
Miscellaneous expenses	$1,358,761	$512,955	$845,806
Cost of supplies and materials	$10,809,966	$6,163,479	$4,646,487
Ore shipped and milled:			
Short tons	11,296,857	5,762,972	5,533,885
Value of product at mine, total	$50,421,837	$32,605,752	$17,816,085
Average per company	$509,311	$1,826,589	$216,583
Bullion contents—			
Copper—			
Pounds	612,555,284	383,894,605	228,660,679
Value	$69,048,933	$43,235,653	$25,813,280
Silver	$5,466,924	$2,849,871	$2,617,053
Gold	$1,782,273	$1,166,286	$615,987
Other metals	$17,986	$15,527	$2,459
Total gross value	$76,316,116	$47,267,337	$29,048,779
Average per ton	$6.75	$8.20	$5.25
Crude ore sold	$4,595,588	$2,617,567	$1,978,021
Dressed ore sold	$8,611,415	$903,074	$7,708,341
Ore smelted	$63,109,113	$43,746,696	$19,362,417

[1] Exclusive of the Amalgamated Copper Company, which is merely a holding company.

It must be borne in mind that the payment of dividends in a given year is not indicative of profits earned during that year. Dividends may be declared from the accumulated surplus of former years. On the other hand, the failure to declare a dividend does not necessarily show a loss; the earnings may have been invested in development work, in new equipment for the plants, in acquiring new property, etc. Some of the principal copper mining companies are close corporations, the stock of which is held by a limited number of persons. As the shares are not on the market, it is often a matter of indifference to the stockholders whether a dividend is declared or the net earnings are accumulated as a surplus.

The chief differences disclosed by the preceding table between the dividend paying corporations and those which paid no dividends in 1902 are as follows:

First. The grade of ore mined was higher with the former than with the latter, viz, $8.20 per ton as against $5.25 per ton.

Second. Where dividends were paid the ore was nearly all smelted at works connected with the mines, whereas in other cases much of the ore was sold.

Third. The average value of product per dividend paying company was $1,826,589, while the average for other companies was only $216,583; apparently it was the largest companies that declared dividends in 1902.

The census returns for 1902 cover a year of low prices of copper. A comparison with the dividends for previous years will be found on a subsequent page, in connection with a study of prices.

Employees and wages.—Wage-earners constituted 95.6 per cent of the total number of employees, and their wages were 92.3 per cent of the total salaries and wages. Table 8 shows, by states and territories, the average number of men, and of boys under 16 years of age, employed during each month.

TABLE 8.—AVERAGE NUMBER OF WAGE-EARNERS EMPLOYED DURING EACH MONTH: 1902.

	United States.	Arizona.	California.	Colorado.	Michigan.	Montana.	New Mexico.	Utah.	All other states and territories.
Men 16 years and over:									
January	24,885	3,534	384	117	13,839	5,603	111	555	742
February	24,658	3,519	345	112	13,257	6,102	121	514	688
March	25,602	3,709	387	124	13,679	6,363	141	498	701
April	26,088	3,686	482	129	14,118	6,304	160	503	706
May	27,073	3,941	543	124	14,512	6,567	146	513	727
June	26,466	3,937	585	117	13,952	6,538	173	513	651
July	26,838	3,854	635	118	14,249	6,656	147	528	651
August	25,908	3,867	664	117	13,760	6,168	182	493	657
September	25,698	3,714	659	113	13,660	6,317	161	487	587
October	26,273	3,742	611	115	13,973	6,585	212	430	605
November	25,720	3,665	434	97	13,490	6,838	212	406	578
December	25,639	3,796	223	97	13,711	6,615	202	404	591
Boys under 16 years of age:									
January	111	50	.....	.....	44	.....	.....	.....	17
February	110	50	.....	.....	43	.....	.....	.....	17
March	113	50	.....	.....	45	.....	.....	.....	18
April	113	50	.....	.....	47	.....	.....	.....	16
May	110	50	.....	.....	43	.....	.....	.....	17
June	106	50	.....	.....	39	.....	.....	.....	17
July	112	51	.....	.....	44	.....	.....	.....	17
August	92	48	.....	.....	27	.....	.....	.....	17
September	92	51	.....	.....	27	.....	.....	.....	14
October	93	50	.....	.....	29	.....	.....	.....	14
November	91	50	.....	.....	27	.....	.....	.....	14
December	93	50	.....	.....	29	.....	.....	.....	14

The average number of wage-earners was greatest, 27,183, in May, and least, 24,768, in February; the variation during the year was not marked.

In the following table the average number of wage-earners at certain specified rates of pay is shown for the various classes of employees, and also the percentage which the number at each rate forms of the total number in the class:

TABLE 9.—DISTRIBUTION OF WAGE-EARNERS ACCORDING TO DAILY RATES OF PAY, BY OCCUPATIONS: 1902.

RATE PER DAY (DOLLARS).	All occupations.		Engineers.		Firemen.		Machinists, blacksmiths, carpenters, and other mechanics.		Miners.		Miners' helpers.		Timbermen and track layers.		Boys under 16 years.		All other wage-earners.	
	Average number.	Per cent of total.	Average number.	Per cent of total.	Average number.	Per cent of total.	Average number.	Per cent of total.	Average number.	Per cent of total.	Average number.	Per cent of total.	Average number.	Per cent of total.	Average number.	Per cent of total.	Average number.	Per cent of total.
Total	[1] 26,007	100.0	552	100.0	487	100.0	1,819	100.0	[1] 12,821	100.0	1,257	100.0	863	100.0	103	100.0	8,105	100.0
0.50 to 0.74	29	0.1	.....	.....	.....	.....	.....	.....	.....	.....	3	0.2	.....	.....	12	11.7	14	0.2
0.75 to 0.99	49	0.2	.....	.....	.....	.....	.....	.....	24	0.2	.....	.....	.....	.....	8	7.7	17	0.2
1.00 to 1.24	201	0.8	2	0.4	1	0.2	3	0.2	1	(2)	110	8.8	6	0.7	20	19.4	58	0.7
1.25 to 1.49	368	1.4	29	5.3	9	1.9	10	0.5	61	0.5	88	7.0	.....	.....	34	33.0	137	1.7
1.50 to 1.74	1,847	7.1	10	1.8	10	2.1	32	1.8	36	0.3	77	6.1	14	1.6	7	6.8	1,661	20.5
1.75 to 1.99	3,354	12.9	27	4.9	78	16.0	90	4.9	137	1.1	497	39.6	95	11.0	.....	.....	2,430	30.0
2.00 to 2.24	6,277	24.1	74	13.4	119	24.4	233	12.8	3,216	25.1	336	26.7	359	41.6	12	11.7	1,928	23.8
2.25 to 2.49	2,066	8.0	43	7.8	4	0.8	137	7.5	1,309	10.2	50	4.0	55	6.4	10	9.7	458	5.6
2.50 to 2.74	2,285	8.8	35	6.3	99	20.3	260	14.3	1,679	13.1	30	2.4	32	3.7	.....	.....	150	1.9
2.75 to 2.99	661	2.5	62	11.2	8	1.7	58	3.2	368	2.9	10	0.8	3	0.3	.....	.....	152	1.9
3.00 to 3.24	961	3.7	21	3.8	20	4.1	173	9.5	374	2.9	18	1.4	28	3.3	.....	.....	327	4.0
3.25 to 3.49	131	0.5	8	1.5	1	0.2	49	2.7	7	(2)	.....	.....	21	2.4	.....	.....	45	0.5
3.50 to 3.74	6,742	25.9	25	4.5	134	27.5	227	12.5	5,552	43.3	38	3.0	207	24.0	.....	.....	559	6.9
3.75 to 3.99	54	0.2	10	1.8	2	0.4	24	1.3	1	(2)	.....	.....	17	2.0	.....	.....	.....	.....
4.00 to 4.24	605	2.3	167	30.3	2	0.4	273	15.0	40	0.3	.....	.....	26	3.0	.....	.....	97	1.2
4.25 and over	377	1.5	39	7.0	.....	.....	250	13.8	16	0.1	.....	.....	.....	.....	.....	.....	72	0.9

[1] Includes 2,206 miners, all in Michigan, who were paid in accordance with the amount of work done; for these the figures shown in this table represent average daily earnings.
[2] Less than one-tenth of 1 per cent.

The range of wages for the bulk of the employees was from $1.50 to $3.74, 24,324 wage-earners, or 93.5 per cent of the total number, being included between those rates. Practically all those classed as miners were paid at least $2 per day, and 5,552 of them, or 43.3 per cent, received between $3.50 and $3.74. Most of the highly paid miners were reported from Montana and Arizona. Of those classed as miners' helpers, 1,257 in all, 66.3 per cent were paid between $1.75 and $2.24, 22.1 per cent having received less than $1.75, and 11.6 per cent, $2.25 or over. There was a wide range in the rates paid to timbermen and track layers; 454, or 52.6 per cent of the total number, were paid between $1.75 and $2.24, and 24 per cent, from $3.50 to $3.74. Practically all of the timbermen and track layers at $3.50 or over were reported from Montana.

There was also a wide range in the rates for engineers, firemen, machinists, and other mechanics. In each of these three classes more than 90 per cent of the wage-earners received $1.75 per day or over. The proportion receiving $3.50 or over was as follows: Engineers, 43.6 per cent; firemen, 28.3 per cent; and machinists and other mechanics, 42.6 per cent. In each case the greatest number at rates of $3.50 or over were reported from Montana and Arizona.

The number of boys under 16 years employed was small, only 103, or less than five-tenths of 1 per cent, having been reported. Their rates varied from 50 cents to $2.49 a day. Of the 103 boys, 50 were employed in Arizona and 37 in Michigan.

The 8,105 employees grouped under "all other wage-earners" constituted 31.2 per cent of the total number. Their duties were so varied as to render impossible any separation into well-defined occupations. The rates of pay for the greater portion of these wage-earners ranged from $1.50 to $2.24 per day, 74.3 per cent being included between those rates.

The following table shows the distribution of wage-earners according to daily rates of pay, by states:

TABLE 10.—DISTRIBUTION OF WAGE-EARNERS ACCORDING TO DAILY RATES OF PAY, BY STATES: 1902.

[Each cumulative percentage shows the proportion of the total number receiving a wage as great as, or greater than, the lowest wage of the given wage group.]

RATE PER DAY (DOLLARS).	UNITED STATES.			ARIZONA.			MICHIGAN.			MONTANA.			ALL OTHER STATES.		
	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.	Average number.	Per cent of total.	Cumulative percentage.
Total	[1]26,007	100.0	.....	3,797	100.0	.....	[1]13,887	100.0	.....	6,388	100.0	.....	1,935	100.0	.....
0.50 to 0.74	29	0.1	100.0	.....	.....	.....	1	(2)	100.0	.....	.....	.....	28	1.4	100.0
0.75 to 0.99	49	0.2	99.9	.....	.....	.....	8	0.1	99.9	.....	.....	.....	41	2.1	98.6
1.00 to 1.24	201	0.8	99.7	18	0.5	100.0	162	1.2	99.9	.....	.....	.....	21	1.1	96.5
1.25 to 1.49	368	1.4	98.9	24	0.6	99.5	197	1.4	98.7	.....	.....	.....	147	7.6	95.4
1.50 to 1.74	1,847	7.1	97.5	47	1.2	98.9	1,652	11.9	97.3	.....	.....	.....	148	7.6	87.8
1.75 to 1.99	3,354	12.9	90.4	580	15.3	97.7	2,705	19.5	85.4	.....	.....	.....	69	3.6	80.2
2.00 to 2.24	6,277	24.1	77.5	346	9.1	82.4	5,805	41.8	65.9	12	0.2	100.0	114	5.9	76.6
2.25 to 2.49	2,066	8.0	53.4	597	15.7	73.3	1,381	9.9	24.1	9	0.1	99.8	79	4.1	70.7
2.50 to 2.74	2,285	8.8	45.4	195	5.1	57.6	1,703	12.2	14.2	33	0.5	99.7	354	18.3	66.6
2.75 to 2.99	661	2.5	36.6	155	4.1	52.5	138	1.0	2.0	.....	.....	99.2	368	19.0	48.3
3.00 to 3.24	961	3.7	34.1	331	8.7	48.4	106	0.8	1.0	229	3.6	99.2	295	15.2	29.3
3.25 to 3.49	131	0.5	30.4	84	2.2	39.7	7	0.1	0.2	10	0.2	95.6	30	1.6	14.1
3.50 to 3.74	6,742	25.9	29.9	1,176	31.0	37.5	2	(2)	0.1	5,347	83.7	95.4	217	11.2	12.5
3.75 to 3.99	54	0.2	4.0	45	1.2	6.5	4	(2)	0.1	5	0.1	11.7	.....	.....	1.3
4.00 to 4.24	605	2.3	3.8	158	4.2	5.3	11	0.1	0.1	415	6.5	11.6	21	1.1	1.3
4.25 and over	377	1.5	1.5	41	1.1	1.1	5	(2)	(2)	328	5.1	5.1	3	0.2	0.2

[1] Includes 2,206 miners paid in accordance with the amount of work done; for these only average daily earnings were obtained.
[2] Less than one-tenth of 1 per cent.

Only Arizona, Michigan, and Montana are shown separately. These 3 states gave employment to 24,072 wage-earners, or 92.6 per cent of the total number employed in mines, the principal product of which was copper ore. Of the 3 states, Montana shows by far the highest rates, 6,095 wage-earners, or 95.4 per cent of the total number, receiving $3.50 per day or over. In Arizona 37.5 per cent of the wage-earners received $3.50 or over per day, and 40.1 per cent from $1.75 to $2.49. In Michigan the wages paid were much lower than in either Arizona or Montana, practically all of the men employed in copper mines in that state receiving between $1.50 and $2.74.

The 1,935 wage-earners grouped under "all other states" are distributed among 13 states, no single state reporting as many as 500.

The tenacity of antiquated forms of industrial relations is exemplified in the few copper mines where labor was performed on a share of the product. This form of employment is frequently found in gold mines, where the miners so employed are locally known as "leasers," "tributers," etc. There were only 7 cases of this kind reported at copper mines, namely, 4 in Montana, of which 3 were in Silverbow county; 2 in Arizona; and 1 in Colorado. In all, 22 men besides the regular wage-earners found employment on such terms in these mines. The total output was valued at $25,567 at the mines, the output of no mine exceeding $10,000 in value. The percentage of copper in the ore varied from 6 to 29 per cent. The share received by the mine owner ranged from 10 to 20 per cent of the gross value of the ore, and from 10 to 25 per cent of the value at the mine, after smelting and freight charges were deducted. The miner, out of his share of the product, furnished his own supplies.

Days in operation.—In the following table 126 copper mines are classified by the number of days in operation; 18 of the 144 mines failed to report on this subject:

TABLE 11.—*Number of mines, classified according to time in operation, by states and territories: 1902.*

STATE OR TERRITORY.	Number of mines reporting.	NUMBER OF DAYS IN OPERATION.											
		30 and less.	31 to 60.	61 to 90.	91 to 120.	121 to 150.	151 to 180.	181 to 210.	211 to 240.	241 to 270.	271 to 300.	301 to 330.	331 to 360.
Total	126	3	2	6	3	7	8	9	3	4	9	33	39
Arizona	31	2	....	1	....	3	4	1	2	2	....	2	14
California	7	....	....	....	1	....	....	1	....	....	1	1	3
Colorado	16	....	....	1	2	3	3	2	....	....	2	3	....
Idaho	1	....	....	....	....	....	....	....	....	....	....	....	1
Michigan	20	....	....	....	....	....	....	....	....	....	....	20	....
Montana	27	....	1	....	....	1	1	3	....	2	2	....	17
New Mexico	7	1	....	1	....	....	....	....	1	....	1	2	1
North Carolina	2	....	....	....	....	....	....	....	....	....	2	....	....
Oregon	1	....	....	1	....	....	....	....	....	....	....	....	....
Tennessee	2	....	....	....	....	....	....	1	....	....	....	1	....
Utah	9	....	....	2	....	....	....	1	....	....	....	4	2
Virginia	1	....	....	....	....	....	....	....	....	....	1	....	....
Washington	1	....	....	....	....	....	....	....	....	....	....	....	1
Wisconsin	1	....	1	....	....	....	....	....	....	....	....	....	....

Miscellaneous expenses.—This item includes rent and royalties of all descriptions, "taxes, insurance, interest, advertising, office supplies, law expenses, injuries and

damages, telegraph and telephone service, gas, and all other sundries not reported elsewhere." The total amount reported under this head was $1,397,465. Of this amount $130,215 was paid in rent and royalties, viz, $33,184 in royalties for mine and mineral land, $22,393 in water rents, and $74,638 in other rents and royalties. On the whole, royalties and rents were but an insignificant item in the copper mining industry. All other miscellaneous expenses aggregated $1,267,250.

Supplies and materials.—The general term "materials" has scarcely any application to copper mining. The "material" operated upon in a mine is the rock underground. The inquiry calling for "total cost of supplies and materials of all kinds used during the year" at the mine contained the following explanatory note:

"The cost of the following materials should be reported under this inquiry: Lumber and timber used for repairs, mine supports, track ties, cars, and all other purposes; iron and steel for blacksmithing, rails, frogs, sleepers, etc., for tracks and repairs, parts of machinery and tools used for renewals and repairs; explosives, water for boilers and for other purposes, fuel, illuminating and lubricating oils, machinery supplies, etc."

All the items here enumerated strictly come under the definition of "supplies." The "material" treated at the mills is the ore which comes from the mine. It is not customary in mining bookkeeping to charge the mill with the value of the ore brought from the mine. In the schedule relating to "reduction works, other than smelters," there were two separate inquiries, one relating to "materials," the other to "supplies." The former called for a statement of the "character of materials used, whether ore, tailings, or other materials," and was confined to "materials bought in 1902." The amount reported in answer to this inquiry is not included in the "cost of supplies and materials" shown in Table 1, but is given as a separate item. Purchased ores formed but a very insignificant part of the total tonnage treated at mills connected with copper mines, namely, 1,068 tons out of a total of 6,558,222 tons treated in 1902.

The explanatory note to the inquiry relating to mill "supplies" enumerated: "Shoes, dies, screens, plates, and other parts of machinery and tools used for renewals and repairs; quicksilver, cyanide of potassium, lumber, iron, steel, oil, fuel, water, etc." The total cost of "supplies and materials," as herein defined, was reported as $11,083,175.

Mechanical power.—The total primary power of all classes used in copper mines aggregated 198,507 horsepower, of which more than two-thirds, viz, 137,772 horsepower, was used in Michigan, and one-fourth, viz, 49,090 horsepower, in Montana. The quantity of power used had no relation to either the value of the product or the copper contents of the ore, but was roughly proportionate to the quantity of crude ore mined, as appears from the following statement:

Horsepower used and tons mined, by states and territories: 1902.

STATE OR TERRITORY.	Total horsepower.	Tons mined.	Horsepower, per cent.	Tons mined, per cent.
United States	198,507	11,780,064	100.0	100.0
Michigan	137,772	6,247,317	69.4	53.0
Montana	49,090	3,428,860	24.7	29.1
All other states and territories	11,645	2,103,887	5.9	17.9

The predominating form of power used in 1902 was steam. The total horsepower used, including all primary power owned and electric power rented, was divided as follows: Steam, 189,426, or 95.4 per cent; compressed air (described in the tables as "other power"), 5,235, or 2.6 per cent; gas or gasoline, 1,184, or six-tenths of 1 per cent; water, 326, or two-tenths of 1 per cent; and rented power, all electric, 2,336, or 1.2 per cent. In addition there were 50 electric motors, having a capacity of 2,312 horsepower.

The average horsepower per mine was 1,379. The power supplied by all mines to other establishments was only 87 horsepower. Twelve mines in Silverbow county, Mont., 1 mine in Salt Lake county, Utah, and 1 in Shasta county, Cal., were supplied with power by other establishments. The arrangement was apparently made feasible by the proximity of mining centers like Butte or Salt Lake City. The mine in Shasta county was supplied by a San Francisco power company from one of its substations located in the mountains.

The total number of steam engines was 792, or an average of 5.5 per mine, with an average capacity of 239 horsepower per engine. The total number of gas or gasoline engines was 35, with an average capacity of 34 horsepower per engine. They were reported from 13 mines, of which 1 used also steampower and 1 waterpower. The total number of electric motors was 50, with an average capacity of 46 horsepower per motor. Electric power was reported from 18 mines, nearly all very large producers, namely, 5 with an output exceeding $1,000,000; 8 with an output ranging from $500,000 to $1,000,000; 1 with a product above $250,000, but less than $500,000; 1 with a product above $100,000, but less than $250,000; 1 with a product above $50,000, but less than $100,000; and 2 with a product less than $10,000, of which 1, however, expended during the year more than $250,000 in development work. Compressed air was reported from 16 mines, of which 8 were located in Montana. Waterpower was reported from 6 mines, of which 2 used also steampower and 1 a gas engine. There were in all 8 water wheels in use, with an average capacity of 41 horsepower per wheel.

