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DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

J. W. POWELL, DIRECTOR

MINERAL RESOURCES

OF THE

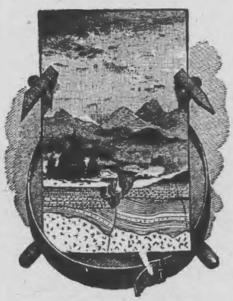
UNITED STATES

CALENDAR YEAR

1886

DAVID T. DAY

CHIEF OF DIVISION OF MINING STATISTICS AND TECHNOLOGY



WASHINGTON

GOVERNMENT PRINTING OFFICE

1887

NOTICE.

This volume, "Mineral Resources of the United States, 1886," is the fourth of a series which began in 1882. Its price is 50 cents. In ordering the different volumes of this series care should be taken to designate the first as "Mineral Resources, 1882," price 50 cents; the second, "Mineral Resources, 1883 and 1884," price 60 cents; the third, "Mineral Resources, 1885," price 40 cents; and this volume as "Mineral Resources, 1886." Remittances should be made by postal note (not stamps), and should be addressed to the Director United States Geological Survey, Washington, D. C.

Corrections, additions, or notice of important omissions, reports and maps of mines and mining districts, pamphlets on metallurgical processes, brief notes on new mineral localities, etc., will be highly appreciated, and should be addressed to David T. Day, U. S. Geological Survey, Washington, D. C. Duplicate copies of such reports, etc., are especially desired for extending the fine set of mining pamphlets in the library of the Survey, and will be thankfully acknowledged if sent to the

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[Mineral Resources of the United States, 1886.]

The publications of the United States Geological Survey are issued in accordance with the statute approved March 3, 1879, which declares that—

"The publications of the Geological Survey shall consist of the annual report of operations, geological and economic maps illustrating the resources and classification of the lands, and reports upon general and economic geology and paleontology. The annual report of operations of the Geological Survey shall accompany the annual report of the Secretary of the Interior. All special memoirs and reports of said Survey shall be issued in uniform quarto series if deemed necessary by the Director, but otherwise in ordinary octavos. Three thousand copies of each shall be published for scientific exchanges and for sale at the price of publication; and all literary and cartographic materials received in exchange shall be the property of the United States and form a part of the library of the organization: And the money resulting from the sale of such publications shall be covered into the Treasury of the United States."

On July 7, 1882, the following joint resolution, referring to all Government publications, was passed by Congress:

"That whenever any document or report shall be ordered printed by Congress, there shall be printed, in addition to the number in each case stated, the 'usual number' (1,900) of copies for binding and distribution among those entitled to receive them."

Except in those cases in which an extra number of any publication has been supplied to the Survey by special resolution of Congress or has been ordered by the Secretary of the Interior, this Office has no copies for gratuitous distribution.

ANNUAL REPORTS.

Of the Annual Reports there have been already published:

I. First Annual Report to the Hon. Carl Schurz, by Clarence King. 1880. 8°. 79 pp. 1 map.—A preliminary report describing plan of organization and publications.

II. Second Annual Report of the United States Geological Survey, 1880–'81, by J. W. Powell. 1882. 8°. lv, 588 pp. 61 pl. 1 map.

III. Third Annual Report of the United States Geological Survey, 1881–'82, by J. W. Powell. 1883. 8°. xviii, 564 pp. 67 pl. and maps.

IV. Fourth Annual Report of the United States Geological Survey, 1882–'83, by J. W. Powell. 1884. 8°. xxxii, 473 pp. 85 pl. and maps.

V. Fifth Annual Report of the United States Geological Survey, 1883–'84, by J. W. Powell. 1885. 8°. xxxvi, 469 pp. 58 pl. and maps.

VI. Sixth Annual Report of the United States Geological Survey, 1884–'85, by J. W. Powell. 1886. 8°. xxix, 570 pp. 65 pl. and maps.

The Seventh and Eighth Annual Reports are in press.

MONOGRAPHS.

Of the Monographs, Nos. II, III, IV, V, VI, VII, VIII, IX, X, XI, and XII are now published, viz:

II. Tertiary History of the Grand Cañon District, with atlas, by Clarence E. Dutton, Capt. U. S. A. 1882. 4°. xiv, 264 pp. 42 pl. and atlas of 24 sheets folio. Price $10.12.

III. Geology of the Comstock Lode and the Washoe District, with atlas, by George F. Becker. 1882. 4°. xv, 422 pp. 7 pl. and atlas of 21 sheets folio. Price $11.

IV. Comstock Mining and Miners, by Eliot Lord. 1883. 4°. xiv, 451 pp. 3 pl. Price $1.50.

V. Copper-Bearing Rocks of Lake Superior, by Roland D. Irving. 1883. 4°. xvi, 464 pp. 15 l. 29 pl. Price $1.85.

VI. Contributions to the Knowledge of the Older Mesozoic Flora of Virginia, by Wm. M. Fontaine. 1883. 4°. xi, 144 pp. 54 l. 54 pl. Price $1.05.

VII. Silver-Lead Deposits of Eureka, Nevada, by Joseph S. Curtis. 1884. 4°. xiii, 200 pp. 16 pl. Price $1.20.

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17. On the Development of Crystallization in the Igneous Rocks of Washoe, Nevada, by Arnold Hague and Joseph P. Iddings. 1885. 8°. 44 pp. Price 5 cents.

18. On Marine Eocene, Fresh-water Miocene, and other Fossil Mollusca of Western North America, by Charles A. White. 1885. 8°. 26 pp. 3 pl. Price 5 cents.

19. Notes on the Stratigraphy of California, by George F. Becker. 1885. 8°. 28 pp. Price 5 cents.

20. Contributions to the Mineralogy of the Rocky Mountains, by Whitman Cross and W. F. Hillebrand. 1885. 8°. 114 pp. 1 pl. Price 10 cents.

21. The Lignites of the Great Sioux Reservation, by Bailey Willis. 1885. 8°. 16 pp. 5 pl. Price 5 cents.

22. On New Cretaceous Fossils from California, by Charles A. White. 1885. 8°. 25 pp. 5 pl. Price 5 cents.

23. Observations on the Junction between the Eastern Sandstone and the Keweenaw Series on Keweenaw Point, Lake Superior, by R. D. Irving and T. C. Chamberlin. 1885. 8°. 124 pp. 17 pl. Price 15 cents.

24. List of Marine Mollusca, comprising the Quaternary fossils and recent forms from American Localities between Cape Hatteras and Cape Roque, including the Bermudas, by William H. Dall. 1885. 8°. 336 pp. Price 25 cents.

25. The Present Technical Condition of the Steel Industry of the United States, by Phineas Barnes. 1885. 8°. 85 pp. Price 10 cents.

26. Copper Smelting, by Henry M. Howe. 1885. 8°. 107 pp. Price 10 cents.

27. Report of work done in the Division of Chemistry and Physics, mainly during the fiscal year 1884–'85. 1886. 8°. 80 pp. Price 10 cents.

28. The Gabbros and Associated Hornblende Rocks occurring in the Neighborhood of Baltimore, Md., by George H. Williams. 1886. 8°. 78 pp. 4 pl. Price 10 cents.

29. On the Fresh-water Invertebrates of the North American Jurassic, by Charles A. White. 1886. 8°. 41 pp. 4 pl. Price 5 cents.

30. Second Contribution to the Studies on the Cambrian Faunas of North America, by Charles D. Walcott. 1886. 8°. 369 pp. 33 pl. Price 25 cents.

31. A Systematic Review of our Present Knowledge of Fossil Insects, including Myriapods and Arachnids, by Samuel H. Scudder. 1886. 8°. 128 pp. Price 15 cents.

32. Lists and Analyses of the Mineral Springs of the United States; a Preliminary Study, by Albert C. Peale. 1886. 8°. 235 pp. Price 20 cents.

33. Notes on the Geology of Northern California, by Joseph S. Diller. 1886. 8°. 23 pp. Price 5 cents.

34. On the relation of the Laramie Molluscan Fauna to that of the succeeding Fresh-water Eocene and other groups, by Charles A. White. 1886. 8°. 54 pp. 5 pl. Price 10 cents.

35. The Physical Properties of the Iron-Carburets, by Carl Barus and Vincent Strouhal. 1886. 8°. 62 pp. Price 10 cents.

36. Subsidence of Fine Solid Particles in Liquids, by Carl Barus. 1887. 8°. 58 pp. Price 10 cents.

37. Types of the Laramie Flora, by Lester F. Ward. 1887. 8°. 354 pp. 57 pl. Price 25 cents.

38. Peridotite of Elliott County, Kentucky, by Joseph S. Diller. 1887. 8°. 31 pp. 1 pl. Price 5 cents.

39. The Upper Beaches and Deltas of the Glacial Lake Agassiz, by Warren Upham. 1887. 8°. 84 pp. 1 pl. Price 10 cents.

40. Changes in River Courses in Washington Territory due to Glaciation, by Bailey Willis. 1886. 8°. 10 pp. 4 pl. Price 5 cents.

Numbers 1 to 6 of the Bulletins form Volume I; Numbers 7 to 14, Volume II; Numbers 15 to 23, Volume III; Numbers 24 to 30, Volume IV; Numbers 31 to 36, Volume V; Numbers 37 to 41, Volume VI. Volume VII is not yet complete.

41. Fossil Faunas of the Upper Devonian—the Genesee Section, New York, by Henry S. Williams. 1886. 8°. 121 pp. 4 pl. Price 15 cents.

42. Report of work done in the Division of Chemistry and Physics, mainly during the fiscal year 1885–'86. F. W. Clarke, chief chemist. 1887. 8°. 152 pp. 1 pl. Price 15 cents.

The following are in press:

43. On the Tertiary and Cretaceous Strata of the Tuscaloosa, Tombigbee, and Alabama Rivers, by Eugene A. Smith and Lawrence C. Johnson. 1887. 8°. 189 pp. 21 pl. Price 15 cents.

44. Bibliography of North American Geology for 1886, by Nelson H. Darton. 1887. 8°. 35 pp. Price 5 cents.

45. Present Condition of Knowledge of the Geology of Texas, by Robert T. Hill. 1887. 8°.

46. The Nature and Origin of Deposits of Phosphate of Lime, by R. A. F. Penrose, jr.

47. Analyses of Waters of Yellowstone National Park, by F. A. Gooch and J. E. Whitfield.

48. On the Form and Position of the Sea Level, by R. S. Woodward.

49. On the Latitude and Longitude of Points in Missouri, Kansas, and New Mexico, by R. S. Woodward.

50. Invertebrate Fossils from California, Oregon, Washington Territory, and Alaska, by C. A. White.

51. On the Subaërial Decay of Rocks and the Origin of the Red Color of Certain Formations, by Israel C. Russell.

VIII. Paleontology of the Eureka District, by Charles D. Walcott. 1884. 4°. xiii, 298 pp. 24 l. 24 pl. Price $1.10.

IX. Brachiopoda and Lamellibranchiata of the Raritan Clays and Greensand Marls of New Jersey, by Robert P. Whitfield. 1885. 4°. xx, 338 pp. 35 pl. Price $1.15.

X. Dinocerata. A Monograph of an Extinct Order of Gigantic Mammals, by Othniel Charles Marsh. 1885. 4°. xviii, 243 pp. 56 l. 56 pl. Price $2.70.

XI. Geological History of Lake Lahontan, a Quaternary Lake of Northwestern Nevada, by Israel Cook Russell. 1885. 4°. xiv, 288 pp. 46 pl. Price $1.75.

XII. Geology and Mining Industry of Leadville, with atlas, by S. F. Emmons. 1886. 4°. xxix, 770 pp. 45 pl. and atlas of 35 sheets folio. Price $8.40.

The following is in press:

XIII. Geology of the Quicksilver Deposits of the Pacific Slope, with atlas, by George F. Becker.

The following are in preparation:

I. The Precious Metals, by Clarence King.

— Gasteropoda of the New Jersey Cretaceous and Eocene Marls, by R. P. Whitfield.

— Geology of the Eureka Mining District, Nevada, with atlas, by Arnold Hague.

— Lake Bonneville, by G. K. Gilbert.

— Sauropoda, by Prof. O. C. Marsh.

— Stegosauria, by Prof. O. C. Marsh.

— Brontotheridæ, by Prof. O. C. Marsh.

— The Penokee-Gogebic Iron-Bearing Series of North Wisconsin and Michigan, by Roland D. Irving.

— Younger Mesozoic Flora of Virginia, by William M. Fontaine.

— Description of New Fossil Plants from the Dakota Group, by Leo Lesquereux.

— Report on the Denver Coal Basin, by S. F. Emmons.

— Report on Silver Cliff and Ten-Mile Mining District, Colorado, by S. F. Emmons.

— Flora of the Dakota Group, by J. S. Newberry.

— The Fossil Fishes and Fossil Plants of the Triassic Rocks of New Jersey and the Connecticut Valley, by J. S. Newberry.

BULLETINS.

Each of the Bulletins contains but one paper and is complete in itself. They are, however, numbered in a continuous series, and may be bound in volumes of convenient size. To facilitate this, each Bulletin has two paginations, one proper to itself and another which belongs to it as part of the volume.

Of this series of Bulletins Nos. 1 to 40 are already published, viz:

1. On Hypersthene-Andesite and on Triclinic Pyroxene in Augitic Rocks, by Whitman Cross, with a Geological Sketch of Buffalo Peaks, Colorado, by S. F. Emmons. 1883. 8°. 42 pp. 2 pl. Price 10 cents.

2. Gold and Silver Conversion Tables, giving the coining values of troy ounces of fine metal, etc., by Albert Williams, jr. 1883. 8°. 8 pp. Price 5 cents.

3. On the Fossil Faunas of the Upper Devonian, along the meridian of 76° 30′, from Tompkins County, New York, to Bradford County, Pennsylvania, by Henry S. Williams. 1884. 8°. 36 pp. Price 5 cents.

4. On Mesozoic Fossils, by Charles A. White. 1884. 8°. 36 pp. 9 pl. Price 5 cents.

5. A Dictionary of Altitudes in the United States, compiled by Henry Gannett. 1884. 8°. 325 pp. Price 20 cents.

6. Elevations in the Dominion of Canada, by J. W. Spencer. 1884. 8°. 43 pp. Price 5 cents.

7. Mapoteca Geologica Americana. A Catalogue of Geological Maps of America (North and South), 1752–1881, by Jules Marcou and John Belknap Marcou. 1884. 8°. 184 pp. Price 10 cents.

8. On Secondary Enlargements of Mineral Fragments in Certain Rocks, by R. D. Irving and C. R. Van Hise. 1884. 8°. 56 pp. 6 pl. Price 10 cents.

9. Report of work done in the Washington Laboratory during the fiscal year 1883–'84. F. W. Clarke, chief chemist; T. M. Chatard, assistant. 1884. 8°. 40 pp. Price 5 cents.

10. On the Cambrian Faunas of North America. Preliminary Studies, by Charles D. Walcott. 1884. 8°. 74 pp. 10 pl. Price 5 cents.

11. On the Quaternary and Recent Mollusca of the Great Basin, with Descriptions of New Forms, by R. Ellsworth Call. Introduced by a Sketch of the Quaternary Lakes of the Great Basin, by G. K. Gilbert. 1884. 8°. 66 pp. 6 pl. Price 5 cents.

12. A Crystallographic Study of the Thinolite of Lake Lahontan, by Edward S. Dana. 1884. 8°. 34 pp. 3 pl. Price 5 cents.

13. Boundaries of the United States and of the several States and Territories, by Henry Gannett. 1885. 8°. 135 pp. Price 10 cents.

14. The Electrical and Magnetic Properties of the Iron-Carburets, by Carl Barus and Vincent Strouhal. 1885. 8°. 238 pp. Price 15 cents.

15. On the Mesozoic and Cenozoic Paleontology of California, by Charles A. White. 1885. 8°. 33 pp. Price 5 cents.

16. On the Higher Devonian Faunas of Ontario County, New York, by John M. Clarke. 1885. 8°. 86 pp. 3 pl. Price 5 cents.

CONTENTS.

LETTER OF TRANSMITTAL.

UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF MINING STATISTICS AND TECHNOLOGY,
Washington, D. C., August 13, 1887.

SIR: I have the honor to transmit herewith a statistical report upon the present condition of the mining industries of the United States. This report is the fourth of the series entitled "Mineral Resources of the United States." The first three volumes contained the statistics from 1882 to December 31, 1885; and the present volume deals with the changes in the mineral industries during the calendar year 1886. In accordance with your instructions it is proposed to issue a fifth report, for the calendar year 1887, in 1888.

Very respectfully, your obedient servant,

DAVID T. DAY,
Geologist in Charge.

Hon. J. W. POWELL,
Director United States Geological Survey.

INTRODUCTORY.

This volume contains a review of the mineral industries of the United States during the calendar year 1886. The statistical tables contained in the three preceding volumes of this series have been brought forward to the close of 1886. With this exception repetition has been avoided wherever possible, and the technical information here contained is supplementary to that already published. The four volumes should therefore be consulted together.

Acknowledgments.—The names of contributors of special articles are given in connection with the subjects of which they were given charge. In regard to sources of information, much valuable aid has been furnished by the State bureaus of labor and statistics and by associations of manufacturers. A large majority of the statistics resulted, however, from applications directly to producers; and, recognizing the fact that it has become necessary for many of them to employ statistical clerks to answer the demands made upon them for information from various compilers, it is gratifying to testify to the general spirit of interest and hearty co-operation which makes a report of this nature possible.

Arrangement of matter.—The subject matter is arranged under the various mineral substances treated. For example, everything pertaining to coal will be found under that head, except its bearing upon other minerals, to which cross references are made.

The time covered by the report is in general the calendar year 1886, except where the conditions of special industries have made other more natural divisions of time. In consideration of the necessary delay in publishing information from so many sources, it should be noted that the statements made by contributors represents their views shortly after the close of the year 1886, although later information has been incorporated in the report in a few instances of important developments. Advance bulletins giving the main facts concerning the more important industries were published as soon as the reports were complete.

Imports and exports.—The statistics of imports and exports are due to the courtesy of the Bureau of Statistics of the Treasury Department; they embrace imported articles entered for immediate consumption, plus the withdrawals from warehouses during the fiscal year ending June 30 of the years mentioned.

The units of quantity adopted are those most commonly in use in the several industries. The ton of 2,240 pounds is in this report called the "long" ton, and that of 2,000 pounds is called the "short" ton; the terms "gross" ton and "net" ton being sometimes misleading, as for instance where "gross ton of ore" might be taken to mean a ton (of perhaps only 2,000 pounds) including moisture, or where "net" might be understood as referring to the weight after deducting the tare of package, etc. In quoting statistics of the European continent the "metric" ton (tonne) of 2,204 pounds avoirdupois is generally adopted and is specified. For Great Britain and its colonies the long ton of 2,240 pounds is the unit. Pounds are avoirdupois throughout, unless otherwise specified.

The statistics of the weights of imports into and exports from the United States are quoted in long tons and long hundredweights (112 pounds), these being the units adopted at the custom-houses.

Calendar and fiscal years.—Unless otherwise specified, years are understood to be calendar years ending December 31. The Government fiscal year ends June 30, and is designated by the number of the calendar year in which it is completed. Imports and exports, with a very few exceptions, are given by fiscal years because they are thus reported by the Treasury Department, and because a considerable delay would ensue if a computation by calendar years were attempted. It is admitted that for purposes of comparison the calendar year would be a more convenient time unit.

MINERAL RESOURCES OF THE UNITED STATES.

CALENDAR YEAR 1886.

DAVID T. DAY,
Chief of Division of Mining Statistics and Technology.

SUMMARY—1886.

METALS.

Iron.—The principal statistics for 1886 were: Domestic iron ore consumed about 10,000,000 long tons; value at mines, $28,000,000. Imported iron ore consumed, 1,039,433 long tons; total iron ore consumed, 11,039,433 long tons. Pig iron made, 5,683,329 long tons, an increase of 1,683,803 tons as compared with 1885; value at furnace, $95,195,760, or $30,483,360 more than in 1885. Total spot value of all iron and steel in the first stage of manufacture, excluding all duplications, $142,500,000, an increase of $49,500,000 as compared with 1885.

Gold and silver.—The total value of gold produced in 1886 was $35,000,000, an increase of $3,199,000 over 1885. The production of silver decreased from $51,600,000 in 1885 to $51,000,000 in 1886.

Copper.—The production in 1886, including 4,500,000 pounds from imported pyrites, amounted to 161,235,381 pounds, valued at $16,527,651, a decrease of 9,727,226 pounds and $1,765,348 in value from 1885. The average price of copper in 1886 declined to 10¼ cents per pound. The copper sulphate made chiefly from ores and matte amounted to 13,400,000, valued at $536,000 at 4 cents per pound.

Lead.—The total production increased to 135,629 tons in 1886, valued at $12,667,749, at an average value of $93.40 per short ton in New York. In 1885 the production was 129,412 tons, valued at $10,469,431. The production of white lead in 1886 is estimated at 60,000 short tons; value, at 6¼ cents per pound, $7,500,000. The total value of the oxides of lead was about $1,535,000.

Zinc.—Production, 42,641 short tons. Value, $3,752,408, at $88 per short ton; an increase of 1,953 short tons and $212,552 in value over 1885. There are preparations for a further increase during 1887. Zinc oxide (zinc white) was also made directly from ores to the amount of 18,000 short tons, valued at $1,440,000.

Quicksilver.—In 1886 the production in California was 29,981 flasks, or 2,291,547 pounds, valued at $1,060,000. This is a decrease of 2,092 flasks, but the total value shows an increase of $80,811. Utah produced 87 flasks of quicksilver in addition to the above. The production of quicksilver vermilion increased to 700,000 pounds, and its value to $392,000 owing to the increase in price of quicksilver.

Nickel.—The production includes 182,345 pounds of metallic nickel, 122 tons of nickel and cobalt matte, 35 tons of exported ore, and 46,138 pounds of nickel-ammonium sulphate; total value, $127,157.

Cobalt.—In addition to 8,689 pounds of cobalt oxide at $2 per pound, ore and matte were produced making the total value $36,878.

Chromium.—Production of chrome iron ore decreasing. In 1886 about 2,000 tons were sold, all from California, where its total value was $30,000.

Manganese.—The production of manganese ores was 30,118 long tons, valued at $277,527. In addition to this, 257,000 tons of iron ore, containing from 2 to 4 per cent. of manganese, were produced, and 60,000 tons of manganiferous ores containing from 4 to 20 per cent. of manganese that were used as fluxes in the silver region. The production of manganese ores in 1885 was 23,258 long tons, valued at $190,281.

Tin.—Development work in the Black Hills resulted in the accumulation of considerable ore piles at the mines awaiting concentration.

Antimony.—Production, 35 tons of metallic antimony, valued at $7,000. A small amount of sulphide of antimony was also sold for chemical manufacture.

Aluminum.—Aluminum bronze containing 10 per cent. aluminum was made to the extent of 50,000 pounds, valued at $20,000 at 40 cents per pound. About 2,500 pounds of iron alloy containing 6 to 8 per cent. aluminum was also sold for $7,000.

Platinum and iridium.—The production of platinum sand was only 50 ounces, valued at $100. About 300 ounces of domestic iridosmine for pen points were sold in 1886 for $1,000.

FUELS.

Coal.—The following statistics have been compiled principally from the direct returns of the operators of individual coal mines, supplemented by valuable contributions from State officials.

The total production of all kinds of coal in 1886, exclusive of that consumed at the mines known as colliery consumption, was 107,682,209 short tons, valued at $147,112,755 at the mines. This may be divided into Pennsylvania anthracite, 36,696,475 short or 32,764,710 long tons, valued at $71,558,126; all other coals, including bituminous, brown coal, lignite, and small lots of anthracite produced in Rhode Island, Arkansas and Colorado, 70,985,734 short tons, valued at $75,554,629. The colliery consumption at the individual mines varies from nothing to 8 per cent. of the product, being greatest at special Pennsylvania anthracite mines and lowest at those bituminous mines where the bed is nearly horizontal and where no steam power or ventilating furnaces are employed. The averages for the different States vary from 3 to 6 per cent., the latter being the average in the Pennsylvania anthracite region.

The total production including colliery consumption was: Pennsylvania anthracite, 34,853,077 long or 39,035,446 short tons; all other coals 73,707,957 short tons, making the total absolute production of all coals in the United States 112,743,403 short tons, valued as follows: Anthracite, $76,119,120; bituminous, $78,481,056; total value, $154,600,176. The total production of Pennsylvania anthracite, including colliery consumption, was 699,473 short tons in excess of that produced in 1885, but its value was $552,828 less. The total production of bituminous coal was 1,086,408 short tons greater than in 1885, while its value was $3,866,592 less. The total production of all kinds of coal shows a gain of 1,785,881 short tons compared with 1885, but a decrease in spot value of $4,419,420.

Coke.—The total production of coke in 1886 was 6,835,068 short tons, valued at the ovens at $11,552,781. This is the largest production ever reached in the United States, the nearest approach to it being in 1883, when 5,464,721 tons were made. This declined in 1884 to 4,873,805 tons. The year 1885 showed a gain upon 1884, the total being 5,106,696 tons. The production for 1886 shows a gain on that of 1885 of 1,728,372 tons, or nearly 34 per cent. The total increase in value was $3,923,663. The production of 1886 is 1,370,347 tons, or 25 per cent. greater than the maximum of previous years.

Petroleum.—The total production was 28,110,115 barrels of 42 gallons each, of which the Pennsylvania and New York fields produced 25,798,000 barrels. The total value, at an average of 71¼ cents, the average value of the Pennsylvania and New York petroleum, was $20,028,457. The production showed an increase of 6,268,074 barrels over the production of 1885.

Natural gas.—No record is kept of the yield in cubic feet. It is estimated that the amount of coal displaced by natural gas in 1886 was 6,353,000 tons, valued at $9,847,150. In 1885 the amount of coal displaced by natural gas was 3,161,600 tons, valued at $4,854,200.

STRUCTURAL MATERIALS.

Building stone.—Value estimated to be about the same as in 1885—$19,000,000.

Brick and tile.—Value, $38,500,000. This value represents an increase of 10 per cent. over last year. The increase in production was slightly greater than 10 per cent. There was some falling off in value during a part of the year.

Lime.—The production is estimated at 42,500,000 barrels, with an average value of 50 cents per barrel.

Cement.—Production of cement from natural rock was 4,350,000 barrels, valued at $3,697,500. Artificial Portland cement, 150,000 barrels, valued at $292,500. The total production of cement of all kinds was 4,500,000 barrels, valued at $3,990,000.

ABRASIVE MATERIALS.

Buhrstones.—The total value of the finished buhrstones was $275,000. The increased use of roller mills affected the French buhrstones more than the domestic stones.

Grindstones.—Total value, $250,000; produced mainly in Ohio and Michigan.

Corundum.—The production in the past few years has been quite steady; in 1886 it was 645 short tons, valued at $116,190.

Novaculite.—The rough whetstones amounted to 1,160,000 pounds, valued at $15,000. The value of the stones is greatly increased by cutting.

Infusorial earth.—The production for the year amounted to 1,200 short tons, with a spot value of $6,000; all from Maryland.

MISCELLANEOUS.

Precious stones.—The value of the rough gems sold in 1886 was $79,056. In addition, gold quartz was sold for specimens and for gems to the value of $40,000. The value of this, when cut, is $100,000.

Phosphate rock.—Total production was 430,549 long tons—all from South Carolina except experimental lots from Alabama, Mississippi, and Florida. The total value was $1,872,936. The production decreased 7,307 long tons and the value $973,128 from 1885.

Marls.—The main production is from New Jersey and is comparatively steady at 800,000 short tons, valued at $400,000. Considerable local use is also made of many small deposits in North and South Carolina, Alabama, Mississippi, and Florida.

Salt.—The total production increased from 7,038,653 barrels (of 280 pounds each) in 1885 to 7,707,081 barrels in 1886. The total value, however, decreased slightly. In 1886 it was $4,736,585, and in 1885 $4,825,345.

Bromine.—Both the production and the average price of bromine increased markedly in 1886. The total production was 428,334 pounds in 1886, and 310,000 in 1885. The total value in 1886 was $141,350, and in 1885, $89,900.

Phosphorus.—Production, 30,000 pounds, valued at $20,000.

Borax.—Production, 9,778,290 pounds, all from California and Nevada. Total value $488,915, at 5 cents per pound for concentrated.

Sulphur.—The production amounted to 2,500 short tons, valued at $75,000.

Pyrites.—About 55,000 long tons were produced, valued at $247,500, at $4.50 per long ton at the mines. In addition 57,000 tons were imported.

Barytes.—Estimated production, 10,000 short tons of crude, valued at $50,000.

Gypsum.—Estimated total production of crude gypsum was 95,250 short tons, valued at $428,625. From this, 50,000 short tons of land plaster and 26,000 short tons of calcined plaster were made. In addition 122,270 tons of crude gypsum were imported, chiefly from Nova Scotia.

Mica.—The production decreased to 40,000 pounds, valued at $70,000. This is exclusive of 1,000 tons of waste, valued at $10,000.

Feldspar.—Production, 14,900 long tons, valued at $74,500, at $5 per ton for the crude material, without being ground. This is an increase of 1,300 long tons over 1885. The price has remained constant.

Flint.—About 30,000 long tons, having a spot value of $120,000, were used in pottery manufacture, besides a considerable amount for sandpaper.

Asbestus.—The domestic production was about 200 short tons, valued at $30 per ton at the mines. The production is decreasing, owing to importation of a better quality from Canada.

Asphaltum.—The production increased to 3,500 tons, valued at $14,000 at the deposits in California. In 1885 the value was $10,500.

Ocher.—Production, including "metallic" paint, umber, and sienna, 15,800 short tons, valued at $285,000.

Graphite.—The production in 1886 was 415,525 pounds, valued at $33,242. In 1885 the production was 327,883 pounds, valued at $26,230. The price remained constant at 8 cents per pound. This is exclusive of 500 tons of impure graphite mined at Cranston, Rhode Island, for metallurgical purposes.

Alum.—Production, 90,000,000 pounds, valued at $1,350,000. About three-fourths is made from imported cryolite, bauxite, aluminous shale, and other raw materials.

Copperas.—Production, 22,000,000 pounds, or 11,000 short tons; value, at 50 cents per hundredweight, $110,000.

Fluorspar.—The annual production for the past three years has been about 5,000 tons, valued at the mines in Indiana at $4.50 per ton, or $22,500 in all.

Rutile.—Production, for coloring artificial teeth, about 600 pounds, valued at $2,000.

Mineral waters.—Considering only the amount sold, the production was 8,950,317 gallons, valued at $1,284,070. This shows a slight total decrease since 1885. This may be only apparent. If all the springs had reported, the figures would probably have shown a total increase, although some large springs undoubtedly sold less.

Lithographic stones.—Considerable effort is being made to develop the industry in Tennessee and Kentucky. About 50 tons were taken out and dressed. The use of the stones has proved quite satisfactory, and will probably increase.

Magnesite.—Heretofore the raw materials for making magnesium compounds have been imported chiefly from Germany. The annual imports of magnesite vary from 100,000 to 2,000,000 pounds. In 1886 the production of magnesite was begun on Cedar mountain, Alameda county, California; the product, amounting to several tons, was shipped to New York.

Totals.—As was remarked in the report for 1883–1884, it is impossible to state the total mineral product in any form which shall not be open to just criticism. It is evident that the production statistics of such incongruous substances as iron ore, metallic gold and silver, the spot value of coal mined and the market value of metallic copper after having been transported hundreds of miles, the spot value of a crude substance like unground, unrefined barytes, and the value of a finished product like brick (in which the cost of manufacture is the leading item) cannot well be taken as items in a general summary. The statistics have been compiled with a view to giving information on those points which are of most interest and utility, and are presented in the form usual in the several branches of trade statistics. The result is that the values stated for the different products are necessarily taken at different stages of production or transportation, etc. Theoretically perfect statistics of mineral products would include, first of all, the actual net spot value of each substance in its crudest form, as taken from the earth; and yet for practical purposes such statistics would have little interest other than the fact that the items could be combined in a grand total in which each substance should be rated on a fairly even basis. The following groupings, therefore, are presented with a full realization of the incongruity of many of the items. The grand total might be considerably reduced by substituting the value of the iron ore mined for that of the pig iron made, by deducting the discount on silver, and by considering lime, salt, cement, borax, etc., as manufactures. It will also be remarked that the spot values of copper, lead, zinc, and chrome iron ore are much less than their respective values after transportation to market. Still the form adopted seems to be the only one which admits of a comparison of the total values of the mineral products from year to year.

Comparing the totals since 1882, a continuous decrease in value is evident in 1883 and 1884. The year 1885 shows a slight increase, while notably increased production and also an increase in value have been the general characteristics of the mineral industries during 1886. The total value of the mineral products increased from, roundly, $428,000,000 in 1885 to $465,000,000 in 1886. The main factor in this gain of $37,000,000 was the increased production of pig iron from 4,044,525 long tons in 1885 to 5,683,329 long tons in 1886, and an appreciation of 75 cents in the average value per ton, making a total gain of $30,483,360 in this industry alone.

Metallic products of the United States in 1886.

	Quantity.	Value.
Pig iron, spot value ... long tons ..	5,683,329	$95,195,760
Silver, coining value ... troy ounces ..	39,445,312	51,000,000
Gold, coining value ... do	1,881,250	35,000,000
Copper, value at New York City (*a*) ... pounds ..	161,235,381	16,527,651
Lead, value at New York City ... short tons ..	135,629	12,667,749
Zinc, value at New York City ... do	42,641	3,752,408
Quicksilver, value at San Francisco ... flasks ..	29,981	1,060,000
Nickel, value at Philadelphia ... pounds ..	214,992	127,157
Aluminum, value at Philadelphia ... troy ounces ..	....	27,000
Antimony, value at San Francisco ... short tons ..	35	7,000
Platinum, value, crude, at New York City ... troy ounces ..	50	100
Total ...	....	$215,364,825

a Including copper from imported pyrites.

Non-metallic mineral products of the United States in 1886 (*spot values*).

	Quantity.	Value.
Bituminous coal, brown coal, lignite, and anthracite mined elsewhere than in Pennsylvania ... long tons ..	65,810,676	$78,481,056
Pennsylvania anthracite ... do	34,853,077	76,119,120
Lime ... barrels ..	42,500,000	21,250,000
Petroleum ... do	28,110,115	20,028,457
Building stone ...	....	19,000,000
Natural gas ...	....	9,847,150
Salt ... barrels ..	7,707,081	4,736,585
Cement ... do	4,500,000	3,990,000
Limestone for iron flux ... long tons ..	4,717,163	2,830,297
South Carolina phosphate rock ... do	430,549	1,872,936
Zinc white ... short tons ..	18,000	1,440,000
Mineral waters ... gallons sold ..	8,950,317	1,284,070
Concentrated borax ... pounds ..	9,778,290	488,915
Gypsum ... short tons ..	95,250	428,625
New Jersey marls ... do	800,000	400,000
Ocher ... long tons ..	15,800	285,000
Manganese ore ... do	30,193	277,636
Pyrites ... long tons ..	55,000	247,500
Bromine ... pounds ..	428,334	141,350
Flint ... long tons ..	30,000	120,000
Corundum ... short tons ..	645	116,190
Precious stones ...	....	79,056
Sulphur ... short tons ..	2,500	75,000
Feldspar ... long tons ..	14,900	74,500
Mica ... pounds ..	40,000	70,000
Crude barytes ... long tons ..	10,000	50,000
Gold quartz souvenirs, jewelry, etc ...	....	40,000
Cobalt oxide, ore, and matte ...	....	36,878
Graphite ... pounds ..	415,525	33,242
Slate ground as a pigment ... long tons ..	3,000	30,000

Non-metallic mineral products of the United States in 1886 (*spot values*)—Continued.

	Quantity.	Value.
Chrome iron ore ....long tons..	2,000	$30,000
Fluorspar ....short tons..	5,000	22,500
Novaculite ....pounds..	1,160,000	15,000
Asphaltum ....short tons..	3,500	14,000
Asbestus ....long tons..	200	6,000
Rutile ....pounds..	600	2,000
Total	....	243,963,063

Résumé of the values of the metallic and non-metallic mineral substances produced in the United States in 1886.

Metals........	$215,364,825
Mineral substances named in the foregoing table........	243,963,063
	459,327,888
Estimated value of mineral products unspecified........	6,000,000
Grand total........	465,327,888

Summary of the mineral products of the United States, calendar years 1882 *to* 1886, *inclusive.*

	Products.	1882.		1883.		1884.		1885.		1886.		
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	METALLIC.											
1	Pig-iron, spot value............long tons..	4, 623, 323	$106,336,429	4, 595, 510	$91, 910, 200	4, 097, 868	$73, 761, 624	4, 044, 525	$64, 712, 400	5, 683, 329	$95, 195, 760	1
2	Silver, coining value.........troy ounces..	36, 197, 695	46, 800, 000	35, 733, 622	46, 200, 000	37, 744, 605	48, 800, 000	39, 910, 279	51, 600, 000	39, 445, 312	51, 000, 000	2
3	Gold, coining value..................do.....	1, 572, 186	32, 500, 000	1, 451, 249	30, 000, 000	1, 489, 949	30, 800, 000	1, 538, 376	31, 801, 000	1, 881, 250	35, 000, 000	3
4	Copper, value at New York City..pounds.	91, 646, 232	16, 038, 091	117, 151, 795	18, 064, 807	147, 805, 407	18, 106, 162	170, 962, 607	18, 292, 999	161, 235, 381	16, 527, 651	4
5	Lead, value at New York City..short tons.	132, 890	12, 624, 550	143, 957	12, 322, 719	139, 897	10, 537, 042	129, 412	10, 469, 431	135, 629	12, 667, 749	5
6	Zinc, value at New York City.......do....	33, 765	3, 646, 620	36, 872	3, 311, 106	38, 544	3, 422, 707	40, 688	3, 539, 856	42, 641	3, 752, 408	6
7	Quicksilver, value at San Francisco. flasks.	52, 732	1, 487, 042	46, 725	1, 253, 632	31, 913	936, 327	32, 073	979, 189	29, 981	1, 060, 000	7
8	Nickel, value at Philadelphia ....pounds..	281, 616	309, 777	58, 800	52, 920	64, 550	48, 412	277, 904	191, 753	214, 992	127, 157	8
9	Antimony, value at San Francisco...short tons	60	12, 000	60	12, 000	60	12, 000	50	10, 000	35	7, 000	9
10	Platinum, value (crude) at New York City, troy ounces..................................	200	600	200	600	150	450	250	187	50	100	10
11	Aluminum, value at Philadelphia, troy ounces......................................	....	....	1, 000	875	1, 800	1, 350	3, 400	2, 550	....	27, 000	11
	Total value metallic products.........	....	219, 755, 109	....	203, 128, 859	....	186, 426, 074	....	181, 599, 365	....	215, 364, 825	
	NON-METALLIC (SPOT VALUES).											
12	Bituminous coal..................long tons..	60, 861, 190	76, 076, 487	68, 531, 500	82, 237 800	73, 730, 539	77, 417, 066	64, 840, 668	82, 347, 648	65, 810, 676	78, 481, 056	12
13	Pennsylvania anthracite.............do....	31, 358, 264	70, 556, 094	34, 336, 469	77, 257, 055	33, 175, 756	66, 351, 512	34, 228, 548	76, 671, 948	34, 853, 077	76, 119, 120	13
14	Petroleum ....barrels..	30, 053, 500	23, 704, 698	23, 400, 229	25, 740, 252	24, 089, 758	20, 476, 294	21, 842, 041	19, 193, 694	28, 110, 115	20, 028, 457	14
15	Lime.......................................do....	31, 000, 000	21, 700, 000	32, 000, 000	19, 200, 000	37, 000, 000	18, 500, 000	40, 000, 000	20, 000, 000	42, 500, 000	21, 250, 000	15
16	Building stone..................................	....	21, 000, 000	....	20, 000, 000	....	19, 000, 000	....	19, 000, 000	....	19, 000, 000	16
17	Salt...................................barrels..	6, 412, 373	4, 340, 140	6, 192, 231	4, 211, 042	6, 514, 937	4, 197, 734	7, 038, 653	4, 825, 345	7, 707, 081	4, 736, 585	17
18	Cement.....................................do....	3, 250, 000	3, 672, 750	4, 190, 000	4, 293, 500	4, 000, 000	3, 720, 000	4, 150, 000	3, 492, 500	4, 500, 000	3, 990, 000	18
19	Limestone for iron flux.........long tons..	3, 850, 000	2, 310, 000	3, 814, 273	1, 907, 136	3, 401, 930	1, 709, 965	3, 356, 956	1, 678, 478	4, 717, 163	2, 830, 297	19
20	South Carolina phosphate rock.......do....	332, 077	1, 992, 462	378, 380	2, 270, 280	431, 779	2, 374, 784	437, 856	2, 846, 064	430, 549	1, 872, 936	20
21	New Jersey marls.............short tons..	1, 080, 000	540, 000	972, 000	486, 000	875, 000	437, 500	875, 000	437, 500	800, 000	400, 000	21
22	Borax ....pounds..	4, 236, 291	338, 903	6, 500, 000	585, 000	7, 000, 000	490, 000	8, 000, 000	480, 000	9, 778, 290	488, 915	22
23	Mica..do....	100, 000	250, 000	114, 000	285, 000	147, 410	368, 525	92, 000	161, 000	40, 000	70, 000	23
24	Ocher.............................long tons..	7, 000	105, 000	7, 000	84, 000	7, 000	84, 000	3, 950	43, 575	15, 800	285, 000	24
25	Crude barytes.....................long tons..	20, 000	80, 000	27, 000	108, 000	25, 000	100, 000	15, 000	75, 000	10, 000	50, 000	25
26	Precious stones................................	....	75, 000	....	74, 050	....	82, 975	....	69, 900	....	79, 056	26
27	Gold-quartz souvenirs, jewelry, etc..........	....	75, 000	....	115, 000	....	140, 000	....	140, 000	....	40, 000	27
28	Pyrites.............................long tons..	12, 000	72, 000	25, 000	137, 500	35, 000	175, 000	49, 000	220, 500	55, 000	247, 500	28
29	Manganese ore.........................do....	3, 500	52, 500	8, 000	120, 000	10, 000	120, 000	23, 258	190, 281	30, 193	277, 636	29
30	Chrome iron ore.......................do....	2, 500	50, 000	3, 000	60, 000	2, 000	35, 000	2, 700	40, 000	2, 000	30, 000	30
31	Asbestus.........................short tons..	1, 200	36, 000	1, 000	30, 000	1, 000	30, 000	300	9, 000	200	6, 000	31

Summary of the mineral products of the United States, etc.—Continued.

	Products.	1882.		1883.		1884.		1885.		1886.		
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	NON-METALLIC (SPOT VALUES)—continued.											
32	Graphite........pounds..	425, 000	34, 000	575, 000	46, 000	....	....	327, 883	26, 231	415, 525	33, 242	32
33	Cobalt oxide........do....	11, 653	32, 046	1, 096	2, 795	2, 000	5, 100	68, 723	65, 373	....	36, 878	33
34	Slate ground as a pigment......long tons..	2, 000	24, 000	2, 000	24, 000	2, 000	20, 000	1, 975	24, 687	3, 000	30, 000	34
35	Sulphur........short tons..	600	21, 000	1, 000	27, 000	500	12, 000	715	17, 875	2, 500	75, 000	35
36	Asphaltum........do....	3, 000	10, 500	3, 000	10, 500	3, 000	10, 500	3, 000	10, 500	3, 500	14, 000	36
37	Corundum........do....	500	80, 000	550	100, 000	600	108, 000	600	108, 000	645	116, 190	37
38	Feldspar........long tons..	14, 000	70, 000	14, 100	71, 112	10, 900	55, 112	13, 600	68, 000	14, 900	74, 500	38
49	Zinc-white........short tons..	10, 000	700, 000	12, 000	840, 000	13, 000	910, 000	15, 000	1, 050, 000	18, 000	1, 440, 000	39
40	Bromine........pounds..	250, 000	75, 000	301, 100	72, 264	281, 100	67, 464	310, 000	89, 900	428, 334	141, 350	40
41	Mineral waters........gallons sold..	....	....	7, 529, 423	1, 119, 603	10, 215, 328	1, 459, 143	9, 148, 401	1, 312, 845	8, 950, 317	1, 284, 070	41
42	Natural gas........	....	215, 000	....	475, 000	....	1, 460, 000	....	4, 854, 200	....	9, 847, 150	42
43	Gypsum........short tons..	....	....	....	....	....	....	90, 405	405, 000	95, 250	428, 625	43
44	Flint........long tons..	25, 000	100, 000	25, 000	100, 000	30, 000	120, 000	30, 000	120, 000	30, 000	120, 000	44
45	Fluorspar........short tons..	4, 000	20, 000	4, 000	20, 000	4, 000	20, 000	5, 000	22, 500	5, 000	22, 500	45
46	Novaculite........pounds..	....	....	....	....	....	....	1, 000, 000	15, 000	1, 160, 000	15, 000	46
47	Rutile........pounds..	500	1, 800	550	2, 000	600	2, 000	600	2, 000	600	2, 000	47
	Total value non-metallic mineral products........	....	228, 410, 380	....	242, 111, 889	....	220, 050, 674	....	240, 114, 544	....	243, 963, 063	
	Total value metallic products........	....	219, 755, 109	....	203, 128, 859	....	186, 426, 074	....	181, 599, 365	....	215, 364, 825	
	Estimated value of mineral products unspecified........	....	8, 000, 000	....	8, 000, 000	....	7, 000, 000	....	7, 000, 000	....	6, 000, 000	
	Grand total........	....	456, 165, 489	....	453, 240, 748	....	413, 476, 748	....	428, 713, 909	....	465, 327, 888	

IRON.

THE AMERICAN IRON TRADE IN 1886.

By James M. Swank,

General Manager of the American Iron and Steel Association.

Production of iron and steel in 1886.—The following table exhibits our remarkable growth in 1886 in the production of iron and steel, compared with our production in 1885, and also compared with our production in the centennial year 1876, only ten years ago:

Comparative growth of production of iron and steel.

Products.	Short tons of 2,000 pounds, except nails.			
	1885.	1886.	Increase per cent.	1876.
Pig iron, including spiegeleisen	4,529,869	6,365,328	40	2,093,236
Bessemer steel ingots	1,701,762	2,541,493	49	525,996
Bessemer steel rails	1,074,607	1,763,667	64	412,461
Open-hearth steel ingots	149,381	245,250	64	21,490
Open-hearth steel rails	4,793	5,255	9	....
Crucible steel ingots	64,511	80,609	25	39,382
All kinds of rolled iron, except rails	1,789,711	2,259,943	26	1,042,101
Iron rails	14,815	23,679	60	467,168
100-pound kegs of iron and steel cut nails	6,696,815	8,160,973	22	4,157,814
Blooms from ore, pig iron, and scrap	41,700	41,909	....	44,628

The production of iron and steel in the United States in 1886 was much the largest that has taken place in any year in the history of the country. Not only was this result attained, but considering the various products as a whole the increased production in that year over the preceding year was exceptionally and phenomenally large. So great was our progress in 1886 that at the close of the year the United States was the first country in the world in the production of steel in its crude forms, of manufactured steel, and of manufactured iron, and we had made a great stride in lessening the distance which separated us only from Great Britain in the production of pig iron. There was a moderate advance in prices of all kinds of iron and steel in 1886. The year was one of great prosperity for the American iron trade. It was not a year of excitement and inflation, but of steady and solid progress.

The rapid growth of the iron and steel industries of the United States since the close of the civil war, in 1865, is shown in the following table of the production in that and subsequent years of all leading iron and steel products:

Statistics of the iron and steel industries in the United States from 1865 *to* 1886 *inclusive.*

Years.	Short tons of 2,000 pounds.						
	Pig iron.	Rolled iron, excluding only iron rails.	Iron rails.	Steel rails.	Rails of all kinds.	Bessemer steel ingots and other steel.	Blooms from pig, scrap, and iron ore.
1865	931,582	500,048	356,292	....	356,292	15,262	63,977
1866	1,350,343	595,311	430,778	....	430,778	18,973	73,555
1867	1,461,626	579,838	459,558	2,550	462,108	22,000	73,073
1868	1,603,000	598,286	499,489	7,225	506,714	30,000	75,200
1869	1,916,641	642,420	583,936	9,650	593,586	35,000	69,500
1870	1,865,000	705,000	586,000	34,000	620,000	75,000	62,259
1871	1,911,608	710,000	737,483	38,250	775,733	82,000	63,000
1872	2,854,558	941,992	905,930	94,070	1,000,000	160,108	58,000
1873	2,868,278	1,076,368	761,062	129,015	890,077	222,652	62,564
1874	2,689,413	1,110,147	584,469	144,944	729,413	241,614	61,670
1875	2,266,581	1,097,867	501,649	290,863	792,512	436,575	49,243
1876	2,093,236	1,042,101	467,168	412,461	879,629	597,174	44,628
1877	2,314,585	1,144,219	332,540	432,169	764,709	637,972	47,300
1878	2,577,361	1,232,686	322,890	559,795	882,685	819,814	50,045
1879	3,070,875	1,627,324	420,160	693,113	1,113,273	1,047,506	62,353
1880	4,295,414	1,838,906	493,762	968,075	1,461,837	1,397,015	74,589
1881	4,641,564	2,155,346	488,581	1,355,519	1,844,100	1,778,912	84,606
1882	5,178,122	2,265,957	227,874	1,460,920	1,688,794	1,945,095	91,293
1883	5,146,972	2,283,920	64,954	1,295,740	1,360,694	1,874,359	74,758
1884	4,589,613	1,931,747	25,560	1,119,291	1,144,851	1,736,985	57,005
1885	4,529,869	1,789,711	14,815	1,079,400	1,094,215	1,917,350	41,700
1886	6,365,328	2,259,943	23,679	1,768,922	1,792,601	2,870,003	41,909

Political economists and students of history will be interested in the following table, which may properly be introduced in this connection, and which shows the growth of the pig-iron industry in the United States from 1810 to 1886, in tons of 2,240 pounds. The figures for 1810, 1840, 1850, 1860, and 1870 have been compiled from the census reports and are for census years; for 1880 and 1886 they have been taken from the records of the American Iron and Steel Association. The figures for 1820 and 1830 are derived from trustworthy sources, but are not official. In the years last mentioned the census statistics do not give the quantities of pig iron produced.

Growth of the pig-iron industry from 1810 *to* 1886.

Years.	Long tons (2240 pounds).	Years.	Long tons (2240 pounds).	Years.	Long tons (2240 pounds).
1810	53,908	1840	286,903	1870	1,832,875
1820	20,000	1850	564,755	1880	3,835,191
1830	165,000	1860	987,559	1886	5,683,329

Imports of iron and steel in 1886.—Large as was our production of iron and steel in 1886, our imports in that year were also large, amounting to 1,098,565 long tons of 2,240 pounds. The indications are that our imports of iron and steel in 1887 will be as large as in 1886. In the following table the quantities of imported pig, bar, band, plate, and sheet iron, rails, old iron, and tinplates are given for every year mentioned, and for 1882 and succeeding years the quantities of other iron and steel which could not be obtained for preceding years are added. In none of the years mentioned, however, is the weight of machinery, hardware, cutlery, fire-arms, and similar manufactured products included.

Imports of iron and steel from 1871 *to* 1886.

Years.	Long tons.	Years.	Long tons.	Years.	Long tons.
1871	1, 141, 933	1877	211, 408	1883	694, 330
1872	1, 183, 066	1878	211, 102	1884	654, 696
1873	640, 858	1879	769, 984	1885	578, 478
1874	301, 647	1880	1, 886, 019	1886	1, 098, 565
1875	239, 712	1881	1, 180, 749		
1876	204, 211	1882	1, 192, 296		

The following table shows the foreign values of all our imports of iron and steel, including fire-arms, hardware, cutlery, machinery, etc., from 1871 to 1886:

Foreign value of iron and steel imports from 1871 *to* 1886.

Years.	Value.	Years.	Value.	Years.	Value.
1871	$57, 866, 299	1877	$19, 874, 399	1883	$47, 506, 306
1872	75, 617, 677	1878	18, 013, 010	1884	37, 078, 122
1873	60, 005, 538	1879	33, 331, 569	1885	31, 144, 552
1874	37, 652, 192	1880	80, 443, 362	1886	41, 630, 779
1875	27, 363, 101	1881	61, 555, 077		
1876	20, 016, 603	1882	67, 075, 125		

The total importations of these sixteen years aggregate $716,173,711 in foreign value. Their cost to our people was, however, much more than this sum—importers' profits, ocean freight, duties, and other charges bringing the total cost up to almost, if not altogether, double the foreign value.

The imports in 1886 included 361,768 long tons of pig iron, 97,311 tons of old and scrap iron and steel, 29,149 tons of bar iron, 41,581 tons of steel rails, 10,322 tons of cotton ties, 149,337 tons of steel ingots, billets, and bars, 257,822 tons of tinplates, and 136,965 tons of wire rods.

This country is a large consumer of tinplates, which are used chiefly for roofing houses, the canning of fruits, vegetables, fish, and oysters, and in the manufacture of dairy and other domestic utensils. All our tinplates are imported, virtually the whole of our supply coming from Great Britain. The following table shows the quantities imported in each of the last sixteen years, with their foreign value.

Imports of tinplates from 1871 *to* 1886.

Years.	Long tons.	Value.	Years.	Long tons.	Value.
1871	82,969	$9,946,373	1879	154,250	$13,227,659
1872	85,629	13,893,450	1880	158,049	16,478,110
1873	97,177	14,240,868	1881	183,005	14,886,907
1874	79,778	13,057,658	1882	213,987	17,975,161
1875	91,054	12,098,885	1883	221,233	18,156,773
1876	89,946	9,416,816	1884	216,181	16,858,650
1877	112,479	10,679,028	1885	228,596	15,991,152
1878	107,864	9,069,967	1886	257,822	17,504,976

Production of iron ore in 1886.—Our production of iron ore in 1886 was much larger than in any previous year, amounting in round numbers to 10,000,000 long tons. The production in 1884 we estimated in a previous report to have amounted to 7,718,129 tons, and in 1885 to 7,600,000 tons. Of the total production in any year except census years it is only possible to give that of leading districts.

In the following table we give in long tons the production of the principal iron-ore districts of the country in 1886, embracing nearly 60 per cent. of the estimated production of the whole country in that year, to which we prefix the figures of production for 1884 and 1885. Nearly all the figures given represent shipments from the mines, and do not include the ore that is left in the stock piles from year to year. This explanation applies to all the Lake Superior mines, the Missouri mines, the Cornwall mines, the New Jersey mines, and to some of the important New York mines. In a series of years, production and shipments are equalized.

Production of iron ore in certain leading districts of the United States in 1884, 1885, *and* 1886.