The exclusive use of gas or water power is characteristic of mining on a small scale. Of the 41 mines coming under the description of small mines there was none with an output exceeding $50,000, while for 7 the value of the product was between $10,000 and $50,000, and for 15 it was between $1,000 and $10,000. At 2 mines

a little over $10,000 each was expended, in 1902, in development work with but small returns.

The use of steampower in copper mines in 1870, 1880, and 1902 is shown in the following statement. No information for 1889 is available.

Steampower used: 1902, 1880, and 1870.

YEAR.	Total number of mines.	NUMBER OF ENGINES.		HORSEPOWER.		
		Total.	Average per mine.	Total.	Average per engine.	Average per mine.
1902	144	792	5.5	189,426	239	1,315
1880	41	135	3.3	13,511	100	330
1870	[1]40	93	2.3	6,328	68	158

[1] Establishments.

Within the past twenty-two years the average number of steam engines, the total horsepower used, and the average horsepower per engine have grown in a remarkable degree. On the other hand, the use of waterpower had practically been discarded in copper mines as early as 1870. The total number of water wheels reported at the Ninth Census was 3 with a total of 70 horsepower, as compared with 93 steam engines with 6,328 horsepower.

The following table shows the number of hoists, pumps, and power drills, with the kind of power used to run the same, for Western and Southern states and territories in 1902. No reports on this subject were received from Michigan (which state has reported more than two-thirds of the horsepower used at mines), Nevada, Virginia, and Wisconsin.

TABLE 12.—HOISTS, PUMPS, AND POWER DRILLS, IN WESTERN AND SOUTHERN STATES AND TERRITORIES, CLASSIFIED BY KIND OF POWER USED: 1902.

STATE OR TERRITORY.	Number of mines reporting.	HOISTS, KIND OF POWER.					PUMPS, KIND OF POWER.						POWER DRILLS, KIND OF POWER.			
		Total number.	Steam.	Gas or gasoline.	Compressed air.	Electric.	Total number.	Steam.	Gas or gasoline.	Compressed air.	Water.	Electric.	Total number.	Steam.	Compressed air.	Electric.
United States	121	228	158	16	51	3	160	153	2	2	2	1	900	135	763	2
Arizona	30	42	31	10		1	17	17					25	1	22	2
California	7	9	5	1	1	2	3	2				1	26		26	
Colorado	18	10	6	2	2		2	1		1			7		7	
Idaho	1	2	2				5	5					3	3		
Montana	27	135	87	1	47		109	106	1		2		710	72	638	
New Mexico	17	9	9				10	10								
North Carolina	2						2	2					4		4	
Oregon	2	2	2				2	2								
Tennessee	2	6	6				4	4					73	56	17	
Utah	13	12	9	2	1		6	4	1	1			49	3	46	
Washington	1												3		3	
Wyoming	1	1	1													

At the mines reporting there were 228 hoists in use in 1902, an average of about two per mine. Of this number 158 were run by steam, 51 by compressed air, 16 by gas or gasoline, and 3 by electricity. The use of compressed air as a motive power for hoists was practically confined to Montana, there being only 2 engines of that class in operation in Colorado, 1 in California, and 1 in Utah. Of the 3 electric hoists, 1 was used in Arizona and 2 in California.

There were 160 pumps in operation, an average of 1 per mine; practically all were operated by steam, the exceptions being 2 each operated by gas or gasoline, compressed air, and water, and 1 by electricity.

Of the 122 mines reporting machinery, the number reporting power drills was 34. At these mines there were 900 power drills in operation, of which nearly four-fifths were reported from Montana. The motive power was mostly compressed air; only 135, less than one-sixth of the number reported, were operated by steam and only 2 by electricity. Those operated by steam were distributed as follows: Montana, 72; Tennessee, 56; and all other states, 7. In the Tennessee copper mines steam still held the first place, only 17 drills having been run by compressed air.

The following is a statement of the tonnage mined and the wages paid to miners and miners' helpers below ground in mines equipped with power drills and in those not reporting them:

Tonnage mined and wages paid to miners and miners' helpers in mines with and without power drills: 1902.

	Number of mines.	TONS MINED.		Wages of miners.	Wages of miners' helpers.
		Number.	Average per mine.		
Total [1]	122	5,440,952	44,598	$7,859,053	$582,765
With power drills	34	4,667,766	137,287	6,039,480	502,015
No power drills reported	88	773,186	8,786	1,819,573	80,750

[1] Michigan, Wisconsin, and Virginia not reported.

It appears that about six-sevenths of all ore produced in the 122 mines reporting came from mines equipped with power drills. The average tonnage per mine thus equipped was about fifteen times as great as the average for other mines. Miners' wages averaged $1.29 per ton for mines having power drills and $2.35 for those reporting none. On the other hand, wages of miners' helpers averaged 11 cents per ton for each class.

There were 32 mines which had no mechanical power; of these 26 were in the development stage, with a total product valued at $78,176, averaging $3,007 per mine; and 6 in the productive stage, with a total product of $121,420, averaging $20,237 per mine. There were, moreover, 9 mines which failed to report on mechanical power, presumably because they had none; their total product was valued at $141,373, averaging $15,708 per mine. This leaves a product of $50,837,067 for the 102 operators (exclusive of 1 holding company) reporting mechanical power, averaging $498,402 per mine. It is evident that the mines without mechanical power were either in the incipient stage or belonged to the type of small mines. These mines were distributed among the states and territories as follows: Arizona, 10; Colorado, 9; New Mexico, 8; Montana, 7; California and Utah, 2 each; Nevada, Virginia, and Wisconsin, 1 each.

In most of the copper mines some mechanical method was used for the transportation of the ore from the mine to the reduction works or the nearest point of shipment. Of the 122 operators reporting on this subject only 29 hauled their ore by teams, while 93, or three-fourths of the whole number, reported some mechanical method of transportation. The total length of railroad tracks reported was 55 miles on the surface and 145 miles underground, and the total number of locomotives in use was 28. Of the 55 miles of surface tracks, 5 companies owned 42 miles, as follows: In Tennessee, the Tennessee Copper Company, 11 miles, and the Ducktown Sulphur, Copper and Iron Company (Limited), 7 miles; in Arizona, the Arizona Copper Company (Limited), 10 miles, and the Detroit Copper Mining Company, 4 miles; and in Idaho, the White Knob Copper Company (Limited), 10 miles. This does not include railroads intended for general traffic. The remaining 13 miles of surface tracks were distributed among 117 mines. No reports on the subject of railroad ownership were received from the Lake Superior region and Virginia.

Water plants are an important part of the mine equipment. The reports showed 66 miles of ditches, flumes, etc., of which 42 were in Colorado, an average of more than 2 miles per mine; 8 in California, an average of more than 1 mile per mine; and 16 in all other states, making an average of 715 feet per mine.

Production.—The value of the output of copper mines was $51,178,036. This was the value at the mine of the product classed as copper ore, rough or dressed. The gross value of the copper contents of the same was $70,175,810; the total value of the copper contents of all ores mined in the United States was $71,192,014. The following table sets forth in detail the relation between these values:

TABLE 13.—*Copper contents of all ores mined, and production of copper mines, values less charges: 1902.*

Total value of copper contents of all ores mined			$71,192,014
Copper contents of gold and silver ores			1,016,204
Copper contents of copper ores			70,175,810
Production of copper mines:			
Contents of ores sold or treated and gross value of same—			
Copper ... pounds	625,004,529	$70,175,810	
Gold ... fine ounces	92,911	1,854,025	
Silver ... fine ounces	11,452,280	5,838,256	
Lead ... pounds	552,070	19,053	
Iron		22	
Increase in stock of ore, estimated value		77,792	
			77,959,958
Less:			
Treatment and freight charges		26,762,189	
Cost of purchased ores, 1,068 tons		19,733	
			26,781,922
Value at the mine			51,178,036

The value of the ore shown is computed in conformity with the customary method adopted in settlements between mine operators and smelters for gold and silver bearing copper ores. The mine operator is credited with the value of the copper and other metals contained in his ore, at a stipulated price per pound of copper, per ounce of gold and silver, etc., and he is charged a stipulated price per ton for treatment and for freight from the mine to the smelter. The difference paid to him is the value of the ore at the mine.

The price of copper averaged 11.2 cents per pound; the price of silver, about 50.9 cents per fine ounce; and gold was generally paid for at the rate of $19.95 cents per fine ounce. The usual allowance for the gold contents of the copper ore was at a round figure of $20 per fine ounce, the difference between this rate and the coining rate of $20.67 per ounce being reckoned among the charges for treatment.

The preceding table shows, among the metallic contents of the copper ore, iron valued at $22. An allowance for iron is made only on those ores which are sufficiently rich in that metal to be of value as a fluxing material.

The increase of the stock of ore represents a portion of the ore mined in 1902 which remained unsold on January 1, 1903. The value is necessarily an estimate. It applies only to the mines the ore from which was sold in crude state, the gross value and the charges being reported for the portion sold, the value of the rest being estimated on the same basis. Where the ore was dressed at the mine, or shipped to a smelter operated under joint management with the mine, it was impossible in most cases to estimate the value of the ore in the bins, the segregation of the cost of milling from other expenses being impracticable.

The increase in the stock of ore reported was 39,494 tons, or three-tenths of 1 per cent, out of a total of 11,780,064 tons mined. Evidently, as a rule, only the tonnage treated was reported. The 1,068 tons of ore purchased by the mills are taken to be a duplication of the product of some mines, which reported the value of their ores sold. Therefore the value of this ore, $19,733, is deducted from the total value reported for

1902. Yet it is possible that this ore may have come, in part at least, from mines idle in 1902. The error, if any, is a negligible quantity.

In the following table the bullion contents of the copper ores mined in 1902 are shown by states and territories:

TABLE 14.—BULLION CONTENTS OF COPPER ORES SOLD AND TREATED, BY STATES AND TERRITORIES: 1902.

STATE OR TERRITORY.	COPPER.		SILVER.		GOLD.		LEAD.		IRON.
	Pounds.	Value.	Fine ounces.	Value.	Fine ounces.	Value.	Pounds.	Value.	Value.
United States	625,004,529	$70,175,810	11,452,280	$5,833,256	92,911	$1,854,025	552,070	$19,053	$22
Arizona	121,235,546	13,351,837	612,744	311,556	15,526	310,071	431,360	15,527	22
California	26,530,204	3,053,817	714,785	370,737	17,211	353,274	.....	.....	.....
Colorado	644,950	64,197	19,603	9,854	715	14,362	61,770	1,329	.....
Michigan	171,102,065	20,100,425	24,953	12,097	.....	.....	.....	.....	.....
Montana	267,779,794	30,034,912	9,675,603	4,935,079	32,153	644,178	.....	.....	.....
New Mexico	7,297,383	[1]400,318	6,048	3,021	229	4,576	.....	.....	.....
Utah	17,600,676	1,795,511	375,874	181,837	26,893	524,225	50,540	1,903	.....
Southern states[2]	12,661,328	1,356,959	11,587	3,510	120	2,240	.....	.....	.....
All other states[3]	152,583	17,834	11,083	5,574	64	1,099	8,400	294	.....

[1] The value for New Mexico is a flat value and does not include charges for smelting and freight.
[2] Includes North Carolina, Tennessee, and Virginia.
[3] Includes Idaho, Nevada, Oregon, Washington, Wisconsin, and Wyoming.

Some silver was contained in the copper ores mined in every state; but the silver contents of the Lake Superior ores were too insignificant to pay for the cost of recovering them, and, as a rule, brought no value to the owner. For the same reason no returns were made to the mine operator for the gold and silver contents of the southern ore, though some of them ultimately reached the eastern electrolytic refineries where the precious metals were saved, thus increasing the refined gold and silver product brought into the market.

The average price realized by the mine operator for the copper contents of his ore varied by states, as shown in the statement below from 5.5 cents per pound in New Mexico to 11.7 cents in Michigan. The extremely low price in New Mexico was a flat price, no charges being made for smelting and freight. The variations in other states were produced by the fluctuations of the New York price of copper in the course of the year, and depended further upon the manner in which the ore was disposed of, as will be fully explained.

Average price per pound of copper in the ore, by states and territories: 1902.

STATE OR TERRITORY.	Cents.
United States	11.2
Arizona	11.0
California	11.5
Colorado	10.0
Michigan	11.7
Montana	11.2
New Mexico[1]	5.5
Utah	10.2
Southern states[2]	10.7
All other states[3]	11.7

[1] The price for New Mexico was a flat price, from which no deduction was made for smelting and freight.
[2] Includes North Carolina, Tennessee, and Virginia.
[3] Includes Idaho, Nevada, Oregon, Washington, Wisconsin, and Wyoming.

All copper ores mined in the United States are reduced to the metallic state by smelting, some after being crushed at stamp mills and dressed, that is, cleaned of worthless rock, and thus concentrated into a smaller volume. Dressing is the universal practice in the Lake Superior district, while in western mines it is infrequent. A comparative statement of ores dressed before smelting and those shipped in crude state follows:

Method of treatment of copper ore: 1902.

	COPPER CONTENTS.			GROSS VALUE.	
	Tons of ore.	Pounds.	Per cent of crude ore.	Aggregate.	Average per ton.
Total	11,464,868	625,004,529	2.73	$70,175,810	$6.12
Dressed before smelting	[1] 6,559,397	223,935,242	1.68	25,987,738	3.89
Smelted in crude state	[2] 4,905,471	401,069,287	4.19	44,188,072	9.24

[1] The contents of 1,068 tons of ore sold by the mine operators and dressed by the purchasers are included under both heads, and to this extent constitute a duplication.
[2] The copper contents of 128,898 tons of ore smelted in crude state were included in one item with those of ore dressed before smelting.

The ore shipped from the mine directly to the smelter was of a higher grade than the average ore which had to be dressed before it could be shipped to the smelter, the average value per ton of crude ore being $9.24 for the former and $3.89 for the latter. Since, however, the dressed ores included Lake Superior copper bearing rock, which is of a much lower value than western crude ores, the latter are presented separately in the following statement:

Copper contents and gross value of western crude ores: 1902.

	COPPER CONTENTS.			GROSS VALUE.	
	Tons of ore.	Pounds.	Per cent of crude ore.	Aggregate.	Average per ton.
Total	5,144,495	441,241,136	4.29	$48,718,216	$9.47
Sold in crude state	[1] 490,248	46,612,446	4.74	4,059,618	8.26
Dressed before smelting	[1] 711,140	52,833,177	3.71	5,888,103	8.28
Smelted in crude state at works connected with mine	3,943,107	341,795,513	4.33	38,771,495	9.83

[1] Includes a duplication of the contents of 1,068 tons of ore, as explained above.

Of the 711,140 tons dressed before smelting only 39,551 tons, or 5.6 per cent, were shipped to outside smelters, the rest, after concentration, was shipped for smelting to works operated by the mine owners. The practice of dressing before smelting was confined to Arizona.

As appears from the preceding statement, the grade of ore did not vary materially with the disposition of the same. The way in which the ore was handled was apparently determined by the equipment of the mining company.

In the copper industry the combination of mining and smelting under the same operator is the predominating type of organization. The total value of the ore shipped to smelting works operated in connection with mines amounted to $40,432,863, whereas the value of the ore shipped to custom smelters was only $10,745,173. The number of mines connected with smelters was 29, and the number from which ore was shipped to custom smelters was 115. The average output per mine was $1,049,409 for the former and $93,436 for the latter.

The following table shows, by states and territories, the gross value and the metallic contents, the charges for treatment and freight and the value of the product at the mine for ores sold and for those smelted by the mine operator The Lake Superior district and the Southern states are combined to avoid disclosing items reported by individual establishments.

TABLE 15.—VALUE OF ORE SOLD AND SMELTED BY OWNER, COST OF REDUCTION, AND VALUE AT MINE, BY STATES AND TERRITORIES: 1902.

	UNITED STATES.			ARIZONA.		CALIFORNIA.	
	Total.	Sold.	Smelted.	Sold.	Smelted.	Sold.	Smelted.
Tons sold and treated	11,464,868	3,966,521	7,498,347	25,913	1,149,319	33,090	202,498
Copper contents:							
Pounds	625,004,529	125,168,829	499,835,700	3,698,128	117,537,418	4,358,339	22,171,865
Per cent of crude ore	2.7	1.58	3.32	7.14	5.11	6.59	5.47
Value	$70,175,810	$13,001,509	$57,174,301	$351,130	$13,000,707	$479,407	$2,571,410
Average value per pound, cents	11.2	10.4	11.4	9.4	11.1	10.9	11.6
Value of by-products:							
Silver	$5,833,256	$1,181,631	$4,651,625	$45,331	$266,225	$117,241	$253,496
Gold	$1,854,025	$205,673	$1,648,352	$8,291	$301,780	$92,958	$260,316
Other metals	$19,075	$19,075	.....	$15,549	.....	.....	.....
Total gross value	$77,882,166	$14,407,888	$63,474,278	$420,301	$13,568,712	$689,606	$3,088,222
Average per ton	$6.79	$3.65	$8.45	$38.03	$11.66	$20.84	$15.25
Cost of reduction and freight	$26,762,189	$3,740,507	$23,021,682	$167,623	$5,557,544	$311,254	$1,866,911
Average per ton	$2.33	$0.95	$3.06	$15.17	$4.77	$9.41	$9.22
Value at mine	[1] $51,119,977	$10,667,381	$40,452,596	$252,678	$8,011,168	$378,352	$1,221,311

	MONTANA.		UTAH.		OTHER WESTERN STATES.[2]		LAKE SUPERIOR DISTRICT AND SOUTHERN STATES.[3]	
	Sold.	Smelted.	Sold.	Smelted.	Sold.	Smelted.	Sold.	Smelted.
Tons sold and treated	405,278	3,027,866	14,152	231,860	52,434	2,085	3,435,654	2,884,719
Copper contents:								
Pounds	31,108,927	236,670,867	2,711,026	14,889,650	8,025,950	68,966	75,266,459	108,496,934
Per cent of crude ore	3.84	3.91	9.58	3.21	7.65	1.65	1.10	1.88
Value	$2,764,036	$27,270,876	$206,068	$1,589,443	$477,071	$5,068	$8,723,797	$12,733,797
Average value per pound, cents	8.9	11.5	7.6	10.7	5.9	7.3	11.6	11.7
Value of by-products:								
Silver	$936,405	$3,998,665	$50,108	$131,729	$16,949	$1,500	$15,597	$10
Gold	$27,404	$616,774	$55,085	$469,140	$19,695	$342	$2,240	.....
Other metals	.....	.....	$1,903	.....	$1,623	.....	.....	.....
Total gross value	$3,727,845	$31,886,315	$313,164	$2,190,312	$515,338	$6,910	$8,741,634	$12,733,807
Average per ton	$9.20	$10.53	$22.13	$9.45	$9.83	$3.31	$2.54	$4.41
Cost of reduction and freight	$1,716,847	$13,339,361	$113,580	$930,704	$192,802	$3,215	$1,238,401	$1,323,947
Average per ton	$4.24	$4.41	$8.03	$4.01	$3.68	$1.54	$0.36	$0.46
Value at mine	$2,010,998	$18,546,954	$199,584	$1,259,608	$322,536	$3,695	$7,503,233	$11,409,860

[1] Does not include $58,059, the difference between value of increase of stock on hand at close of year, having been neither sold nor smelted, and the value of ore purchased, included here but not shown in Table 1.
[2] Includes Colorado, Idaho, Nevada, New Mexico, Oregon, Washington, and Wyoming.
[3] Includes Michigan, North Carolina, Tennessee, Virginia, and Wisconsin.

The cost of reduction and freight includes all charges of any description deducted by the buyer of the ore from the gross value of the same, whenever the ore was sold, or all charges made by the smelting works against the mine whenever both were operated by the same owner. Most of the Michigan mines reported separately commissions, selling expenses, etc.; some reported separately the cost of haulage from mine to smelter.

When a mine was operated in connection with a smelter, a separate report was secured for the latter, except in one case, where the smelter was operated merely as a test for a few days. The inquiries called for the total amount paid in salaries and wages during the year 1902, the cost of supplies used during the year, and miscellaneous expenses, covering substantially the same items as indicated above; also total tolls received for custom smelting and refining, as well as total tolls paid on the product of the smelter shipped for further treatment to other smelters and refineries. In accordance with the general plan of the census of mines and quarries the expenses of the smelting works were not included among mining expenses. But when no charges were made on the books of the smelter against the mine, both being operated as one establishment, the total expenses

reported for the smelter were regarded as the cost of smelting the ores shipped from the company's mine and were deducted from the gross value of the bullion contents, in order to arrive at the value at the mine. Thus the gross value in Table 13 represents the value of the refined product, and the value at mine is that of the ore computed as herein explained. No attempt was made to estimate the profits of the operator on the smelting of the ores mined by him, as it would be purely a matter of conjecture. It was assumed that the ore was treated at cost, and the profit, if any, is therefore included in the value of the product at the mine.

When, in addition to the ores mined, custom ores were treated by the smelter, the expenses of the smelter were apportioned between the ores mined and those purchased on the basis of the tonnage, and the amount chargeable against the mine was deducted from the gross value. The total quantity of custom ores thus treated was only 447,944 tons, as compared with 7,513,269 tons shipped from mines operated under the same management, or 5.6 per cent of the total quantity treated. Thus any error in that calculation could not materially affect the results.

The value of the product at the mine, thus computed, represents the value of the ore, crude or dressed. The value of the ore at the mine shown in Table 13 differs slightly from that shown in Table 15. The difference amounts to $58,059, which is due to the omission from Table 15 of the estimated value of the increase of stock of ore, amounting to $77,792, and the inclusion of the cost of purchased ores, amounting to $19,733.

The average tenor of copper in the crude ore was 2.7 per cent or "units" of 20 pounds to the ton, and the average value per pound of copper contents was 11.2 cents; the gross value per ton on that basis averaged $6.79. Of the ores sold, nearly seven-eighths were Lake and Southern low-grade ores; taking the United States as a whole, therefore, the average percentage of copper for ore sold appears to have been less than one-half of the average for ores smelted. A comparison by states discloses a different condition; with the exception of Montana, ores shipped to custom smelters were of a higher grade than those smelted at the mine; apparently, low-grade ore could not bear the expense of shipment to a distant smelter, and could be profitably treated only at the mine. In Montana the grade of ore does not differ in the two cases, which is due to the fact that most of the mines are centered near Butte, so that the cost of transportation is not of such importance as elsewhere. The last group, combining the Lake Superior district and the Southern states, merely reflects the defects of the United States average, the reasons for which have been explained.

The average value realized per pound of copper is 1 cent less for ore sold than for ore smelted by the owner. The same relation is observed everywhere, the difference in price on Western ores varying from seven-tenths of a cent in California to 3.1 cents in Utah. The margin represents a part of the charges for the treatment of the ore. The low price reported from "other Western states" is due to the fact, as explained above, that in New Mexico ores containing 7,297,383 pounds of copper, and valued at $400,318 were sold at a flat price, no deductions being made for treatment. In the Lake Superior district the same value is allowed per pound of fine copper in the dressed ore (locally known as "mineral") and in refined bullion. The slight variation of one-tenth of a cent is due to the difference in Southern ores.

The average charges for treatment and freight must be compared by states or groups of states, inasmuch as the result for the United States is affected by the inclusion of Lake ores which are shipped to the smelter after being considerably reduced in weight by dressing. Of the total quantity of Lake ores, 5,036,547 tons were reduced to 120,042 tons of mineral—that is, to 2.4 per cent of the original weight. This method naturally reduced the cost per ton of rock treated. Compared by states the cost of treatment varies; in California and Montana, as well as in the Lake Superior district and in the Southern states, there is no apparent difference between the charges on ores sold and those smelted by the mine operator, whereas in all other Western states the cost of treatment is higher for the former than for the latter.

A segregation of the cost of reduction into charges for treatment and freight was not in all cases obtainable. The aggregate charges for reduction amounted to $26,762,189. This amount was distributed as follows:

Cost of reduction of ores: 1902.

	All ores.	Ore sold.	Ore smelted by owner.
Total	$26,762,189	$3,740,507	$23,021,682
Charges for treatment, etc.	22,124,950	2,633,857	19,491,093
Freight	3,402,359	549,260	2,853,099
Not reported separately	1,234,880	557,390	677,490

As appears from the preceding statement, 95.4 per cent of the total cost of reduction reported for ores smelted by the mine operators, and 85 per cent of the total reported for ores sold, could be segregated into freight and other charges. Freight, as far as reported, amounted to about one-sixth of the cost of reduction for ores and concentrates shipped to outside smelters, and to about one-eighth for ores smelted at works connected with the mine. The item of freight amounted, in all, to $3,402,359, which was equal to a charge of 4.4 per cent on the gross value of the ore.

Mines and mills.—When a mine and reduction works were operated under the same management, separate reports were required for each, and special schedules were provided for the purpose. Still the mine operator

was given the option of making one report covering both the mine and the reduction works, whenever it was impracticable to report them separately.

In the Lake Superior district, where ore dressing is an integral part of copper mining, the reports furnished by the mine operators included in each case both the mine and the mill. Separate reports for mine and mill were received from each of the 7 western operators. A summary of these reports is presented in the following table:

TABLE 16.—*Summary of mines combined with mills where separately reported: 1902.*

	Mines and mills.	Mines.	Mills.
Number of mines and mills	7	7	7
Salaries	$164,517	$131,404	$33,113
Wages	$1,562,646	$1,277,963	$284,683
Contract work	$44,891	$44,891	.....
Miscellaneous expenses	$137,213	$76,713	$60,500
Cost of supplies and materials	$716,468	$592,887	$123,581
Cost of purchased ores	$19,733	.....	$19,733
Value of product at mine	$4,237,688	.....	.....
Ore mined, short tons	734,555	734,555	.....
Crude ore shipped to smelters, short tons	146,160	.....	.....
Ore milled, short tons:			
From mine	585,539	.....	585,539
Purchased	1,068	.....	1,068
Concentrates produced, short tons	77,903	.....	77,903
Bullion contents of ore shipped and milled:			
Copper—			
Pounds	57,370,088	.....	.....
Gross value	$6,116,100	.....	.....
Silver	$45,263	.....	.....
Gold	$25,022	.....	.....
Other metals	$15,527	.....	.....
Total gross value	$6,201,912	.....	.....

The following table is a summary of all mines that were separately reported, with and without mill connection. Lake Superior mines, as stated, do not come within this category. The table is confined to mines only; no data relating to mills are included therein.

TABLE 17.—*Summary, exclusive of mills, for mines with mill connections compared with mines not connected with mills: 1902.*

	Mines reporting.	Mines with mill connection.	Mines not connected with mills.
Number of mines	123	7	116
Salaries	$1,187,267	$131,404	$1,005,863
Wages	$12,121,518	$1,277,963	$10,843,555
Contract work	$177,043	$44,891	$132,152
Miscellaneous expenses	$862,519	$76,713	$785,806
Cost of supplies and materials	$6,271,175	$592,887	$5,678,288
Value of product at mine	$32,872,560	$3,735,811	$29,136,749
Ore mined, short tons	5,542,712	734,555	4,808,157
Ore shipped and milled:			
Short tons	5,493,218	731,699	4,761,519
Bullion contents—			
Copper—			
Pounds	453,452,464	56,920,088	396,532,376
Value	$50,055,442	$6,096,367	$43,959,075
Silver	$5,821,159	$45,263	$5,775,896
Gold	$1,854,025	$25,022	$1,829,003
Other metals	$19,075	$15,527	$3,548

Where the mine was connected with a mill the value of product reported was that of the mill product, which would not be comparable with the value reported by mines without a mill connection; the value at mine has, therefore, been estimated in the same manner as in cases where the ore was smelted at works connected with the mine; the total reported expenses of the mill have been deducted from the value of the mill product, and the difference is taken to represent the value of the crude ore at the mine. The gross value of the product is obtained by deducting the cost, $19,733, of ore purchased for the mill, from the gross value of the bullion contents; the same amount being deducted from the reported value of copper, in order to obtain the value of the copper contents of the ore mined. The value of the copper contents of purchased ore, of course, exceeded the price paid by the mill for the crude ore. Yet as the copper contents of purchased ores were less than 1 per cent of the total quantity treated, they may be regarded as a negligible quantity.

Comparison by geographic divisions.—The growth of the copper production in the United States is mainly the result of the development of copper mining in Montana and Arizona. In 1879 five-sixths of the production of the United States came from Michigan; though the annual production of Michigan has since more than trebled, the relative share of Michigan had declined to a little over one-fourth in 1902, while the output of Montana and Arizona for the year 1902 amounted to nearly three-fifths of the production of the United States. The copper production of the above three states and of the United States since the year 1883 when records for Montana and Arizona began, is presented in the following table:

TABLE 18.—*Production of the United States, and of the Lake Superior, Montana, and Arizona districts: 1883 to 1902.*

[United States Geological Survey, "Mineral Resources of the United States," 1902.]

[Long tons.]

YEAR.	Total production, United States.	LAKE SUPERIOR.		MONTANA.		ARIZONA.	
		Production.	Per cent of total.	Production.	Per cent of total.	Production.	Per cent of total.
1883	51,574	26,653	51.6	11,011	21.3	10,658	20.7
1884	64,708	30,961	47.8	19,256	29.8	11,935	18.4
1885	74,052	32,209	43.5	30,267	40.9	10,137	13.7
1886	70,430	36,124	51.3	25,362	36.0	6,990	9.9
1887	81,017	33,941	41.9	35,133	43.4	7,940	9.7
1888	101,054	38,604	38.2	43,704	43.2	14,195	14.0
1889	101,239	39,364	38.7	43,849	43.3	13,654	13.5
1890	115,966	45,273	38.9	50,437	43.5	15,534	13.4
1891	126,839	50,992	40.2	50,028	39.5	17,800	14.0
1892	154,018	54,999	35.7	72,860	47.3	17,160	11.1
1893	147,033	50,270	34.2	69,290	47.1	19,200	13.1
1894	158,120	51,031	32.3	81,729	51.6	19,873	12.6
1895	169,917	57,737	34.0	84,900	50.0	21,408	12.6
1896	205,384	64,073	31.2	99,071	48.2	32,560	15.8
1897	220,571	64,858	29.4	102,807	46.6	36,398	16.5
1898	235,050	66,291	28.2	92,041	39.2	49,624	21.1
1899	253,870	65,803	25.9	100,503	39.6	59,399	23.4
1900	270,588	64,938	24.0	120,865	44.7	52,820	19.5
1901	268,782	69,772	25.9	102,621	38.2	58,383	21.7
1902	294,423	76,165	25.9	128,075	43.8	53,547	18.2

A comparative summary by geographic divisions is presented in Table 19. The Lake Superior district is practically synonymous with the state of Michigan; the returns of the present census of mines and quarries show only 1 small mine in Wisconsin, with an output valued at less than $500.

TABLE 19.—*Comparative summary of western, Lake Superior, and southern copper mines: 1902.*

	Western states.	Lake Superior district.	Southern states.
Number of mines	118	25	5
Salaries	$1,106,056	$598,076	$64,324
Wages	$12,212,957	$8,745,204	$193,244
Contract work	$177,043	$11,725	.....
Miscellaneous expenses	$859,031	$474,446	$63,988
Cost of supplies and materials	$6,293,251	$4,688,419	$101,505
Value of product at mine	$32,206,884	$18,247,417	$665,676
Ore mined, short tons	5,186,183	6,247,352	346,529
Ore shipped and milled:			
Short tons	5,145,563	5,971,650	348,723
Bullion contents—			
Copper—			
Pounds	441,241,136	171,102,065	12,661,328
Value, total	$48,718,216	$20,100,635	$1,356,959
Average per pound, cents	11.0	11.7	10.7
Silver	$5,817,649	$12,097	$3,510
Gold	$1,851,785	.....	$2,240
Other metals	$19,075	.....	.....
Total gross value	$56,406,725	$20,112,732	$1,362,709
Average percentage of copper in ore	4.29	1.43	1.82
Average return from by-products:			
Per ton mined	$1.48	$0.002	$0.017
Per ton sold and treated	$1.49	$0.002	$0.016
Per pound of copper, cents	1.7	.....	.....

Lake Superior district.—Until the development of copper mining in the Western states, in the early eighties, the Michigan mines were practically the only source of domestic production of copper. A comparative summary of census statistics for Michigan copper mines beginning with 1860 is presented in the following table:

TABLE 20.—*Comparative summary, Michigan: 1860 to 1902.*

	1902	1880	1880	1870	1860
Number of mines	20	(1)	19	[2] 27	[2] 30
Salaried officials, clerks, etc.:					
Number	419	[3] 41	(4)	(4)	(4)
Salaries	$598,076	$67,369	(4)	(4)	(4)
Wage-earners:					
Average number	13,887	[3] 5,695	5,190	4,188	3,631
Wages	$8,744,892	$3,174,363	$2,661,243	$2,346,535	$1,388,208
Contract work	$11,725	$306,627	.....	.....	.....
Miscellaneous expenses	$473,501	$1,247,978	(1)	(1)	(1)
Cost of supplies and materials	$4,688,419	$2,682,491	$1,215,206	$555,416	$139,600
Product:					
Pounds of copper	171,102,065	87,455,675	45,830,262	(1)	(1)
Value	$20,563,353	(1)	$7,979,232	$4,312,167	$2,282,182

[1] Not reported.
[2] Establishments.
[3] Foremen included in wage-earners.
[4] Not reported separately.

The noteworthy feature disclosed by the preceding table is the gradual concentration of production from one census to another. Assuming that the establishments reporting in 1860 and 1870 represented mines, the number of mines decreased from 1860 to 1880, and since then has remained about the same; but the output at each census has been about double the value or the quantity reported at the preceding census. The average production per mine was as follows: In 1860, $72,379; in 1870, $159,710; in 1880, $419,960; and in 1902, $1,028,168.

The progress in the equipment of mines went on in proportion to the increase in the volume of production. This is illustrated by the growth of the number and horsepower of steam engines used, as summarized in the following statement:

Steam engines and horsepower in Michigan: 1902, 1880, and 1870.

YEAR.	Number of mines.	NUMBER OF ENGINES.		HORSEPOWER.		
		Total.	Average per mine.	Total.	Average per engine.	Average per mine.
1902	20	439	22.0	137,522	313	6,876
1880	19	113	5.9	12,715	112	669
1870	[1] 27	86	3.2	5,943	69	220

[1] Establishments.

The preceding statement clearly shows the remarkable growth of the application of steampower, especially within the last two decades. The average power employed in the production of 1 short ton of fine copper in 1880 was equal to fifty-five hundredths of 1 horsepower, and in 1902 to 1.61 horsepower, nearly threefold.

Of the 20 mines reporting in 1902, 13 made complete reports, stating the quantity of rock treated, the quantity of mineral produced, and the fine copper contents of the mineral; 3 failed to state the quantity of rock treated, but reported the quantity of mineral and copper contents; 4 reported the quantity of rock treated and the fine copper contents, but failed to report the quantity of mineral produced. The total reported quantity of rock hoisted was 6,247,317 tons, of which 5,971,615 tons were treated and 275,702 tons, or 4.4 per cent, were rejected as too poor to go to the stamp mill.

Complete reports from 13 mines showed 5,036,547 tons treated at stamp mills, with a yield of 240,084,170 pounds of mineral, containing 144,217,300 pounds of fine copper. The rock was reduced by treatment to 2.4 per cent of its weight; the fine copper contents averaged 60.1 per cent of the mineral, or 1.4 per cent of the weight of the rock. Returns from 16 mines showed 5,971,615 tons of rock treated, containing 165,631,605 pounds of fine copper, or 1.4 per cent of the quantity of ore treated. Returns from 17 mines showed 249,569,244 pounds of mineral, yielding 149,262,636 pounds of fine copper, or 59.8 per cent.

The percentage of mineral produced varied in individual cases from six-tenths of 1 per cent to 2.4 per cent of the rock treated, and the copper contents varied from 53.4 per cent to 91 per cent of the mineral. The proportion of 2.4 per cent of mineral to the quantity of rock treated and 60 per cent for the fine copper contents of the mineral, or 1.4 per cent for the fine copper contents of the rock, may be taken as representing the general average. Upon this basis the quantity of rock treated in cases where mineral alone was reported may be estimated at 198,000 tons, which would raise the quantity reported to about 6,179,000 tons, or 3.2 per cent.

The total quantity of rock hoisted in 1889 was 2,363,733 tons, of which 2,137,653 tons were treated, a part of the ore being rejected as too poor to go to the stamp

mill. This quantity of ore yielded 117,804,926 pounds of mineral, or an average of 2.8 per cent. The average percentage of fine copper in the mineral was 74.2 per cent.

The progress of copper mining in the Lake Superior district is shown in the following statement:

Production and dividends of Lake copper mines, by quadrennial periods: 1879 to 1902.[1]

PERIOD.	Quantity of fine copper (pounds).	GROSS VALUE.		DIVIDENDS.		Average gross value per pound, less dividends per pound (cents).
		Total.	Average per pound (cents).	Amount.	Average per pound (cents).	
1879-1882	204,094,755	$37,769,141	18.5	$10,413,620	5.1	13.4
1883-1886	282,121,955	35,683,232	12.6	7,867,500	2.8	9.8
1887-1890	352,086,633	50,755,245	14.4	10,715,000	3.0	11.4
1891-1894	464,335,117	49,963,618	10.8	12,700,000	2.7	8.1
1895-1898	562,056,573	63,996,758	11.4	19,553,250	3.5	7.9
1899-1902	615,920,822	95,929,592	15.6	33,066,550	5.4	10.2
1899-1901	444,818,757	75,829,167	17.0	29,626,550	6.7	10.3
1902	171,102,065	20,100,425	11.7	3,440,000	2.0	9.7

[1] Compiled from the Copper Handbook, Vol. III, page 573.

In the statement which follows all Lake Superior copper companies are divided into three classes: (1) Those whose total dividends since organization have more than equalled the amount of capital stock issued, (2) those whose dividends have not equalled the amount of capital stock issued, and (3) those which have never paid any dividends.

Capital stock issued and total dividends paid since organization by Lake Superior mining companies.[1]

	Number of companies.	Stock issued.	Dividends paid.
Total	60	$46,038,500	$117,685,920
Dividends in excess of stock issued	10	5,122,000	116,045,920
Dividends short of stock issued	6	3,987,500	1,640,000
No dividends paid	44	36,929,000	.....

[1] The Copper Handbook, Vol. III, page 592.

The large majority of the Lake Superior copper mining companies have never paid any dividends. Of the 16 dividend paying companies 4 were absorbed by other companies, 2 of which were themselves dividend paying; 2 were closed after a successful career; 1 was closed after earning in eleven years enough to retire its outstanding capital stock; and 1 was closed after proving a losing venture. This leaves 10 active dividend paying companies, of which, however, only 3 paid dividends in 1902. The total number of active companies reported to the census of 1902 was 20; it is therefore apparent that 10 of this number had never paid any dividends. Of the 44 companies which at one time or another have operated in the Lake Superior region 34 were inactive or did not exist during the census year. The 2 mines mentioned above which closed after proving profitable investments were Cliff, which from 1849 to 1867 netted in dividends $2,407,620, after earning an amount equal to its capital stock of $111,000, and Central, which from 1864 to 1891 netted in dividends $1,870,000, after earning an amount equal to its capital stock of $100,000.

A very instructive record of mining for a long series of years is presented in the published reports of the Quincy Mining Company. It was organized in 1848 and reincorporated in 1878 with a capital stock of $2,500,000, and had paid in dividends since organization to the close of 1902, $13,920,000. The company operated its own smelter in connection with its mine, and marketed refined copper. The statistics are given in the following statement:[1]

Quincy Mining Company: 1866 to 1902.

YEAR.	Product (pounds).	Yield of fine copper per fathom broken (pounds).	Price obtained per pound (cents).	Cost per pound exclusive of construction (cents).	Number of miners.	Average monthly contract wages.
1866	2,114,220	451	31.3	29.0	227	$53.16
1867	1,921,620	526	22.7	18.9	167	50.83
1868	1,417,941	447	25.2	23.1	167	50.44
1869	2,417,365	446	21.9	16.7	210	51.10
1870	2,496,774	528	21.5	15.3	181	46.09
1871	2,409,501	441	22.8	15.2	104	47.08
1872	2,269,104	391	32.5	22.9	233	60.62
1873	2,621,087	491	26.5	18.6	223	62.42
1874	3,050,154	577	21.9	15.1	234	43.38
1875	2,798,281	485	22.7	15.8	217	46.74
1876	3,078,171	507	20.0	15.7	227	47.13
1877	2,837,014	467	18.6	15.1	247	43.79
1878	2,991,050	395	14.9	14.0	234	41.50
1879	2,639,958	403	16.3	13.7	212	38.76
1880	3,609,250	563	18.5	11.8	192	49.10
1881	5,702,606	766	18.7	10.6	212	48.54
1882	5,682,663	800	17.1	9.5	152	48.83
1883	6,012,239	850	13.7	8.9	165	46.02
1884	5,680,087	722	12.2	8.6	157	43.35
1885	5,848,497	710	11.4	7.5	132	44.00
1886	5,888,517	638	11.1	6.8	140	45.80
1887	5,603,691	781	11.7	8.6	142	48.40
1888	6,367,809	690	15.9	10.1	158	49.60
1889	6,405,686	690	12.0	9.4	145	49.15
1890	8,064,253	769	15.7	8.2	146	52.60
1891	10,542,519	685	12.8	9.1	182	53.40
1892	11,103,926	572	11.2	8.8	238	53.75
1893	14,398,477	574	10.4	7.1	259	49.60
1894	15,484,014	584	9.5	5.7	285	50.70
1895	16,304,721	517	10.1	5.9	336	50.00
1896	16,863,477	477	10.0	6.5	379	52.00
1897	16,924,618	481	11.1	6.8	393	52.52
1898	16,354,061	513	12.0	6.8	381	52.50
1899	14,301,182	427	17.0	8.1	401	56.72
1900	14,116,551	391	16.6	9.3	433	62.00
1901	20,540,720	409	16.1	8.8	533	62.00
1902	18,988,491	347	12.0	9.0	562	62.00

The preceding statement shows that the average annual production of the company increased after 1866 nearly tenfold, whereas the average number of miners employed increased about 2½ times—that is, the average miner is able to produce with modern methods and machinery about four times as much as in 1866. The cost of production per pound has been reduced to less than one-third of what it was in 1866.