Districts.	Long tons of 2,240 pounds.		
	1884.	1885.	1886.
Marquette range, Michigan	1,557,389	1,430,422	1,621,887
Menominee range, Michigan and Wisconsin	895,634	680,435	880,006
Gogebic range, Michigan and Wisconsin	1,022	119,766	756,281
Vermilion lake, Minnesota	62,124	225,484	304,396
Miscellaneous mines, Michigan	1,879	441	....
Total production of Lake Superior mines	2,518,048	2,456,548	3,562,570
Missouri mines	233,225	169,162	379,776
Cornwall mines, Pennsylvania	412,320	508,864	688,054
New Jersey mines	393,710	330,000	500,501
Chateaugay mines, near Lake Champlain, New York	214,394	143,278	214,800
Crown Point mines, New York	} 290,500	} 235,799	60,084
Port Henry mines, New York			298,868
Other Lake Champlain mines, New York			15,000
Hudson River Ore and Iron Company, New York	90,000	55,000	75,000
Tilly Foster mines, New York	35,964	18,910	17,728
Forest of Dean mines, New York	20,370	18,274	18,000
Salisbury region, Connecticut	25,000	32,000	36,000
Cranberry mines, North Carolina	3,998	17,839	24,106
Tennessee Coal, Iron and Railroad Company's Inman mines, Tennessee	70,757	94,319	81,650
Total of all the above districts	4,308,286	4,079,993	5,972,137

The annual shipments of iron ore from the mines of the Lake Superior region since the beginning of its development in 1854 have been as follows in long tons:

Shipments of iron ore from the Lake Superior region.

Years.	Long tons.	Years.	Long tons.	Years.	Long tons.
1854	3,000	1865	236,208	1876	992,764
1855	1,449	1866	278,796	1877	1,014,687
1856	36,343	1867	473,567	1878	1,111,110
1857	25,646	1868	491,449	1879	1,375,691
1858	15,876	1869	617,444	1880	1,908,647
1859	68,832	1870	830,940	1881	2,314,502
1860	114,401	1871	779,607	1882	2,966,375
1861	49,909	1872	900,901	1883	2,341,227
1862	124,169	1873	1,162,458	1884	2,518,048
1863	203,055	1874	919,557	1885	2,456,548
1864	243,127	1875	891,257	1886	3,562,570

The total shipments during the thirty-three years covered by the above table amounted to 31,030,160 long tons. The value of this ore at the mines was about $100,000,000.

The Lake Superior region still remains our most important source of domestic supply of iron ore; its prominence in this respect is increasing from year to year. It embraces that portion of the States of Michigan, Wisconsin, and Minnesota which lies near this largest of all American lakes. In 1886 it increased its production more than a million tons over that of 1885. In 1883 the Gogebic mines and the Vermilion Lake mines in this region had not been opened. The development of the mines of these two districts, which has since taken place, is without precedent in this country in the magnitude of the results attained. The ores of these mines and of nearly all the mines of the Lake Superior region are adapted to the production of steel.

The Cornwall mines, in Lebanon county, Pennsylvania, constitute our second most important source of iron-ore supply. The following table shows the production of iron ore, in long tons, by these mines from the time they were first opened in 1740 to the close of 1886. They are now generally referred to as the Cornwall Ore Bank, but were originally known as the Cornwall Ore Hills. They have produced more ore than any other single iron-ore property in the country.

Production of iron ore from the Cornwall mines, Pennsylvania.

	Long tons.	cwts.
From 1740 to 1790, three furnaces, each 2,000 tons yearly, about	300,000	00
From 1790 to 1848, six furnaces, each 2,000 tons yearly, about	700,000	00
From April 1, 1848, to January 1, 1853	173,190	11
From January 1, 1853, to February 1, 1864 (date of formation of Cornwall Ore Bank Company)	1,351,717	05

From the formation of the Cornwall Ore Bank Company, as follows:

	Long tons.	cwts.		Long tons.	cwts.
1864 (11 months)	165,915	02	1877	171,588	19
1865	114,802	11	1878	179,299	03
1866	216,659	16	1879	268,488	06
1867	202,755	03	1880	231,172	18
1868	165,843	03	1881	249,050	01
1869	173,428	16	1882	309,680	11
1870	174,407	17	1883	363,143	10
1871	176,054	15	1884	412,319	17
1872	193,317	01	1885	508,864	06
1873	166,782	06	1886	688,054	07
1874	112,429	04			
1875	98,924	17	Total from 1864	5,480,884	00
1876	137,901	11			

Grand total from 1740 to January 1, 1887 (long tons) 8,005,791 16

Much attention has in late years been given to the development of the iron-ore mines of the Champlain district in New York, a district which has long been celebrated for the great richness and purity of its ores. It will be seen from our table that this district is the third in importance of our sources of iron-ore supply.

Imports of iron ore in 1886.—Our imports of iron ore in 1886 amounted to 1,039,433 long tons. Our consumption of iron ore in 1886 was therefore over 11,000,000 long tons. In the following table we give the imports of iron ore in the last eight years, in long tons. Previous to 1879 the imports never amounted in any one year to 100,000 tons.

Imports of iron ores from 1879 to 1886.

Years.	Long tons.	Years.	Long tons.
1879	284, 141	1883	490, 875
1880	493, 408	1884	487, 820
1881	782, 887	1885	390, 786
1882	589, 655	1886	1, 039, 433

The first considerable importation of iron ore into this country was in 1873, when about 60,000 tons were imported, the most of which came from Canada. In 1879 we commenced to import largely from the Mediterranean countries. Before that year the imports from Canada had fallen off. Our first imports from Cuba commenced in 1884.

Our supply of foreign iron ore comes almost wholly from Spain, Algeria, Elba, and Cuba. Very little is now obtained from Canada, but the prospects of largely increased imports from the Dominion are favorable. Ireland has sent us a few cargoes of iron ore in late years, and the island of Seriphos in the Grecian archipelago has sent us still larger quantities. A few years ago the annual importation of a large quantity of iron ore by the iron and steel manufacturers of the United States would not have been regarded as within the range of probability, so ample are our own iron-ore resources. But this result has taken place, despite the virtual doubling of the duty in the tariff act of 1883, and notwithstanding our largely increased home production. The adaptability of the imported ores to the manufacture of steel and their cheapness and richness are the principal causes of the increased importations in recent years. Foreign ores have been largely used as far west as Pittsburgh and Wheeling, and in small quantities at even more distant places in the interior, but the principal consumption is at places near the Atlantic seaboard in the States of Pennsylvania, New Jersey, New York, and Maryland. The tendency is certainly toward a still larger annual consumption of these ores. The imports thus far in 1887 are larger than in the same period of 1886, amounting to 422,687 tons in the first four months of 1887, the foreign value of which averaged $1.75 per ton. It is a fact of much significance that the Pennsylvania Steel Company has this year purchased a large tract of land at Sparrow's point, on the Patapsco river, below Baltimore, in Maryland, on which it will erect two large blast furnaces, to be finished in 1888, and to be supplied with foreign ore.

It may with great positiveness be stated that this country possesses apparently inexhaustible resources of all the various kinds of iron ore that the needs of modern metallurgy require, with the possible single exception of manganiferous iron ore for the manufacture of spiegeleisen and ferromanganese, and even this kind of ore is mined to-day in large quantities in Arkansas. Almost pure manganese is found in Virginia, and it is largely used in the manufacture of ferromanganese in American furnaces. We are even exporters of manganese to foreign countries. Our production of spiegeleisen and ferromanganese is annually increasing; in 1886 it amounted to 47,982 short tons, chiefly from domestic ores. There exists, however, one difficulty in the general use of some of our best American iron ores. They are remote from some of the leading points of consumption, which are necessarily near the sources of fuel supply. It is this remoteness which chiefly gives occasion for the importation of foreign ores, which are brought to Atlantic ports at very low rates by both steam and sailing vessels, principally, however, by steamers. It is also a fact worthy of notice, for which geologists may find a reason, that nowhere in this country are our best steel-making ores found in proximity to mineral fuel, either anthracite or bituminous, while in some parts of the Lake Superior region even timber suitable for the manufacture of charcoal is almost wholly wanting.

Production of iron and steel by States in 1886.—Thirty-one States, two Territories, and the District of Columbia contributed to our production of the leading articles of iron and steel in 1886. We present herewith a table which shows the production in that year of each State and of each of the other political divisions mentioned. In this table Missouri is placed with the western States. It is sometimes classified with the southern States, but its true place is indicated in the table, which is as follows:

Production by States of all kinds of iron and steel in 1886.

States and Territories.	Short tons of 2,000 pounds, except nails.						
	Pig iron.	Rolled iron, including iron rails.	Iron and steel cut nails. Kegs of 100 lbs.	Steel rails.	Total iron and steel rails.	Bessemer steel ingots and other steel.	Blooms from pig, scrap, and iron ore.
Maine	5,060	8,486					
Vermont							175
New Hampshire						3,350	
Massachusetts	8,124	61,322	516,749	19,683	19,683	48,107	
Rhode Island		14,168					
Connecticut	19,390	15,976				2,336	
New England	32,574	99,952	516,749	19,683	19,683	53,793	175

Production by States of all kinds of iron and steel in 1886—Continued.

States and Territories.	Short tons of 2,000 pounds, except nails.						
	Pig iron.	Rolled iron, including iron rails.	Iron and steel cut nails. Kegs of 100 lbs.	Steel rails.	Total iron and steel rails.	Bessemer steel ingots and other ingots.	Blooms from pig, scrap, and iron ore.
New York	233, 618	102, 472	34, 015	53, 100	53, 100	89, 996	15, 507
New Jersey	157, 886	60, 282	345, 168	....	64	13, 033	642
Pennsylvania	3, 293, 289	1, 176, 286	2, 569, 237	1, 113, 119	1, 122, 714	1, 743, 619	20, 836
Delaware	....	34, 272	....	....	....	....	....
Middle States	3, 684, 793	1, 373, 312	2, 948, 420	1, 166, 219	1, 175, 878	1, 846, 648	36, 985
Maryland	30, 502	22, 347	....	....	....	950	4, 653
District of Columbia	....	192	....	....	....	....	....
Virginia	156, 250	40, 581	212, 552	....	....	....	....
North Carolina	2, 200	....	....	....	....	....	20
Georgia	46, 490	....	....	....	....	....	....
Alabama	283, 859	32, 065	206, 500	....	1, 400	....	....
Texas	3, 250	924	....	....	320	....	....
West Virginia	98, 618	7, 874	899, 600	1, 770	1, 770	78, 401	....
Kentucky	54, 844	38, 308	144, 000	....	....	....	....
Tennessee	199, 166	14, 510	88, 289	....	1, 500	854	61
Southern States	875, 179	156, 801	1, 550, 941	1, 770	4, 990	80, 205	4, 734
Ohio	908, 094	355, 126	1, 703, 790	90, 810	91, 267	263, 299	....
Indiana	16, 660	42, 224	339, 992	....	5, 178	210	....
Illinois	501, 795	110, 182	614, 055	430, 975	434, 170	541, 404	....
Missouri	74, 523	15, 800	....	49, 540	49, 540	69, 521	15
Iowa	....	200	....	....	....	....	....
Michigan	190, 734	21, 509	....	....	....	2, 340	....
Wisconsin	65, 933	60, 147	205, 480	....	....	....	....
Minnesota	....	1, 000	....	....	....	....	....
Nebraska	....	250	5, 000	....	....	....	....
Western States	1, 757, 739	606, 438	2, 868, 317	571, 325	580, 155	876, 774	15
Colorado	10, 451	6, 299	52, 383	6, 618	7, 966	8, 308	....
Wyoming Territory	....	9, 853	....	....	369	....	....
California	1, 750	30, 967	224, 163	3, 307	3, 560	4, 275	....
Oregon	....	....	....	....	....	....	....
Washington Territory	2, 842	....	....	....	....	....	....
Far Western States	15, 043	47, 119	276, 546	9, 925	11, 895	12, 583	....
Grand total	6, 365, 328	2, 283, 622	8, 160, 973	1, 768, 922	1, 792, 601	2, 870, 003	41, 909

Twenty-three States and one Territory made pig iron in 1886, the same number, but not the same States, as in 1884 and 1885. Maine made pig iron in 1885 and 1886 but not in 1884; California made pig iron in 1884 and 1886 but not in 1885; Oregon made pig iron in 1884 and 1885 but not in 1886. Of the total production of pig iron in 1886 Pennsylvania produced over 51 per cent., Ohio 14 per cent., Illinois 7.8 per cent., and Alabama 4.4 per cent. All other States made less than Alabama.

Twenty-six States, Wyoming Territory, and the District of Columbia, rolled iron in 1886. The same States and other divisions rolled iron in 1885, as did also New Hampshire, which State rolled steel only in 1886. Of the total production of rolled iron in 1886, Pennsylvania made over 51 per cent., Ohio over 15 per cent., Illinois nearly 5 per cent., New York over 4 per cent., and Massachusetts, New Jersey, and Wisconsin each less than 3 per cent.

Sixteen States made cut nails in 1886, and the same States gave us the production of 1884 and 1885. Of the total production in 1886, Pennsylvania made 31 per cent., Ohio 21 per cent., West Virginia 11 per cent., Massachusetts 6 per cent., Illinois 7.5 per cent., and New Jersey and Indiana each 4 per cent.

Fourteen States and one Territory made rails in 1886. Of these States eight made Bessemer steel rails, namely, Massachusetts, New York, Pennsylvania, West Virginia, Ohio, Illinois, Missouri, and Colorado. Pennsylvania and California made all the open-hearth steel rails. The other States, New Jersey, Alabama, Texas, Tennessee, and Indiana, and Wyoming Territory, made only iron rails, which were also made by Pennsylvania, Ohio, Illinois, Colorado, and California. Massachusetts has only one Bessemer plant, and steel rails constitute only a part of its product. New York and Missouri also have only one Bessemer plant each, neither of which was fully employed in 1886, owing to temporary causes. Of the total production of rails in 1886 Pennsylvania made over 62 per cent. and Illinois 24 per cent.

Nine States, 31 works, and 65 converters made Bessemer steel in 1886, of which works six were Clapp-Griffiths. The States were Massachusetts, New York, Pennsylvania, West Virginia, Tennessee, Ohio, Illinois, Missouri, and Colorado. Pennsylvania made 59 per cent. of all the Bessemer steel ingots produced in 1886, and Illinois 21 per cent.

Eight States made open-hearth steel in 1886, namely, New Hampshire, Massachusetts, New York, New Jersey, Pennsylvania, Ohio, Illinois, and California. Pennsylvania made over 70 per cent. of the total production of open-hearth steel in 1886.

Seven States made crucible steel in 1886, namely, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Maryland, and Michigan. Tennessee and Illinois made crucible steel in 1885, but none in 1886. Ohio made crucible steel prior to 1885, but none in that year or in 1886. Pennsylvania made 76 per cent. of the total production of crucible steel in 1886.

Four States, namely, Pennsylvania, Maryland, Ohio, and Indiana, made the very small quantity of blister, puddled, and patented steel which was produced in 1886.

Six States, Vermont, New York, New Jersey, North Carolina, Tennessee, and Missouri, made blooms and billets directly from the ore in 1886, and three States, New Jersey, Pennsylvania, and Maryland, made blooms from pig and scrap iron in that year, both products being made in forges.

The table which we have given will further repay perusal by showing the position of the several grand divisions in the production of leading products of iron and steel. The decadence of New England in the production of all kinds of iron and steel is most striking. This decadence is chiefly the work of the past few years, but the results established by the table are likely to be permanent. Pennsylvania gives prominence to the group of middle States; its leadership in the manufacture of all kinds of iron and steel is a constant source of wonder. The southern States have in late years limited their energies as iron and steel manufacturers chiefly to the production of pig iron, for a large part of which they seek a market outside their own boundaries. West Virginia is the only one of the southern States which produces any considerable quantity of steel. The western States, upon the other hand, have iron and steel industries that are more diversified. In 1886 Illinois actually made more steel than pig iron. Notwithstanding the growing importance of the southern States as manufacturers of pig iron, the West in 1886 made twice as much of this product as the South, showing that there is room for the South still further to develop its pig-iron industry. The Rocky Mountain and Pacific States and Territories do not present a favorable showing for 1886, but the small totals for that year were largely due to temporary causes which have already disappeared or may be expected soon to disappear.

Our production of iron and steel in 1886 *compared with that of* 1856.—The following table, compiled from the records of the American Iron and Steel Association, gives for comparison the production of some of the leading articles of iron and steel in 1856 and 1886 in all the grand divisions of the United States. While not comprehensive of the whole range of our iron and steel industries, it is complete for the products mentioned. This table has never before been printed. It shows very clearly the relative growth of the different grand divisions in the manufacture of iron and steel in the last thirty years, which takes us back to four years before the civil war.

Comparison of the production of iron and steel in 1856 *and* 1886.

Territorial divisions.	Years.	Short tons of 2,000 pounds, except nails.				
		Pig iron.	Rolled iron, including iron nail plate and iron rails.	Nails, kegs of 100 pounds.	Rails of iron and steel.	Blooms from pig, scrap, and iron ore.
New England	1856	34,051	78,989	560,000	20,015	6,776
	1886	32,574	99,952	516,749	19,683	175
Middle States	1856	614,593	366,542	1,021,709	124,708	63,790
	1886	3,684,793	1,373,312	2,948,420	1,175,878	36,985
Southern States	1856	143,184	70,601	217,168	12,869	19,619
	1886	875,179	156,801	1,550,941	4,990	4,734
Western States	1856	119,870	41,718	25,872	2,070	1,517
	1886	1,757,739	606,438	2,868,317	580,155	15
Far western States	1856	....	....	....	....	....
	1886	15,043	47,119	276,546	11,895	....
Total	1856	911,698	557,850	1,824,749	159,662	(*a*)91,702
	1886	6,365,328	2,283,622	8,160,973	1,792,601	41,909

a Including 7,000 tons sold direct in bars from the bloomaries and about 14,000 tons hammered into bars, axles, and anchors by the forges, leaving 68,182 tons as the total quantity of blooms going into rolling mills.

All the rails made in 1856, namely, 159,662 short tons, were iron rails, while all those made in 1886, namely, 1,792,601 short tons, were steel rails, except only 23,679 short tons of iron rails. During the period covered by these thirty years we built up an iron-rail industry which in 1872 produced 905,930 short tons of iron rails, and when iron rails had served their day we built up a steel-rail industry which in 1886 produced 1,768,922 short tons of steel rails. This change from iron to steel rails is one of the most remarkable events in our history.

It will be seen that the manufacture of iron and steel in the United States is a widely-extended industry and one which is eminently national in its character. Every grand division of the country is represented in the foregoing tables—the middle States leading, followed in order by the western States, the southern States, New England, and the far western States and Territories.

Our production of iron and steel compared with that of other countries.—While the foregoing statistics show the wonderful progress of our country in the manufacture of iron and steel in recent years, the commanding position which it has attained as an iron and steel manufacturing country is best shown by a comparison of its achievements with those of other countries.

The following table gives the world's production of pig iron and steel in the most recent years for which statistics are available. English tons of 2,240 pounds are used in giving the statistics of Great Britain, the United States, Russia, and "other countries," and metric tons of 2,204 pounds for all the continental countries of Europe except Russia. As the difference between the long ton and the metric ton is so trifling it is not necessary to change official figures:

World's production of iron and steel.

Countries.	Pig iron.		Steel.	
	Years.	Tons.	Years.	Tons.
Great Britain	1886	6, 870, 665	1886	2, 364, 670
United States	1886	5, 683, 329	1886	2, 562, 502
Germany and Luxemburg	1886	3, 489, 231	1886	1, 360, 620
France	1886	1, 507, 850	1886	466, 913
Belgium	1886	697, 110	1886	139, 215
Austria and Hungary	1886	726, 835	1886	256, 023
Russia	1882	498, 400	1882	225, 140
Sweden	1885	464, 737	1885	80, 550
Spain	1883	139, 920	1886	15, 000
Italy	1884	18, 405	1884	3, 450
Other countries (estimated)	1886	150, 000	1886	30, 000
Total	....	20, 246, 482	....	7, 504, 083
Percentage of the United States	....	28	....	34

This table places the United States first in the production of steel and second only to Great Britain in the production of pig iron. We may add that it is also the first country in the production of rolled iron. In 1886 Great Britain rolled 1,616,701 long tons of puddled iron, a much larger quantity than any other European country, while in the same year the United States rolled 2,038,948 long tons, or 422,247 tons more than Great Britain. We did not, however, pass our great rival in the production of steel until last year, this circumstance alone justifying the designation of 1886 as a remarkable year for the American iron trade. In that year we made 197,832 long tons more steel than Great Britain.

The United States is shown by the table to be the producer of 28 per cent. of the world's annual output of pig iron, and of 34 per cent. of its annual output of steel. This prominence must astonish the reader. But our prominence in the production of iron and steel gives less occasion for astonishment than our undoubted pre-eminence as consumers of iron and steel. We are the first country in the world in the consumption of pig iron, manufactured iron, and steel. As has already been shown, we annually import from foreign countries, and particularly from Great Britain, large quantities of iron and steel in all forms, which we consume in addition to the products of our own iron and steel works. Our exports of iron and steel do not amount to 1 per cent. of our total production; hence virtually all of the iron and steel that we produce and import is consumed within our own borders.

The world's production of pig iron.—From the most reliable information that is obtainable we have compiled the following table of the world's production of pig iron at various periods since the close of the last century, with which we end our present summary of iron and steel statistics.

World's production of pig iron from 1800 *to* 1886.

Years.	Long tons.	Years.	Long tons.	Years.	Long tons.
1800	825, 000	1870	11, 900, 000	1879	13, 950, 000
1830	1, 825, 000	1871	12, 500, 000	1880	17, 950, 000
1850	4, 750, 000	1872	13, 925, 000	1881	19, 400, 000
1856	7, 000, 000	1873	14, 675, 000	1882	20, 750, 000
1865	9, 250, 000	1874	13, 500, 000	1883	21, 000, 000
1866	9, 300, 000	1875	13, 675, 000	1884	19, 475, 000
1867	9, 850, 000	1876	13, 475, 000	1885	19, 100, 000
1868	10, 400, 000	1877	13, 675, 000	1886	20, 246, 482
1869	11, 575, 000	1878	13, 925, 000		

No exhibit could more clearly and effectually show the progress which the civilized world has made in the nineteenth century in the use of iron and steel. We know that the nations of antiquity made but little iron and steel, and there is no reason to believe that prior to the close of the last century the nations of modern times made as much iron and steel annually by all processes of manufacture as they then made of pig iron. The world has, therefore, as our table shows, increased its production of iron in eighty-six years of the present century more than twenty-fold. Its increased production of steel in the same period has been relatively much greater.

THE AMERICAN IRON INDUSTRY FROM ITS BEGINNING IN 1619 TO 1886.

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In the preceding paper we have shown the present condition of the iron industry of this country, and the position of each State and Territory with reference to this present condition. We propose now to consider the changes which have taken place in the location and characteristics of the American iron industry—the causes of its prominence in some sections and its lack of prominence in others. In entering upon this subject we will first mention the leading facts in our colonial iron history.

The first attempt that was made in this country to manufacture iron was made on Falling creek, in Virginia, in 1619; but in 1622 the Indians destroyed the works and massacred all the workmen. No further attempt to manufacture iron is known to have been made in Virginia during the seventeenth century. Iron was made in that century in Massachusetts, Rhode Island, Connecticut, and New Jersey. Massachusetts was the first colony to establish iron works which lived. This was in 1643, at Lynn. Connecticut successfully established iron works at New Haven in 1658. Rhode Island certainly made iron as early as 1675, at Pawtucket and elsewhere. New Jersey made iron at Tinton Falls, in Monmouth county, as early as 1676, and probably as early as 1674. A small quantity of iron was made as an experiment in Pennsylvania about 1692, but the location of this experimental enterprise is not known. Before the close of the seventeenth century there were many iron enterprises in the three New England colonies mentioned, but no additional iron works had been established in New Jersey.

In the eighteenth century, and before the commencement of the revolutionary war, all the colonies except Georgia engaged in the manufacture of iron, those which had not previously established iron works now doing so in the order here mentioned: Virginia about 1714, Maryland about 1715, Pennsylvania in 1716, Delaware about 1725, North Carolina about 1725, New York about 1740, New Hampshire about 1750, and South Carolina in 1773. Georgia has no colonial iron history, its first iron enterprise having been established about 1790. New Jersey commenced to manufacture iron in bloomaries from its magnetic ores about 1710. Vermont, which was the first State admitted into the Union formed by the thirteen colonies, made iron in furnaces and bloomaries from hard ores about 1775, and about the same time iron was made in bloomaries in York county, Maine, from bog ores. Before the close of the century iron was made in Kentucky and Tennessee. Kentucky's pioneer enterprise was Bourbon furnace, in Bath county, completed in 1792, and Tennessee's pioneer enterprise was a bloomary forge at Embreeville, built in 1790.

The virtual neglect of the iron industry in Virginia during the first hundred years of its existence as an English colony will naturally attract attention. The causes of this neglect appear to have been the strong bent of its people toward agricultural pursuits and particularly the cultivation of tobacco, their consequent disinclination to build up towns and cities in which only the mechanic arts can flourish, and the practical absence of iron ore in the tidewater region, which was for many years the only part of the colony that was open to settlement. When the iron industry finally obtained a foothold in Virginia in the early part of the eighteenth century it was away from the tidewater region, on the upper waters of the Rappahannock river, where iron ore was found in abundance.

Upon the other hand, Massachusetts, Rhode Island, and Connecticut successfully established the iron industry early in their colonial history because their people were more inclined to mechanical employments and to gather together in towns than those of Virginia, because the soil and climate of New England were not so well adapted to agricultural pursuits as those of Virginia, and because they found iron ore near the sea coast, where their first settlements were located. So, also, the first iron works in New Jersey were located near the sea coast, and, we may add, they were established largely through the co-operation of a New England family named Leonard which had settled in Monmouth county.

The ore which the pioneer iron manufacturers of New England and New Jersey first used was bog ore. This kind of ore was found in abundance in the swamps and ponds near the sea coast. It was exclusively used in New England during the whole of the seventeenth century and the early part of the eighteenth. In the latter century "rock ores" were found in the western part of New England which gave better results than the bog ores. In this century hard ore was also found at a few places in New England near the sea coast. Before the close of the century bog ore of superior quality was taken in considerable quantities to the eastern parts of Massachusetts from Egg Harbor, in New Jersey, for use in blast furnaces.

The bog ores of New England were chiefly used in the production of hollow ware and other castings directly from blast furnaces, which furnaces, for this reason, were sometimes called foundries. In New York, Pennsylvania, Maryland, and Virginia the pioneers in the manufacture of iron paid more attention from the first to the production of pig iron for conversion into bar iron in refinery forges than the early New England manufacturers. Indeed, they in part supplied New England with bar iron and also with pig iron for its refinery forges. The explanation is that these colonies had better ores than the bog ores of New England, and could make from them better bar iron, whether the ores were first smelted in furnaces or were directly converted into bar iron in bloomaries. Bar iron was, however, made in all the colonies in bloomaries as well as in refineries, although there never were many bloomaries in Pennsylvania and Maryland. The term "bloomary" was synonymous in the early days in this country with a Catalan forge, but it is not now generally used in that sense.