Montana, Arizona, and New Mexico.—Copper mining in Montana, Arizona, and New Mexico did not develop until the eighties. Very scant information on copper mines in that region is recorded in the reports of the Tenth Census. Arizona reported 110 wage-earners whose wages aggregated $77,128. The production did

[1] For 1866 to 1901, taken from the Copper Handbook, Vol. III, pages 458 and 459; for 1902, from the report of the company.

not exceed 7,650 tons of ore, which contained 3,183,750 pounds of copper.

Montana reported in 1880 only 523 tons of ore containing 1,212,500 pounds of copper, and New Mexico had only 13 tons to show, which yielded 4,055 pounds of copper.

A comparative summary for the years 1902 and 1889 follows:

TABLE 21.—COMPARATIVE SUMMARY FOR ARIZONA, MONTANA, AND NEW MEXICO: 1902 AND 1889.

	Year.	SALARIED OFFICIALS, CLERKS, ETC.		WAGE-EARNERS.		Contract work.	Miscellaneous expenses.	Cost of supplies and materials.	PRODUCT.		
		Number.	Salaries.	Average number.	Wages.				Tons of ore.	Copper contents. Pounds.	Copper contents. Per cent ratio per ton.
Arizona	1902	258	$399,275	3,797	$3,497,528	$122,337	$256,753	$2,135,676	1,210,301	121,235,516	5.01
	1889	14	23,762	838	726,021	23,774	48,242	325,020	155,586	31,362,685	10.08
Montana	1902	310	494,415	6,388	7,339,773	40,975	456,108	3,649,127	3,428,860	267,779,794	3.90
	1889	10	22,515	1,948	2,010,940	2,722	138,288	1,029,990	698,837	97,868,064	7.00
New Mexico	1902	24	32,120	164	128,483	10,266	26,858	49,408	46,993	7,297,383	7.76
	1889	5	7,250	240	184,701	1,320	8,338	30,469	34,586	3,883,014	5.61

The average copper contents per ton of ore mined in Montana and Arizona has considerably decreased since 1889. It may be inferred from these figures that the development of those parts of the country, and the introduction of improved processes, have made it possible to treat lower grades of ore, which could not have been profitably worked in 1889.

Smelters connected with mines.—The following table is a summary for smelters connected with mines; the expenses shown therein (salaries and wages, miscellaneous expenses, supplies and materials) are not included in the statistics of copper mines, having been used merely in estimating the value of the ore at the mine as explained on a previous page, under the head of "production."

TABLE 22.—SUMMARY OF SMELTERS AND REFINERIES CONNECTED WITH MINES: 1902.

CHARACTER OF SMELTING WORKS.	Number of establishments.	Salaries and wages.	Miscellaneous expenses.	Supplies and materials, not including ores.	Cost of refining.	Freight on bullion shipped.	MATERIALS TREATED. Ore from mine (short tons).	MATERIALS TREATED. Purchased ore (short tons).	Purchased matte (short tons).	Copper produced (pounds).
Total	29	$8,796,932	$2,156,205	$9,033,227	$1,961,001	$1,536,788	4,161,772	411,029	36,915	557,111,390
Treating ore from mine only	16	2,322,779	321,351	2,466,770	954,316	984,819	958,255	.....	.....	166,483,274
Treating ore mined by company and purchased ore	7	1,715,338	98,858	1,732,249	981,016	511,675	811,677	162,208	17,248	112,245,520
Connected with refinery	6	4,758,815	1,735,996	4,834,208	25,669	40,294	2,391,840	248,821	19,667	278,382,596

The summary is not intended as a complete presentation of the business transacted by the smelters, which is beyond the scope of the census of mines and quarries. The cost of purchased ores is therefore not included in the statement, nor are the earnings from the treatment of custom ores given therein. Copper smelters located in Michigan are not comprised in this statement. It includes, however, the Buffalo smelter of the Calumet and Hecla Mining Company, to which a portion of its product is shipped for treatment.

The copper product shown contains a duplication of 11,808,230 pounds, representing the contents of matte produced by one of the smelters and further treated at two of the six smelters and refineries included in the summary. The total copper product of these smelters was accordingly 545,603,160 pounds.

Copper contents of all ores mined, including gold and silver ores.—The production discussed in the preceding pages is that which is credited to the copper mines, as therein defined. For certain comparative purposes it is necessary to show the copper contents of all ores mined, including those whose chief value is that of their precious metal contents. The following statement shows the copper contents of all ores mined in 1902, by sources of production:

Copper contents of all ores mined, by sources of production: 1902.

SOURCE OF PRODUCTION.	Pounds.	Gross value at mine.
Total	639,033,392	$71,192,014
Copper mines	625,004,529	70,175,810
Gold and silver mines	14,028,863	1,016,204

The share contributed by each state or territory to the copper production of the United States is shown in the following table:

TABLE 23.—*Copper contents of all ores mined, by states and territories: 1902.*

STATE OR TERRITORY.	Pounds.	Value.
United States	639,033,392	$71,192,014
Arizona	121,409,275	13,367,135
California	26,549,063	3,055,908
Colorado	5,841,074	450,355
Georgia	9,500	1,235
Idaho	86,442	9,149
Michigan	171,102,065	20,100,425
Montana	268,440,090	30,092,781
Nevada	29,114	3,134
New Mexico	8,017,902	462,053
North Carolina	418,801	45,531
Oregon	46,154	2,800
South Dakota	787	67
Tennessee	12,284,515	1,316,991
Utah	24,720,824	2,272,692
Virginia	3,246	398
Washington	72,540	10,890
Wisconsin	.....	210
Wyoming	2,000	260

Consumption of copper ores.—In order to verify the accuracy of the returns for the production of copper mines, they must be compared with the reports of all copper smelters showing the consumption of copper ores as materials for smelting.

With that purpose in view the special schedule relating to copper mines contained an inquiry calling for the name and address of the mill or works at which the ore was treated. The special schedule provided for mills ("reduction works other than smelters") called for the "name, location, and character of establishment to which the product was sold or shipped for final treatment." A similar inquiry was inserted in the special schedules addressed to smelters. These inquiries were intended to trace the product from the producer to the consumer, as well as to guard against duplications in cases where the same product was successively treated by different establishments.

Only 4 mines failed to answer the inquiry. The total production of those mines was 257 tons of ore, containing 20,604 pounds of copper, having a gross value of $2,212; in a total production of copper the gross value of which exceeded $70,000,000, this is a negligible quantity.

Copper ore mined in the United States is eventually converted into metallic copper in this country, with the exception of a small quantity exported in the shape of matte. Matte (called also "regulus") is a semi-metallic product obtained from ore by fusion; it contains from 25 to 70 per cent of copper and is blown by further fusion to metallic copper.

A portion of the ore was thus concentrated at local matte smelters and shipped for further treatment to other smelters which produce pig copper. The total fine copper contents of matte shipped, according to reports received at the Bureau of the Census, amounted to 43,339,268 pounds. Of this quantity, 6,717,594 pounds were shipped to New York brokers for export; 13,325,690 pounds were traced from the matte smelters to the plants where the matte was converted into metallic copper; 22,977,984 pounds were reported by copper smelters as the contents of purchased matte, the producers of the matte failing to report; and 319,000 pounds were reported by shippers, the destination of the matte not being stated.

The copper contents of the matte, with the exception of the 13,325,690 pounds which were reported by both shippers and buyers, must be included in the total output of copper. The 319,000 pounds reported only by shippers were either intended for export, or they may have been duplicated in the report of some other smelter. Compared with the total production of the United States, the error would amount to only five-hundredths of 1 per cent.

The production of matte and metallic copper, as reported by smelters, is shown in the statement below.

The Lake Superior ores were smelted at the following works: The output of the Calumet and Hecla Mining Company and the Quincy Mining Company at their own smelters, from which reports were secured; the mineral from all other mines was treated by the Quincy Mining Company and by the Lake Superior Smelting Company, at Hancock, Mich. No report was secured from the latter. The copper product of Lake Superior ores has, therefore, been taken from the reports of the Michigan mining companies, including the two above named, which had their own smelters.

Some copper was produced by lead smelters engaged principally in the treatment of gold and silver bearing ores; the quantity reported by them is shown separately in the following statement:

Production of metallic copper and matte in the United States: 1902.

Metallic copper:	Fine copper (pounds).
From—	
Western and southern ores	424,721,738
Lake Superior ores	171,102,065
Imported ores	40,797,847
Reported by lead smelters	18,931,168
Matte	43,339,268
	698,892,086
Deduct duplication in matte	13,325,690
Total output of smelters	685,566,396
Less product of imported ores	40,797,847
Total copper product of all domestic ores	644,768,549
Reported by mine operators	[1] 639,033,392
Variance	5,735,157

[1] Includes 14,028,863 pounds reported as by-product of gold and silver ores.

The variance between the output of mines and smelters is less than 1 per cent.

The United States Geological Survey reports the total output of copper refineries as 699,508,644 pounds, and estimates the copper contents of imported ores at 40,000,000 pounds; the difference, 659,508,644 pounds, is taken to represent the copper production of the United States for 1902. This estimate exceeds the production of mines by 20,475,252 pounds, or 2.9 per cent, and the output of smelters by 15,340,155 pounds, or 2.4 per cent.

There naturally would be a difference between the copper contents of ore shipped from the mines and the quantity of copper produced by smelters and refineries. Where the ore was smelted by the mine operator the quantity reported, as a rule, represented the actual recovery of fine copper; but where the ore was shipped to a custom smelter the quantity reported represented the assay contents which were paid for. Furthermore, the periods covered by the returns were not in all cases the same, some companies reporting for their various fiscal years nearest to the calendar year 1902. Then, too, the stocks on hand and in process carried at the smelters and refineries fluctuate from one year to another. In one case reported to this office the deliveries of an electrolytic copper refinery for 1902 differed from the receipts for the same year by more than 40,000,000 pounds of fine copper. Again, duplications can not always be avoided. That the variance between the quantities reported for the several stages of the copper industry is confined within such narrow limits vouches for the substantial accuracy of the results.

Mineral lands.—The primary distinction between mining and manufacturing is that in the former industry there are three factors of production, viz, land, capital, and labor, while only labor and capital are essential in the latter. The present census of mines and quarries is the first in which the scope of the inquiry has in some branches been extended to the ownership of mineral lands. Though the special schedule provided for gold, silver, lead, and copper mines was confined to mineral lands, it is probable that in some cases the reports included all lands of any description, such as timber lands, building lots, etc.

The following table shows the distribution of mineral lands, by title of tenure, for the United States and by states and territories. For 5 of the 144 mines no report was made on this subject—3 in Arizona, 1 in New Mexico, and 1 in Virginia; 1 establishment was a holding company.

TABLE 24.—*Summary of mineral lands, by states and territories: 1902.*

STATE OR TERRITORY.	Total acres.	LAND OWNED.		LAND LEASED.	
		Number of mines.	Acres.	Number of mines.	Acres.
United States	86,523	[1] 122	83,270	[1] 20	3,253
Arizona	13,754	27	13,754		
California	6,120	6	5,960	1	160
Colorado	1,664	14	1,422	4	242
Idaho	544	1	544		
Michigan	39,281	20	39,281		
Montana	2,572	23	2,306	4	266
Nevada	200	1	200		
New Mexico	4,478	10	3,895	6	583
North Carolina	2,357	2	1,257	1	1,100
Oregon	1,400	2	1,400		
Tennessee	11,600	2	10,750	1	850
Utah	1,088	11	1,056	2	32
Washington	800	1	800		
Wisconsin	320	1	320		
Wyoming	345	1	325	1	20

[1] Of this number 4 mines reported both owned and leased land.

Of the acreage owned, as shown in the preceding table, 91 acres were reported by the owners as leased to other parties, viz, 16 acres in Montrose county, Colo., on which copper was not mined, and 75 acres distributed among other states and territories, upon which miners were virtually employed on a share of the product, as explained on a previous page. In the above table, consequently, these 91 acres are not duplicated.

The leasing of land apparently plays a very subordinate part in copper mining. The royalties on the 3,253 acres leased aggregated $33,184, or a little over $10 per acre. The greater part of the acreage, namely, 2,080 acres, was held by 4 operators, who, in addition to leased land, operated their own mines and made in each case only one report for the entire operation. A summary for those mines which were operated exclusively on leased land is presented in the following table:

TABLE 25.—*Number of mines operating exclusively on leased lands, acres leased, value of product, and royalties paid: 1902.*

STATE OR TERRITORY.	Number of mines.	Acreage leased.	Value of product at mine.	Royalties paid.
United States	16	1,173	$85,103	$21,291
Colorado	4	242	1,620	360
Montana	4	266	29,955	7,579
New Mexico	5	473	49,014	11,508
All others[1]	3	192	4,514	1,844

[1] Includes California, 1; Utah, 2.

The mines operated on leased land were all very small producers; a little over one-half of that land, viz, 652 acres, was still under development. The royalties paid amounted to about one-fourth of the value of the product at the mine.

In the following table all mines are classified by the area of mineral lands owned and leased:

TABLE 26.—ACREAGE OF MINERAL LANDS, BY STATES AND TERRITORIES: 1902.

STATE OR TERRITORY.	TOTAL.		20 ACRES OR LESS.		21 TO 99 ACRES.		100 TO 999 ACRES.		1,000 TO 4,999 ACRES.		5,000 ACRES AND OVER.	
	Number reporting.	Acreage.	Number reporting.	Acreage.	Number reporting.	Acreage.	Number reporting.	Acreage.	Number reporting.	Acreage.	Number reporting.	Acreage.
United States	139	86,523	28	340	26	1,307	59	17,345	23	48,861	3	18,670
Arizona	27	13,754			3	200	21	4,821	3	8,733		
California	7	6,120	1	20	1	60	4	1,040			1	5,000
Colorado	18	1,664	4	40	8	435	6	1,189				
Idaho	1	544					1	544				
Michigan	20	39,281					4	2,740	15	31,541	1	5,000
Montana	27	2,572	17	168	5	191	5	2,213				
Nevada	1	200					1	200				
New Mexico	16	4,478	3	60	3	153	9	2,265	1	2,000		
North Carolina	2	2,357							2	2,357		
Oregon	2	1,400					1	100	1	1,300		
Tennessee	2	11,609							1	2,930	1	8,670
Utah	13	1,088	3	52	6	268	4	768				
Washington	1	800					1	800				
Wisconsin	1	320					1	320				
Wyoming	1	345					1	345				

The correlation between ownership of land and value of production is shown in the following table:

TABLE 27.—*Acreage owned and leased, and value of product: 1902.*

SIZE OF HOLDING.	Number of mines.	AREA.		VALUE OF PRODUCT AT MINE.		AVERAGE VALUE.	
		Acres.	Per cent.	Amount.	Per cent.	Per mine.[1]	Per acre.[2]
Total	144	86,523	100.0	$51,178,036	100.0	$357,888	$586
Less than 100 acres	54	1,647	1.9	5,926,937	11.6	109,758	3,599
100 to 999 acres	59	17,345	20.0	20,963,808	40.9	355,319	1,209
1,000 to 4,999 acres	23	48,861	56.5	23,622,384	46.2	1,027,060	483
5,000 acres and over	3	18,670	21.6	164,951	0.3	54,984	9
Acreage not reported	[3]5			499,956	1.0	124,989	

[1] This average is computed only for mines reporting product.
[2] This average is computed only for mines reporting acreage.
[3] Includes one holding company.

It appears that the value of the production of the mines bore no close relation to the area of mineral lands owned or leased. Still the average value of production per mine increased with the increase in the area of mineral lands owned up to 5,000 acres, though not in the same ratio.

The average value of production per acre decreased as the area increased and the three largest owners were among the smallest producers. It is probable that while the smaller properties were under active operation the larger were awaiting development.

Concentration of the industry.—Copper mining is a highly centralized industry, as appears from the following tables. Table 28 shows the acreage of all mineral lands by districts.

TABLE 28.—ACREAGE OF MINERAL LANDS, BY DISTRICTS: 1902.

	TOTAL.		20 ACRES OR LESS.		21 TO 99 ACRES.		100 TO 999 ACRES.		1,000 TO 4,999 ACRES.		5,000 ACRES AND OVER.	
	Number reporting.	Acreage.	Number reporting.	Acreage.	Number reporting.	Acreage.	Number reporting.	Acreage.	Number reporting.	Acreage.	Number reporting.	Acreage.
United States	139	86,523	28	340	26	1,307	59	17,345	23	48,861	3	18,670
Western states	114	32,965	28	340	26	1,307	54	14,285	5	12,033	1	5,000
Lake Superior district	21	39,601					5	3,060	15	31,541	1	5,000
Southern states	4	13,957							3	5,287	1	8,670

The preceding table clearly illustrates the degree of concentration in the ownership of mineral lands; 78 per cent of the entire area was held by 26 companies, of which 16 were in the Lake Superior district. In the Southern states there were no mining properties of less than 1,000 acres; in the Lake Superior district only 5 held less than 1,000, the average for these being 612 acres. All small mines were located in the Western states, where the concentration was less pronounced.

Table 29 shows the classification of all copper mines of the United States by value of production.

TABLE 29.—*Classification of copper mines by value of production: 1902.*

GROUP BY VALUE.	Number in each group.	VALUE OF PRODUCT AT MINE.	
		Amount.	Per cent.
Total	144	$51,178,036	100.00
Less than $500	21	4,015	0.01
$500 to $999	9	6,523	0.01
$1,000 to $9,999	44	155,552	0.30
$10,000 to $49,999	25	578,766	1.13
$50,000 to $99,999	6	379,162	0.74
$100,000 to $249,999	8	1,160,087	2.27
$250,000 to $499,999	8	3,265,037	6.38
$500,000 to $999,999	11	8,171,374	15.97
$1,000,000 and over	12	37,456,920	73.19

As seen from the preceding table, about three-fourths of the output was contributed by 12 mines producing over $1,000,000 each, and only about one-ninth by 121 mines producing less than $500,000 each.

A similar classification by geographic divisions is impossible without disclosing the individual returns of some mine. It may be stated, however, from an examination of the statistics of production arranged by states, in the same manner as above, that the same proportions shown in the table obtain, with but slight variations, in Montana, Arizona, and the Lake Superior district, which furnish together 92 per cent of the production of the United States. The mines located in other states ranged, according to their output, as follows: 1 over $1,000,000; 1 over $500,000, but less than $1,000,000; 2 over $250,000, but less than $500,000. The output of these 4 mines was valued at $2,928,958, or 71.6 per cent of the total product of these states. There were, moreover, 62 mines distributed as follows: 6 producing over $100,000, but less than $250,000 each, with an aggregate output of $819,661, or 20.1 per cent of the total; 11 producing more than $10,000, but less than $100,000 each, with an output of $269,839, or 6.6 per cent; and 45 producing less than $10,000 each, with an aggregate output of $69,584, or 1.7 per cent.

The preceding statistics, dealing as they do with individual mines or operating companies as units, do not fully express the actual degree of concentration which manifested itself in a variety of forms. One holding company, the Amalgamated Copper Company, controlled, through the ownership of stock, 6 copper mining companies in Montana. The combined production of these companies for the year ending June 1, 1903, according to their sworn statements filed with the assessors of Silverbow county, Mont., aggregated 3,140,380 tons of ore, having a gross value of $33,635,176. Compared with the total production of the copper mines of the United States, as reported at the census of 1902, or for the fiscal year nearest to the same, the output of the Amalgamated Copper Company constituted 27.4 per cent of the tonnage and 43.1 per cent of the gross value.