During the eighteenth century the iron industry of this country was chiefly confined to the production of iron for domestic and simple mechanical purposes. There were no railroads, no locomotives, no freight and passenger cars, no iron bridges, no iron ships, no buildings with iron fronts and iron joists, no heavy pumping or hoisting machinery, no steam engines of any kind, no telegraph wires, and no wire fences. Pots and kettles, and irons and sad-irons, clock weights and stoves, mill irons and plow points were cast at the furnaces. Nails were made by hand in chimney corners from rods which were slit in slitting mills. The first slitting mills in the colonies were erected in Massachusetts very early in the eighteenth century. This colony gave much attention in that century to the manufacture of nails as a household industry, and so also did some other colonies. Thomas Jefferson required about a dozen of the younger slaves owned by him to make nails, and it is recorded that "they made about a ton of nails a month, at a considerable profit." But little steel was made, and most of the tools used were imported. All the fuel used in the iron industry was charcoal, and all the power used was water power. There were no rolling mills for bar iron; all that was made was hammered under tilt hammers and trip hammers.

In 1759 Israel Acrelius, the historian of the Swedish colonies in America, wrote as follows: "Pennsylvania, in regard to its iron works, is the most advanced of all the American colonies. When New Jersey is added to it one can safely say that from the Delaware the greatest part of the iron in America is taken. Herewith, however, the provinces of Maryland, Virginia, and New York deserve to be mentioned."

During the whole of our colonial history the iron industry grew in all the colonies, and both pig iron and bar iron were exported to England. These were the mother country's raw materials, which she did not then produce in large quantities, owing to a scarcity of charcoal for fuel in her furnaces. From these raw materials she manufactured all kinds of finished products, which she sent to the colonies, and which she insisted they should not make for themselves. Some progress was made, however, before the Revolution in the manufacture of nails, axes, hoes, sickles, hardware, such machinery as was in use, and other finished products, and while the war continued a fresh impetus was given to their manufacture in all the colonies. New England was most prominent in the manufacture of finished products throughout the whole of the eighteenth century, its people very early displaying a genius which they still retain for the reproductive branches of the iron industry. How much the country at large was dependent upon it for iron products of skilled workmanship is shown by the following incident in the early settlement of Ohio: In 1789 the crank for the first sawmill built in Ohio was carried by pack horses over the mountains to the Youghiogheny river, and thence shipped by water to its destination on Wolf creek, 16 miles from Marietta. It weighed 180 pounds, and was made in New Haven, Connecticut, for the New England Ohio company.

Great Britain gradually substituted bituminous coal for charcoal, and introduced the puddling furnace, the rolling mill for bar iron, and the blowing engine. These improvements gave her in the last quarter of the eighteenth century substantial advantages over other iron-producing countries. After the Revolution we find that the competition of the mother country seriously retarded the growth of our own iron industry, especially in the manufacture of bar iron, sheet iron, hoops, edge tools, nails, hardware, chains, agricultural implements, and machinery of all kinds. British competition also largely prevented us from manufacturing steel. The production of castings was also seriously affected at all points near the Atlantic coast. The cost of transportation from the sea coast into the interior acted, however, for many years as a protection to the domestic iron manufacturer whose furnace or forge or bloomary was also in the interior. Except during fitful periods of relief, resulting from the second war with Great Britain and the passage of the tariff acts of 1824, 1828, and 1842, British competition operated as a serious obstacle to the growth of our iron industry from the time of the achievement of our independence down to the passage of the tariff act of 1861 and the commencement of the civil war in that year.

Notwithstanding the severity of foreign competition, our iron industry was extended into new fields as fast as the country was opened to settlement. Ohio made iron in 1804. A nailery in Indiana Territory is mentioned in 1810, which made in that year 20,000 pounds of nails, valued at $4,000. Many other States and Territories successively commenced the manufacture of iron during the early decades of the present century. In Missouri extensive and valuable deposits of iron ore were early discovered, and iron was made within its borders before its admission into the Union in 1821. Iron was made in Michigan, Wisconsin, and Illinois before 1840. The first shipment of iron ore from the wonderful Lake Superior region was made in 1850. The first furnace in Alabama appears to have been built in 1818 a few miles west of Russellville, in Franklin county.

During the first decade of the present century we continued to hammer all the bar iron that was made, but before the close of the second decade some progress had been made in the manufacture of bar iron in rolling mills in connection with the puddling furnace. This innovation was first practiced at Pittsburgh and its vicinity, and ere long bar iron was rolled in many other places. A strong prejudice in favor of hammered iron continued, however, until about 1840, but in 1886 there were not 100 tons of hammered bar iron made in the whole country. Rolling mills have almost completely displaced the old bloomaries. The refinery forges have also been rapidly reduced in number, and none of them now make bar iron. Such bloomaries and refinery forges as remain are chiefly employed in the production of blooms for plate and sheet iron, boiler tubes, iron rods, and iron wire. The rolling mill gave Pittsburgh its start in the manufacture of iron. It could command an abundant supply of bituminous coal for puddling and heating furnaces and for generating steam, and it could obtain blooms and pig iron from neighboring forges and blast furnaces. Pittsburgh never made any pig iron until 1859.

The steam engine was introduced into this country in connection with the manufacture of iron about the close of the first decade of the present century. A rolling mill to make plate and sheet iron, but not bar iron, was built at Pittsburgh in 1811 and 1812 by Christopher Cowan, and was operated by "a powerful steam engine, 70 horse-power." A furnace in Adams county, Ohio, was built about 1814, and was blown by steam power. These were among the earliest iron works in the country at which steam was used. But for many years the engines at blast furnaces were deficient in power, and it was not until after 1850 that engines of necessary power were built. David Thomas, of Catasauqua, Pennsylvania, was the first person in the country to fully realize the value of powerful blowing engines in the working of blast furnaces. With the general introduction of large engines after 1850 the use of water power in connection with blast furnaces rapidly declined; it had previously yielded to steam power at most of our rolling mills. The introduction of steam power enabled localities which had mineral fuel, but were without water power, to engage in the manufacture of iron and to wrest from less favored localities a part of their iron trade. Pittsburgh, which has no water power, has been the greatest gainer from the use of steam. There are now very few iron works in the country that are operated by water power.

Charcoal remained the only fuel used in this country in connection with the manufacture of iron down to the early part of this century, when both anthracite and bituminous coal were introduced under engine boilers and in rolling mills. But their use even for these purposes did not become general until many years later, while they were not used at all in blast furnaces, except experimentally, until about 1840. In that year only six furnaces in the whole country used anthracite coal, and in the same year only three furnaces used bituminous coal. The use of anthracite coal came rapidly into favor as a blast-furnace fuel after 1840, but bituminous coal exercised no appreciable influence upon our pig-iron industry until about 1860. In 1854 this country still made more pig iron with charcoal than with anthracite coal. The next year charcoal was passed by anthracite, but it was not until 1869 that it was passed by bituminous coal. Anthracite continued to be the leading fuel until 1875, when it, too, was passed by bituminous coal, which has since continued to be the favorite blast-furnace fuel. The use of charcoal in rolling mills entirely ceased about 1860. Just prior to this year uncharred wood had been used in a few heating and puddling furnaces connected with rolling mills in several States. Charcoal is still used in the manufacture of blooms in forges and bloomaries, but the production of these works is now very small, and it is decreasing from year to year.

In 1834 the hot blast was introduced into this country in connection with the blowing of blast furnaces, its first practical application being made in that year at Oxford furnace, in New Jersey. This improvement enabled us a little later to use anthracite coal as a blast-furnace fuel, and it also stimulated the production of charcoal pig iron as well as subsequently that made with bituminous coal.

After we had commenced the use of anthracite and bituminous coal in the blast furnace, and particularly after we had commenced to build large blowing engines, the sizes of our furnaces and their capacity were greatly increased, but it was not until about 1850 that any furnace in the country could produce 150 tons of pig iron in a week, and not until 1865 that this product had ceased to excite surprise. In January, 1887, furnace "F" of the Edgar Thomson Steel Works, near Pittsburgh, made 8,398 long tons of pig iron; in one week of that month it made 2,161 tons, and in one day it made 414 tons.

Machines for cutting nails were invented in New England before the close of the last century, but they were not perfected until long after the commencement of the present century. They were not generally adopted until after 1830, but for many years afterwards wrought-iron nails continued to be used. Now these nails are very rarely used, and the slitting mill which once made the rods for the chimney-corner nails is to-day a curiosity. Within the last few years we have introduced the manufacture of wire nails. In August, 1886, there were twenty-seven wire-nail works in the United States, and the production in that year was about 600,000 kegs of 100 pounds each. In 1887 it promises to be 1,000,000 kegs.

Very little steel was made in this country prior to 1860. Down to that year most of the steel which we manufactured was blister steel, made by cementation from bar iron, and very little of this was of the best qualities. As late as 1831 it was a subject of congratulation at a convention of American iron manufacturers that "American competition has excluded the common blister steel altogether," which was not much to boast of. Even this boast could not have been made a few years later, for British competition again made itself severely felt in repressing the manufacture of this inferior quality of steel, as it had previously done and continued to do with the better qualities, whether made by the cementation or the crucible process. In 1860 the manufacture of crucible steel, after having encountered many disappointments, was established at Pittsburgh under favorable auspices, and the tariff legislation of the following year assured its continuance. In 1866 the Bessemer steel industry was placed on a favorable basis by the consolidation in that year of all the American patents for the manufacture of this kind of steel. In 1868 we commenced the manufacture of open-hearth steel. Our steel industry has been greatly encouraged by the tariff legislation of Congress, and to-day it is the first in the world in the quantity of steel annually produced. It may be said to be wholly the creation of the last twenty-seven years.

The iron industry in this country in the seventeenth and eighteenth centuries was almost entirely in the hands of individual manufacturers, firms of two or more manufacturers being uncommon, and corporate organizations being almost unknown. In a list of thirty-two Pennsylvania iron manufacturers whose names were attached to a petition in 1785, the name of a company or firm does not once appear. Now our large iron and steel enterprises are almost entirely in the hands of corporations.

American iron enterprises were not usually located in communities or centers until after the close of the first quarter of the present century. As late as 1829 it was stated by Zachariah Allen, in his "Science of Mechanics," that "the manufacturing operations in the United States are all carried on in little hamlets, which often appear to spring up in the bosom of some forest, gathered around the waterfall that serves to turn the mill wheel." The most notable exceptions to the rule of isolation which prevailed in the American iron industry prior to the second quarter of this century are found in the groups of bloomaries in northern New Jersey, northern New York, and western Vermont. Pittsburgh was the first iron center to be established after the commencement of the rolling-mill era, about 1830.

The introduction of railroads into this country, about 1830, opened a way for a much larger consumption of iron and steel than had previously been possible. Yet so low was the duty on iron rails, which were the only kind used in this country until 1863, when we imported a few steel rails, that we did not begin to manufacture heavy iron rails until 1844. In 1850 only two rail mills were in operation, and in 1856 we made only 142,555 long tons of rails. In 1881 we made 1,646,518 long tons, nearly all of which was steel rails. We began to make steel rails in 1865. We owe the great demand for iron and steel in recent years largely to the wonderful development of our railroad system. Our railroads consume one-half of all the iron and steel we now make.

The exhaustion of its bog ores and the increasing scarcity and dearness of charcoal closed many of the blast furnaces in the eastern parts of New England soon after the beginning of the present century, and at a later day other furnaces in the western parts of New England were closed, either from the scarcity and high prices of charcoal or the high prices of anthracite coal, which latter had been introduced from Pennsylvania as a substitute for charcoal. New England is, therefore, no longer prominent in the manufacture of pig iron, because its command of the raw materials is not so absolute as it once was. Most of the pig iron it now makes is of a special quality and made with charcoal in the celebrated Salisbury district of Connecticut, which obtains its supply of fuel from points outside as well as inside the State. Producing a scanty supply of pig iron, and having to depend largely on outside sources for its supply of this article and wholly on them for its supply of mineral fuel, it was natural that the rolling-mill industry of New England should also decline and that its steel industry should make but slow progress. Nearly all the bloomaries of western Vermont have been abandoned because of the scarcity of charcoal and the wastefulness of the bloomary method of making iron. Foreign competition has also in years gone by exercised a baneful influence on the iron industry of New England, which, owing to the disadvantages mentioned, it was but poorly fitted to resist. At present the manufacture of nails in New England is especially affected by the competition of other sections which enjoy the advantages of cheap fuel and particularly of natural gas.

It must not be forgotten, however, that New England still retains all its former enterprise and activity in the manufacture of a large number of finished products of iron and steel, including many specialties which had their origin within its borders. The Ames shovel and the Collins ax are New England products. In the production of finished products of iron and steel New England must always be prominent.

New York and New Jersey have not maintained their ancient prestige as iron and steel manufacturers, although it cannot be said that they have retrograded. They did not promptly recognize the transition that was taking place from iron to steel. The growing scarcity of charcoal and the absence of mineral fuel within their borders have also impeded their progress. Both States ship iron ore to their neighbors.

Early in its history Pennsylvania pushed to the front in the manufacture of iron, because it possessed good ores, an abundance of timber suitable for making charcoal, and numerous small streams for turning water-wheels, and because its people, especially its German settlers, appear to have possessed a greater genius for making iron than the people of any other section. It will be remembered that the Germans have been noted for many centuries for their skill as workers in iron. In their choice of the manufacture of iron as a permanent occupation the Germans of eastern Pennsylvania were joined by many English and Welsh settlers. When the central and western parts of Pennsylvania were opened to settlement we find Germans again leading in establishing the manufacture of iron. At Pittsburgh, however, the Scotch-Irish soon became the ruling element in the iron industry, as in everything else. At a later day we find Philadelphia capital, largely in the hands of Friends, or Quakers, invested in iron and steel enterprises in the Lehigh valley, at Johnstown, and elsewhere, while many New England men had added their business energy to help leaven the whole lump of Pennsylvania iron-making enterprise.

But without other special advantages than those mentioned Pennsylvania never could have attained her wonderful prominence as a manufacturer of iron. She possessed from the first superior facilities for supplying markets outside her own boundaries. In the east she had the Delaware river as a channel of communication with her neighbors, and when she commenced to make iron at Pittsburgh and its vicinity she had the Ohio river, by which, after 1811, when the first steamboat, the "New Orleans," was built in that city, she could command all the markets of the West. Then, again, when charcoal began to be an expensive fuel, she had a monopoly of anthracite coal in the East and of the best bituminous coal in the West. More recently she was first to develop the use of natural gas in the manufacture of rolled iron and steel.

Something else must be said of Pennsylvania. Its far-seeing iron manufacturers were the first in the country to realize the full significance of the change from iron to steel which had commenced about the close of our civil war. They saw the magnitude of the coming revolution, and they had the courage at once to resolve to take a prominent part in it. So they invested a large amount of capital in Bessemer, open-hearth, and crucible steel works, and with these they have been able to meet the country's extraordinary demand for steel rails and for steel in all forms.

It is not many years since it was regarded as an open question whether the western States would ever manufacture iron in large quantities. By many it was supposed that the scarcity of timber for charcoal and the absence of good coking coal would prevent the manufacture of pig iron in the prairie States from reaching respectable proportions. But experience has shown that Connellsville coke may be profitably taken many hundred miles west to meet the ores of Lake Superior and Missouri, especially since our blast-furnace practice has been so perfected that we can make a ton of pig iron with less than a ton of coke. Other things being equal, it ought to be as economical to take Connellsville coke to western furnaces as to bring Lake Superior ores to Pennsylvania furnaces. Charcoal pig iron is also still made in considerable quantities in some of the western States. Michigan annually produces more pig iron with this fuel than any other State in the country. Colorado has its own ores and coking coal. In the manufacture of steel and rolled iron many western States are favored with an abundant home supply of suitable coal, while those which are not so favored can receive supplies from their neighbors. Nor do western facilities for the manufacture of iron and steel end here. Ohio and Indiana have natural gas fields of great extent, which are soon to be made the basis of a great expansion of the iron and steel industries of these States and possibly of contiguous western States. The extraordinary growth of the railroad system in the West and the rapid increase in the population of western States are agencies which have supplied western iron and steel manufacturers with a large home market for their products. To compete with them in this market eastern manufacturers are burdened with increased freight charges. It is not surprising, therefore, from a consideration of all the influences mentioned, that the West, commencing with Ohio and ending with Colorado, should have built up in the last few years iron and steel industries second only in productiveness to those of the old middle States—New York, New Jersey, Pennsylvania, and Delaware. In 1886 Ohio made as much pig iron as the whole country made in 1859. In 1886 Illinois made more pig iron than both New York and New Jersey. In the same year, also, Illinois made more steel rails than the whole country made in 1876.

In the production of machinery, stoves, hardware and all other finished iron and steel products the West has displayed all the enterprise for which it is so widely noted.

The iron industry of the southern States has had a checkered career. Maryland and Virginia were very active in the manufacture of iron in the last century and far into the present century. Both of these colonies and North Carolina shipped iron to England before the Revolution. Long before that event hoes made in Virginia and North Carolina were sold in New York. North Carolina long continued to supply most of its own iron wants, and South Carolina had a flourishing iron industry on its northern border early in the present century. Tennessee and Kentucky made large quantities of iron during the first half of this century, much of which was shipped by water routes to other southern States and to Pittsburgh and other points on the Ohio river. Georgia and Alabama, however, made only small quantities of iron for local use before the commencement of the civil war.

Before the war, however, the iron industry in all these States had ceased to go forward and in some of them had commenced to decline. The competition of northern iron had not only restricted the sale of southern iron in northern markets but it had also invaded southern markets, particularly through the medium of steamboat navigation on the Ohio and Mississippi rivers. This competition especially affected the manufacture of bar iron, the South not having adopted the rolling mill so generally as the North, and rolled iron being more cheaply manufactured than that made in bloomaries or refinery forges. North Carolina, Tennessee, Georgia, and Alabama had at one time before the war over a hundred bloomaries. It was inevitable that the primitive methods of manufacturing bar iron in bloomaries and refinery forges should yield to the cheaper methods supplied by the puddling furnace and the rolling mill.

Other causes, however, contributed to the decadence before the war of the southern iron industry. The continued use of charcoal had here and there destroyed the forests, so that many iron works were deprived of their supply of this fuel. The South, too, was but poorly supplied before the war with railroads, and the lack of these prevented it from competing with the North in northern markets, and also placed it at a disadvantage in supplying some of its own markets. On the seaboard, too, foreign competition was always active. Finally it must be said that the growing attention which was given before the war to agricultural pursuits and the reliance which was everywhere placed on slave labor in all branches of industry were two powerful influences which seriously interfered with the manufacture of iron in the southern States.

The war impoverished the South. When it ended its iron industry was in a demoralized condition. Here and there, however, northern capital came to the aid of the southern iron industry, and in time the prosperity of southern agriculture gave to enterprising southern iron men capital of their own. The panic of 1873 and the years of depression which followed delayed the development of a new iron industry in the South, but since the clouds of depression lifted in 1879 the work of building new furnaces and rolling mills and steel works has gone steadily forward. About two years ago a phenomenal "boom" in the iron industry of the South commenced, and it has continued to the present time with unabated intensity. So active and earnest has this progressive movement been, that three new furnaces were completed in the South in 1886 and twenty-seven were in course of erection or under contract on May 1, 1887. Most of these furnaces are of large capacity, and all of them are of modern construction. Even as late as the close of the war there were few furnaces in the South which used coke as fuel; nearly all used charcoal. Now coke is in general use.

The growth of the southern iron industry during the past few years is shown in the following statistics of its production of pig iron, much of which has found a market in the North, owing to the cheapness with which the raw materials can be brought together in the South and the favorable transportation facilities which now exist. (We do not regard Missouri as a southern but as a western State.)

Production of iron in the southern States from 1880 *to* 1886.

States.	Short tons of 2,000 pounds.						
	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Alabama	77,190	98,081	112,765	172,465	189,664	227,438	283,859
Tennessee	70,873	87,406	137,602	133,963	134,597	161,199	199,166
Virginia	29,934	83,711	87,731	152,907	157,483	163,782	156,250
West Virginia	70,338	66,409	73,220	88,398	55,231	69,007	98,618
Kentucky	57,708	45,973	66,522	54,629	45,052	37,553	54,844
Georgia	27,321	37,404	42,440	45,364	42,655	32,924	46,490
Maryland	61,437	48,756	54,524	49,153	27,342	17,299	30,502
Texas	2,500	3,000	1,321	2,381	5,140	1,843	3,250
North Carolina	....	800	1,150	....	435	1,790	2,200
Total	397,301	471,540	577,275	699,260	657,599	712,835	875,179

With the growth of its pig-iron industry and the erection of rolling mills and steel works, the South has also commenced to manufacture its own iron into all those domestic and mechanical forms for a supply of which it has heretofore too largely relied upon the North.

Of all the southern States which once were prominent in the manufacture of iron, North Carolina and South Carolina have conspicuously failed to respond to the progressive spirit which we have described. The former State, although rich in iron ore and in timber suitable for charcoal, and having also some undeveloped bituminous coal fields, has now fewer iron enterprises of any kind than at any time within the last hundred years of its history. Lack of capital and the remoteness of most of her iron-ore deposits from railroad communication are the leading causes of this decadence, and to these may be added the destruction of the bloomary industry of North Carolina through the competition of rolled iron from other States. There are now only two charcoal furnaces in the State (one of which is for sale), and there is not one coke furnace or rolling mill. Only a few bloomaries are left.

South Carolina presents a yet more remarkable instance of decadence in the manufacture of iron. This State has large deposits of magnetic iron ore in Union, Spartanburg, and York counties, and in Anderson and Greenville counties there are also excellent ores. These counties have forests of good timber which might supply charcoal for fuel. Iron was made in this section for many years, commencing with the Revolution. In 1856 there were eight furnaces, three rolling mills, and two refinery forges in South Carolina. After the close of the war the fires in all its furnaces died out, and since then no iron in any form has been made within the limits of the State. South Carolina furnishes the only instance in the history of the country of a State having wholly abandoned the manufacture of iron. Lack of capital since the war is assigned as the principal cause of the failure to relight the fires of its *ante bellum* iron works, some of which are still standing.

Maryland does not now make as much pig iron or rolled iron as it did for some years after the war, but Maryland can scarcely be called a southern State, although it is classified as such. Its ancient iron industry rested on charcoal, which it can now supply only in limited quantities, while it has no mineral fuel suitable for use in blast furnaces. Two new furnaces are, however, now being built below Baltimore. Its future blast-furnace industry will doubtless rest largely on foreign ores, which can meet on Chesapeake bay the anthracite coal and Connellsville coke of Pennsylvania.

The iron and steel industries in the Rocky Mountain and Pacific coast sections of our country appear to be entering upon a period of greater activity than they have recently experienced. In Colorado a new blast furnace is being completed by the Colorado Coal and Iron Company. At San Francisco the allotment of the Government contract for the construction of the cruiser Charleston has satisfactorily tested the capacity of the only steel works on the Pacific coast. It has just been telegraphed that the steel stern-post for the cruiser mentioned was successfully cast at the works of the Pacific Rolling Mill Company, at San Francisco, on June 22. The post is 22 feet long on the keel, with an upright of 20 feet, and weighs upwards of 15,000 pounds. The open-hearth steel department of this company was added to its original plant in 1884. We are informed that the legal difficulties which have for some time embarrassed the Oregon Iron and Steel Company are about disappearing. It has recently been reported that the Moss Bay Hematite Iron and Steel Company, of Workington, England, has decided to remove its plant to Washington Territory.

SOUTHERN RESOURCES FOR THE MANUFACTURE OF IRON AND STEEL.

No reference to the present condition of the iron and steel industries of the United States can be complete which does not consider, even briefly, the ability of the southern States to maintain the claims which are now made in their behalf as iron and steel manufacturers.

It will not be forgotten that before the civil war the southern iron industry rested almost wholly upon charcoal as a fuel for its blast furnaces, and that it had but few rolling mills to create a demand for bituminous coal. In those days charcoal pig iron was in more general use in all parts of the country than it is now. The South, therefore, was in line with the popular demand for pig iron, and as its iron ores were widely distributed it was prepared to meet its own wants for pig iron and to a limited extent to compete with northern furnaces in their own markets. Upon the other hand the competition of foreign manufacturers and of northern rolling mills in supplying southern markets with finished iron limited the home demand for its own pig iron.

After the war the South had to meet two conditions of the iron industry which were at variance with her conservative methods. One of these was the growing tendency to cheapen the production of pig iron by substituting mineral fuel for charcoal, the South being at a disadvantage in this particular because it had but few coal mines opened and did not care to open any more. The other was the established superiority of the rolling mill over the bloomary and the refinery forge in the manufacture of bar iron, and the South had few rolling mills. At a still later day the South was confronted with the strong tendency to substitute steel for iron, and she had not even one steel works of any kind. The South, therefore, since the war has had not only to lift up a prostrated iron industry, but she has had to do this by adopting practically new methods with which she was not generally familiar.

How has the South met these hard conditions? In the manufacture of pig iron she has made remarkable progress in substituting home-made coke for charcoal. She now has 44 completed coke furnaces, 67 completed charcoal furnaces, and 3 anthracite furnaces, making 114 furnaces in all, and has 24 coke and 3 charcoal furnaces in course of erection. The coke furnaces built and building would as a rule be a credit to Pennsylvania if they were located in that State. In the manufacture of bar iron she has shown that she too prefers the rolling mill to the bloomary or forge, but her progress in building rolling mills has not been so rapid as it might have been. In the whole South, including Maryland and West Virginia, there are not now more than thirty rolling mills for the manufacture of bar iron, plate and sheet iron, and iron rails. In meeting the demand for steel as a substitute for iron the South has now five Bessemer steel works, two open-hearth steel works, and two crucible steel works. A survey of the foregoing facts shows that the manufacture of pig iron in the South has received the most attention since the war, and that its progress has been really remarkable, while the manufacture of rolled iron and steel has not been neglected.

An important question naturally arises: Does the South possess the resources needed to sustain her iron and steel industries even upon their present scale of development? Has she an abundance of ores and coking coal, and are many of her ores suitable for the manufacture of steel?

Iron ore is found in nearly every southern State, and in most of them it is found in abundance and is widely distributed. There can be no doubt about the existence of a sufficient quantity of iron ore to sustain a southern iron industry for generations to come. Maryland and West Virginia will, however, continue to use some foreign ores because they can be cheaply obtained and are adapted to the manufacture of steel. Neither of these States has yet developed any native steel-making ores. We do not look for the remainder of the South to import any kind of iron ore, as we do not see where she could economically bring together ore and fuel and limestone.

The ores found in the South are as a rule suitable only for the manufacture of foundry pig iron and of pig iron for use in rolling mills. In the western part of North Carolina the celebrated Cranberry ore, which is well adapted to the manufacture of steel by the original, or acid, Bessemer process, constitutes a noteworthy exception to this rule. This ore is now used in the manufacture of pig iron which is converted into steel at Chattanooga by the process mentioned. Other ores of the same general characteristics, but thus far undeveloped, exist in considerable quantities in the same part of North Carolina, in Roan mountain in eastern Tennessee, and possibly in the northwestern part of South Carolina, but with these exceptions we do not know of any extensive deposits of low phosphorus ores in any southern State, and it is only ores of this character which can be used in the manufacture of Bessemer steel by the original process. It is entirely probable that western North Carolina and eastern Tennessee will before many years be called upon for considerable supplies of Bessemer ores possessing the characteristics mentioned, but it is also just as probable that these ores will be chiefly smelted elsewhere, as good coking coal in the immediate vicinity of the ore deposits is practically wanting.

It has been widely claimed that the South possesses ores which are admirably adapted to the manufacture of Bessemer steel by the basic process, as they are high in phosphorus. But it is also necessary that the ore to be used in the manufacture of basic pig iron should be low in silica. Does the South possess an abundance of iron ore containing these two essential qualities? This may be doubted. But, granting that a sufficient supply of iron ore of this quality exists in the South, has it been demonstrated that the manufacture of basic steel can be economically prosecuted in this country? This demonstration has certainly not been made. And in this connection it is certainly a significant fact that the five Bessemer steel works which have already been established in the South were built to manufacture steel by the acid process. The legal difficulties in the way of using the basic process could have been surmounted long ago if there had existed economic reasons why this process should have been preferred to the acid process, or why it should have been used at all.

With regard to the supply of coking coal in the South it may be admitted that it is not so generally distributed as that of iron ore, and that much of it is not of the best quality. This statement would, however, be misleading if we did not add that railroad facilities in the South are being so perfected that but little inconvenience need be experienced in taking good coke from where it is made to where it is wanted, as, for instance, from southwestern Virginia to eastern Tennessee. And it may also be added that the mistake which has recently been made in some parts of the South of building blast furnaces in advance of the development of neighboring coke-producing coal deposits will doubtless be remedied in a year or two. Nor should it be forgotten that in many southern States charcoal can be obtained for many years to come as a furnace fuel in localities where coke may not be economically available.

It is claimed that the South possesses advantages in the proximity of its ores, fuel, and limestone, and in cheap labor which enable it to manufacture pig iron more cheaply than any other section of the country. This claim is undoubtedly true of several southern States, and it should everywhere be frankly conceded. Upon this matter the testimony of Sir I. Lowthian Bell, the highest authority in England on the manufacture of pig iron, is valuable. His opinion is based upon his personal observation of the resources of the South during a visit to that section in 1874. He says: "In the southern States of Tennessee and Alabama, and to some extent in Georgia, there are very large deposits of iron ore which lie so near to the coal fields of the valleys watered by the Alabama and Black Warrior rivers as to render, in all likelihood, the cost of bringing together the materials for making iron not more than it is on the river Tees. The natural conditions under which ore and fuel are found are such that it would be difficult to find a locality of any magnitude in any country where these minerals can be more cheaply wrought than in Alabama. Ultimately there seems nothing, so far as our present knowledge permits us to judge, to prevent these southern States from becoming the cheapest iron-making centers in the Union." They are that now.

But cheapness is not the only *desideratum*. A constant market for the consumption of pig iron is even more necessary. Thus far the rehabilitated southern pig-iron industry has chiefly depended on the markets of the North for the orders to keep its furnaces active. This is an uncertain dependence, as a depression in the iron trade of the North, such as has frequently occurred, would be followed by very low prices and by sharp competition among northern furnace owners which the South might not be able to meet. The cost of transportation to northern markets, from $3 to $4 per ton, which southern operators must always pay, might completely rule out southern pig iron. It would be far better for the South if it would seriously make the attempt to consume all its own pig iron. It ought to make its own plows and other agricultural implements, its own wagons, stoves, chains, axes, shovels, nails, horseshoes, cotton ties, steam engines and boilers, locomotives, iron and steel rails, and all other articles which are made wholly or in part of iron or steel. The future prosperity of its iron and steel industries depends upon the prompt adoption of this policy. To make pig iron however cheaply and pay the freight on it to northern markets, taking in return northern finished products of iron and steel and paying the freight on them, is not wisdom, but folly.

The South will be richer and more prosperous than it now is when it resolves to supply as far as possible all its own wants, whether they relate to food or clothing, furniture or house building, the implements of the farm or any kind of machinery, the equipment of its railroads or the making of the tools of the cunning workman.

THE IRON ORES EAST OF THE MISSISSIPPI RIVER.

BY JOHN BIRKINBINE.

The subject of American iron ores cannot be said to have received the attention its importance demands and any attempt to investigate it in a general way requires the perusal of numerous volumes and special papers to obtain data, which, when collected, leave voids to be filled only by personal correspondence or visitation. Hence a complete résumé of the iron ore resources of the United States will not be attempted at present, but an effort will be made to supplement the information upon "Iron ores in the United States" in "Mineral Resources of the United States, 1883 and 1884," by Mr. James M. Swank, so as to form a basis for a more complete paper. This contribution should therefore be read in connection with Mr. Swank's monograph rather than as a complete article, for it is not considered desirable to repeat data which have been published except in so far as may be necessary to make the paper of value. An attempt, however, will be made to show the present positions of some of the prominent ore-producing districts, both as regards their present development and the influence which they have exerted in the past on the iron industry of the country.

This paper will not treat of iron-ore deposits west of the Mississippi river except those of Missouri, as data were not accessible in time for presentation in proper form, and any discussion of a few deposits would add but little to the information already published. This division is made solely to present a more complete record of the eastern section of the country and not to overlook the important deposits of some of the western States and Territories, among which are: Colorado, where ores in abundance are found and which have been but slightly developed, although furnishing rapidly developing smelting plants; Texas, whose brown hematites have encouraged the erection of two blast furnaces; Oregon, where the iron industry is now dormant by reason of legal complications but not on account of scarcity of good ores; and California, in which State iron manufacture has had a checkered existence. Washington, Utah, Montana, and other Territories, as also Iowa and Arkansas, have deposits of good iron ores. While this paper was in preparation Vol. XV. of the Census Reports, entitled "Mining Industries (excluding precious metals)," was made accessible, and it was deemed advisable to restrict its scope until the data therein published could be compared with what was collected by personal effort, so as to avoid repetitions.

To enumerate the iron-ore deposits of the United States would require a discussion of the economic minerals of every State and Territory, for in the few from which no iron ore has been mined or smelted it would be unsafe to assert that deposits have not been found, and reports of the existence of iron ores have been made which would indicate them as being present apparently in all or nearly all of the political divisions of the nation. As would be surmised from their wide distribution, the iron ores of the United States include practically all varieties and compositions; we mine magnetites, red and brown hematites, and carbonates in quantity. The magnetites include all grades, from nearly pure magnetic oxide of iron to ore disseminated through gangue, and too lean to smelt; the red hematites embrace the specular, micaceous, dyestone or fossil ores, ranging in composition from practically pure anhydrous sesquioxide of iron to ferruginous rocks. The brown hematites which are most widely distributed embrace the turgite, goëthite, limonite, pipe ore, and bog ore; the latter being used to but a limited extent. The carbonates also exist in all known varieties and are liberally distributed as clay-ironstone, siderite, kidney ore, black band, etc.

The production of iron ore in the United States in 1886 is estimated as exceeding 10,000,000 long tons. The consumption of ore in producing the 5,683,329 long tons of pig iron made in 1886 was probably 11,700,000 long tons. The importation of foreign ores amounted to 1,039,433 long tons. The forge and mill cinder used is estimated at 345,000 long tons, leaving an apparent consumption of domestic ores of 10,315,567 long tons.

But although the stocks at many of the prominent mines were less at the close of 1886 than at the beginning of the year, the newer districts, such as the Gogebic and Vermilion, and in fact all of the mines where shipments were not carried on largely after the close of navigation, rapidly accumulated stocks, so that the output of our American mines was between 10,500,000 and 11,000,000 long tons in 1886, representing a value at the points of extraction of not less than $18,000,000.

No better indication of the growth of our iron-producing capacity need be desired than the fact that while the prominent mines of Lake Champlain, New Jersey, Cornwall, Pilot Knob, Iron Mountain, etc., have kept up their quota, Alabama, Virginia, North Carolina, and Tennessee have largely increased their output, and in addition to the regular amounts from the Menominee and Marquette regions, the notable Vermilion mines of Minnesota and the Gogebic range in Michigan and Wisconsin have entered the list, but with all this we have imported at the rate of over 1,000,000 tons of foreign ores per annum. The development of new districts showing capacities for producing so large an amount of high-grade ores has interfered considerably with the efforts to work the Canadian mines on an extended scale, and would probably have affected the older districts more seriously had not the increased demand from our blast furnaces furnished a ready market for the output of the mines.

MAINE.

While numerous small deposits of limonite and magnetic ores are known to exist in Maine, the only ones of any recognized commercial importance at present are those at the Katahdin Iron Works, in Piscataquis county, and the beds contiguous to the Aroostook river, in Aroostook county. Mr. O. W. Davis, jr., states that "the Katahdin ore is found on the sides and summit of an elevation that is from 200 to 400 feet above the level of the river. When the surface became exhausted, it was found that extensive deposits existed at various depths; these were the product of oxidation of the ledge *in situ* occurring to the depth of 10 to 30 feet. These are sources of the present supply of the furnace.

"The beds originally found on the surface were practically free from sulphur, or, if it existed, it was as a sulphate which was readily driven off by roasting the ore in heaps on the ground. But the beds formed *in situ* were found to contain from 2 to 4 per cent. of sulphur, largely as sulphide, which could only be driven off by intense heat in presence of abundance of air." Below will be found partial analyses of these ores:

Analyses of Katahdin iron ore, Piscataquis county, Maine.

	Old bed or surface ore.		New bed or ledge ore.	
	No. 1.	No. 2.	No. 1.	No. 2.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Metallic iron	51.76	53.81	47.76	57.34
Sulphur	.69	1.24	3.90	1.24
Phosphorus	.09	.07	.04	.05

Concerning the Aroostook County ores Mr. Davis says: "In some places the deposits are of great thickness and extent. At one or two points there is a thickness of 10 to 12 feet, while at another point the writer uncovered the rocks and took samples of the iron ore at every 10 feet in width for a total width of 90 feet—the ore analyzing from 42 to 48 per cent. of metallic iron, with from .50 to 1.40 per cent. of phosphorus."

Analyses of Aroostook iron ore, Maine.

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Metallic iron	36.40	46.77	41.93
Metallic manganese	7.40	3.20	2.72
Phosphorus	1.09	.61	.94
Siliceous matter	....	19.20	26.07
Sulphur	None.	None.	None.

Mr. O. S. Thomas supplies the following partial analyses of a magnetic ore occurring at Iron mountain, Cumberland county:

Analyses of magnetic iron ore from Iron mountain, Cumberland county, Maine.

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Iron	20.70	58.10	39.84
Sulphur	....	....	.84

Both Vermont and New Hampshire produce iron ores, and formerly sustained a small iron industry, but none is now smelted there. Near Franconia furnace, New Hampshire, magnetite, yielding below 50 per cent. of iron, was taken for many years from a bed ranging from 5 to 20 feet in thickness. The Vermont ores embrace brown hematites, yielding about 45 per cent. of iron; a carbonate ore, giving in the raw state 32 per cent. of iron; magnetite, and magnetic sand.

MASSACHUSETTS AND CONNECTICUT.

The early iron industry of these States was established near the coast, but gradually moved westward; it is now confined to the territory close to the western boundary and to the region generally recognized as the Salisbury district, situated in Berkshire county, Massachusetts, Litchfield county, Connecticut, and Columbia and Dutchess counties, New York, where large quantities of brown hematites are mined, a considerable portion being obtained from underground workings, as the deposits in some cases partake more of the character of veins than of pockets. All the ore is crushed and washed, and the average as mined from this region, which has for over a century maintained its reputation for superior quality of ore, will yield 45 per cent. of iron. The Connecticut mines in the Salisbury region produced 36,000 long tons of ore in 1886. Analyses were given in Mr. Swank's paper referred to above.

At Roxbury a deposit, of small commercial importance, but of technical interest as being a crystallized carbonate, is reported.

RHODE ISLAND.

From the shores of some of the islands forming this State, magnetic ore sands have been obtained, and a deposit of magnetite in Cumberland county is described by Mr. M. Standish as "The Cumberland Iron Mountain," where a homogeneous mass of porphyritic magnetic iron ore appears to have protruded through the overlying granite and gneiss, and risen to a height of 104 feet above the adjoining meadow; the other measurements being, length, 462 feet; width, 132 feet. This hill appears to be the visible outcrop of the main body, which increases in magnitude with the depth, as well as can be judged by surface indications and magnetic survey. This outcrop or hill is practically without soil, the ore rising to the extreme apex. The ore appears to be richer in iron at the surface level than at the apex, and an analysis by Dr. Delbrunner of his own sample of a large quantity of ore taken from the lowest or surface level shows the following chemical composition:

Analysis of iron ore from Cumberland mountain, Cumberland county, Rhode Island.

	Per cent.
Magnetic oxide	55.25
Moisture	0.65
Manganese oxide	3.22
Silicic acid	13.74
Titanic acid	3.84
Phosphoric acid	trace.
Carbonic acid	trace.
Alumina	15.04
Lime	4.24
Magnesia	3.75
Loss	0.27
Total	100.00
Metallic iron	40.00

This ore was used for producing charcoal iron until anthracite iron was introduced, since which time it has been shipped to different parts of this country, but the cost of production and transportation to distant points has been too great to admit of a large consumption.

An analysis by Professor Welles of hematite found near Providence, and which has been used is considerable quantity, shows:

Analysis of hematite iron ore from near Providence, Rhode Island.

	Per cent.
Peroxide of iron	76.285
Protoxide of iron	trace.
Moisture, carbonic acid and other volatile matter	14.95
Silica	4 84
Alumina	2.10
Sulphur (sulphuric acid 0.118)	0.039
Phosphorus (phosphoric acid 0.453)	0.182
Protoxide of manganese	0.08
Lime	0.50
Magnesia	0.41
Loss	0.20
Total	99.586
Metallic iron	53.40
When calcined	63.60

NEW YORK.

The most important iron-ore region in New York State is the "Lake Champlain district," embracing groups of mines located as follows:

(1) Thirteen miles west from, and 1,300 feet above Lake Champlain at Crown Point, where the veins have an apparent strike of 2 miles in length.

(2) Seven miles west from, and 1,200 feet above, Lake Champlain, at Port Henry, where the veins have an apparent strike 4 miles in length.

The Port Henry mines are 12 miles north of the Crown Point mines. Both of these deposits may be considered as in the foothills of the Adirondack mountains.

(3) Thirty miles west from, and 1,900 feet above, Lake Champlain, at Plattsburgh, where the apparent strike of the veins is 9 miles in length. This deposit is known as the Chateaugay mines; it is 60 miles north of the Port Henry mines, and is not considered as being identical in formation with the others. It is in the Adirondack mountains.

(4) Other deposits between those named, or closer to the lake, have also been exploited and operated. Many small mines were formerly worked for forges and have since been abandoned. The mines are supplied with branch railroads which connect with railroads and shipping docks on Lake Champlain and at Crown Point, Port Henry, and Plattsburgh.

This district has been an important factor in the development of our iron industry, the first recorded operation having been made at the Cheever ore bed near Port Henry in 1804, since which time ore has been continuously mined for the bloomaries or modified Catalan forges which were established throughout the district to make wrought iron directly from the ore with charcoal, and also for blast furnaces. The Penfield mine at Crown Point was opened in 1825, but it was not until 1881 that the Chateaugay mines were practically developed. Twenty years ago there were 120 bloomaries in Essex county. The ores of the district are hard, compact magnetites lying with steep dips, and while requiring much labor and explosives to mine them, demand little or no timbering, the roofs being firm and supported by pillars of ore. They are remarkably free from water, when the depth of the underground workings is considered, the mines near Crown Point having reached a depth of 300 feet, which is also about the average of the mines near Port Henry, although in the latter a depth of 900 feet has been obtained at one point. One shaft at the Chateaugay mines has been carried down 600 feet, and in the outlying operations the Arnold Hill mine has reached 700 feet in the deepest working. There are no indications of an exhaustion of these deposits, which have contributed more liberally to our iron ore supplies than is generally supposed. Mr. Frank S. Witherbee and Hon. Smith M. Weed, who have kindly supplied valuable information concerning the deposits, estimate the production of the various mines prior to 1886 as follows:

Estimated production of iron ores in the Lake Champlain district, New York, prior to 1886.

	Long tons.
Crown Point mines	1,500,000
Port Henry mines	8,000,000
Chateaugay mines	1,500,000
Arnold Hill, Palmer Hill, and other Essex and Clinton County mines	2,000,000
Making the total estimated output of this district to 1886	13,000,000

Mr. Witherbee states that of the 8,000,000 tons estimated as taken from the Port Henry mines about 6,500,000 tons were taken from territory one-half mile square. The different mines produced the following quantities in 1886:

Production of iron ore in the Lake Champlain district in 1886.

	Long tons.
Crown Point mines	60,084
Port Henry mines	298,868
Chateaugay mines	214,800
Other mines, about	15,000
Total	588,752

The statements concerning the strikes as above given are not intended as defining absolute distances, for there are peculiarities in the formation, such as exhibited by the Old Bed No. 21 workings near Port Henry, which appear to be local and limited to a strike of about one mile, no ore of a similar character having been discovered in other districts. The widths of the beds vary greatly, but an average of the Crown Point and Port Henry ores may be taken at 8 feet, except the No. 21 mine at Port Henry, which has shown a width of 300 feet. The Chateaugay bed averages about 18 feet in width. In addition to the partial analyses given by Mr. Swank the following complete determinations were furnished by Messrs. Witherbee, Sherman and Company as being average analyses taken of large samplings of the varieties of their ore as shipped:

Analyses of iron ores from Port Henry, New York.

	New bed, pure ore.	Old bed No.21 ore.	New bed, lean ore.
	Per cent.	*Per cent.*	*Per cent.*
Metallic iron	68.24	66.18	50.38
Oxygen with the iron	26.01	25.23	19.20
Insoluble siliceous matter	4.32	1.94	29.11
Phosphoric acid	.038	2.45	.05
Lime	.14	2.27	.17
Alumina	.28	.76	.32
Magnesia	....	.14	....
Protoxide of manganese	....	.36	....
Water	.38	....	.54
Undetermined matter and loss	.592	.67	.23
Total	100.00	100.00	100.00
Phosphorus	.017	1.07	.0218

The new bed produces some remarkably fine crystals of iron ore, and specimens have been obtained from it approximating theoretical purity. Analyses of iron ore from Crown Point, New York, furnished by Mr. A. L. Inman, show:

Analyses of iron ore from Crown Point, New York.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Protoxide of iron	21.32	20.62
Sesquioxide of iron	47.38	49.72
Magnesia	.10	.21
Alumina	1.97	2.62
Lime	.36	.68
Phosphoric acid	.08	.06
Sulphur	.02	.02
Silica	27.48	24.52
Total	98.71	98.45
Metallic iron	49.74	50.84
Phosphorus	.035	.026

The composition of other Lake Champlain ores is shown below.

Analyses of Arnold Hill and Palmer Hill ores.

	Arnold Hill.		Palmer Hill.	
	No. 1.	No. 2.	No. 1.	No. 2.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Iron	59.92	61.28	44.94	63.45
Phosphorus	.079	.113	.023	.002
Phosphorus in 100 parts of iron	.131	.184	.053	.003

Analyses of Chateaugay and Port Henry ores also appear in Mr. Swank's paper. The Lake Champlain district may be considered as the northern exposure in the United States of the magnetic ores which are found along the mountains from the drainage area of the Saint Lawrence to that of the Gulf of Mexico.

The magnetites along Grasse river in Saint Lawrence county, New York, were examined by the late Prof. B. Silliman, who reported them as containing the following:

Analyses of magnetites on Grasse river, Saint Lawrence county, New York.

	No. 1.	No. 2.	No. 3.	No. 4.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Iron	57.42	58.59	54.32	57.81
Manganese	0.23	0.29	0.29	0.50
Phosphorus	0.14	0.01	0.01	Trace.
Alumina,	3.45			
Lime	4.46			
Magnesia	3.09			
Sulphur	0.35	0.08	0.08	0.41
Silicic acid	3.32	8.77	13.34	8.55
Water	0.51			

Magnetites carrying considerable sulphur are found in Washington county, about 40 miles south of Crown Point, but they have not been worked recently, and late developments of magnetite near Jayville, in Saint Lawrence county, have been undertaken. This county has furnished large amounts of red hematite ores, of which future mention will be made.

Some of the deposits lying near those now operated show favorable indications as to quantity, but are not mined on account of the large percentage of titanium which they carry. As our knowledge of iron manufacture increases we will undoubtedly overcome the physical difficulties which efforts to smelt titaniferous ores have encountered, and the presence of this metal may be, perhaps, even considered as advantageous in certain processes of manufacture.

A titaniferous ore at Port Leyden (Lewis county) occasioned the erection of a blast-furnace plant, concerning which Mr. George D. Colby says: "With a view of ascertaining the amount and quality of the ore which led to the erection of these works the present company made borings with a diamond drill to a depth of 300 feet. The core of the borings indicated an abundance of ore, but of such chemical composition that no attempt has been made by this company to produce pig iron from it." An analysis of this ore is given below:

Analysis of iron ore from Port Leyden, New York.

	Per cent.
Magnetic oxide of iron	52.67
Bisulphide of iron	5.86
Manganese	1.12
Alumina	5.21
Lime	8.38
Silica	10.95
Sulphur	3.12
Phosphorus	2.59
Titanic acid	9.31
Total	99.21
Metallic iron	40.90

Magnetites occur again in southeastern New York, in Putnam and Orange counties, within 50 miles of New York city; those of the former county being prominent, owing to peculiarities of formation and composition. They are apparently large lenses or chimneys of ore, with faults, making mining expensive. The annual output of these mines approximates 45,000 tons. Mr. Arthur F. Wendt described the method of filling worked-out rooms with masonry so as to get the ore from roofs and pillars, and gives the following analyses of some of the ores (Transactions of the American Institute of Mining Engineers, Vol. XIII., pages 478-488.):

Analyses of Putnam County, New York, iron ores.

	Tilly Foster mine.			Mahopac mine.	Croton mine.
	No. 1.	No. 2.	No. 3.		
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Iron	50.64	46.76	47.43	54.225	49.74
Phosphorus	0.019	0.028	0.027	0.012	0.21
Sulphur	0.050	....	....	0.014	0.52
Magnesia	13.20	....	....	10.065	....
Silica	12.67	10.12	12.69	8.78	18.93
Manganese	0.17	....	....	0.144	0.51
Alumina	....	....	....	3.078	8.55
Lime	....	....	....	1.45	2.10

The attempt to use the concrete pillars has not been as successful as was anticipated, and the Tilly Foster mine is reported as crushing these artificial supports.

The red hematites of Saint Lawrence and Jefferson counties have been operated for seventy years. Mr. George D. Colby (Journal of the United States Association of Charcoal Iron Workers, Vol. VI., pages 262 to 271) gives the product of the Rossie mines up to 1885 as 309,000 tons, as much as 40,000 tons having been taken in one year from openings 125 to 200 feet deep. Analyses of these ores gave the following results:

Analyses of iron ores from the Rossie mines, New York.

	Caledonia ores.									Keene ores.		
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 1.	No. 2.	No. 3.
	Pr. ct.	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*
Peroxide of iron	82.99	98.34	96.51	75.30	83.87	88.43	98.13	98.26	34.16	56.54	76.64	57.93
Protoxide of iron	......	......	......	......	......	......	......	.24	29.65	12.49	......	12.72
Protoxide of manganese	.32	......	......	.15	......	......	......	......	......	Tr.	......	.07
Alumina	.92	......	.42	1.69	1.32	1.03	......	......	2.09	.69	2.80	4.54
Lime	4.14	......	Tr.	7.04	......	......	......	......	4.13	8.23	......	2.32
Magnesia	1.33	......	Tr.	.38	1.60	1.94	......	......	1.81	2.13	1.74	.85
Silica	5.17	.88	2.03	10.12	13.20	3.64	.48	1.10	3.54	4.28	6.40	10.97
Carbonic acid	(*a*) 4.96	......	......	5.41	......	......	......	.15	20.99	15.01	......	9.75
Phosphoric acid	.24	.45	......	Tr.	......	......	.02	.16	.09	.36	......	.16
Sulphur	.06	.35	......	.03	......	......	......	.02	.04	......	.02	.07
Carbonate of lime and water	......	......	......	......	......	......	......	......	......	....	12.40	......
Totals	100.13	100.02	98.96	100.12	99.99	95.04	98.63	99.93	96.50	99.73	100.00	99.38
Metallic iron	58.09	68.82	67.05	52.71	58.20	61.90	68.69	68.97	46.97	49.30	53.66	50.23

a Carbonic acid and water.

The old Sterling mine is reported as 600 feet long, 100 feet wide, and 150 feet deep, with a producing capacity of 50,000 tons per annum of ore, showing the following composition:

Analyses of Sterling ores.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Sesquioxide of iron	79.52	69.51
Manganese	.19	.07
Alumina	1.12	1.27
Lime	4.18	3.24
Magnesia	1.07	.96
Phosphoric acid	.26	.50
Sulphuric acid	.08	None.
Silica	9.80	20.89
Water	.48	1.20
Metallic iron	55.66	48.66
Phosphorus	.11	.22

Other ores in the vicinity show:

Analyses of iron ores from the Clark and Pike mines, Saint Lawrence County, New York.

	Clark and Pike mines.		
	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Metallic iron	65.19	56.25	53.40
Oxygen with iron	27.39	24.11	22.89
Alumina	0.93	1.81	1.92
Lime	2.03	2.97	2.80
Silica	0.74	8.81	8.09
Magnesia	0.23	0.80	1.44
Phosphorus	0.21	0.17	0.30
Sulphur	Trace.	None.	0.04

Central New York abounds in what is called Clinton ore, a red fossiliferous hematite, made up of lenticular grains containing on the average about 44 per cent. of iron, though it often runs higher than this, one specimen analyzed by Prof. A. H. Chester affording more than 62 per cent. The ore bodies are in nearly horizontal seams, from 6 to 24 inches in thickness; they are sometimes mined by stripping off the surface and sometimes by underground workings. The averages of a large number of analyses of the Clinton ore are reported by Professor Chester to have the following composition:

Analyses of Clinton iron ores, New York.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Silica	13.09	16.04
Metallic iron	44.40	45.10
Alumina	5.99	3.83
Manganese oxide	0.19	0.33
Lime	5.85	5.48
Magnesia	2.69	0.92
Sulphur	0.31	0.20
Phosphorus	0.53	0.97
Carbonic acid	6.08	4.10
Moisture	1.45	2.45
Oxygen, with iron and phosphorus	19.71	20.60
Total	100.29	100.02

These deposits have been operated for ninety years; the first lease for digging ore was granted in 1797. About 75,000 tons of carbonate ore mined and roasted by the Hudson River Ore and Iron Company in Columbia county were extracted in 1886; the Dutchess and Columbia County brown hematites amounted in the aggregate during the year to 30,000 tons, and the Orange and Rockland County mines have produced somewhat more than this quantity.

The brown hematites, as noted under Massachusetts and Connecticut, extend along the eastern boundary of New York and are included by common consent in the Salisbury region, although some of them are far removed from the original Salisbury district. Analyses of some of these ores in Dutchess and Columbia counties show, when dried at 212° F.

Analyses of iron ores from Dutchess and Columbia counties, New York.

	No. 1.	No. 2.	No. 3.	No. 4.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Iron	46.80	47.45	46.45	38.65
Manganese	0.983	0.306	1.816	2.986
Alumina	4.549	1.884	3.506	5.001
Silica	14.02	15.02	14.100	22.40
Phosphorus	0.349	0.135	0.367	0.273
Sulphur	....	0.019	0.007	....

NEW JERSEY.

Some of the earlier iron industries of New Jersey were operated with bog ores, but most of the development of New Jersey mineral resources so far as iron is concerned has been upon the magnetic ores which are mined in the northern part of the State at elevations of from 200 to 1,000 feet above the sea. In the one hundred and seventy-five years during which these deposits have been worked, they have produced an aggregate of probably 14,000,000 long tons of ore.