Closely allied with the Amalgamated Copper Company was the Tennessee Copper Company, whose directorate included two of the directors of the former. Its mining properties situated in Tennessee produced in 1902, according to the report of the directors to the stockholders, 8,103,534 pounds of copper, gross value, $1,024,450, which amounted to 1.3 per cent of the gross value of the output of all copper mines, as reported to the Bureau of the Census.

Next in importance after the Amalgamated Copper Company was the Calumet and Hecla Copper Company of Michigan. President Alexander Agassiz reported for the fiscal year ending April 30, 1903, a production of 38,316 long tons of fine copper, equal to 85,827,840 pounds.[1] The fine copper contents of the copper ores treated in the United States in 1902, as reported to the Bureau of the Census, amounted to 625,004,529 pounds. The production of the Calumet and Hecla Copper Company accordingly approximated 14 per cent of the total output of the copper mines of the United States.

The third place was held by the United Copper Company, which was organized in Montana under the corporate name of the Montana Ore Purchasing Company. The latter reported to the assessors of Silverbow county, Mont., for the fiscal year ended June 1, 1903, an output of 293,332 tons of ore having a gross value of $3,587,692. Mr. F. Augustus Heinze, president of the company, made the following statement to the press regarding the production of the company:

Production of the United Copper Company: 1902 and 1901.[1]

YEAR.	Copper (pounds).	Silver (ounces).	Gold (ounces).
1902	30,374,696	919,590	11,269
1901	30,318,328	1,083,474	4,631

[1] The Commercial and Financial Chronicle, Vol. 76, pages 870 and 927.

Compared with the output of the copper mines of the United States, the production of the United Copper Company constituted 4.6 per cent of the total gross value, or 4.8 per cent of the fine copper contents.

An important group of mines was represented by 7 Michigan companies, which, though maintaining a separate corporate existence, were united under a common management through the ownership of the stock by the same group of stockholders. These were the Winona Copper Company, the Wolverine Copper Mining Company, the Mohawk Mining Company, the Atlantic Mining Company, the Baltic Mining Company, the Michigan Copper Company, and the Champion Copper Company. The total output of these companies, as shown in their published reports, yielded 25,237,594 pounds of fine copper having a gross value of $2,992,335, and constituted 4 per cent of the fine copper contents, or 3.8 per cent of the gross value reported at the census of 1902 for all copper mines.

The respective shares contributed by the above-named companies to the production of the United States are shown in the following statement:

Percentage production of eleven companies formed of total: 1902.

COMPANY.	Per cent of the output of United States.
Total	67
Amalgamated Copper Company	43
Tennessee Copper Company	1
Calumet and Hecla Copper Company	14
United Copper Company	5
Seven Michigan companies	4

[1] The Commercial and Financial Chronicle, Vol. 77, page 193.

This list is not exhaustive; it does not include the United Verde Copper Company of Arizona and the Colusa-Parrott Copper Company of Montana, which are controlled by the same interests, and probably some other mines for which there are no available data. The properties enumerated in the preceding statement contribute two-thirds of the output of the United States.

The possibilities for further centralization are indicated by the location of the general offices of the mining companies. Of the 144 mines, 49 had their offices in the East—31 in New York and 18 in Boston. The output of these mines aggregated 463,445,212 pounds of copper out of a total output of 639,033,392 pounds; that is, 72 per cent of the production of the United States.

During the years 1900, 1901, and 1902, the output of the principal copper producers was handled by a joint selling agency—the United Metals Selling Company. This company was organized on January 29, 1900, and included among its incorporators two representatives of interests identified with the Amalgamated Copper Company. Its patronage, however, was not confined to that company alone. The company's charges were from 1.5 to 2.5 per cent for selling copper. Its total sales for 1902 were estimated by the Boston News Bureau at 545,000,000 pounds,[1] which amounted to 83 per cent of the output of refined copper for the year, as estimated by the United States Geological Survey.

In 1892 an association of copper producers, known as the American Producers' Association, was formed. It represented the following mines: Montana district, those of the Amalgamated Copper Company; Arizona district—Verde, Arizona, Queen, Detroit, Dominion; Lake Superior district—Calumet, Tamarack, Quincy, Osceola, Atlantic, Franklin, Tamarack, jr., Kearsarge, Wolverine, and Central.[2] Other companies joined the association subsequent to the date on which that list was compiled.[3] The association received from its members reports of the production of copper, which were compiled and published monthly. The production of the mines affiliated, as well as of those outside the association as contained in these reports, is shown in the following comparative statement:

American production of copper, as reported by the American Producers' Association: 1892 to 1902.

[Long tons.]

YEAR.	Total.	Reporting mines.	Outside sources.
Second six months of 1892	65,526	59,239	6,287
1893	142,490	129,760	12,730
1894	159,623	142,543	17,080
1895	171,197	155,497	15,700
1896	203,894	189,494	14,400
1897	216,106	204,206	11,900
1898	234,272	216,222	18,050
1899	262,206	230,806	31,400
1900	268,787	227,987	40,800
1901	265,255	223,355	41,900
1902	295,656	258,056	37,600

[1] The Commercial and Financial Chronicle, Vol. 70, page 284; Vol. 76, page 334.

[2] Monthly Summary of Commerce and Finance of United States, May, 1900, page 3107.

[3] United States Geological Survey, "Mineral Resources of the United States," 1902, page 166.

Early in 1903 large producing interests withdrew from the American Association, declining to furnish statistics, so that the monthly compilations have ceased.

It is worthy of note that the centralizing tendency in the operation of copper mines has been accompanied by a growing decentralization of property interests. This clearly appears from the following statement of the number of stockholders of copper mining companies of the Lake Superior district where the corporate form of organization has entirely superseded firm or individual ownership.

Number of shareholders in Lake copper companies: 1896 to 1902.[1]

YEAR.	Number of shareholders.	Refined copper produced, gross value.	PER CENT OF INCREASE SINCE 1896.	
			Number of shareholders.	Gross value.
1896	6,598	$15,758,935	.....	.....
1897	7,208	16,530,843	9.2	4.9
1898	8,897	17,829,871	34.8	13.1
1899	11,072	26,098,382	67.8	65.6
1900	18,026	23,691,928	173.2	50.3
1901	20,665	26,038,571	213.2	65.2
1902	22,568	20,100,425	242.0	27.5

[1] The Copper Handbook, Vol. III, pages 573, 574, and 594. The production of 1902 is taken from Census returns. The percentages were computed in the Bureau of the Census.

Production on a small scale.—As may be inferred from the degree of concentration shown above, the day of copper mining on a small scale is past. A survival of old time methods was presented by 3 mines operated by waterpower. The more modern small gas or gasoline engine enabled 12 other mines to conduct operations on a small scale. A summary of these 15 mines, using waterpower or gas exclusively, is presented in the following table:

TABLE 30.—*Summary of mines using only water wheels, or gas or gasoline engines: 1902.*

Number of mines	15
Salaries	$31,043
Wages	$149,902
Contract work	$350
Miscellaneous expenses	$11,611
Cost of supplies and materials	$50,761
Tons of ore produced:	
Total mined	16,528
Sold	5,250
Treated	7,419
Gross value of ore sold or treated	$279,273
Copper contents:	
Pounds	2,634,000
Value	$256,451
Value of by-products:	
Silver	$18,416
Gold	$3,686
Lead	$720
Reduction charges, freight, etc	$106,324
Value of product at mine	$172,949
Expended in development work	$75,216
Average percentage of copper in the ore	10.4
Average value:	
Fine copper, cents per pound	9.7
Gross value per ton	$22.04
Average cost of reduction, per ton	$8.39

The total output of the 15 mines summarized in the preceding table amounted to $172,949 in value, to which should be added the sum of $75,216, representing the value of development work done during the year. The ore was exceptionally rich, yielding 10.4 per cent of fine copper. The average price realized per pound of copper was 9.7 cents, which brought $22.04 per ton of crude ore. The average cost of reduction amounted to

$8.39 per ton, which left $13.65 per ton as value at mine, whereas the gross value of all copper ores mined and treated in the United States averaged only $6.79 per ton. It is probable that it was only the exceptionally high grade of the ore that made mining on so small a scale possible.

The world's production and the world's copper market.—The United States is to-day the chief producer of copper in the world; nearly two-thirds of the world's output in 1902 was furnished by the United States. The following table is a summary of the production of the copper mines of the world:

TABLE 31.—PRODUCTION OF COPPER MINES OF THE WORLD: 1879 TO 1902.[1]

[Long tons.]

	1902	1901	1900	1899	1898	1897	1896	1895	1894	1893	1892	1891
Total for the world	542,470	518,788	484,799	472,244	429,626	399,730	373,363	334,565	324,505	303,530	310,472	279,391
Total for North America	349,870	318,640	301,237	290,971	260,846	237,135	220,843	189,720	178,365	162,730	165,825	138,919
United States	294,600	267,410	268,787	262,206	234,271	216,060	203,893	172,300	159,695	147,210	152,620	128,179
Canada and Newfoundland	19,485	20,800	10,400	9,430	10,140	7,705	5,800	5,800	6,900	7,040	5,890	5,540
Mexico	35,785	30,430	22,050	19,335	16,435	13,370	11,150	11,620	11,770	8,480	7,315	5,200
Total for South America	38,750	42,385	36,095	32,730	30,065	25,300	26,340	24,925	26,810	27,320	29,015	29,015
Argentina	240	85	75	65	125	200	100	150	230	160	200	210
Bolivia	2,000	2,000	2,100	2,500	2,050	2,200	2,000	2,250	2,300	2,500	2,860	2,150
Chile	28,930	30,780	25,700	25,000	24,850	21,900	23,500	22,075	21,340	21,350	22,565	19,875
Peru	7,580	9,520	8,220	5,165	3,040	1,000	740	450	440	460	290	280
Venezuela	.....	.....	.....	.....	.....	.....	.....	.....	2,500	2,850	3,100	6,500
Total for Europe	90,985	93,013	89,887	92,993	88,430	89,855	86,730	84,375	83,780	81,890	85,182	80,937
Austria-Hungary, including Bosnia and Servia	1,500	1,335	1,355	1,505	1,540	1,655	1,285	1,310	2,120	1,425	1,385	1,250
England	600	532	650	635	640	520	555	580	445	425	495	720
Germany	21,605	21,720	20,410	23,460	20,085	20,145	20,065	16,555	17,200	16,150	17,295	16,150
Italy	3,370	3,000	2,955	2,965	2,965	3,480	3,400	2,500	2,600	2,500	2,500	2,200
Russia	8,000	8,000	6,740	7,210	6,260	6,025	5,100	5,280	5,000	5,000	4,900	4,800
Sweden and Norway	5,020	3,825	4,385	4,130	4,095	3,995	3,000	3,200	2,240	2,395	2,145	1,902
Spain and Portugal	49,790	53,621	52,872	52,168	52,375	53,060	53,325	54,950	54,175	53,995	56,462	53,915
Turkey	1,100	980	520	920	470	975	.....	.....	.....	.....	.....	.....
Asia (Japan)	29,775	27,475	27,840	28,310	25,175	23,000	21,000	18,430	20,050	18,000	18,000	17,000
Australia	28,640	30,875	23,020	20,750	18,000	17,000	11,000	10,000	9,000	7,500	6,500	7,500
Africa	4,450	6,400	6,720	6,490	7,110	7,440	7,450	7,115	6,500	6,090	5,950	6,020

	1890	1889	1888	1887	1886	1885	1884	1883	1882	1881	1880	1879
Total for the world	269,455	261,205	258,026	223,798	217,086	225,592	220,249	199,406	181,622	163,369	153,959	151,963
Total for North America	125,435	114,669	108,776	83,914	72,740	76,403	66,659	54,167	42,871	33,433	26,960	25,300
United States	116,325	105,774	101,710	79,109	69,805	74,050	64,700	51,570	40,470	30,882	25,010	23,350
Canada and Newfoundland	4,785	5,115	4,300	2,755	2,685	1,978	1,668	2,108	2,000	2,218	1,550	1,550
Mexico	4,325	3,780	2,766	2,050	250	375	291	489	401	333	400	400
Total for South America	33,960	31,478	37,090	33,570	40,088	44,573	48,269	47,485	51,108	44,389	47,616	53,815
Argentina	150	190	150	170	180	233	159	293	800	307	300	300
Bolivia	1,900	1,200	1,450	1,300	1,100	1,500	1,500	1,680	3,259	2,655	2,000	2,000
Chile	26,120	24,250	31,240	29,150	35,025	38,500	41,648	41,099	42,900	37,989	42,916	49,318
Peru	150	275	250	50	75	229	362	395	440	615	600	600
Venezuela	5,640	5,563	4,000	2,900	3,708	4,111	4,600	4,018	3,700	2,823	1,800	1,597
Total for Europe	80,990	83,898	85,560	80,214	76,433	77,516	75,961	72,554	66,243	65,960	60,245	54,620
Austria-Hungary, including Bosnia and Servia	1,510	1,525	1,868	1,414	1,099	1,185	1,270	1,290	1,115	1,270	1,290	1,145
England	935	905	1,456	389	1,471	2,773	3,350	2,620	3,464	3,875	3,662	3,462
Germany	17,625	17,356	15,230	14,875	14,465	15,250	14,782	14,643	13,316	12,742	10,800	9,000
Italy	2,200	3,500	3,500	2,500	2,100	2,000	2,000	1,600	1,400	1,480	1,380	1,140
Russia	4,800	4,070	4,700	5,000	4,875	5,100	4,700	4,400	4,000	3,700	3,300	3,300
Sweden and Norway	2,220	2,272	2,356	2,380	2,770	3,335	3,444	3,394	3,388	3,635	3,500	3,212
Spain and Portugal	51,700	54,270	56,450	53,706	49,653	47,873	46,415	44,607	39,560	39,258	36,313	33,361
Turkey	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Asia (Japan)	15,000	15,000	11,600	11,000	12,000	10,000	10,000	7,600	4,800	3,900	3,900	3,900
Australia	7,500	8,300	7,450	7,700	9,700	11,400	14,100	12,000	11,000	10,000	9,700	9,500
Africa	6,570	7,860	7,550	7,400	6,125	5,700	5,260	5,600	5,600	5,687	5,538	4,828

[1] Compiled by Henry R. Merton & Co., Ltd., London; cited in Statistical Compilations of Lead, Copper, Spelter, Tin, Silver, Nickel, Aluminum, and Quicksilver, by the Metallgesellschaft and the Metallurgische Gesellschaft A.-G., 1898, page 10, and 1903, pages 6 and 7.

As shown by the preceding table, North and South America, since 1882, have been the chief source of the world's supply of copper. While the production of South America has declined, North America as a copper producer has, since 1892, overshadowed the rest of the world. Since 1895 the mines of the United States alone have furnished more than one-half of the world's copper.

Among European producers the Iberian peninsula held the first place. Prior to 1882 its output exceeded the production of the United States, and, in 1882, both countries were on the same level, but within the following twenty years the production of Spain and Portugal increased by only about 25 per cent, while the production of the United States in 1902 was more than seven times as large as it was twenty years before.

Mexico, which prior to 1894 was but a small factor in the world's production of copper, has since that year more than trebled its output and gained third place among the copper producing countries.

Next after Mexico was Japan, which since 1890 has doubled its output, and Australia, whose progress has been still more rapid. Germany has shown no appreciable gains since 1896, and has been outranked by Mexico and Australia.

In the table which follows, the refined copper product of smelters and refineries of all countries since 1889, as compiled by the Metallgesellschaft and Metallurgische Gesellschaft A.-G., is compared with the copper contents of the output of all copper mines, as compiled by Henry R. Merton & Co., Limited.

TABLE 32.—*Copper output of mines and smelters of all countries: 1889 to 1902.*[1]

YEAR.	MINES.	SMELTERS.	
	Metric tons.	Metric tons.	Per cent of mine output.
Total	5,389,009	5,404,885	100.3
1889	265,384	267,182	100.7
1890	273,765	282,251	103.1
1891	283,861	291,225	102.6
1892	315,439	317,137	100.5
1893	308,387	304,700	98.8
1894	329,698	328,000	99.5
1895	339,919	351,500	103.4
1896	379,337	393,200	103.7
1897	406,126	418,900	103.1
1898	436,500	433,300	99.3
1899	479,800	480,000	100.0
1900	492,556	487,200	98.9
1901	527,089	517,550	98.2
1902[2]	551,148	532,700	96.7

[1] Cited in report by the Metallgesellschaft and Metallurgische Gesellschaft A.-G., 1903.
[2] Figures for United States exceed United States Census figures by 6,149,608 pounds. As the difference is less than 1 per cent, the estimate of Henry R. Merton & Co., Ltd., is retained for the sake of comparison.

The variations between the output of mines and smelters have been confined within narrow limits, viz, between 3.7 per cent above and 3.3 per cent below the mine output. This close agreement is due to the fact that copper is mostly mined and smelted by the same producers; either quantity may therefore be used for comparisons.

The following table shows the growth of the world's production of copper during the past century:

TABLE 33.—*Growth of the world's copper production in the nineteenth century.*[1]

[Long tons.]

DECADE.	World's production of each decade.	Increase of production over previous decades.	Average annual production for each decade.	Increase of average annual production.
1801 to 1810	91,000	.....	9,100	.....
1811 to 1820	96,000	5,000	9,600	500
1821 to 1830	135,000	39,000	13,500	3,900
1831 to 1840	218,400	83,400	21,840	8,340
1841 to 1850	291,000	72,600	29,100	7,260
1851 to 1860	506,999	215,999	50,699	21,599
1861 to 1870	900,000	393,001	90,000	39,300
1871 to 1880	1,189,000	289,000	118,900	28,900
1881 to 1890	2,373,398	1,084,398	237,339	108,439
1891 to 1900	3,708,901	1,335,503	370,890	133,550

[1] The Copper Handbook, Vol. III, page 565.

A study of the table shows that during the first two decades of the past century the production of copper remained practically stationary. From 1820 to 1880 the average yearly production more than doubled once in every twenty years. Within the last two decades of the century the annual average production more than trebled, increasing from 118,900 tons during the years from 1871 to 1880 to 370,890 tons from 1891 to 1900. The annual average output from 1881 to 1890 exceeded the average for the preceding decade by 118,439 tons, i. e., by 99.6 per cent, and the annual average for the years from 1891 to 1900 showed an increase over the preceding decade amounting to 133,551 tons, or 56.3 per cent. Though the increase in production during the last decade was absolutely greater than during the preceding period, yet owing to the enlarged volume of production the relative increase appears smaller.

The extraordinary progress of copper mining within the last two decades was stimulated by the rapid extension of the uses of electricity to all branches of industry. The United States has been the chief factor in this progress. The production of the United States increased from 1879 to 1902 more than twelvefold. The share of the United States in the progress of copper mining is shown in the following comparative summary by quadrennial periods:

TABLE 34.—OUTPUT OF COPPER MINES OF THE UNITED STATES AND OTHER COUNTRIES, BY QUADRENNIAL PERIODS: 1879 TO 1902.[1]

[Long tons.]

PERIOD.	TOTAL PRODUCTION.				INCREASE OVER PRECEDING PERIOD.			
	All countries.	United States.	Other countries.	Per cent United States.	All countries.	United States.	Other countries.	Per cent United States.
1879 to 1882	650,913	119,712	531,201	18.4	.....	.....	.....	.....
1883 to 1886	862,333	260,125	602,208	30.2	211,420	140,413	71,007	66.4
1887 to 1890	1,012,484	402,918	609,566	39.8	150,151	142,793	7,358	95.1
1891 to 1894	1,217,898	587,704	630,194	48.3	205,414	184,786	20,628	90.0
1895 to 1898	1,537,284	826,524	710,760	53.8	319,386	238,820	80,566	74.8
1899 to 1902[2]	2,018,301	1,093,003	925,298	54.2	481,017	266,479	214,538	55.4

[1] Henry R. Merton & Company's figures, cited in the report by the Metallgesellschaft and Metallurgische Gesellschaft A.-G., October, 1903.
[2] Figures for United States exceed United States Census figures by 6,149,608 pounds. As this is less than 1 per cent, the estimate of Henry R. Merton & Co. Ltd., is retained for sake of comparison.

Up to the period from 1895 to 1898 the United States was rapidly gaining over all other countries. From 1887 to 1894 practically all the increase in the world's production of copper came from the United States. During the years from 1895 to 1898 the United States outranked all other countries. During the last period, closed by the census year 1902, the production of the United States maintained its rate of growth, but mining in other countries took on a new life under the stimulus of high prices, as will be shown below, and the increase in their output nearly reached that of the United States.

In Table 35 the world's production and consumption of copper are shown since the year 1895, when the United States surpassed the total production of all other countries. All countries are arranged in two classes: (1) Those whose domestic consumption of refined copper exceeded the output of their own mines, and (2) those whose mines produced more than was consumed at home. For the sake of brevity, the former are designated as "importing countries" and the latter as "exporting countries."