A table prepared by Prof. George H. Cook, State geologist, shows that the maximum annual output of the New Jersey mines was in 1882, when 932,762 long tons were mined, and the next largest output was in 1880, namely, 745,000 tons. The output of 100,000 tons was first reached in 1865. Last year 500,501 tons were produced.

The causes enumerated in Mr. Swank's paper, in addition to the necessity of roasting some of the ores to remove the sulphur, have rather retarded their development in late years. Most of the mining is done underground at an average depth of 300 feet, the deepest mining being nearly 800 feet. In the northern part of the ore territory "franklinite" is produced—a mineral containing iron, manganese, and zinc, which is first roasted for the purpose of volatilizing the zinc in the form of oxide, which is condensed in suitable chambers, and the residuum is afterwards smelted in blast furnaces to produce spiegeleisen.

The quantity of this mineral (franklinite or zinc ore) mined in 1886 was 43,877 tons, which are not included in the above total.

Mr. J. Wesley Pullman, in a paper upon the product of the Hibernia mine, one of the New Jersey group, in the Transactions of the American Institute of Mining Engineers, Vol. XIV., page 904, states that it was opened about 1750, but gives no figures of production until 1854, but up to January 1, 1864 (ten years), 104,521 long tons were mined, and from the last date to January 1, 1886, 1,716,438 long tons were mined; an average of 78,020 tons per annum. In 1880 this mine produced 145,029 tons. Concerning the New Jersey ores Mr. Pullman says: "These ores are of two classes: 1, lean and siliceous ores, free from sulphur and running from 40 to 48 per cent. iron, after careful cobbing, but purely Bessemer as to phosphorus; and 2, sulphur ores, containing from 1½ to 4 per cent. sulphur, but running 50 to 58 per cent. metallic iron, somewhat irregular in phosphorus, but rarely going above .065 per cent., and frequently down to .035 per cent., and less. A very considerable quantity of these ores was worked up to 1874–'75 for Bessemer iron, and being sold at a slightly better price (per unit of iron) than the phosphatic ores the mines referred to enjoyed a moderate degree of success." The following is a complete analysis of the Hibernia ore (sample and analysis by L. C. Bierwith, of Dover):

Analysis of iron ore from the Hibernia mine, New Jersey.

	Per cent.
Soluble in acids:	
Magnetic oxide of iron	82.371
Bisulphide of iron	.711
Alumina	3.650
Lime	1.175
Magnesia	.390
Phosphoric acid	.803
Carbonic acid	1.045
Fluorine	Trace.
Insoluble residue:	
Silica	6.925
Protoxide of iron	.878
Alumina	1.525
Lime	.407
Magnesia	.608
Total	100.488
Total metallic iron	60.66
Phosphorus	0.3524

Other analyses of New Jersey ores.

	Forty-six analyses of "blue ore" from Chester.	Twenty-eight analyses of "Green Pond" ore.	Eleven analyses of "red ore."
	Per cent.	*Per cent.*	*Per cent.*
Iron	48.60 to 57.68	52.153 to 58.32	53.955 to 57.497
Phosphorus	0.021 to 0.058	0.048 to 0.113	0.047 to 0.074
Sulphur	1.815 to 3.47	2.912 to 2.92	. 0.127
Silica	8.69 to 13.86	13.60	6.15 to 12.64
Lime and magnesia	....	....	6.45 to 18.81

Limonites are also mined in New Jersey to a limited extent, the percentage of iron ranging from 38 to 43, and the phosphorus from 0.2 to 0.6.

PENNSYLVANIA.

The magnetites of Pennsylvania are found chiefly along the flank of the South mountain, the most notable deposits being the Cornwall Ore hills, which for over one hundred and forty years have furnished ore for smelting. The aggregate output to date is 8,005,791 long tons, of which 688,054 long tons were mined in 1886.

This deposit is unique, consisting of a mass of magnetic ore confined by trap walls forming three hills, and is mined more cheaply than any ore of similar grade in the country. The ore, while sufficiently low in phosphorus for Bessemer steel purposes, carries, on an average, 2 per cent. of sulphur, which is partially removed by roasting in kilns with waste coal. This calcination is carried on at the blast furnaces which use the ore, and not by the Cornwall Ore Bank Company which mines it. Compressed air is used to operate the drills which perforate the ore for the purpose of blasting it into convenient size for shipment, but a considerable amount is soft, requiring no blasting. The average yield of the ore is 48 per cent. of iron, but the silica varies greatly. Some copper is found in the deposit, but this is generally mined in advance of the iron ore, and hence affects it but slightly.

The Cornwall Ore hills are worked above the water level and are practically the removal of elevated ground, while the other deposits named are excavations below the general level, or underground workings. Full analyses appear in Mr. Swank's paper.

Second in importance to the Cornwall Ore hills in Pennsylvania is the group of mines of magnetic iron ore at Boyerton, where underground mining is the rule, the depths varying from 200 feet to 600 feet. In one instance a shaft is being sunk which is expected to strike the beds of ore at from 1,200 to 1,400 feet below the surface. There are two apparently distinct seams of ore, known as the "blue" and "black." The dip of the former is about 45° and of the latter from 32° to 45°. The seams range in width from 5 to 50 feet, the average being about 20 feet. These ores range in composition from 37 to 54 per cent. of iron; phosphorus varies from 0.02 to 0.07 per cent., and the ores usually carry 1 per cent. and upwards of sulphur. The French Creek and Dillsburg magnetites are of nearly similar composition. In fact but few Pennsylvania magnetites have a sufficiently small percentage of sulphur to permit of smelting them economically unless previously roasted.

Brown hematites are abundant in eastern, southern, and central Pennsylvania, a practically continuous series of pockets existing in the Lehigh, East Pennsylvania, Lebanon, Cumberland, Shenango, Susquehanna, Nittany, and Juniata valleys. This ore is found generally in connection with clay and limestone, and must be washed to prepare it for use. In eastern Pennsylvania the heavy drafts made by the numerous iron furnaces, and the imperfect mining which in many cases was attempted, has exhausted some of the pockets or made their exploitation too expensive, and as a consequence supplies of hematites from Spain or New York State are sought. In the southern section many of the ores are high in phosphorus, and lately some of the best Virginia ores have been carried to Pennsylvania furnaces.

The Lehigh County hematites show the following ranges of composition when dried at 212°:

Analyses of hematite from Lehigh county, Pennsylvania.

	Lowest.	Highest.	Average.
	Per cent.	*Per cent.*	*Per cent.*
Iron	28.10	58.50	46.09
Sulphur	....	....	.025
Phosphorus	.025	3.135	.344
Manganese	Trace...	9.28	1.275
Insoluble residue	....	....	17.16

The average of actual mining, however, will not reach 40 per cent. of iron.

Sixteen analyses of the East Penn valley (Pennsylvania) hematites.

	Lowest.	Highest.	Average.
	Per cent.	*Per cent.*	*Per cent.*
Iron	32.80	52.10	44.30
Sulphur	.005	.62	.030
Phosphorus	.038	1.269	.316
Manganese	.065	2.968	.888
Insoluble residue	7.850	32.71	19.10

The following table, prepared by Prof. A. S. McCreath (Second Geological Survey of Pennsylvania, M. 3, page xv), shows:

Average percentage of iron, manganese, and phosphorus in certain groups of ores from the Cumberland valley, Pennsylvania.

Number of samples.	Name of group.	Iron.	Manganese.	Total iron and manganese.	Phosphorus.	Phosphorus in 100 parts of iron.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
6	South Pennsylvania Railroad brown hematites	44.341	1.009	45.350	.522	1.177
4	South Pennsylvania Railroad bog ores	38.087	Trace...	38.087	.051	.133
13	Mont Alto railroad	46.054	1.114	47.168	.268	.581
6	Shippensburg "limestone ores"	46.208	.599	46.807	.155	.335
8	Shippensburg "mountain ores"	42.933	1.820	44.753	.667	1.553
12	South Mountain railroad	40.083	2.057	42.140	.537	1.334
4	Boiling Springs	36.087	2.898	38.985	.947	2.624
3	Dogwood Run (Dillsburg) brown hematites	43.650	.703	44.353	.447	1.024
6	Dillsburg magnetites	43.875	.102	43.977	.028	.063

Analyses of twenty-three samples of brown hematite in the Juniata valley, Pennsylvania.

	Lowest.	Highest.	Average.
	Per cent.	*Per cent.*	*Per cent.*
Iron	(*a*)20.62	51.9	39.13
Insoluble residue	....	....	27.28

a Bog ore.

In addition to the determinations of the Dillsburg magnetites as above, the following analyses are presented to show the composition of other ores. These were made from stock piles at the Warwick furnace, Pennsylvania, and represent the run of one of the Boyertown mines after roasting, and the run of the Seisholtzville ore, raw:

Analyses of magnetite from the Boyertown and Seisholtzville mines, Pennsylvania.

	Boyer-town.	Seisholtz-ville.
	Per cent.	*Per cent.*
Silica	12.,0	12.90
Alumina	2.45	2.80
Lime	13.23	1.40
Magnesia	3.75	2.81
Iron	44.00	47.025
Phosphorus	.045	.06
Sulphur	.50	....

Analyses of the Chestnut Hill ore of Lancaster county, Pennsylvania. (*a*)

	Per cent.
Iron	45.20
Manganese	1.01
Sulphur	.003
Phosphorus	.448
Water	10.97
Insoluble residue	19.015

a ⅓ lump, ⅔ fine ore.

The brown hematites are scattered also through the western section of the State, one variety locally known as "buhrstone" ore having sustained, with the admixture of carbonates and Lake Superior ores, extensive industries in western Pennsylvania and eastern Ohio. The analyses of these are as follows:

Analyses of "buhrstone" iron ore (hematite) from western Pennsylvania.

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Iron	53.519	43.818	53.607
Manganese	.720	.908	.663
Sulphur	.022	.021	.066
Phosphorus	.363	.104	.409
Water	13.00	12.72	18.294
Insoluble residue	6.00	4.30	2.885

In the foothills of the Allegheny mountains some of the ores most used show the following analytical results:

Average analyses of iron ores from the foothills of the Allegheny mountains, Pennsylvania.

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Iron	47.05	51.60	36.10
Manganese	.685	.425	.382
Sulphur	.113	.029	.023
Phosphorus	.221	.060	.081
Water	9.66	10.51	9.811
Insoluble residue	16.12	12.26	32.83

The carbonate ores, while liberally distributed, are mined chiefly in the bituminous coal regions; Fayette county producing ores of the following general composition:

Average analyses of carbonate iron ores from Fayette county, Pennsylvania.

	Calcined.		Raw.	
	No. 1.	No. 2.	No. 1.	No. 2.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Iron	54.80	35.50	37.50	38.90
Manganese	1.65	.820	.691	.383
Sulphur	1.654	.145	.512	.383
Phosphorus	.174	.042	.123	.115
Carbonic acid	....	34.45	....	....
Water	....	1.09	....	....
Insoluble residue	7.92	7.45	4.735	9.25

Another prominent deposit in Cambria county shows iron from 11 to 36 per cent. in the natural state, and when calcined, as follows:

Analyses of calcined iron ore from Cambria county, Pennsylvania.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Iron	32.11	54.35
Phosphorus	.232	.424
Sulphur	.138	.210

The fossil ores are found in comparatively thin seams, and have sustained a considerable blast-furnace industry in northern and central Pennsylvania. Their analyses are as follows:

Analyses of fossil ore from Cambria county, Pennsylvania.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Iron	41.90	47.10	50.05	42.75	33.80
Manganese	.280	.194	.448	....	....
Sulphur	.035	.033	.028	.021	.004
Phosphorus	.237	.174	.561	.113	.358
Water	1.805	6.19	4.979	....	....
Insoluble residue	4.80	17.855	12.385	27.43	3.851

Pennsylvania has therefore an abundance of ores, but a considerable portion of the supply which is necessary to maintain this State as the largest producer of iron comes from other points. The eastern section consumes foreign ores as well as some from New York and New Jersey. The middle section uses some Virginia and foreign ores, and the western portion relies largely on Lake Superior ores. The iron ore mining industry of the State is, however, one of great importance, and more than one-half of its ore supply is extracted from workings within the State.

OHIO.

The prominence which the State of Ohio has achieved as second in order of iron production, Pennsylvania being first, is due more to its cheap fuel than to the quality of its iron ores, the development of late years being in large part owing to the use of the rich hematites and magnetites from the Lake Superior region, a large portion of which is received at the lake ports of Ohio, Cleveland being the principal receiving station. All the iron ores of any value in Ohio are among the rocks forming the Lower Coal Measures, and although liberally distributed there are but few localities where they are sufficiently abundant to encourage iron-smelting industries. Except the iron districts of Tuscarawas valley, Hocking valley, and of the Hanging Rock region in southern Ohio, the Lake Superior ores are now the main dependence of the iron manufacture in the State, with the addition that on the Ohio river and in central Ohio assistance is derived to some extent from the Missouri ores, which are similar in character.

The Ohio ores are limonites, carbonates (including kidney, block, and limestone ores), and black band; they are generally found in thin seams, and require calcination before use in the blast furnace.

The difference between roasted and unroasted ore will be shown by the following analyses:

Analyses of gray limestone ore from the Hocking valley, Ohio.

	Roasted.	Raw.
	Per cent.	*Per cent.*
Sesquioxide of iron	63.78	(*a*)
Silica	22.15	15.80
Lime	1.12	2.97
Magnesia	.42	1.26
Alumina	7.43	} 10.64
Oxide of manganese	....	}
Carbonic acid and organic matter	....	23.75
Water	.95	2.78
Phosphorus	.18	.08
Sulphur	.38	.15
Metallic iron	44.65	30.20

a Not determined.

The increase in sulphur in the roasted ore is probably due to the coal slack used in the pile.

The best known section is the Hanging Rock district on the Ohio river, where iron of excellent quality has been produced for many years and where at present a considerable amount of iron which has a high reputation is smelted with charcoal. This district has a width along the Ohio river of 12 to 15 miles and extends northward into Ohio 65 to 70 miles. In describing the Hanging Rock iron ores it is stated in Vol. V., Geological Survey of Ohio, that "the ores are limonites or hydrous peroxides of iron, and, to a smaller extent, calcareous and argillaceous carbonates. The beds were, however, in their original condition as ores, probably all carbonates; but the oxidizing action of water and the atmosphere has changed them, wherever such action was possible, into hydrous peroxides or limonites."

There are four perfectly distinct and persistent seams of ore, varying from 4 to 16 inches in thickness, besides several accumulations of kidney ore in the accompanying beds of shale. The "red limestone" is the richest and most valued ore, and contains on an average about 40 per cent. of metallic iron, and those furnaces producing the best quality of pig iron use it almost exclusively. It contains on an average about 10 per cent. of silica, and the amount of lime and alumina is never very large in the clean ore. Manganese amounts, on an average, to somewhat more than 1¼ per cent. Sulphur is present in very small quantities, and in the mean of many analyses rarely exceeds 0.03 per cent. Phosphorus, however, is almost always present, and is the most considerable of the damaging impurities, there being on an average about 0.3 per cent.

The "block" ores are of much less importance than the ores of the limestone seam already mentioned, and, lying beneath this stratum at different depths, from 50 feet and more, are accessible only in the valleys of the western part of the region. They are limonite ores containing from 30 to 40 per cent. of iron, but are chiefly characterized as being more or less siliceous. The name "block" ore arises from the strata being cut by vertical seams, which divide them into blocks of quite regular shapes. In general, these block ores may be said to average about 8 or 10 inches, and to yield in the furnace about 33 per cent. of iron.

Besides these stratified ores the shales of the Coal Measures frequently contain large accumulations of kidney ore, the argillaceous carbonate or clay-iron-stone. It is an ore highly appreciated for the ease with which it can be reduced, though on an average it rarely contains more than 33 per cent. of iron.

The following are offered as typical analyses of Hanging Rock ores:

Red limestone ore vein.

	Roasted.	
	No. 1.	No. 2.
	Per cent.	*Per cent.*
Siliceous matter	7.27	6.85
Sulphur	.063	.172
Phosphorus	.108	.116
Metallic iron	54.810	47.902
Carbonate of lime	trace.	.715

Gray limestone ore vein.

	Per cent.
Metallic iron	40.88
Calcium carbonate	12.50
Siliceous matter	5.00
Manganese dioxide	2.35
Phosphorus	.232
Sulphur	.282
Organic matter	.950
Carbonic acid	21.00
Moisture	4.00

Gray kidney ore.

	Per cent.
Metallic iron	40.36
Silica	8.78
Carbonate of lime	5.25
Phosphate of lime	.43
Sulphur	1.04

Other analyses of iron ores in Lawrence county, Ohio.

	No. 1.	No. 2.	No. 3.	No. 4.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Silica	13.61	26.22	17.90	22.14
Alumina	3.00	.68	....	7.86
Oxide of iron	56.00	61.34	71.09	62.30
Lime	2.90	5.24	....	3.09
Magnesia	1.95	....	....	.92
Sulphur	.34	.117	....	....
Phosphoric acid	.32	.408	.68	....
Oxide of magnesia	....	.78	....	....
Iron	39.20	42.93	49.76	....
Phosphorus	....	.18	.29	....

The Mahoning region, in the northeastern section of the State, is the largest producer of iron, but the blast furnaces use chiefly Lake Superior ores, sometimes with a mixture of local carbonates or of black-band ores.

The Hocking region, in southern central Ohio, was in 1877–'78 the scene of unusual excitement in blast-furnace construction, owing to the convenience of ore, coal, and flux, which occurred in nearly horizontal layers, overlying each other; but the limonite, which as an outcrop was of such satisfactory character as to yield a high percentage of iron, degenerated under cover into lean carbonates or ferruginous limestone, and the coal was found to be of inferior quality for furnace use.

Analyses of some of the Hocking Valley, Ohio, ores after roasting.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Metallic iron	35. 37	36. 96	30. 20	44. 65	38. 70
Siliceous matter	11. 58	2. 73	15. 80	22. 15	35. 73
Lime	4. 47	3. 86	2. 97	1. 12	....
Alumina	1. 78	4. 82	10. 64	9. 31	....
Magnesia	1. 23	1. 87	1. 26	. 42	....
Phosphoric acid	. 60	. 83	. 16	. 41	1. 55
Sulphur	. 54	. 52	. 15	. 40	. 01
Phosphorus	0. 257	0. 356	0. 07	0. 175	0. 66

	Logan furnace, (from ore pile).	Moxahala furnace, (from ore pile).
	Per cent.	*Per cent.*
Siliceous matter	6. 18	....
Metallic iron	31. 80	37. 40
Phosphorus	1. 84	2. 41

Analyses of iron ores from Perry and Muskingum counties, Ohio.

	Perry County bowlder ore.	Muskingum County block ore.
	Per cent.	*Per cent.*
Silica	11. 97	5. 38
Iron protoxide	29. 04	42. 53
Iron sesqui-oxide	14. 43	7. 85
Alumina	6. 29	3. 61
Manganese oxide	. 83	1. 75
Lime	6. 10	3. 57
Magnesia	2. 83	2. 45
Carbonic acid	25. 68	31. 53
Phosphoric acid	. 828	. 431
Sulphur	. 024	. 241
Water and organic matter	2. 41	. 53
Moisture	. 41	. 38
Total	100. 842	100. 252
Metallic iron	32. 70	38. 60
Phosphorus	. 361	. 188
Sulphur	. 024	. 241

The limestone ores of this region are represented by the following determinations made by the State geological survey:

Analyses of limestone iron ores.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Metallic iron	28.6	28.2	29.0	29.3	45.2	46.7	39.2
Siliceous matter	13.7	45.8	17.0	11.2	10.2	17.75	27.6
Phosphorus	.24	.09	.17	.38	.30	.28	.26
Loss on ignition	28.7	11.6	22.0	24.5	16.9	13.0	13.6

The black-band ores are abundant in central Ohio; they range from 20 to 30 per cent. of iron, when crude, and from 45 to 55 per cent. iron when calcined. The following may be taken as typical analyses:

Analyses of black-band iron ores from the Mahoning valley, central Ohio.

	Raw.	Roasted.
	Per cent.	*Per cent.*
Volatile matter	30.50	....
Siliceous matter	11.84	24.0
Carbonate of iron	43.26	(*a*) 72.0
Oxide of iron	8.94	....
Oxide of manganese	1.00	} 4.0
Phosphate of lime	Trace.	
Carbonate of lime	1.87	
Carbonate of magnesia	2.03	
Alumina	Trace.	....
Sulphur	.18	....
Total	99.62	100.0
Metallic iron	27.12	54.4

a Sesqui-oxide of iron.

Analyses of black-band ores from the Tuscarawas valley, Ohio.

	Raw.	Calcined.	Raw.	Raw.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Carbonic acid	15.00	....	3.47	....
Water	....	0.25	} 27.36	20.06
Volatile matter	21.10	....		
Siliceous matter	26.22	17.02	13.26	11.89
Iron peroxide	8.79	75.00	41.08	2.00
Iron protoxide	23.02	....	1.80	(*a*) 52.61
Alumina	.70	.60	7.93	6.04
Manganese	1.70	1.65	1.10	.432
Lime	1.70	2.80	2.07	1.44
Magnesia	.88	1.48	.65	1.292
Phosphoric acid	.492	.773	1.362	.451
Sulphur	.11	Trace.	.175	1.08
Total	99.712	99.573	100.257	97.295
Metallic iron	24.06	52.50	30.15	26.80
Phosphorus	....	....	.592	.196
Sulphur	.11	.773	.175	1.08
Specific gravity	2.321	3.411	....	....

a Carbonate of lime.

Analyses of other raw black-band ores.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Silicic acid	25.52	24.16	26.22	30.32	21.84	27.20
Volatile matter	13.30	20.06	21.10	11.70	26.28	18.80
Iron carbonate	45.86	33.60	34.69	39.31	36.64	38.51
Iron sesquioxide	7.40	9.14	10.42	9.50	9.03	6.25
Alumina	.50	5.75	.70	....	1.00	1.00
Manganese	2.10	1.85	1.70	1.30	.30	2.35
Carbonate of lime	1.50	.95	2.00	2.86	2.00	2.72
Magnesium carbonate	3.26	4.20	1.84	2.50	1.96	2.49
Sulphur	.17	.30	.11	.31	.13	.21
Phosphoric acid	.096	.032	....	....	Trace.	.63
Phosphate of lime	....	....	1.07	1.20	....	....
Total	99.706	100.042	99.85	99.00	99.18	100.16
Metallic iron	27.32	22.62	24.06	25.63	24.00	22.96
Phosphorus	.043	.018	.27	.30	Trace.	.28
Iron in calcined ore	43.94	35.08	37.69	35.91	41.27	35.72

The thickness of these ores is greater than the others named, often reaching 6 to 10 feet in width, and reported in one case at 19 feet.

In southwestern Ohio there is a small development of lean fossil ore, one partial analysis showing:

Analysis of lean fossil ore from southern Ohio.

	Per cent.
Carbonate of lime	48.00
Iron	30.00
Phosphoric acid	1.28

The iron ores of Ohio cannot therefore be considered as of superior character, and it is probable that less ore was mined in that State in 1886 than was extracted ten years previous to that date.

The production of iron ore in Ohio in 1886 is given by Mr. Thomas B. Bancroft, inspector of mines, as follows:

Production of iron ores in Ohio in 1886.

Counties.	Black-band.	Hematite.
	Tons of 2,268 pounds.	*Tons of 2,268 pounds.*
Columbiana	....	11,651
Gallia	....	5,436
Hocking	....	10,173
Jackson	....	58,036
Lawrence	....	94,900
Mahoning	13,952	....
Perry	6,355	10,195
Scioto	....	11,112
Trumbull	12,251	....
Tuscarawas	51,389	....
Vinton	....	59,034
Total	83,947	260,537

THE LAKE SUPERIOR REGION.

The most important iron-ore producing territory of the country, furnishing the material from which nearly one-third of our total pig-iron product is made, is the Lake Superior region, embracing four districts, to which it is probable additions will be made, as it is hardly presumable that in a section as yet so unsettled the mineral wealth has been fully determined; these districts, in the order of their development, are—

1. The Marquette district of the north peninsula of Michigan, near to Lake Superior, which produced in 1886, 1,621,887 long tons.

2. The Menominee range, south of the Marquette district in Michigan and Wisconsin, which produced 880,006 long tons in 1886.

3. The Gogebic range, west of the Marquette and Menominee districts in Michigan and Wisconsin, which produced in 1886, 756,281 long tons.

4. The Vermilion district in Minnesota, which produced in 1886 304,396 long tons, making a total for the Lake Superior region of 3,562,570 long tons, and bringing up the aggregate output from this region (since the first mining in the Marquette district) in thirty-three years to 31,030,160 long tons. The progress of the region has been wonderful in late years, the phenomenal development of the Menominee range, ten years ago being outdone by that of the Vermilion and Gogebic districts, which were unbroken wildernesses three years ago.

Notwithstanding the unprecedented activity in the shipment of Lake Superior ores, but ten mines produced over 100,000 tons each in 1886, five of these being in the Marquette region, two in the Menominee region, and two in the Gogebic iron range. The tenth is the Minnesota Iron Company, which has several mines in the Vermilion district in Minnesota, the product of which is aggregated in its report. The following are the names of the mines and the districts in which they are located, placed in the order of their output in 1886:

Output of the ten largest mines in the Lake Superior region in 1886.

	Long tons.
Minnesota Iron Company, Vermilion district	304, 396
Lake Superior mine, Marquette district	267, 622
Colby mine, Gogebic district	257, 432
Republic mine, Marquette district	241, 161
Cleveland mine, Marquette district	203, 664
Chapin mine, Menominee district	198, 871
Vulcan mine, Menominee district	143, 930
Champion mine, Marquette district	137, 593
Lake Angeline mine, Marquette district	131, 731
Norrie mine, Gogebic district	124, 844
Total for ten mines	2, 011, 244

This is more than one-half of the aggregate product of the four Lake Superior districts.

The annual output of the Lake Superior region did not reach 500,000 long tons until after 1868; in 1873 over 1,000,000 long tons were mined.

This last figure, however, was not again reached until 1877, since which time the output has, with one or two exceptions, steadily increased, passing 2,000,000 long tons in 1881, and reaching 3,562,570 long tons in 1886.

Up to the present time no one district or group of mines has produced as much iron ore as the mines comprising the Marquette district, where mining commenced in 1854; in 1886, 1,621,887 long tons were taken out, the total to date being 23,346,819 long tons. The year 1887 will be one of great activity in this district; it will produce more ore than last year, possibly an increase of 400,000 tons; but this increase will come from small non-Bessemer producers that can work advantageously on a high-priced market. Every one of the large Marquette County mines may be considered as now worked to nearly full capacity, and there is apparently no practical way to increase their output materially.

The old mines are in the main looking fairly well, though, of course, each year's product depletes them more and more, but they will be enabled to keep up their usual average of shipments for years to come. As the old lenses of ore fail in them, others are opened, but all the time the mine becomes deeper, and more uncertain and difficult and expensive to work. The Champion mine is now from 600 to 700 feet deep, the Republic is nearly as deep, and the Lake Superior, Cleveland, and Barnum mines are from 450 to 550 feet down. The York, once a prolific mine, appears now to be practically exhausted; it had produced at the close of 1886, 1,035,001 long tons.

The maximum output of the Marquette district was 1,831,357 long tons in 1882, and the shipment of 1,621,887 long tons in 1886 makes that year rank second, while 1881, with 1,587,831 tons, and 1884, with 1,557,389 tons, rank third and fourth, respectively. Iron was first mined in this district at the Jackson mine, Negaunee, forty years ago, and the first iron manufactured from it was made at a bloomary in the neighborhood, but it was not until 1855, when the Sault Sainte Marie canal was cut through, that any regular shipments were made to ports on the lower lakes. Since then the shipments have been rapidly and almost steadily increasing. The deposits of ore are found in the Huronian series, overlying the Laurentian, and the workable ores, giving their trade designations, embrace the "red specular," "magnetic," "second class," "soft hematite," and the "flag" or "slate" ores. The topography of the region is an alternation of high and rocky hills with swampy ground and lakes. The general direction of the whole series is east and west, though the Republic group is situated some 10 miles to the south of the "range." The remarks made above concerning the depletion of the mines must not be interpreted as imputing failure or exhaustion, but it should be remembered that in treating of the Lake Superior mines we deal in large figures, and what elsewhere would be rated as a large mine is here of ordinary dimensions.

To appreciate properly the importance of the Marquette district the following notes concerning some of its remarkable mines are presented:

The Lake Superior mine heads the list as a producer, having commenced shipments in 1858 with 4,658 tons, reaching in 1867, 149,935 tons; it has never fallen below 100,000 long tons per annum since that date. It reached its maximum output in 1882, when 296,509 tons were shipped, and up to the close of 1886 (twenty-nine years) it had produced 3,892,195 long tons.

Second in order is the Cleveland mine, which shipped 3,000 long tons in 1854 and reached an output of 102,112 tons in 1868, which figure has been exceeded every year since that time, the maximum shipment of 225,674 tons being in 1884, and the total to close of 1886, 3,497,213 long tons.

The Jackson mine, which produced 30,000 long tons in 1856, reached in 1867 an output of 127,491 long tons, and attained its maximum in 1871, 132,297 tons; the total shipments to date being 2,604,551 long tons.

The Republic mine opened in 1872 with a shipment of 11,025 tons. It increased the output in the year following to 105,453 tons, which figures have been exceeded in every succeeding year, the maximum output being 277,757 tons in 1884; the total shipments to close of 1886 were 2,582,826 long tons.

The Champion mine commenced shipments in 1868 with 6,255 tons, reaching in 1880, 112,401 tons, and attaining a maximum product of 210,180 tons in 1884; the total to the close of 1886 being 1,761,564 long tons.

It will thus be seen that, including the York mine referred to above, six mines in the Marquette district have reached aggregate productions exceeding 1,000,000 tons, and the grand total for these six mines is 15,373,350 long tons, or 65 per cent. of the total output of the Marquette district. This leaves a total production of 7,973,469 long tons for the remaining fifty-three mines which have been or are now operated in the Marquette district.

In addition to the analyses given by Mr. Swank the following are presented by Mr. T. B. Brooks, of the geological survey of Michigan, as representing the average composition of the four classes of ore produced in the Marquette district. The determinations of ore from special mines vary considerably from these figures, notably in the amount of phosphorus.

Average composition of the non-Bessemer iron ores of the Marquette district, Michigan.

	Red specular ores.	Black magnetic and slate ores.	Soft hematites.	Flag ore.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Protoxide of iron	....	19.639	....	....
Sesquioxide of iron	90.52	67.761	75.75	70.98
Oxide of manganese	Trace.	.13	.80	Trace.
Alumina	1.39	2.13	1.536	2.01
Lime	.70	.68	.36	.45
Magnesia	.42	.69	.294	.20
Sulphur	.05	.132	.110	.03
Phosphoric acid	.258	.199	.185	.13
Silicic acid, silica, or insoluble siliceous matter	5.892	7.828	14.035	25.12
Water combined	.77	.811	3.94	1.08
Water uncombined			1.18	
Volatile matter	....	....	1.81	....
Total	100.000	100.000	100.000	100.000
Metallic iron	62.915	62.93	52.649	49.332
Phosphorus	.111	.085	.078	.053
Metallic manganese	Trace.	.091	.56	Trace.
Sulphur	.05	.132	.11	.03
Specific gravity	4.74	4.59	3.88	4.09

The Menominee range commenced shipments of ore in 1877, when 4,593 tons were produced from the Vulcan mine, but the district was not fairly opened and railroad connections secured until 1879, when the output was 245,672 tons. In 1886 the product of the range was 880,006 long tons.

The Chapin, Ludington, Vulcan, and Norway mines continue to hold good rank as shippers, although none of them will probably again reach the output of former years. The Norway produced in 1886 about half of her maximum product, and all are getting deep for soft-ore mines to be profitably worked.

A sketch of the operations of the Hamilton Ore Company, furnished by Mr. J. T. Jones, shows a shaft sunk at the boundary of the Chapin, Ludington, and Hamilton properties as passing vertically through 650 feet of hanging wall to strike the ore body which the No. 1 shaft of the Ludington mine encountered under the surface and followed to a depth of over 500 feet. The Hamilton shaft has reached a depth of 900 feet, and a drill hole passed through 400 feet additional before striking the foot wall. The plan shows a body of ore and vein matter 140 feet wide on a dip of 75°. No new discoveries of any remarkable promise have been made in the range in years, though under the stimulus of prices many abandoned workings have been reorganized and much prospecting has been going on continuously. The annual limit of the range is probably 700,000 tons of non-Bessemer and 250,000 tons of Bessemer ore as it now appears, but a good "strike" may materially augment these figures.

The Chapin mine has been the greatest producer in the Menominee range. Starting in 1880 with a shipment of 34,558 tons, it reached

134,521 long tons in the following year, and never fell below this output in succeeding years. The shipment in 1886 was 198,871 tons, and the maximum was reached in 1884, when 290,972 tons were shipped; the total to the close of 1886 has been 1,329,686 long tons, an average of 189,955 tons per annum, making the Chapin mine lead any other mine in the Lake Superior district, which has been a producer for a number of years.

Next in order of production is the Norway mine, which was opened in 1878 with a shipment of 7,276 tons, reaching in 1880 a maximum of 198,165 tons, and producing 93,876 tons in 1886, bringing the total up to 919,749 long tons.

The Vulcan, the pioneer mine, opened in 1877, produced 4,593 tons in that year; in 1884 it reached an output of 101,722 tons, and attained its maximum in 1886, with a shipment of 143,930 tons, making its total output 816,305 long tons. The Vulcan is the only large producer in the Menominee range which has not exceeded the shipment of 1886 in previous years. It will thus be seen that up to date these three mines, Chapin, Norway, and Vulcan, have produced 3,065,740 long tons, close to one-half of the total output of the Menominee range to date.

Several mines which have been on the list as great producers attained but a small proportion of their former product in 1886. Among these may be mentioned the Ludington, which opened in 1880 with a shipment of 8,816 tons; it reached its maximum in 1885, the production amounting to 124,194 tons, and produced in 1886, 74,454 tons, bringing the total to 466,787 long tons. The Florence mine shipped in 1880, its first year, 14,143 tons, attained its maximum in 1882: 160,155 tons, and produced 8,210 tons in 1886, making the total 323,241 long tons. The Commonwealth opened in 1880 with a shipment of 9,643 tons, reached an output of 115,862 tons in 1882, and produced in 1886, 51,186 tons, a total to date of 351,673 long tons.

The Iron River mine commenced shipping in 1882, with 29,115 tons, reaching 100,369 tons in the following year, and in 1886 it shipped 78,591 tons, a total to date of 316,352 long tons.

The Perkins mine has produced a total of 342,224 tons since 1879, when it was opened; its maximum output was in 1883, viz., 76,514 tons, and its shipment in 1886 was 12,852 long tons.

The total product to date of these last five mines is 1,800,277 long tons, about 30 per cent. of the total output of the district. This figure added to the output of the Chapin, Norway, and Vulcan mines as given above, leaves a total of 1,330,670 long tons as the product of the remaining twenty-five mines which have been or now are operated.

The year 1882 was also the year of largest production in the Menominee range, when 1,135,018 tons were mined, 1883 following next with 1,047,863 tons, then 1884, producing 895,634 tons, and 1886 fourth, with 880,006 long tons.

The two ranges combined only exceeded the output of last year in 1882, when 2,966,375 tons were shipped, as against 2,501,893 tons in 1886. The outputs of these ranges since 1880 have been as follows:

Combined output of the Marquette and Menominee ranges from 1880 *to* 1886.

Years.	Long tons.
1880	1, 908, 647
1881	2, 314, 502
1882	2, 966, 375
1883	2, 341, 227
1884	2, 453, 023
1885	2, 110, 857
1886	2, 501, 893
Total	16, 596, 524

Up to 1884 these ranges comprised the Lake Superior region, but in that year the Gogebic and Vermilion mines commenced shipments; it was not, however, until 1885 that they materially affected the totals, the total output from the four districts having been as follows:

Total output from the Lake Superior region in the past three years.

Years.	Long tons.
1884	2, 518, 048
1885	2, 456, 548
1886	3, 562, 570

THE GOGEBIC RANGE.

The importance of the Marquette and Menominee ranges having been well considered by Mr. Swank in his contribution (*vide* "Mineral Resources of the United States," 1883–'84, pages 257 to 290), further note of them and the composition of their ores will not now be attempted, but the newer regions (the Gogebic and Vermilion) will be treated more in detail; not because they are of greater importance, but because their later development has permitted of but a limited publication of their extent and character. In order of importance as shippers the various districts comprising the Lake Superior region ranked in 1886 as follows: (1) Marquette; (2) Menominee; (3) Gogebic; (4) Vermilion, and this order will be maintained in 1887, with the possibility of the Gogebic and Menominee ranges changing places, but it is probable that these two districts will not vary greatly in their outputs for 1887.

Geographically the Gogebic iron range may be described as running nearly parallel with the southern shore of Lake Superior and about 15 miles distant from it. The Montreal river (which is the boundary between the State of Wisconsin and the upper peninsula of Michigan), flowing northward into the lake, cuts through the range nearly midway between the extremes of the present exploitations, about one-half of the ore strike, as now believed to be determined, lying in Ontonagon county, Michigan, and the other half in Ashland county, Wisconsin.

The occurrence of ores similar in character to those of the Gogebic iron range in lenses or pockets in the Marquette and Menominee ranges naturally points to like deposits in this newer district, and there seems good reason to believe that the ores lie in lenses of greater or less width and depth throughout an ore-bearing stratum confined by the quartzite hanging wall of what is believed to be the north vein, and the foot wall of what is usually known as the south vein, with a greater probability of finding the ore in this newer region, owing to the apparent persistence and regularity of the foot wall. Local opinions favor, however, and not without reason, the existence of two veins, although the presence of two apparently distinct ore bodies is shown so far in but few instances. The belief in the existence of two veins is based upon their positions relative to the foot wall, and also to a greater percentage of manganese in the south vein.

The mines already opened and worked show a high grade of red hematite ores, most of which are strictly of the Bessemer class, the balance of the ore prepared for shipment being rich in iron and close to the Bessemer limit in phosphorus. While some ores high in manganese are mined, none can be said to be high in phosphorus, and it is doubtful if the run of any of the developed properties would show 2 parts of phosphorus in 1,000 of iron. It may be asserted as a rule that where the ore lies in large masses but little of it will require sorting, and even in mining the proportion of lean ore and foreign material is insignificant, except near the confining walls or where "horses" of rock occur. These "horses" are by no means uncommon, and are found in most of the mines now extensively opened, but they are not a cause for discouragement; for already after passing through a "horse" ore has been found below it, or the projection of a "horse" into the ore body has apparently forced the ore in front of it. A fact of apparent similarity to the older regions is in the grouping of the large producers along a comparatively limited strike, and it is probable that the Gogebic range will show the great proportion of its future shipments made from a few large mines.

As the dip of the ore-bearing rocks is 65° to 70°, the usual method has been to open a slope on the foot wall, carrying it down on this wall of quartzite and drifting in levels from it. Some of the mines show open cuts where the drift resting upon the ore deposit was light, and in these the skip roads are laid on the foot wall. The methods of mining have been influenced to a considerable extent by the desire to get the ore out promptly and place the mines in the list of producers, with the object of appreciating the market value of the stocks. The appearance of the ores from the various mines and in some cases from the same mine differs materially both as to color and hardness. The colors are nearly black, blue black, brown, and almost brick red; the hardness varies from a soft mass of finely comminuted ore to compact lumps, and occasionally grape, needle, or kidney forms, with brilliant surface. Up to the present time the shipments have been confined to ores within the Bessemer limit, of 1 part of phosphorus in 1,000 parts of iron, or 0.06 phosphorus in an ore containing 60 per cent. of iron; and where the amount of phosphorus exceeds this limit, the average has been maintained by mixing with ore lower in phosphorus. There will, however, be a considerable supply of rich ores which may be available for other than Bessemer purposes, and these should find a ready market.

From the Gogebic mines the following amounts were shipped in the first and second years of development:

Production of iron ores from the leading Gogebic mines in 1885 *and* 1886.

	1885.	1886.
	Tons.	*Tons.*
Colby	84,302	257,432
Norrie	15,419	124,844
Ashland	6,471	74,015
Germania	5,634	20,069
Aurora	....	94,553
Iron King	....	29,184
Ironton	....	18,424
Kakagon	....	18,497
Pabst	1,103	17,688
Puritan	....	16,388
Total for 1886	....	671,094

Between the eastern and western extremes of practical exploration upon the Gogebic iron range the distance is fully 30 miles, but the properties held as iron-lands extend to the east and west of these extremes. The real work of development to date is covered by a distance of about 20 miles along the ridge.

The most eastern section which may be fairly considered as open is locally known as the Sunday Lake district, having Wakefield, Michigan, as its business center. Here several mines, notably the Brotherton, Sunday Lake, and Iron Chief, shipped in the aggregate about 31,000 tons of ore in 1886 from underground workings, and as in this vicinity the ridge is less defined and the ground at a lower level, the exploitation has been more expensive and difficult and the progress less marked than elsewhere. The ore-bearing rocks apparently strike through Sunday lake. Following west 3 miles the Black river cuts through the ridge, and the ore has been found in this gap. Three miles still further, the highest elevation of the ridge is found (reported as 1,100 feet above Lake Superior or 1,700 feet above tide) at the Colby mine, which overlooks the town of Bessemer, Michigan, built on the northern slope of the ridge. Just west of the Colby mine the strike of the ore-bearing rocks crosses a valley about half a mile wide, and then follows the ridge for about 5 miles to where the main branch of the Montreal river cuts through it, and in the western half of this section are found three mines, the Aurora, Norrie, and the Ashland, which, next to the Colby, have been the principal producers, and whose aggregate output for the year 1886 was about 320,000 tons; in addition others of smaller capacity are operated. After rising from the valley of the Montreal river into Wisconsin the ore mines are on elevated ground for about 3 miles, in which there are several producers.

After crossing the west branch of the Montreal river there are few more producing mines, but exploitation has been carried beyond this stream for 3 miles, and further west large syndicates own land on which prospecting is fairly active.

The Colby mine, the best known and the largest developed working in the Gogebic iron range, is at present operated under a lease which has less than two years to run. The time limit has undoubtedly encouraged the large outputs of 84,302 tons in 1885, the first year of actual working, and 248,810 tons in 1886. The mine being located at the most elevated point in the region, is reached by a switch-back railway connection which formerly ran directly into the open workings, and the ore was dug and loaded on to the cars which carried it to Ashland for shipping. While the open pitwork of the Colby and Aurora mines are the features of the Gogebic region, the deposit as found in the Norrie and Ashland mines indicates what may be considered as specially good mines, and if one-half of those already operating can reach the output of these the district will be an enormous producer. As underground workings must eventually be generally adopted, the operations of these two mines will prove a guide as to the future possibilities of others according to the width of the ore bodies. In them are also found the "horses" which add to the uncertainty of the mining enterprises.

Judging from present developments it would appear that the Gogebic iron range has as advantages over the Marquette and Menominee ranges, a better average quality of ore for Bessemer purposes, an apparently more regular formation and consequently greater probability of continuity of the ore body, or of connecting lenses and the possibility, for the present at least, in a number of cases of cheaper mining. As compared with the older districts, the Gogebic iron range has a longer distance to transport its ore by lake and a shorter season of navigation; if the railroad connections projected are carried out, and an outlet at Escanaba or on Green Bay is obtained, the distance from such port or ports will necessitate a longer haul by railroad than from either of the other districts. As compared with the Vermilion district in Minnesota, the Gogebic iron range has a shorter haul by railroad to its present shipping point, and also shorter lake transportation.

A second range, 12 miles south of and nearly parallel to the Gogebic range, gives strong magnetic attraction, and parties are now exploring for magnetic iron ores. What the future will develop is beyond surmise, but it does not seem at all improbable that the iron regions tributary to Lake Superior will continue to augment their output, and that new discoveries will make this great region a producer of iron ore second to no other. Within a year a rival in importance to the Gogebic iron range may be discovered, and even now preliminary work is being done on properties far removed from either of the districts now developed. Most of the mines that were on the shipping list in 1886 have been sinking and opening up ground for the season's work. No large deposits have been found during winter development except possibly at the Anvil and Ryan. A great many explorations are being carried on, but the most productive portion of the range seems to be in Michigan, from the Montreal river to the Colby open quarry (11 miles). The greatest depth which has been attained is 275 feet at the Ashland mine. The Norrie mine comes next, being 250 feet deep.

The Ashland mine has not opened up much ground on the fourth level, so that while it cannot be affirmed that the vein widens as it increases in depth, still the lens is wider at the third than at the second level and much longer. The third level of the Ashland showed a width in the fall of 1886 of 145 feet when "soaprock" was struck. In May, 1887, a cut made through about 15 feet of this (the supposed hanging wall) was made, and ore again found that analyzed 63 per cent. of iron and 0.011 of phosphorus. A cross-cut 35 feet in this ore at last reports showed no signs of a hanging wall.

Analyses of some of the ores of the Gogebic region.

	Iron.	Phosphorus.	Silica.	Manganese.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Iron King mine:				
North vein	60.85	0.027	5.44	1.30
South vein	55.74	.034	3.47	12.28
Norrie mine:				
From stockpile	62.83	.0474	5.18	
Aurora mine:				
From cars	62.93	.0278	3.65	
Germania mine: (a)				
From stockpile No. 1	59.38	.058		
Number 2	59.70	.056		
Pabst mine (check sample):				
Searle, of Hurley	58.47	.040		
Haldeman, of Colby	58.46	.044		
Joliet Steel Works		.031		
Camp, of Pittsburgh		.035		
W. J. Olcott	58.38	(b).037		
		(b).036		
		.036		
Superior mine:				
1	64.83	.047		
2	65.18	.040		
3	64.25	.054		
4	59.30	.079		
Anvil mine	60.00	.035	4.00	3.88
Ryan mine:				
1	61.78	.050		
2	64.15	.064	3.73	
3	57.67	.044		
Hoppenjar mine (magnetic ore)	51.49	.059		
Ashland mine (average for season's shipments, 48 cargoes)	64.50	.047	3.65	

a Messrs. Kerr & Olcott, analysts. *b* Volumetric.

The occurrence of manganese cannot from present exploitations be considered as being at all regular, but its appearance in what is called the south vein is more general than in the ore of the so-called north vein. The proportions of this metal vary from a trace to 33 per cent. in quantities of ore, and specimens of pyrolusite are found. Alumina is found in most of the ores, the amount varying from 0.5 to 5 per cent., while the sulphur is from 0.03 to .13 per cent. Water to the extent of 5 per cent. exists in the hard ores and to a greater amount in the softer varieties. Traces of sulphur, magnesia, and lime are also determined by analysis.

The Colby mine produces an ore which carries more manganese than most of those on the Gogebic range, the average composition of the ore as shipped being as follows:

Average composition of shipments of iron ore from the Colby mine, Gogebic range.

	Per cent.
Iron	58.5
Manganese	3.5
Phosphorus	.04

Some of the ore taken from what was termed the south vein carried as much as 33 per cent. of manganese. Other analyses of the ore from this mine show the following:

Additional analyses of iron ore from the Colby mine, Gogebic range.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Iron	58.67	59.59
Silica	5.87	6.13
Phosphorus	.049	.05
Alumina	1.05	.51
Manganese	3.49	8.45

The location of the Colby mine near the crest of the hill, and the ore-bearing matter being of such thickness as to permit of mining it in open quarry along the strike of the vein, makes it probably rank next to the Cornwall ore hills of Pennsylvania for cheap mining, with the Aurora mine following third. As the workings follow down, the expense of extraction in this region will be augmented, and either the present methods must be changed or expensive timbering employed. Already some of the deeper mines find the cost of timbering too great, and experiments are being made with a view to working the deposits out and allowing the roof material to fall as the mining progresses. The ore as a rule is too soft to be reliable for pillars or supports.

In addition to the portion of the Gogebic range which lies in Wisconsin, that State has a considerable amount of brown hematite and fossil ores, which have supplied ore for an iron-producing industry, which has been active for a number of years. The most interesting of these Wisconsin ores is a large deposit near the western shore of Lake Michigan, where the fossil ore occurs in lenticular grains, resembling in appearance flaxseed, from which it takes its name.

Analysis of "flaxseed" ore, Dodge county, Wisconsin, by C. E. Wright.

	Per cent.
Peroxide of iron	61.38
Alumina	6.05
Carbonate of lime	17.14
Carbonate of magnesia	8.40
Peroxide of manganese	.12
Silica	3.49
Sulphuric acid	.05
Phosphoric acid	2.91
Total	99.54
Metallic iron	42.97
Phosphorus	1.27

MINNESOTA.

The most important development of iron ore in Minnesota is near Tower, Saint Louis county, a town which owes its existence to the opening of a large deposit of specular iron ore by the Minnesota Iron Company. In exploring the country in the year 1875 in the neighborhood of Vermilion lake, about 70 miles northwest of Lake Superior, a fine outcrop of ore was discovered on a ridge with a strike nearly east and west. After a critical examination of the exposure, test pits were sunk to determine the persistence of the ore body. The showing in them and the uncovering of outcroppings were so satisfactory, that the present owners purchased large tracts of land, arranged for mining equipment, constructed a railroad from Agate bay, or Two Harbors, through a then unbroken wilderness, for 68 miles to the ore body, and erected shipping docks for handling the ore from cars to vessels. At the close of the year 1886 this railroad was extended 26 miles southwest from Two Harbors to Duluth.

The shipments from the dock at Two Harbors up to date have been as follows:

	Long tons.
1884, August 1 to November 1	62,124
1885, May to November	225,484
1886, May to November	304,396
The shipments of 1887 are estimated at	400,000

The mines are in two series of nearly parallel ridges, dividing a great swamp into different drainage areas, from some of which the waters flow into Lake Superior, from others into Hudson's bay, and from still others into the Mississippi river. Geographically the present development is 80 miles due north of Duluth, about latitude 48°. To reach the mines from the lake the railroad ascends 1,100 feet in the first 12 miles after leaving Lake Superior, and then crosses a series of ridges dividing the swamps at elevations of from 800 to 1,000 feet above the lake, the latter being the approximate altitude of the mines, viz, 1,000 feet above Lake Superior, or 1,600 feet above the ocean level.

The developments show apparent lenses of ore lying *en échelon* between nearly vertical walls, the foot wall being slate and the hanging wall banded jasper and "soap rock;" the widths and depths of the excavations vary; in fact, no absolute data concerning the depth of the deposit has yet been obtained, for all shafts heretofore sunk have been in ore. There are two apparent ore strikes on different ridges about half a mile apart, the larger workings being on the north ridge, the one nearest Vermilion lake. The excavations are all open quarries, but in the future it is the intention to do much of the mining under ground; the existence of ore between the two ridges has also been determined by wells, etc. On the north ridge the ore deposit is being worked almost continuously on a strike of about one mile; in fact, the openings are all operated under one management, and in several instances the workings run together. The openings along the north ridge are known by various names, and from west to east they may be described as follows: The Breitung opening is about 100 feet long and 50 feet deep, showing irregular widths of ore from 10 to 40 feet, and a strike less defined than found to the east. The Tower No. 1 opening is 250 feet long, 100 feet deep; the ore body is from 20 to 60 feet in width; at one point it was 155 feet wide. A shaft is now being sunk in the bottom and is 25 feet in ore. The Tower No. 2 opening is 150 feet long, 60 feet deep, and has an average width of 100 feet of ore. Where the surface is stripped, a width of fully 200 feet is exposed, but this has not yet been reached in mining. The Ely opening is 400 feet long, 50 feet deep, and from 20 to 120 feet in width. The Stone pit is opened for 700 feet in length and 100 feet in depth, the ore body varying from 6 to 120 feet in width. A shaft is being sunk in the bottom, and is now down 40 feet. The Stuntz opening is 300 feet long, 50 feet deep, and 20 to 60 feet wide. On the south ridge there are two openings:

The North Lee has been opened 200 feet in length, 50 feet in depth, and 30 to 40 feet in width; a shaft has been sunk 50 feet below the bottom and drifts are being run from this. The South Lee shows a vein 20 feet wide, exposed for about 100 feet in length, but little ore has been taken from this exposure up to the present time.

The ore is hard, and must all be removed by explosives, dynamite, with about 50 per cent. of nitro-glycerine, being chiefly used, but the hard character of the ore has its compensation in furnishing firm pillars for future underground workings, and in being richer in metallic iron than the softer ores. An interesting study of glacial action is offered by the faces of the great ore body as exposed by stripping; this has in some cases deeply scored the hard ore, and in others polished great surfaces to nearly a metallic luster. The stripping will scarcely average 8 feet of bowlder drift; the greatest depth so far encountered is 25 feet, and for a considerable portion of the strike the ore protruded from or lay just beneath the soil.

The character of the ore is a hard specular of unusual richness; in physical character closely resembling that taken out of the Champion mine in the Marquette district, and some of the best specimens from the Ashland mine in the Gogebic region. To indicate the character of the ore chemical analyses will be quoted, but a reliable index is the fact that the company has made one contract for the current year, which is for the delivery of 135,000 long tons of ore guaranteed not to average below 67½ per cent. metallic iron, and with phosphorus not to to exceed 0.06. In addition, the company will ship over 200,000 tons of ore guaranteed to average at least 67 per cent. of iron, with phosphorus 0.06, and 40,000 to 50,000 tons of ore guaranteed to show between 62 and 64 per cent. of iron, with phosphorus at 0.06 per cent. There are one or two companies who could deliver large amounts of ore as rich in iron and as low or possibly lower in phosphorus, but there is probably no iron-ore company in the United States that would undertake to meet the above guarantee for 350,000 tons of ore in 1887.

An examination of one hundred and fifteen analyses, made by F. Prince, M. E., of Minnesota Bessemer ore, as taken to the stock pile, from January 1 to March 31, 1887, shows an average of iron, 67.7; phosphorus, 0.06; silica, 1.5. The lowest determination was iron, 65.29; phosphorus, 0.067; silica, 3.79.

And the highest was iron, 69.28; phosphorus, 0.049; silica, 0.68.

The phosphorus in the Vermilion ores varies considerably, the extremes being from 0.021 to 0.110; but in most of the ore as now found it is between 0.04 and 0.07. The following are complete analyses of the ore taken from the different stock piles and analyzed by Mr. Prince:

Analyses of iron ores from the Vermilion range.