It must be understood, however, that some of the countries designated here as "importing" also exported considerable quantities of copper, while those designated as "exporting" may have imported copper ore, matte, etc., to be later reexported as refined copper. In calculating the domestic consumption for each country its imports are added to its production, and its exports are deducted from the total; the increase or decrease of the stocks of copper from year to year is also taken into account wherever ascertainable. The estimate of domestic consumption which is arrived at in this manner represents the supply of copper available for domestic consumption, but is not necessarily identical with the quantity actually consumed in manufactures for which copper serves as material.

In Table 35 the column headed "product of mines" represents only the production of copper from domestic ores, as reported by Henry R. Merton & Co., Ltd.; the column "consumption" represents the supply available from all sources for domestic consumption, as computed by the Metallgesellschaft and Metallurgische Gesellschaft A.-G.; the "net demand for imported copper" in the list of importing countries and the "net supply available for export" in the list of exporting countries represents, in each case, the difference between the totals of the two columns just mentioned. The table thus shows, on the one hand, the share contributed by each copper mining country to the world's supply of copper, and on the other hand the demand for unmanufactured copper directly exercised by the manufacturing industries of each country.

TABLE 35.—WORLD'S PRODUCTION AND CONSUMPTION OF COPPER, BY COUNTRIES: 1895 TO 1902.

[Long tons.]

IMPORTING COUNTRY.	1902			1901			1900			1899		
	Product of mines.	Consumption.	Net demand for imported copper.	Product of mines.	Consumption.	Net demand for imported copper.	Product of mines.	Consumption.	Net demand for imported copper.	Product of mines.	Consumption.	Net demand for imported copper.
Total	35,075	328,635	293,560	34,587	279,226	244,639	32,110	317,148	285,038	35,775	276,620	240,845
Great Britain	600	118,638	118,038	532	103,552	103,020	650	107,034	106,384	635	85,137	84,502
Germany	21,605	100,324	78,719	21,720	82,243	60,523	20,410	107,176	86,766	23,460	96,094	72,634
France	.....	52,060	52,060	.....	42,382	42,382	.....	51,780	51,780	.....	48,442	48,442
Austria-Hungary	1,500	18,862	17,362	1,335	17,926	16,591	1,355	19,382	18,027	1,505	16,855	15,350
Russia	8,000	17,219	9,219	8,000	13,873	5,873	6,740	13,972	7,232	7,210	13,578	6,368
Italy	3,370	10,218	6,848	3,000	9,214	6,214	2,955	8,211	5,256	2,965	7,560	4,595
Belgium	.....	6,592	6,592	.....	6,396	6,396	.....	6,150	6,150	.....	5,412	5,412
Netherlands	.....	2,361	2,361	.....	2,361	2,361	.....	2,361	2,361	.....	2,361	2,361
Exports from Europe	.....	2,361	2,361	.....	1,279	1,279	.....	1,082	1,082	.....	1,181	1,181

EXPORTING COUNTRY.	Product of mines.	Kept for domestic consumption.	Net supply available for export.	Product of mines.	Kept for domestic consumption.	Net supply available for export.	Product of mines.	Kept for domestic consumption.	Net supply available for export.	Product of mines.	Kept for domestic consumption.	Net supply available for export.
Total	507,395	218,063	289,332	484,201	247,261	236,940	452,689	163,413	289,276	436,469	196,674	239,795
North America:												
United States	294,600	199,959	94,641	267,410	236,733	30,677	268,787	151,427	117,360	262,206	185,851	76,355
Canada and Newfoundland	19,485	.....	19,485	20,800	.....	20,800	10,400	.....	10,400	9,430	.....	9,430
Mexico	35,785	.....	35,785	30,430	.....	30,430	22,050	.....	22,050	19,335	.....	19,335
South America:												
Chile	28,930	.....	28,930	30,780	.....	30,780	25,700	.....	25,700	25,000	.....	25,000
Other South American countries[1]	9,820	.....	9,820	11,605	.....	11,605	10,395	.....	10,395	7,730	.....	7,730
Europe:												
Sweden and Norway	5,020			3,825			4,385			4,130		
Spain and Portugal	49,790	2,853	53,057	58,621	2,558	55,868	52,872	2,066	55,711	52,168	1,968	55,250
Turkey	1,100			980			520			920		
Asia (Japan)	29,775	15,251	43,164	27,475	7,970	50,380	27,840	9,920	40,940	28,310	8,855	40,205
Australia	28,640			30,875			23,020			20,750		
Africa	4,450	.....	4,450	6,400	.....	6,400	6,720	.....	6,720	6,490	.....	6,490

[1] Includes Argentina, Bolivia, and Peru.

TABLE 35.—WORLD'S PRODUCTION AND CONSUMPTION OF COPPER, BY COUNTRIES: 1895 TO 1902—Continued.

IMPORTING COUNTRY.	1898			1897			1896			1895		
	Product of mines.	Consumption.	Net demand for imported copper.	Product of mines.	Consumption.	Net demand for imported copper.	Product of mines.	Consumption.	Net demand for imported copper.	Product of mines.	Consumption.	Net demand for imported copper.
Total	31,490	299,703	268,213	31,825	300,572	268,747	30,405	284,166	253,761	26,225	232,060	205,835
Great Britain	640	102,696	102,056	520	107,771	107,251	555	114,799	114,244	580	90,080	89,500
Germany	20,085	95,455	75,370	20,145	88,355	68,210	20,065	78,161	58,096	16,555	62,787	46,232
France	.....	48,756	48,756	.....	51,035	51,035	.....	42,529	42,529	.....	37,560	37,560
Austria-Hungary	1,540	18,313	16,773	1,655	16,917	15,262	1,285	14,566	13,281	1,310	12,665	11,355
Russia	6,260	17,219	10,959	6,025	19,187	13,162	5,100	18,006	12,906	5,280	13,775	8,495
Italy	2,965	7,671	4,706	3,480	7,665	4,185	3,400	6,856	3,456	2,500	6,534	4,034
Belgium	.....	5,707	5,707	.....	6,100	6,100	.....	5,412	5,412	.....	4,920	4,920
Netherlands	.....	2,361	2,361	.....	2,361	2,361	.....	2,361	2,361	.....	2,361	2,361
Exports from Europe	.....	1,525	1,525	.....	1,181	1,181	.....	1,476	1,476	.....	1,378	1,378
EXPORTING COUNTRY.	Product of mines.	Kept for domestic consumption.	Net supply available for export.	Product of mines.	Kept for domestic consumption.	Net supply available for export.	Product of mines.	Kept for domestic consumption.	Net supply available for export.	Product of mines.	Kept for domestic consumption.	Net supply available for export.
Total	398,136	137,086	261,050	367,905	120,135	247,770	342,958	109,773	233,185	308,340	126,075	182,265
North America:												
United States	234,271	121,933	112,338	216,060	104,294	111,766	203,893	94,424	109,469	172,300	116,433	55,867
Canada and Newfoundland	10,140	.....	10,140	7,705	.....	7,705	5,800	.....	5,800	5,800	.....	5,800
Mexico	16,435	.....	16,435	13,370	.....	13,370	11,150	.....	11,150	11,620	.....	11,620
South America:												
Chile	24,850	.....	24,850	21,900	.....	21,900	23,500	.....	23,500	22,075	.....	22,075
Other South American countries[1]	5,215	.....	5,215	3,400	.....	3,400	2,840	.....	2,840	2,850	.....	2,850
Europe:												
Sweden and Norway	4,095			3,995			3,000			3,200		
Spain and Portugal	52,375	1,673	55,267	53,060	1,968	56,062	53,325	2,263	54,062	54,950	1,771	56,379
Turkey	470			975			.....			.....		
Asia (Japan)	25,175			23,000			21,000			18,430		
Australia	18,000	13,480	29,695	17,000	13,873	26,127	11,000	13,086	18,914	10,000	7,871	20,559
Africa	7,110	.....	7,110	7,440	.....	7,440	7,450	.....	7,450	7,115	.....	7,115

[1] Includes Argentina, Bolivia, and Peru.

The recapitulation which follows shows the share of the world's output consumed at home and exported; the domestic consumption is obtained by adding the production of importing countries to the domestic consumption of exporting countries.

TABLE 36.—*World's production, domestic consumption, and supply available for export, with per cent of total production: 1895 to 1902.*

[Long tons.]

YEAR.	Total production.	Domestic consumption.	Net supply available for export.	PER CENT OF PRODUCTION.	
				Domestic consumption.	Net supply available for export.
Total	3,555,585	1,575,972	1,979,613	44.3	55.7
1895	334,565	152,300	182,265	45.5	54.5
1896	373,363	140,178	233,185	37.5	62.5
1897	399,730	151,960	247,770	38.0	62.0
1898	429,626	168,576	261,050	39.2	60.8
1899	472,244	232,449	239,795	49.2	50.8
1900	484,799	195,523	289,276	40.3	59.7
1901	518,788	281,848	236,940	54.3	45.7
1902	542,470	253,138	289,332	46.7	53.3

Tables 35 and 36 bring out the fact that copper is preeminently an article of international trade. More than one-half of the copper mined was exported for consumption to other countries. With the exception of the United States, the principal producers of copper had practically no market for it at home. The United States, though holding the first place among the consumers of copper, was also largely dependent upon the foreign market for the sale of the product of its mines.

There is a difference amounting from a fraction of 1 per cent to over 10 per cent between the total net supply available for export and the total net demand for imported copper. The variance is due in part to the well-known disagreement between export and import statistics and partly to the fact that the resmelting of old copper enters into the calculation of the consumption for some countries.

On the whole, the copper mines of the United States have since 1895 supplied over one-third of the demand for imported copper, as shown in the following table:

TABLE 37.—*Consumption of copper in importing countries and exports of domestic copper from the United States: 1895 to 1902.*

[Long tons.]

YEAR.	Importing countries' net demand for imported copper.	Available for export in the United States.	Supplied by other countries.
Total	2,060,638	708,473	1,352,165
1895-1898	996,556	389,440	607,116
1899-1902	1,064,082	319,033	745,049
1895	205,835	55,867	149,968
1896	253,761	109,469	144,292
1897	268,747	111,766	156,981
1898	268,213	112,338	155,875
1899	240,845	76,355	164,490
1900	285,038	117,360	167,678
1901	244,639	30,677	213,962
1902	293,560	94,641	198,919

The principal consumers of copper besides the United States were Great Britain, Germany, and France. The same countries were also the principal importers of

copper, while the United States, Spain, and Portugal were the principal exporters of domestic copper. Next after Spain and Portugal as exporters of domestic copper followed, in consecutive order, Mexico, Chile, Japan, Australia, and Canada.

Europe being the principal market for copper, a comparative table is next presented showing in parallel columns the gross exports to Europe from other continents, the net supply of domestic copper available for export, and the excess of the one over the other.

TABLE 38.—TRADE OF THE PRINCIPAL EXPORTING COUNTRIES WITH EUROPE: 1895 TO 1902.

[Long tons.]

EXPORTING COUNTRY.	1902				1901			
	Domestic supply available for export.	Actual exports to Europe.	Excess of— Domestic supply over exports to Europe.	Excess of— Exports to Europe over available supply.	Domestic supply available for export.	Actual exports to Europe.	Excess of— Domestic supply over exports to Europe.	Excess of— Exports to Europe over available supply.
Total	231,825	226,599	73,130	67,904	174,672	164,415	71,381	61,124
North America:								
United States	94,641	162,545	.....	67,904	30,677	91,801	.....	61,124
Canada and Newfoundland	19,485	9,839	45,431	.....	20,800	8,659	42,571	.....
Mexico	35,785				30,430			
South America:								
Chile	28,930	21,942	6,988	.....	30,780	23,024	7,756	.....
Other South American countries	9,820	.....	9,820	.....	11,605	.....	11,605	.....
Asia (Japan)	43,164	14,169	10,891	.....	50,380	20,367	9,449	.....
Australia		18,104			.....	20,564		

EXPORTING COUNTRY.	1900				1899			
	Domestic supply available for export.	Actual exports to Europe.	Excess of— Domestic supply over exports to Europe.	Excess of— Exports to Europe over available supply.	Domestic supply available for export.	Actual exports to Europe.	Excess of— Domestic supply over exports to Europe.	Excess of— Exports to Europe over available supply.
Total	226,845	217,546	42,972	33,673	178,055	176,222	36,564	34,731
North America:								
United States	117,360	151,033	.....	33,673	76,355	111,086	.....	34,731
Canada and Newfoundland	10,400	11,315	21,135	.....	9,430	11,118	17,647	.....
Mexico	22,050				19,335			
South America:								
Chile	25,700	19,482	6,218	.....	25,000	16,825	8,175	.....
Other South American countries	10,395	.....	10,395	.....	7,730	.....	7,730	.....
Asia (Japan)	40,940	18,596	5,224	.....	40,295	20,663	3,012	.....
Australia		17,120				16,530		

EXPORTING COUNTRY.	1898				1897			
	Domestic supply available for export.	Actual exports to Europe.	Excess of— Domestic supply over exports to Europe.	Excess of— Exports to Europe over available supply.	Domestic supply available for export.	Actual exports to Europe.	Excess of— Domestic supply over exports to Europe.	Excess of— Exports to Europe over available supply.
Total	198,673	194,819	31,923	28,069	184,268	178,288	18,189	12,209
North America:								
United States	112,338	140,407	.....	28,069	111,766	123,975	.....	12,209
Canada and Newfoundland	10,140	10,036	16,539	.....	7,705	15,251	5,824	.....
Mexico	16,435				13,370			
South America:								
Chile	24,850	17,711	7,139	.....	21,900	17,711	4,189	.....
Other South American countries	5,215	.....	5,215	.....	3,400	.....	3,400	.....
Asia (Japan)	29,695	12,201	3,030	.....	26,127	11,118	4,776	.....
Australia		14,464				10,233		

EXPORTING COUNTRY.	1896				1895			
	Domestic supply available for export.	Actual exports to Europe.	Excess of— Domestic supply over exports to Europe.	Excess of— Exports to Europe over available supply.	Domestic supply available for export.	Actual exports to Europe.	Excess of— Domestic supply over exports to Europe.	Excess of— Exports to Europe over available supply.
Total	171,673	162,576	15,436	6,339	118,771	103,509	15,262	.....
North America:								
United States	109,469	115,808	.....	6,339	55,867	54,214	1,653	.....
Canada and Newfoundland	5,800	11,217	5,733	.....	5,800	10,725	6,695	.....
Mexico	11,150				11,620			
South America:								
Chile	23,500	18,596	4,904	.....	22,075	19,285	2,790	.....
Other South American countries	2,840	.....	2,840	.....	2,850	.....	2,850	.....
Asia (Japan)	18,914	8,855	1,959	.....	20,559	11,315	1,274	.....
Australia		8,100				7,970		

The preceding table clearly shows the place of each producing country in the world's copper trade. Beginning with the year 1896, the United States showed a growing excess of exports to Europe over its domestic supply, whereas in all other copper producing countries the supply available for export exceeded the direct exports to Europe. The excess of the exports from the United States in 1901 and 1902 was very near the surplus of all other countries, after deducting their direct exports to Europe. These figures demonstrate that the United States has within late years gained control of the export trade of non-European copper producing countries.

A closer study of the statistics shows that the direct exports to Europe from Canada and Mexico have fallen off slightly, while the supply of copper available in these countries for export has more than trebled since 1895. All this copper found its way to the United States, to be reexported to Europe. The direct exports to Europe from Canada and Mexico are but a minor portion of their total copper exports. The United States has also a fair share of the copper trade of Japan, Australia, and Chile, though these countries for the most part maintain direct relations with Europe.

The share of the United States in each of the principal European copper markets, namely, Great Britain, Germany, and France, is shown in the following table. The imports reported by these countries from the United States represent actual exports from this country, both of domestic and foreign copper.

TABLE 39.—COPPER CONSUMPTION OF GREAT BRITAIN, GERMANY, AND FRANCE, AND IMPORTS FROM THE UNITED STATES: 1895 TO 1902.

[Metric tons.]

YEAR.	GREAT BRITAIN.			GERMANY.			FRANCE.		
	Consumption.[1]	Imported from the United States.[2]	Supplied from other sources.	Consumption.[1]	Imported from the United States.[2]	Supplied from other sources.	Consumption.[1]	Imported from the United States.[2]	Supplied from other sources.
1895	91,551	20,923	70,628	63,813	31,311	32,502	38,174	11,999	26,175
1896	116,674	40,446	76,228	79,438	42,504	36,934	43,224	22,357	20,867
1897	109,531	33,387	76,144	89,798	50,420	39,378	51,869	26,592	25,277
1898	104,373	39,608	64,765	97,014	52,473	44,541	49,552	23,125	26,427
1899	86,528	21,438	65,090	97,664	47,742	49,922	49,233	25,098	24,135
1900	108,782	32,557	76,225	108,927	66,264	42,663	52,626	29,575	23,051
1901	105,243	21,761	83,482	84,840	42,422	42,418	43,074	14,237	28,837
1902	120,576	44,345	76,231	101,963	60,274	41,689	52,909	29,936	22,973

[1] From the Metallgesellschaft and Metallurgische Gesellschaft A.-G., 1903, page 9.
[2] From United States Geological Survey, "Mineral Resources of the United States," 1902, pages 193 and 195.

Germany was the largest European consumer of American copper. The German copper market depended upon the United States for more than one-half of its supply, the balance being furnished by the German mines and by imports from other countries. The second place among the consumers of American copper was held by Great Britain; the position of American copper in the English market was important, yet far from dominant. The French market has, since 1896, developed a large demand for American copper; in 1902 two-thirds of the copper consumed in France was imported from the United States.

International organization among producers.—The degree of concentration which has been noted in the United States was also characteristic of the copper mining industry in other countries.

In Spain the two largest mines, the Rio Tinto and the Tharsis, were operated by English corporations, the former being controlled by the Rothschild interests.[1] The Rio Tinto produced in 1901, 79,279,520 pounds of fine copper, and the Tharsis 16,636,480 pounds. They furnished four-fifths of the production of Spain.

In Mexico the two largest mining companies were the Greene Consolidated Copper Company, an American corporation, and the Compagnie du Boleo, supposed to be controlled by the French house of the Rothschilds.[2] The former reported, for the year ending August 1, 1902, a product of 27,854,497 pounds of fine copper in matte and bullion,[3] and the latter produced in 1901, 24,153,197 pounds.[4] The combined production of these two mines represented two-thirds of the total output of Mexico.

In Germany the Mansfeld mines produced in 1901 42,067,200 pounds of copper, which was practically all the copper produced in Germany.

The concentration of the copper mining industry under the control of a limited number of companies facilitated organization among them. The first attempt at organization was the Secretan syndicate, which was formed in Paris in the fall of 1887, with the object of improving the price of copper. The syndicate was organized with a capital stock of 100,000,000 francs, divided into shares of 1,000,000 francs each. In October, 1887, fine copper was quoted in London at from £39 to £40 per ton. The syndicate made contracts with mining companies in all parts of the world for their entire supply at prices ranging from £68 to £70 per ton.

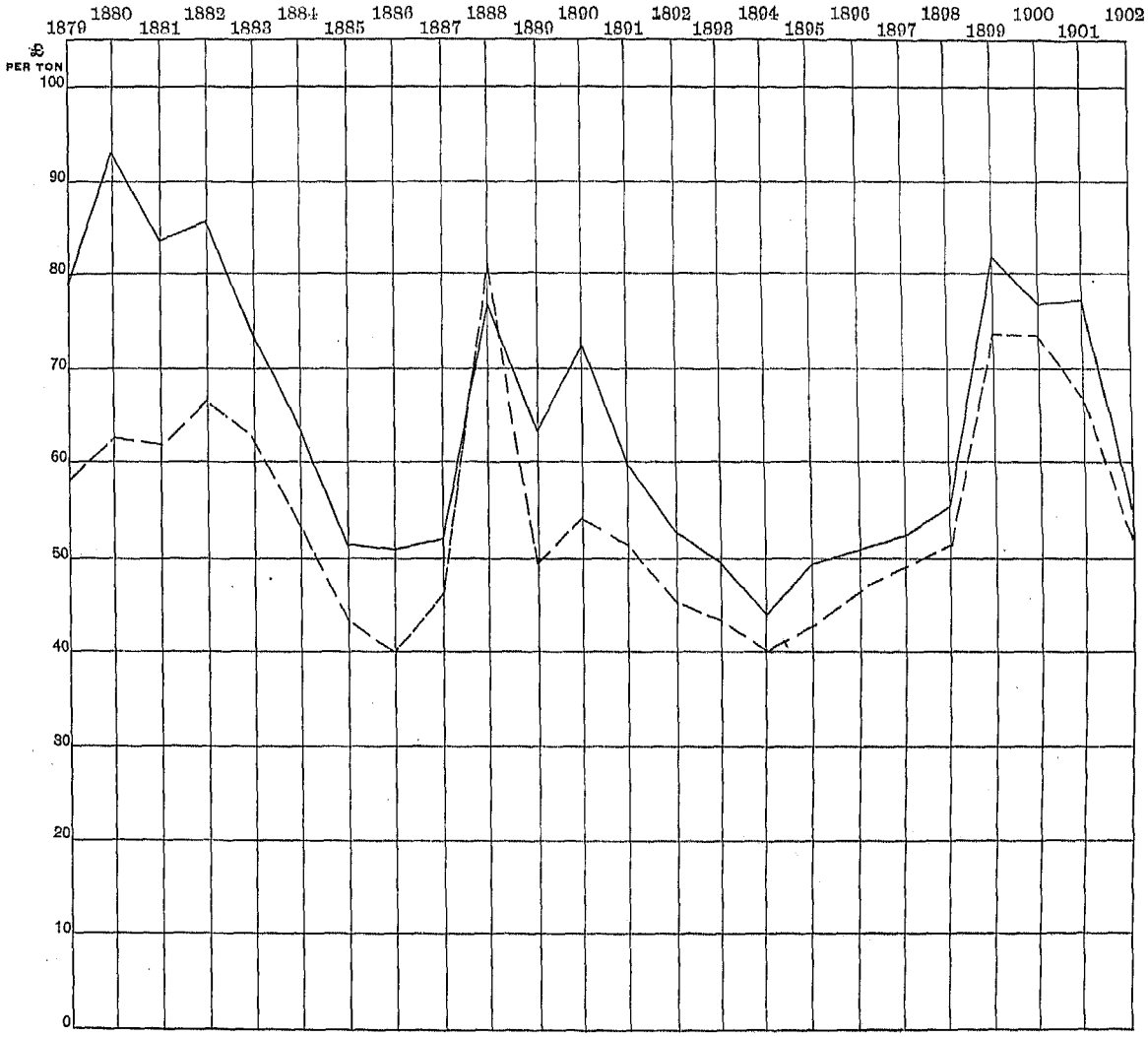
[1] The Copper Handbook, Vol. III, pages 471 and 512; The Truth about the Trusts, by John Moody, page 40.

[2] The Copper Handbook, Vol. III, pages 471 and 512; The Truth about the Trusts, page 211.

[3] Annual Report of the Greene Consolidated Copper Company, 1902.

[4] The Copper Handbook, Vol. III, page 566.

DIAGRAM I.—AVERAGE PRICES OF COPPER, NEW YORK AND LONDON: 1879 TO 1902.



———Price at New York - - - - - -Price at London

The price of copper immediately took an upward course and was soon driven as high as £100 per ton. High prices stimulated the extension of mining, and the output was greatly increased. In order to sustain the price the syndicate was compelled to buy all copper that was offered to it. On the other hand, consumers reduced their stock to the lowest limit, preferring to buy from day to day. As a result, the visible stock of copper rapidly increased, rising from 42,301 tons on January 1, 1888, to 104,105 tons a year later. Though it was financed by one of the leading French banks, La Banque de Paris et de Pays Bas, and had the support of the Bank of France, the scheme finally collapsed, ending in the bankruptcy of the syndicate.[1]

In 1892 an organization was created, known as the European Producers' Committee. It represented the principal mines of Spain and Portugal, Germany, the Cape Colony, Mexico, and Australia, and was managed by European boards of directors. The mines have reported their output each month to a secretary in London since July, 1892.[2] As previously stated, simultaneously with the European organization, the American Producers' Association was organized, and both organizations maintained friendly relations and exchanged monthly reports with each other. The share of the world's output which was controlled by these two organizations is shown in the following table:

TABLE 40.—*World's production and output of American and foreign reporting mines: 1893 to 1902.*

[Long tons.]

YEAR.	World's production.[1]	PRODUCTION OF REPORTING MINES.			
		American.[2]	Foreign.[2]	Total.	
				Quantity.	Per cent of world's product.
1893	303,530	142,490	81,785	224,275	73.9
1894	324,505	159,623	88,531	248,154	76.5
1895	334,565	171,197	86,178	257,375	76.9
1896	373,363	203,894	86,196	290,090	77.7
1897	399,780	216,106	88,270	304,376	76.1
1898	429,626	234,272	84,554	318,826	74.2
1899	472,244	262,206	89,240	351,446	74.4
1900	484,799	268,787	89,431	358,218	73.9
1901	518,788	265,255	100,241	365,496	70.5
1902	542,470	295,656	108,875	404,531	74.6

[1] From compilation by Henry R. Merton & Co., Limited.
[2] From United States Geological Survey, "Mineral Resources of the United States," 1902, pages 166 and 167.

In 1903 large producing interests withdrew from the American Association, declining to furnish statistics in the future, so that the monthly compilations have ceased.[3] Considering that the United States supplies two-thirds of the copper product of the world, the termination of the understanding between American producers means that the international organization among copper producers, which was represented by the two associations, has practically come to an end.

Prices.—The price of copper governing in the United States is the New York price for Lake copper, the price of electrolytic copper, being usually from one-eight to one-fourth of a cent lower; the price ruling in the international market is the London price for standard copper. Table 41 is a comparative table showing the average annual prices of copper in New York and London since 1879.

TABLE 41.—*Average prices of copper, London and New York: 1879 to 1902.*[1]

YEAR.	Standard copper at London, price per long ton.			LAKE COPPER AT NEW YORK.	
				Cents per pound.	English equivalent (£ per long ton).
	£	s.	d.		
1879	58	3	9	17⅛	79
1880	62	14	7	20⅛	93
1881	61	16	9	18⅝	83¾
1882	66	10	5	18⅝	85½
1883	62	17	11	15⅞	73½
1884	53	17	6	13⅞	64
1885	43	11	0	11⅛	51⅛
1886	40	1	8	11	51
1887	46	0	5	11½	52
1888	81	11	3	16¾	77
1889	49	14	8	13¾	63⅛
1890	54	5	3	15¾	72¾
1891	51	9	4	12⅞	59½
1892	45	13	2	11½	53
1893	43	15	6	10⅞	49½
1894	40	7	4	9½	43¾
1895	42	19	7	10¾	49½
1896	46	18	1	10⅞	50⅞
1897	49	2	7	11½	52½
1898	51	16	7	12	55⅝
1899	73	18	9	17¾	82
1900	73	12	6	16.70	77
1901	66	19	8	16.77½	77½
1902	52	11	5	11.97½	55½

[1] "Comparative Statistics of Lead, Copper, etc.," compiled by the Metallgesellschaft and Metallurgische Gesellschaft A.-G., October, 1903, page 10.

The movement of prices is illustrated by Diagram I. The solid line representing the New York price runs above the broken line representing the London price, with the single exception of the year 1888, when the London price, by a sudden bound, rose to heights never witnessed either before or since within the last two decades. Although the New York price promptly responded, yet for once it stopped below the London price. The reason for this extraordinary rise was the attempted corner of the London market by the Secretan syndicate. The failure of the scheme drove the London price down; the New York price also receded, yet not quite as low, and the former relative position was restored.

The opening of copper mines in Montana and Arizona resulted in a downward tendency of prices from 1882 to 1886, which is shown by the movement of both lines in the diagram. A slight improvement marked the year 1890, after which a downward movement set in

[1] Le Journal des Économistes, Vol. XLV, 1889, page 425; L'Économiste Français, March 9, 1889, page 289.
[2] Monthly Summary of Commerce and Finance of the United States, May, 1900, page 3107.
[3] United States Geological Survey, "Mineral Resources of the United States," 1902, page 167.

DIAGRAM II.—PRODUCTION, CONSUMPTION, AND EXPORTS OF COPPER IN THE UNITED STATES: 1895 TO 1902.

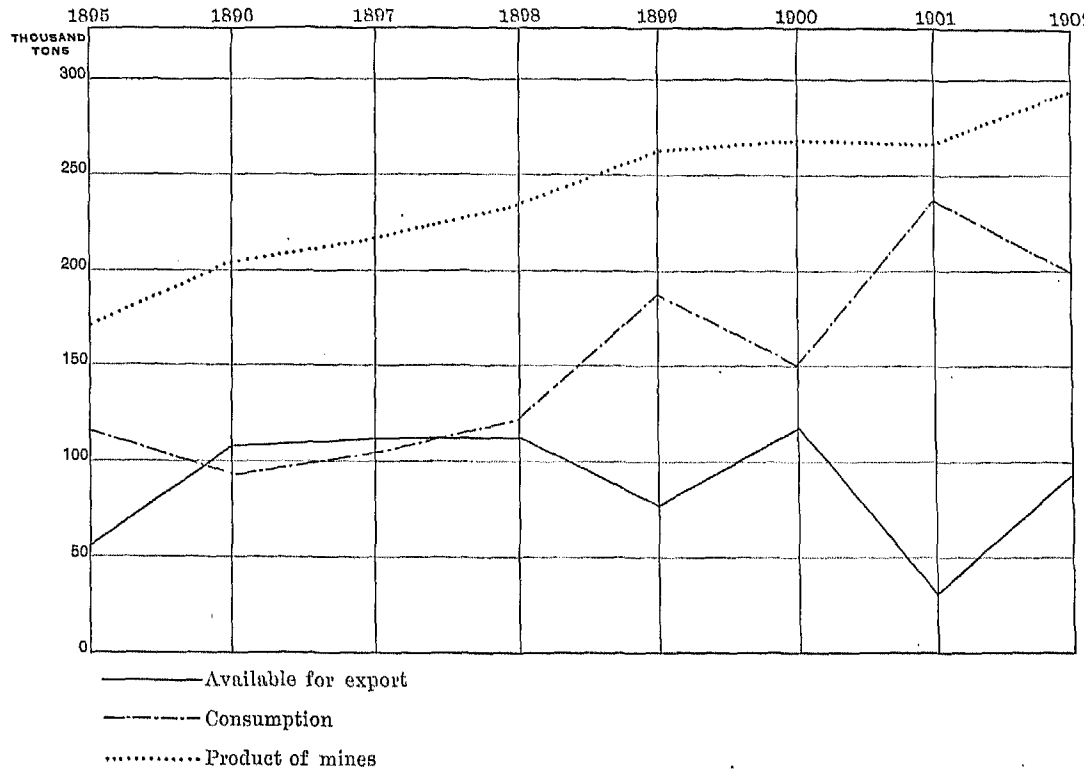
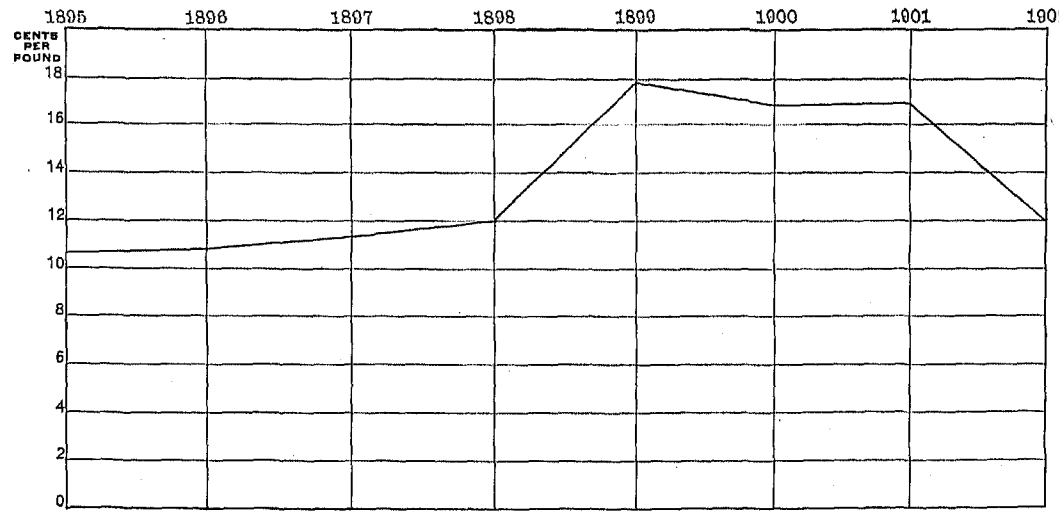


DIAGRAM II A.—AVERAGE NEW YORK PRICES OF COPPER: 1895 TO 1902.



again, which touched its lowest point in 1894. The lines then take again an upward course.

The diagram also makes possible a study of the effect of organization among producers upon the movement of prices. Since 1892 the copper producers have kept informed from month to month concerning the output of the principal copper mines in all parts of the world. The output of the mines outside of the European and American associations did not exceed one-fourth of the world's production of copper. Thus the principal mines have been enabled to adjust their production with regard to the general state of the copper supply. The diagram shows that this knowledge of the demand and supply has not had the effect of steadying the prices; the range of fluctuations in New York and London since 1892 has been as wide as it was prior to that year. The difference between the New York and the London price shown by the distance between the solid and the broken lines has somewhat narrowed and, through all the vicissitudes of the market, has been less subject to fluctuation than before 1892.

In 1899 the Amalgamated Copper Company was organized. According to an official statement issued by the company, it adopted from the beginning the "policy of maintaining a firm price." Its selling agents were therefore "instructed not to attempt to force upon the market more than was actually needed for consumption, but to maintain a firm price."[1] The price was raised from 12 cents to 17 cents in 1899 and was maintained, with a slight reduction, until December, 1901, when the company was forced to reduce the price to the former level of 12 cents. The reason given for this reduction was the failure of other copper producing companies to take the same view of the situation and to maintain a firm price by restricting their output. The effect of this policy upon the copper trade can be studied from the preceding tables and the diagrams illustrating the same.

Diagrams II and II_A show the production of copper in the United States, the supply held for domestic consumption, the domestic supply available for export, and the average New York prices of copper from 1895 to 1902. The upward movement of the solid line in Diagram II_A, representing the New York price, is followed by a similar movement of the dotted line in Diagram II representing the copper output of the mines in the United States. The solid line in Diagram II representing the net domestic supply available for export moves in the opposite direction; the rise of prices in 1899 is shown to have been accompanied by a decrease of exports; in 1900 a slight reduction in the price was attended by an increase of exports; in 1901 the price was maintained, but the exports sank to the lowest point; in 1902 the slump in the price was followed by an increase of the exports. The solid line in Diagram II_A representing prices and the dash-and-dot line representing in Diagram II the amount of the domestic product held at home and available for domestic consumption run almost parallel.

The movements of the solid line in Diagram II_A and of the dotted line in Diagram II indicate that the high prices of 1899 to 1901 stimulated production. In order to maintain a firm price it was necessary to reduce exports, which resulted in an increase of the supply available for domestic consumption.

The relation between the available supply and the actual demand for domestic consumption in 1900, 1901, and 1902 is shown in the data published by the United States Geological Survey. The available supply is computed by adding the production of domestic copper and imports of copper in ore, matte, bars, etc., entered for consumption, and by deducting from the sum the exports of copper. The demand, or estimated consumption, is obtained by deducting the increase in producers' stocks from the available supply, or by adding to it the decrease in producers' stocks. The following statement shows the relation of supply and demand to prices:[2]

Supply and demand and prices in the United States: 1900 to 1902.

YEAR.	Supply (pounds).	Demand (pounds).	*Excess of* supply over demand (pounds).	*Excess of* demand over supply (pounds).	PRICE OF LAKE COPPER IN NEW YORK (CENTS PER POUND).	
					Highest.	Lowest.
1900	362,891,121	356,891,121	6,000,000	.....	17¼	16
1901	517,761,014	382,761,014	135,000,000	.....	17	12⅞
1902	425,339,486	551,688,131	.....	126,348,645	13¼	10⅞

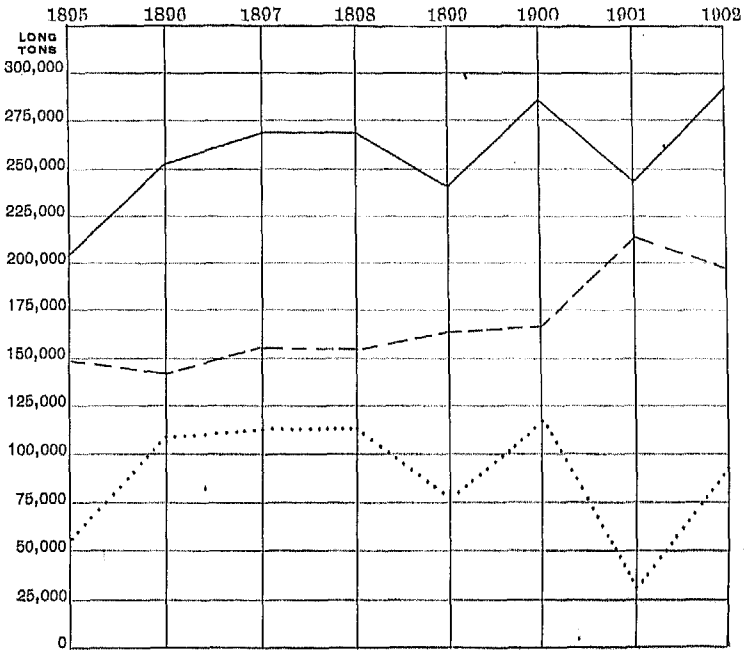
In 1900 the copper producers managed to keep the supply close to the limits of demand; the price was maintained between 16 and 17¼ cents per pound. In 1901 the domestic demand remained almost stationary, but the supply increased enormously, which was due to a reduction in the foreign exports. In the face of this increased supply the price was for fully eleven months held at the same level as during the year before, and only in December, 1901, was it reduced to 12⅞ cents. Except for a brief slump to 10⅞ cents in January, 1902, and a rise to 13¼ in February, the price during the year fluctuated between 11½ and 12¾ cents, and at these prices nearly all of the surplus was absorbed in the domestic market; the demand in 1902 exceeded by 44 per cent that of the previous year.

The effect of high prices upon the American trade with Europe is shown in Diagram III. The solid line representing the net demand for imported copper and the dotted line representing the share supplied by the United States run almost parallel. An increase of the demand in Europe, as here represented, increases imports from the United States; a slackening of the demand reduces imports from the United States. At

[1] The Commercial and Financial Chronicle, Vol. 73, page 1314.

[2] United States Geological Survey, "Mineral Resources of the United States," 1902, pages 188 and 189.

DIAGRAM III.—EUROPEAN DEMAND FOR IMPORTED COPPER: 1895 TO 1902.



———Net demand for imported copper

·····Supplied by United States

– – – – –Supplied by other countries

DIAGRAM IV.—CONSUMPTION OF IMPORTED COPPER IN GREAT BRITAIN, IMPORTS FROM THE UNITED STATES AND OTHER COUNTRIES: 1895 TO 1902.

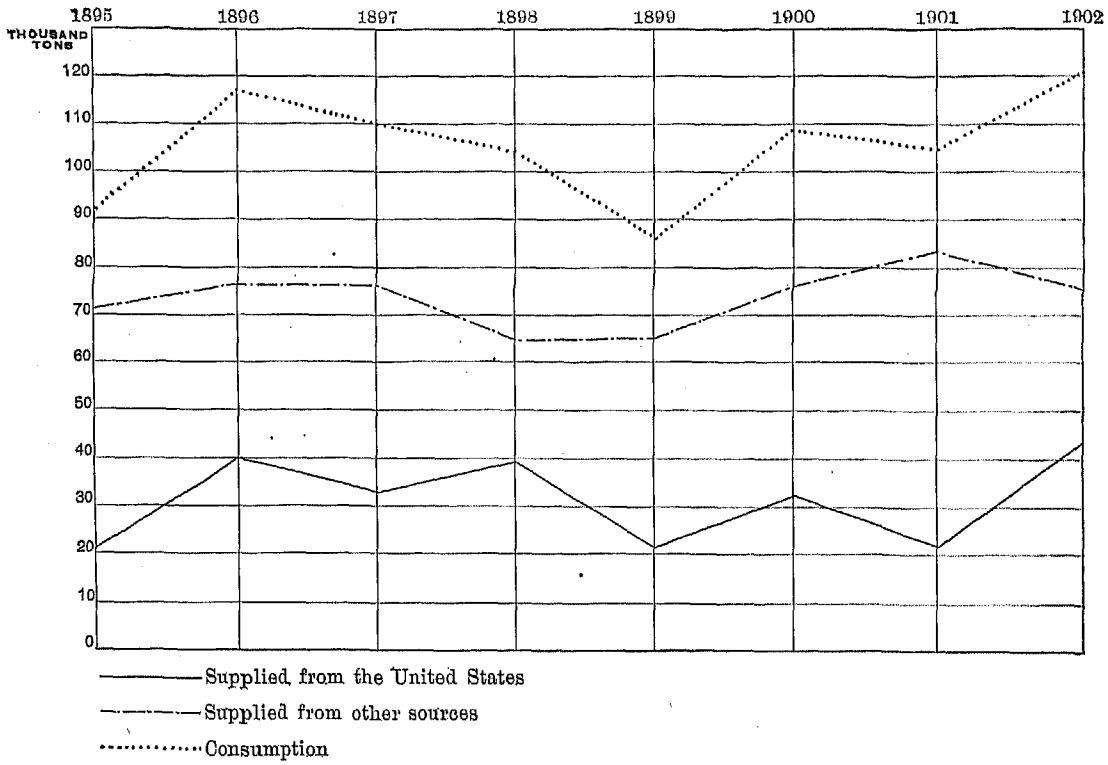


DIAGRAM IV A.—AVERAGE LONDON PRICES OF COPPER: 1895 TO 1902.

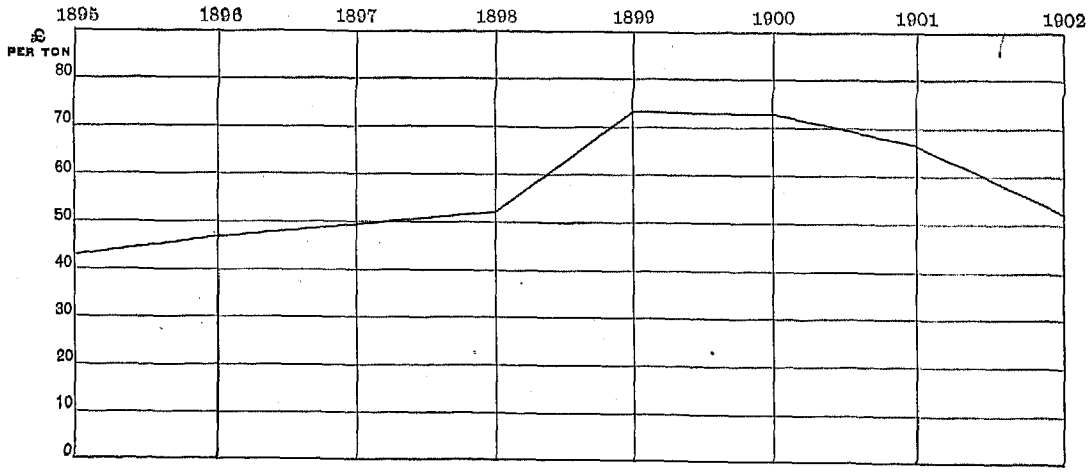


DIAGRAM V.—CONSUMPTION OF COPPER IN FRANCE:
1895 TO 1902.

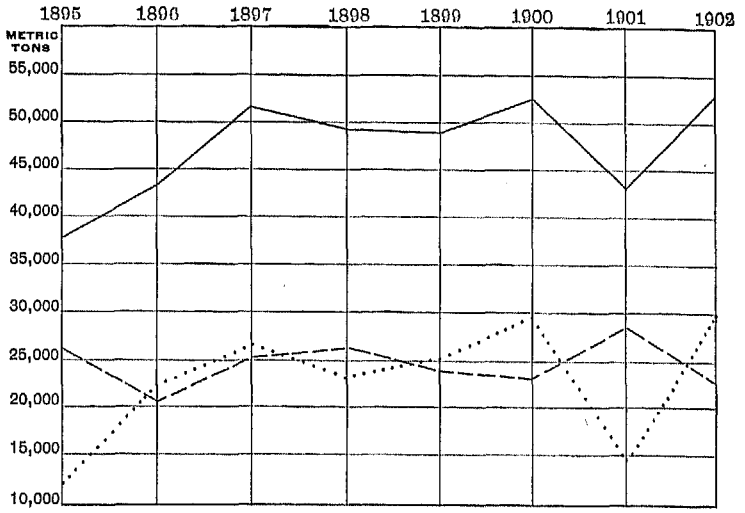
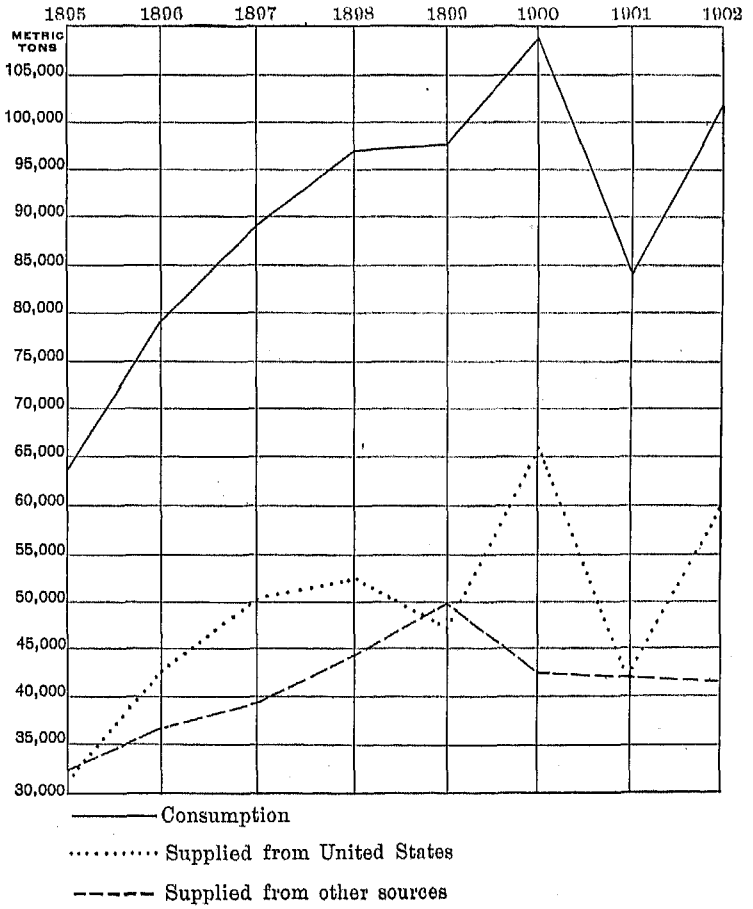


DIAGRAM VI.—CONSUMPTION OF COPPER IN GERMANY:
1895 TO 1902.



the same time, with reduced exports from the United States, the line of dashes representing the imports from other countries is slowly rising; in 1901, notwithstanding the fall in the European demand, the line suddenly goes up, while imports from the United States show a heavy decline. The rise of the demand and a parallel rise of the imports from America in 1902 are accompanied by a decline in the imports from other sources.

A comparison of the totals for the quadrennial periods 1895 to 1898 and 1899 to 1902 (see Table 37) shows that while the European demand rose from 996,556 to 1,064,082 long tons, the imports from the United States fell from 389,440 to 319,033 tons.

The effect of the latest price movement upon the American export trade was not alike in the principal European markets.

Diagrams IV and IV_A illustrate the correlation between the London price, the consumption in Great Britain, and the imports from the United States and other countries. The results appear to be the same as shown for Europe as a whole. In the French market the decline of American imports, as shown in Diagram V, created somewhat of an increase in the imports from other countries, not, however, corresponding to the shortage of the former. Diagram VI shows for Germany a parallel movement between the consumption of that country and the imports from the United States; yet the decline of American imports in 1901 did not increase the imports from other countries.

While the effect of high prices from 1899 to 1901 upon the export trade may appear unfavorable, yet it was declared by the Amalgamated Copper Company, in its official statement, that "the portion of the copper which has been sold has realized a larger profit than would have been realized had all the copper which had been produced been sold at a much lower price." This view is borne out by the following comparison of the production, prices, and dividends for the years 1895 to 1902:

Production, prices, and dividends: 1895 to 1902.

YEAR.	Production of copper (pounds).	Average price per pound (cents).	DIVIDENDS.	
			Amount.	Average per pound (cents).
1895	380,614,080	10.73	$4,200,000	1.10
1896	460,060,160	10.98	5,575,000	1.21
1897	494,079,040	11.36	8,222,000	1.66
1898	526,512,000	12.05	12,647,000	2.40
1899	568,668,800	17.76	28,042,000	4.93
1900	602,808,640	16.65	30,074,000	4.99
1901	601,489,280	16.72	24,396,000	4.05
1902	639,033,392	12.16	11,038,242	1.73

Table 42, which follows, shows in detail the statistics of copper mines for 1902:

TABLE 42.—DETAILED SUMMARY: 1902.

	United States.	Arizona.	California.	Colorado.	Michigan.	Montana.	New Mexico.	Utah.	All other states.[1]
Number of mines	144	30	7	18	20	27	17	13	12
Number of operators	144	30	7	18	20	27	17	13	12
Character of ownership:									
Individual	19	1	2	1	.....	5	8	1	1
Firm	23	8	.....	4	.....	8	2	1	.....
Incorporated company	100	21	4	13	20	14	6	11	11
Other form	2	.....	1	.....	.....	.....	1	.....	.....
Salaried officials, clerks, etc.:									
Total number	1,208	258	38	25	419	310	24	51	83
Total salaries	$1,768,456	$399,275	$48,033	$17,338	$598,076	$494,415	$32,120	$71,155	$108,044
General officers—									
Number	116	25	.....	3	49	21	.....	9	9
Salaries	$311,479	$52,556	.....	$633	$148,729	$61,434	.....	$16,517	$31,610
Superintendents, managers, surveyors, foremen, etc.—									
Number	400	87	19	14	123	91	14	17	35
Salaries	$655,475	$155,868	$27,644	$11,185	$185,561	$187,635	$21,500	$24,193	$41,889
Foremen below ground—									
Number	337	59	10	5	152	75	6	14	16
Salaries	$459,611	$101,063	$12,480	$4,500	$164,477	$135,335	$6,870	$17,665	$17,221
Clerks—									
Number	355	87	9	3	95	123	4	11	23
Salaries	$341,891	$89,788	$7,909	$1,020	$99,309	$110,011	$3,750	$12,780	$17,324
Wage-earners:									
Aggregate average number	26,007	3,797	496	115	13,887	6,388	164	487	673
Aggregate wages	$21,151,405	$3,497,528	$445,247	$108,981	$8,744,892	$7,339,773	$128,483	$439,612	$446,889
Above ground—									
Total average number	7,584	1,178	111	23	4,817	1,192	29	41	193
Total wages	$5,358,509	$1,072,028	$105,236	$22,368	$2,546,064	$1,410,431	$29,842	$40,934	$131,606
Engineers, firemen, and other mechanics—									
Average number	2,858	450	77	14	1,293	885	20	33	86
Wages	$2,792,418	$538,565	$78,068	$15,588	$939,284	$1,095,830	$24,412	$34,714	$65,957
Miners—									
Average number	53	11	.....	.....	19	.....	2	.....	21
Wages	$47,829	$11,241	.....	.....	$13,176	.....	$1,200	.....	$22,212
Boys under 16 years—									
Average number	68	47	.....	.....	5	.....	.....	.....	16
Wages	$30,091	$25,720	.....	.....	$1,305	.....	.....	.....	$3,666
All other wage-earners—									
Average number	4,605	670	34	9	3,500	307	7	8	70
Wages	$2,488,171	$496,502	$27,168	$6,780	$1,592,299	$314,601	$4,230	$6,220	$40,371

[1] Includes operators distributed as follows: Idaho, 1; Nevada, 1; North Carolina, 2; Oregon, 2; Tennessee, 2; Virginia, 1; Washington, 1; Wisconsin, 1; Wyoming, 1.

TABLE 42.—DETAILED SUMMARY: 1902—Continued.

	United States.	Arizona.	California.	Colorado.	Michigan.	Montana.	New Mexico.	Utah.	All other states.
Wage-earners—Continued.									
Aggregate wages—Continued.									
Below ground—									
Total average number	18,423	2,619	385	92	9,070	5,196	135	446	480
Total wages	$15,792,896	$2,425,500	$340,011	$86,613	$6,198,828	$5,929,942	$98,641	$398,678	$315,283
Miners—									
Average number	12,768	1,679	341	82	5,381	4,518	118	435	214
Wages	$11,900,164	$1,706,580	$299,177	$78,878	$4,018,260	$5,155,224	$88,223	$389,907	$164,415
Miners' helpers—									
Average number	1,257	700	18	7	392	4	14	9	113
Wages	$777,210	$471,150	$16,425	$6,300	$189,224	$3,900	$7,528	$7,402	$75,281
Boys under 16 years—									
Average number	35	3			32				
Wages	$13,800	$1,300			$12,500				
All other wage-earners[1]—									
Average number	4,363	237	26	3	3,265	674	3	2	153
Wages	$3,101,722	$246,470	$24,409	$1,935	$1,978,844	$770,218	$2,890	$1,369	$75,587
Average number of wage-earners at specified daily rates of pay:									
Engineers—									
$1.00 to $1.24	2				1				1
$1.25 to $1.49	29				23				6
$1.50 to $1.74	10				10				
$1.75 to $1.99	27				23				4
$2.00 to $2.24	74	1			69				4
$2.25 to $2.49	43				43				
$2.50 to $2.74	35	1	2		32				
$2.75 to $2.99	62		1		55				6
$3.00 to $3.24	21	1	7	2	1		2	6	2
$3.25 to $3.49	8		2	1				5	
$3.50 to $3.74	25	10	3	1			7	4	
$3.75 to $3.99	10	10							
$4.00 to $4.24	167	34		3		124		2	4
$4.25 and over	39	17				20	2		
Firemen—									
$1.00 to $1.24	1								1
$1.25 to $1.49	9				4				5
$1.50 to $1.74	10				9				1
$1.75 to $1.99	78				76				2
$2.00 to $2.24	119				119				
$2.25 to $2.49	4				4				
$2.50 to $2.74	99	7	3		87			2	
$2.75 to $2.99	8	8							
$3.00 to $3.24	20	6	2			8	1	3	
$3.25 to $3.49	1			1					
$3.50 to $3.74	134	20				108	1	1	4
$3.75 to $3.99	2	2							
$4.00 to $4.24	2					2			
Machinists, blacksmiths, carpenters, and other mechanics—									
$1.00 to $1.24	3				2				1
$1.25 to $1.49	10				1				9
$1.50 to $1.74	32				30				2
$1.75 to $1.99	90				82				8
$2.00 to $2.24	233	9			213	2			9
$2.25 to $2.49	137	8	8		120				1
$2.50 to $2.74	260	32	5		214	9			
$2.75 to $2.99	58		7		48		1		2
$3.00 to $3.24	173	76	18	1	11	60	1	5	1
$3.25 to $3.49	49	34	4	1	5			2	3
$3.50 to $3.74	227	53	14	4	1	149	2	1	3
$3.75 to $3.99	24	17			4	3			
$4.00 to $4.24	273	89	1		2	170	2	2	7
$4.25 to $4.49	250	15			4	230	1		
Miners—									
$0.75 to $0.99	24								24
$1.00 to $1.24	1								1
$1.25 to $1.49	61	14							47
$1.50 to $1.74	36	7					9		20
$1.75 to $1.99	137	98					24		15
$2.00 to $2.24	2,076	85	67		1,967		1		6
$2.25 to $2.49	1,309	324	2		931		52		
$2.50 to $2.74	1,679	101	74	9	1,287		13	179	16
$2.75 to $2.99	368	53	115	4				191	5
$3.00 to $3.24	1,514	93	79	43	1,215		19	61	4
$3.25 to $3.49	7							4	3
$3.50 to $3.74	5,552	955	4	26		4,471	2		94
$3.75 to $3.99	1	1							
$4.00 to $4.24	40	5				35			
$4.25 and over	16	4				12			
Miners' helpers—									
$0.50 to $0.74	3								3
$1.00 to $1.24	110				110				
$1.25 to $1.49	88				64				24
$1.50 to $1.74	77				32		6		39
$1.75 to $1.99	497	482					5		10
$2.00 to $2.24	336	149			186				1
$2.25 to $2.49	50	48							2
$2.50 to $2.74	30		18				3	9	
$2.75 to $2.99	10								10
$3.00 to $3.24	18	7		7		4			
$3.50 to $3.74	38	14							24
Timbermen and track layers—									
$1.00 to $1.24	6				5				1
$1.50 to $1.74	14				9				5
$1.75 to $1.99	95				95				
$2.00 to $2.24	359				359				
$2.25 to $2.49	55				55				
$2.50 to $2.74	32		1		30			1	
$2.75 to $2.99	3		3						
$3.00 to $3.24	28	6	18	2	1			1	
$3.25 to $3.49	21	17	4						
$3.50 to $3.74	207	1				185	2		19
$3.75 to $3.99	17	15				2			
$4.00 to $4.24	26					26			

[1] Includes timbermen and track layers.

TABLE 42.—DETAILED SUMMARY: 1902—Continued.

	United States.	Arizona.	California.	Colorado.	Michigan.	Montana.	New Mexico.	Utah.	All other states.
Average number of wage-earners at specified daily rates of pay—Continued.									
Boys under 16 years—									
$0.50 to $0.74	12								12
$0.75 to $0.99	8				4				4
$1.00 to $1.24	20	18			2				
$1.25 to $1.49	34	3			31				
$1.50 to $1.74	7	7							
$2.00 to $2.24	12	12							
$2.25 to $2.49	10	10							
All other wage-earners—									
$0.50 to $0.74	14				1				13
$0.75 to $0.99	17				4				13
$1.00 to $1.24	1,958				1,942				16
$1.25 to $1.49	187	7			74				56
$1.50 to $1.74	661	33		3	562				63
$1.75 to $1.99	1,530				1,529				1
$2.00 to $2.24	1,928	140	5		1,752	10	8		13
$2.25 to $2.49	458	207	9		228	9		5	
$2.50 to $2.74	150	54	11	3	53	24		2	3
$2.75 to $2.99	152	94	2		35			1	20
$3.00 to $3.24	327	142	6	4	18	157			
$3.25 to $3.49	45	33			2	10			
$3.50 to $3.74	559	123	1		1	434			
$4.00 to $4.24	97	30			9	58			
$4.25 and over	72	5			1	66			
Average number of wage-earners employed during each month:									
Men 16 years and over—									
January	24,885	3,534	384	117	13,839	5,603	111	555	742
February	24,658	3,519	345	112	13,257	6,102	121	514	688
March	25,602	3,709	387	124	13,679	6,363	141	498	701
April	26,088	3,686	482	129	14,118	6,304	160	503	706
May	27,073	3,941	543	124	14,512	6,567	146	513	727
June	26,466	3,937	585	117	13,952	6,538	178	513	651
July	26,838	3,854	685	118	14,249	6,656	147	528	651
August	25,908	3,867	664	117	13,760	6,168	182	493	657
September	25,698	3,714	659	113	13,660	6,317	161	487	587
October	26,273	3,742	611	115	13,973	6,585	212	430	605
November	25,720	3,665	434	97	13,490	6,838	212	406	578
December	25,639	3,796	223	97	13,711	6,615	202	404	591
Boys under 16 years—									
January	111	50			44				17
February	110	50			43				17
March	113	50			45				18
April	113	50			47				16
May	110	50			43				17
June	106	50			39				17
July	112	51			44				17
August	92	48			27				17
September	92	51			27				14
October	93	50			29				14
November	91	50			27				14
December	93	50			29				14
Contract work:									
Amount paid	$188,768	$122,337		$965	$11,725	$40,975	$10,266		
Number of employees	195	121		3	9	28	31		
Miscellaneous expenses:									
Total	$1,397,465	$256,753	$15,367	$4,608	$473,501	$456,108	$26,858	$71,448	$92,822
Royalties and rent of mine and mining plant	$130,215	$7,679	$1,200	$360	$2,842	$85,409	$12,123	$12,166	$8,436
Rent of offices, taxes, insurance, interest, and other sundries	$1,267,250	$249,074	$14,167	$4,248	$470,659	$370,699	$14,735	$59,282	$84,386
Cost of supplies and materials	$11,083,175	$2,135,676	$211,163	$58,221	$4,688,419	$3,649,127	$49,408	$166,226	$144,935
Value of product	$51,178,036	$8,279,224	$1,599,663	$71,411	$18,247,207	$20,563,353	$271,270	$1,459,192	$686,716
Power:									
Total horsepower	198,507	5,637	1,018	442	137,772	49,090	849	754	2,945
Owned—									
Engines—									
Steam—									
Number	792	56	12	7	439	218	15	13	32
Horsepower	189,426	4,808	408	275	137,522	43,057	846	405	2,105
Gas or gasoline—									
Number	35	24	2	2		3	1	3	
Horsepower	1,184	804	50	42		196	3	89	
Water wheels—									
Number	8		1	1		1		1	4
Horsepower	326		5	75		1		50	195
Other power—									
Number	34	1	2	1	3	20		2	5
Horsepower	5,235	25	125	50	250	4,030		110	645
Rented—									
Electric, horsepower	2,336		430			1,806		100	
Electric motors owned—									
Number	50	8	10	1	10	18		1	2
Horsepower	2,312	405	430	7	101	1,189		100	80
Supplied to other establishments, horsepower	87					87			