	Per cent.	Per cent.	Per cent.
Iron	67.99	68.37	68.32
Phosphorus	.053	.057	.046
Silica	1.35	1.10	1.35
Alumina	....	.50	.25
Magnesia	....	.014	Nil.
Sulphur	.005	.007	Nil.
Loss by ignition	....	.56	.66

It is noticeable that the leaner ores are of practically the same composition, except as to silica, as the rich ore, indicating that the inferior ores are those which, lying near the walls or horses of rock, carry free silica. In mining this ore, as above stated, two grades only are made; the great bulk of the ore (fully five-sixths of all that is mined) is sold as Minnesota Bessemer, and is guaranteed to contain: Iron, 67½ per cent. or over; phosphorus, 0.06 or under; while the second grade of ore, Red Lake, is merely the ore which, being mined close to the walls or "horses" of rock, has more free silica; it is sold to yield iron 62 per cent. or over; phosphorus, 0.06 per cent. or under. In mining the ore the walls are fairly well defined, so that but comparatively small quantities of waste are taken off with the ore. The dump piles of refuse would, however, show from 25 to 45 per cent. of iron. Some of this refuse is used for metaling the road bed of the Duluth and Iron Range railway. In estimating for ore in stock piles, it is found that 9 cubic feet will weigh one long ton.

The remarkable purity of the ore and the extent of the deposit at Vermilion lake has encouraged active operations along what is believed to be the strike of the ore, and also upon other ridges, notably one known as the Messaba range, about 15 miles south of the present developments. Some of these explorations have been so satisfactory that it appears very probable that Minnesota will vie with Michigan and Wisconsin as an iron ore producer. The developments east of the mines which are now operated were sufficiently encouraging to secure preliminary steps being taken for the construction of a railroad over 100 miles in length from Duluth, but the parties interested finally purchased the mines of the Minnesota Iron Company, just described, and of the Duluth and Iron Range railroad at a price which made it one of the largest transactions consummated in this country; by this arrangement it is expected that the ground already prospected will be promptly opened and much ore produced for shipment via Lake Superior. Until further developments are made information as to their extent or character cannot be supplied, but an idea of the possible character of the ores to be obtained from this new district is presented by the following analyses of magnetic iron ores claimed to have come from the Messaba range:

Analyses of magnetic iron ore from the Messaba range, Minnesota.

	No. 1.	No. 2.	No. 3.	No. 4.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Iron	63.13	65.62	64.33	58.74
Phosphoric acid	.37	.18		.23
Water				.45
Siliceous matter	8.70	4.06	9.98	13.28
Sulphur				
Lime	1.69	3.15	2.04	1.18
Magnesia	.52	.50	1.29	.98
Manganese	.54	.42	1.01	1.36
Alumina	.22	.35		.62
Specific gravity				4.53

Numbers 1 and 2 were by Mr. Taylor, of Cleveland; number 3, by Mr. Campbell, of New York; number 4, by Mr. Britton, of Philadelphia.

The following analyses by Mr. Courtis, of Detroit, are reported to represent surface magnetite from a point 35 miles northwest of Lake Superior, at Grand Marais:

Analyses of surface magnetite from Grand Marais, Minnesota.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Ferric oxide	54.50	56.38
Ferrous oxide	20.83	23.52
Phosphoric acid	.055	.067
Sulphur		
Titanic acid	None.	None.
Silica	21.47	18.075
Manganese	Trace.	Trace.
Undetermined	3.145	1.958
Total	100.000	100.000
Iron	54.35	57.88
Phosphorus	.0214	.029

MARYLAND.

The brown hematites which occur in southern Pennsylvania are also found in central Maryland, and the carbonate ores which have been used by the charcoal blast furnaces in the neighborhood of Baltimore are chiefly found as nodules in pockets of moderate size; they are mined in the eastern section along with occasional limonite. An analysis of the latter ore, after being calcined to drive off water and carbonic acid, is as follows:

Analysis of brown hematite from central Maryland.

	Per cent.
Peroxide of iron	63.394
Alumina	7.204
Oxide of manganese	2.740
Silica	20.460
Sulphur	trace.
Phosphoric acid	397
Metallic iron	45.776
Metallic manganese	1.974
Phosphorus	.173

Bog ores were formerly smelted on the Eastern Shore, but none are now mined there, and several unimportant magnetite and fossil deposits exist in the State.

VIRGINIA.

This State has an abundance of brown and red hematites which support a rapidly growing iron producing industry. Prof. A. S. McCreath has treated many of these deposits in detail in a monograph called the "Mineral Wealth of Virginia," from which the following résumé is taken:

Shenandoah Valley ores.—"The average of thirty-four samples of the brown hematite ores (excluding the manganiferous ores) from the Shenandoah Valley shows the following composition when dried at 212° F.:

Average analysis of thirty-four samples of Shenandoah Valley (Virginia) iron ores.

	Per cent.
Metallic iron	48.834
Phosphorus	.477
Phosphorus in 100 parts iron	.976

"Of these, seven samples represent very cold-short ores, which would be specially adapted for the manufacture of pig iron for conversion into steel by the basic process." They show an average composition as follows:

Analysis of ores for the basic process from the Shenandoah valley, Virginia.

	Per cent.
Metallic iron	49.580
Phosphorus	1.322
Phosphorus in 100 parts iron	2.666

Omitting these from the calculation we get the following, which will perhaps show more accurately the general average character of the Shenandoah Valley ores:

Average character of Shenandoah Valley iron ores.

	Per cent.
Metallic iron	48.646
Phosphorus	.259
Phosphorus in 100 parts iron	.532

New River and Cripple Creek region.—Along New river and Cripple creek, in southwest Virginia, there is an iron-ore belt in the body of the great limestone formation which yields ores of remarkable purity and seemingly in great abundance. For a distance of 25 or 30 miles the ore possesses great uniformity in character. The average of seventeen samples of these limestone ores shows the following composition when dried at 212° F.

Average analysis of limestone ores from the New River and Cripple Creek region.

	Per cent.
Metallic iron	54.514
Phosphorus	.106
Phosphorus in 100 parts iron	.194

"Only one sample shows less than 50 per cent. metallic iron; and in no case is the phosphorus over 0.2 per cent. While perhaps only a few of them can be used *per se* for the manufacture of Bessemer pig iron, nearly all of them would be found sufficiently low in phosphorus to be valuable for mixture with more refractory Bessemer ores."

The analyses of nine samples of the red hematite and magnetite show the following average:

Analysis of nine samples of red hematite amd magnetite from the Cripple Creek region, Virginia.

	Per cent.
Metallic iron	62.090
Phosphorus	.032
Phosphorus in 100 parts iron	.51

The brown hematite ores which are sometimes found accompanying them are equally pure, especially in regard to phosphorus. The average of four samples shows the following:

Average of four samples of brown hematite ores from the Cripple Creek region, Virginia.

	Per cent.
Metallic iron	54.532
Phosphorus	.031
Phosphorus in 100 parts iron	.056

The largest development during 1886 was in the Cripple Creek and New River section, and from a subsequent paper (Comparison of Some Southern Coke and Iron Ores, Transactions of the American Institute of Mining Engineers, Vol. XV.) the following is taken:

"The Cripple Creek ore-supply consists entirely of brown hematites or limonites from two grand geological horizons: (1) A lower, slightly leaner and harder limonite, generally referred to the transition slates occurring between the Potsdam sandstone No. I. and the Cambro-Silurian limestones No. II., and locally known as the 'mountain ores'; and (2) an upper, generally neutral, richer and less siliceous limonite, occurring in the body of the great valley limestone formation, and called locally 'limestone ores.' Analyses of the ores dried at 212° F., all personally sampled and incorporated without any selection in the two following lists, according to their determined geological horizons, show the following composition:

Analyses of iron ores associated with Potsdam Sandstone formation No. I. in the Cripple Creek region, Virginia.

	A.—Mountain ores in Potsdam slates.					B.—Mountain ores in Potsdam sandstone.	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Metallic iron	51.100	44.700	52.400	49.550	49.450	46.400	43.750
Phosphorus	.399	.539	.554	.117	.530	1.070	.878
Siliceous matter	10.150	19.590	7.620	8.810	10.020	15.350	20.910
Phosphorus in 100 parts iron	.780	1.205	1.057	.236	1.071	2.306	2.006

"In the above table the average of group "A" shows metallic iron, 49.440; phosphorus, 0.428; siliceous matter, 11.238; phosphorus in 100 parts iron, 0.869 per cent. The average of group "B" shows: metallic iron, 45.075; phosphorus, 0.974; siliceous matter, 18.130; phosphorus in 100 parts iron, 2.156."

"Thirty-four analyses of limestone ores associated with the Cambro-Silurian limestone show the following:

Range in composition of limestone iron ores in the Cripple Creek region, Virginia.

	Range.		Average per cent.
Iron	50.25	to 57.9	54.766
Phosphorus	.030	.207	.082
Siliceous matter	4.25	14.760	6.907
Phosphorus in 100 parts iron	.058	.403	.150

"Six analyses made from samples collected during a previous survey show an average composition for the mountain ores of group "A," as follows: Metallic iron, 50.841; phosphorus, 0.196; siliceous matter, 10.332; phosphorus in 100 parts iron, 0.386. And a similar averaging of two samples of the Potsdam ore of group "B" gave metallic iron 50.975; phosphorus, 1.308; siliceous matter, 7.220; phosphorus in 100 parts iron, 2.571. It is certainly remarkable, and a point of much importance to the region, that these limestone ores show such a wonderful uniformity over a territory of fully 40 miles in length and from 1 to 3 miles in width. The analyses of many show them to be well within the limits for Bessemer purposes; indeed one-half of them might be classed as Bessemer ores, or ores which would yield a pig iron containing not over 0.1 per cent. of phosphorus."

Although a considerable amount of lump ore can be obtained at many points in the district, the larger bulk of the ore to be mined will be "wash ore." Professor McCreath's analyses are generally reported as dried at 212° F.

The demand for ores, which an enlarged output of pig iron produced in 1886, encouraged the transportation of some of these ores to Pennsylvania, and they are now being sent to furnaces in that State in considerable quantities. One ore of rather remarkable composition for a brown hematite, for which contracts amounting to 50,000 tons have been made in Pennsylvania, shows the following composition:

Analysis of washed hematite ore from Cripple creek, Virginia.

	Natural state.	Dried at 212° F.
	Per cent.	*Per cent.*
Metallic iron	52.992	56.025
Metallic manganese	.355	.375
Phosphorus	.057	.061
Sulphur	.056	.059
Alumina	.634	.670
Lime	.955	1.010
Manganese	.538	.569
Silica	5.098	5.390
Moisture	5.413	....

The James River ores, consisting of magnetites, limonite, and specular and fossil ores, have not been so thoroughly exploited as those in the districts named, and the same may be said of the western portion of the State.

Concerning the ores of the southwestern part of the State Mr. C. R. Boyd states, in the Transactions of the American Institute of Mining Engineers, Vol. XV., that nine samples of the semi-magnetic red ore, taken from different parts of the ore bodies, yield an average as follows:

Average composition of semi-magnetic iron ore from southwest Virginia.

	Per cent.
Metallic iron	62.09
Phosphorus	.032
Phosphorus in 100 parts iron	.051

An average of four samples of the brown iron ores of these measures, which form nearly 50 per cent. of the whole body as now showing, is as follows:

Analysis of brown iron ores from southwest Virginia.

	Per cent.
Metallic iron	54.532
Phosphorus	.031
Phosphorus in 100 parts iron	.0568

The red fossils, a continuation of which is largely developed in east Tennessee, are reported to yield on analysis:

Analysis of red fossil ores from southwest Virginia.

	Per cent.
Metallic iron	52.60
Sulphur	.018
Phosphorus	.116
Insoluble matter	18.140

The advance in the mineral development of Virginia has encouraged the exploration and development of numerous iron ore deposits, some of which have been of great extent and value, while others have become exhausted long before yielding the amount of ore expected of them, owing more to a want of careful investigation than to any abnormal uncertainty of the ores. The brown hematite ores of Virginia are often associated with zinc and cadmium, deposits having been noticed as forming in some of the blast furnaces; other ores carry considerable manganese, or occur with manganese ores.

WEST VIRGINIA.

West Virginia produces but a small amount of ore, and although fossil ores and carbonates are found, but few deposits have been worked to any considerable extent. The State, however, has not been as thoroughly explored as some of its neighbors, and it is probable that the construction of additional railroads will develop some ore deposits of interest and value.

NORTH CAROLINA.

Magnetites.—The most important and largely developed deposit is in Mitchell county, and indications favor the continuance of the vein into Ashe and Watauga counties, to the northeast. The principal working is the Cranberry mine, a large open quarry from which 24,106 long tons were mined in 1886, the total output for three years being 45,943 long tons, but the deposit has long been worked to supply forges. Magnetites also outcrop in most of the counties in the western part of the State south of Mitchell county. A vein of titaniferous magnetic ore is reported to exist nearly parallel with the Cranberry vein, about 5 miles to the east; it has not been developed. East of the Blue Ridge, in McDowell and Rutherford counties, a vein of magnetite is reported, but has never been practically developed. A fourth belt of magnetites, consisting of several veins, runs through Stokes, Lincoln, and probably other counties into South Carolina. This has been worked to a small extent in forges; limonites are also found in this belt, which formerly sustained some small blast furnaces and forges. Northeast of Greensboro a large show of titaniferous magnetite has been exposed by numerous test pits, and some of it has been shipped. It contains 45 to 60 per cent. of iron and 8 to 14 per cent. of titanic acid. In Randolph county magnetites are also reported. Red and brown hematites are found in Randolph and Chatham counties, and have been smelted in furnaces in the latter.

The southwestern section of the State abounds in limonite ores which formerly sustained numerous Catalan forges. Late analyses by Professors Britton and McCreath of some of these ores show the following composition:

Composition of Cranberry, North Carolina, magnetites from the Tennessee furnace stoc piles.

	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Iron	54.08	51.91	50.82	45.37	44.47	39.34
Sulphur	.028	.142	.104	.041	.278	.398
Phosphorus	.007	.007	.009	.009	.0154	.013
Manganese	.277	....	....	.295	.40	....
Silica	15.22	18.75	20.20	24.89	23.60	....
Lime	5.89	6.26	....	9.74	9.74	....

Analyses of iron ores from southwestern North Carolina.

Iron.	Phosphorus.	Manganese.	Phosphorus in 100 parts. of iron.
Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
64.89	0.029	....	0.143
47.83	.389	....	.813
52.79	.616	....	1.166
54.17	.798	10.44	1.475
40.34	.53	....	1.313
40.70	1.089	....	2.675
36.01	.069	....	.181
41.32	.502	....	1.213

An average taken from 23 samples representing ores throughout the region shows:

Average composition of limonite iron ores from southwestern North Carolina.

	Per cent.
Metallic iron	50.020
Oxygen with the iron	(a)21.090
Water	10.760
Silica	9.080
Phosphoric acid (phosphorus 0.712)	1.631
Sulphur	.021
Alumina	1.710
Sesqui-oxide of manganese	5.220
Lime	.070
Magnesia	.040
Titanic acid	None.
Organic and undetermined matter and loss	0.358
Total	100.000

a A small amount of magnetic oxide present.

Phosphorus, 1.423 parts in 100 parts iron.

These ores extend into Georgia, and a series of manganiferous iron ores and manganese ores are found scattered through the district.

Vol. XV. of the Census Reports gives considerable space to and quotes numerous analyses of the North Carolina iron ores, and Mr. Swank gives analyses of the Cranberry magnetites. The following composition of the magnetic ore of Guilford and Buckingham counties is reported by Prof. J. P. Lesley:

Analyses of magnetic iron ores from Guilford and Buckingham counties, North Carolina

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Magnetic oxide	79.78	....
Titanic acid	12.08	8.65
Oxide of manganese	.28	.83
Sesqui-oxide of chromium	.32	.12
Silicic acid	.75	1.50
Magnesia	2.04	2.02
Alumina	4.62	2.00
Lime	.13	.75
Total	100.00	....

SOUTH CAROLINA.

Ores exist in the western part of the State, and a century ago the smelting of these ores was commenced in that State, but for thirty years no iron has been made there. Notice of some of the ores of North Carolina extending into this State has been made above.

GEORGIA.

The iron-ore region of Georgia is in its northwestern section, and embraces some of the limonites described as occurring in North Carolina and Alabama, and the red fossil ores of east Tennessee. They have sustained a considerable industry in producing iron with charcoal in blast furnaces and in Catalan-forge fires, and are now in demand for the coke furnaces of Georgia and Tennessee. Manganese ores also occur among the limonites. The percentage of iron in these ores may be considered as being between 45 and 50 per cent., although they range from 30 to 58 per cent. The phosphorus is high, though varying between wide limits, some being as low as .05, and others showing over 1.5 per cent. Analyses of some of these ores are given in Vol. XV. of the Tenth Census Reports. The following are added from the sources named:

Representative analyses of the fossil ores of Georgia. (*a*)

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Iron	38.48	46.82
Silica	7.32	22.69
Phosphorus	3.19	.350

(*a*) By Mr. H. S. Fleming.

Mr. Fleming states that the Georgia brown hematites give analytical results as follows:

Analyses of brown hematites from Georgia.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Iron	40.62	42.16	44.77	45.48	45.22	50.86
Alumina	5.47	7.80	8.64	7.09	4.79	6.62
Silica	25.81	22.13	16.34	15.46	21.29	10.29
Phosphorus	1.196	.846	.424	1.22	.623	.834

The Georgia brown hematites are very largely used with the soft fossil ores. They are quite hard, and vary in color from a reddish-brown through a dark-brown to black. The first is low in phosphorus and high in silica, and the latter low in silica and high in phosphorus. They are so unreliable in composition that it is impossible to judge of their quality by looking at them.

Analyses of the brown ores in Georgia by Dr. John B. Porter.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Silica	11.65	10.65	21.04	17.62	11.84	9.08
Iron	50.81	50.00	54.60	44.02	50.66	49.20
Phosphorus	.85	.92	.018	.135	.148	.557
Sulphur	.05	....	....	....	....	....
Magnesia	.54	....	....	....	....	....
Lime	.41	....	....	....	....	....

The latter authority also gives the following as representing a specular ore near Cartersville:

Analysis of specular iron ore from Cartersville, Georgia.

	Per cent.
Silica	27.53
Iron	45.63
Phosphorus	.193
Magnesia	.069

Mr. McCreath gives the following:

Analysis of a soft Georgia fossil ore.

	Per cent.
Metallic iron	56.250
Phosphorus	.611
Siliceous matter	9.570
Phosphorus in 100 parts of iron	1.086

The Dade Coal Company is reported as having mined and shipped about 10,500 long tons of iron ore from their limonite mines in Bartow county, Georgia, in 1886.

ALABAMA.

The nearness of the ores to fuel, the apparent abundance of iron ores, and the ease with which they can be worked, have caused a very rapid development of iron manufacture in Alabama, and consequently an activity in the exploitation of the iron-ore mines. The principal occurrences of iron ore in Alabama may be generally described as three nearly parallel belts passing through the northern half of the State from northeast to southwest. The most easterly belt comprises a series of limonites which have been and are now the dependence of a charcoal iron-producing industry second only to that of Michigan. Magnetite is also reported east of this belt. The second belt lying to the west and north of that just described is the continuation of the red fossil ores from Tennessee and Georgia, and it is this deposit which has encouraged the development of the coke iron industry and the rapid blast furnace construction. Some limonite ores occur in this second belt. A third belt may be considered as embracing the limonites entering the northwestern part of the State as an extension of the western iron belt of Tennessee. This is not as extensive as either of the others named.

Concerning the Alabama district, Dr. J. B. Porter, in the paper referred to above, remarks:

"Almost all the known ores of iron occur in the region under consideration, but, with very few exceptions, only two of them are mined. These two are the limonites or brown ores, as they are called in the South, and the Clinton fossil ore or red ore. The exceptions mentioned are specular hematites, magnetites, and in one case pyrite; but the quantity of these ores mined is very small. In the South the appearance of the limonites is exactly normal, and they occur in the same geological valleys that carry them in Virginia and Pennsylvania. The ores are called brown and hydrated oxides of iron, and, in general, have not quite enough water to be true limonites; however, they are approximately so, and the common habit of calling them all by that name has been followed. The ores generally occur in masses, or collections of nodules, capping a hill. Often the whole hill or the top of it is a great collection of lumps of ore in a mass of earth and clay. In many cases these ore hills are fully 100 feet in height and very extensive. Occasionally also the limonites are found in fissure veins, or otherwise in place in the rock, but in these cases mining on them soon shows them to be weathered pyrites. They occur in Cherokee, Calhoun, Talladega, Shelby, and Bibb counties in the old limestone valleys in immense quantities; and in smaller amount, although still enormous, in Saint Clair, Jefferson, Tuscaloosa, Marshall, and Blount counties in anticlinal valleys which expose the same rocks."

The ordinary low manganese ores of the vicinity are well represented by the following analysis:

	Per cent.
Silica	6.74
Iron	55.66
Phosphorus	.095

An analysis of a general sample taken from all ores now mined at the Shelby Iron Works is as follows:

Average analysis of iron ore from the Shelby Iron Works, Alabama.

	Per cent.
Silica	7.51
Iron	53.62
Phosphorus	.160

A review of the partial and complete analyses accompanying this paper shows iron from 30.52 to 66.10 and phosphorus from a trace to 1.52, and the following are selected from the table:

General analyses of Alabama ores.

	Silica.	Iron.	Phosphorus.	Sulphur.	Manganese oxide.	Alumina.	Lime and magnesia.	Water.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Raw	10.79	53.38	.631	.03	.30		.38	10.60
Raw	8.88	55.99	.267					
Calcined	7.80	56.13	1.07	.001	4.18			
Raw	11.71	48.25	.06		3.77	3.59		11.52
Raw	7.06	55.20	.16	.14	1.49	2.37	.59	9.25
Roasted	11.74	56.19	.05	.16	.75	1.59	.69	3.80
Raw	22.00	41.90	.053	.070	.79	8.95	.62	7.49
Washed	11.03	51.24	.164		1.23	8.43	.82	4.92
Roasted	9.16	60.01	.059	.018	1.84	1.93	.52	.65
Raw	3.06	57.91	.24	.45	.95	.35	1.21	7.41
Raw	12.16	52.55		.14		.30	.47	12.14

The Alabama brown ores are often roasted in heaps with wood or charcoal braize, partly to free them from water, and partly to separate the earthy matter; and after roasting are screened, for the latter reason. They average about 11 per cent. of water, and roasting not only frees them from this, but from some earth, and thus increases their richness very materially, as will be shown by the following analyses:

Analyses of Alabama brown-ores.

	Raw.	Roasted.	Washed.
	Per cent.	*Per cent.*	*Per cent.*
Silica	14.85	9.16	11.03
Iron	46.12	60.01	51.24
Phosphorus	.013	.059	.164
Alumina	9.13	1.93	8.43

Messrs. McCreath and D'Invilliers quote the following as taken from furnace stock piles, the determinations being for the raw brown hematite ore dried at 212°:

Analyses of raw brown hematite ore dried at 212° F.

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Metallic iron	53.750	49.812	48.500
Phosphorus	.622	.466	.449
Siliceous matter	8.330	13.960	19.990
Phosphorus in 100 parts of iron	1.157	.935	.926

The sub-Carboniferous brown ores of northwest Alabama, which form the third belt or portion of a belt, are reported by Dr. Porter as having the following composition:

Analyses of sub-Carboniferous brown iron ores from northwestern Alabama.

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Silica	5.58	2.86	2.74
Iron	56.45	58.46	39.23
Phosphorus	.402	.332	.282
Sulphur	....	.085	....
Magnesia and lime	....	.407	1.92
Alumina	.09	1.41	5.54
Manganese oxide	.26	.188	.28
Water	12.31	11.85	32.52

Analyses of clay-ironstones or carbonates from northwestern Alabama.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Silica	5.21	14.94
Iron	35.00	35.04
Phosphorus	.149	....
Sulphur	.137	....
Lime and magnesia	5.91	9.95
Manganese oxide	.17	1.20
Alumina	4.05	.13
Water	2.40	.84

Analyses of the black-band iron ores of Alabama.

	Raw.	Calcined.	Calcined.
	Per cent.	*Per cent.*	*Per cent.*
Silica	7.76	7.95	12.48
Iron	30.39	52.47	48.89
Phosphorus	.246	.520	.396
Sulphur	....	Trace.	.94
Lime and magnesia	....	7.40	....
Alumina	....	8.50	....

The fossil-ore belt has been the main dependence of the rapidly advancing coke-iron industry of Alabama; and in describing them Messrs. McCreath and D'Invilliers thus speak of the Clinton or "Red Mountain" ores, as they are locally termed: "The ore is found in the Red Mountain group of rocks, corresponding to the Clinton epoch of New York and to No. V. of Pennsylvania, which in this portion of Alabama forms monoclinal hills on either side of an anticlinal valley of Cambro-Silurian limestone, in which Birmingham is situated. These hills rise 200 to 250 feet above the plain of the valley, their crests practically marking the outcrop of iron ore, and are remarkably regular and persistent as ridges throughout the length of the State northeast and southwest.

The East Red Mountain ore group has a thickness of 22 feet for a few miles south of Birmingham; but no such development is found to the north or south of this area, nor on the parallel ridge on the western side of the valley. The present ore supply comes very largely from this portion of the East Red mountain, the Redding mines here being the most extensive operation in the district. It is at these mines that the Clinton ore has its finest development; it is worked on its outcrop in long open cuts 40 to 50 feet deep, by short cross-cuts through the overlying measures, and by a slope now sinking on the bed from a little above water-level. The dip is southeast 20° to 30° toward the Cahaba coal fields, and conforms to the slope of the mountain. The overlying strata, capping the ore bed here and for some distance north and south, are nowhere over 25 or 30 feet thick, consisting of red shale, thin-bedded sandstones, and some white chert. The total thickness of the ore bed is about 22 feet, in two main divisions, separated by a few inches of slate. The upper, richer (?), coarse-grained and more granular bed is 9 to 11 feet thick, and the lower, slightly leaner (?), finer-grained and laminated bed is usually about 13 feet thick. This lower portion of the bed is only taken in large open cuts along the outcrop, and at present the cross-cuts reaching the bed from the east side of the hill remove only the upper bed down to the slate parting. The ore outcrop extends along the East Red mountain, south of Birmingham, a distance of at least 35 miles, to Vance's station, and varies in thickness from 4 to 22 feet. Opposite Birmingham and down as far as Grace's Gap, about 5 miles, the ore seems to be quite siliceous.

On the West Red mountain no ore bed over 6 feet thick has been found, and no mining operations are now in progress there. At the Eureka mines, a little further northeast along the East mountain, the ore is quite as thick as at the Redding mines, though spread through about 30 feet of measures, while to the southwest, at the Woodward Furnace Company's mine, the same general thickness and excellence of the bed are maintained.

Analyses of some of the red ores from the Clinton formation No. V., Alabama.

	Soft ore.			Hard ore.			
	No. 1.	No. 2.	No. 3.	No. 1.	No. 2.	No. 3.	No. 4.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Metallic iron	52.425	52.650	52.275	39.525	39.325	39.425	41.762
Phosphorus	.262	.270	.323	.341	.341	.325	.307
Siliceous matter	17.600	17.770	17.960	13.080	12.050	11.100	28.450
Phosphorus in 100 parts of iron	.499	.512	.618	.862	.867	.824	.735
Lime	15.040	15.310	15.040	15.040	15.310	15.040	4.070

The great uniformity of both the soft and hard fossil ores, as shown in the first six analyses, is very striking, unless it be remembered that the geographical range covered by the samples is quite small. The above analyses likewise show that the ores are well adapted to the manufacture of mill and foundry iron, while, of course, they are ruled out of consideration as Bessemer ores, even if used in comparatively small quantities in mixtures."

Mr. H. S. Fleming gives the following furnace analyses of some of the Alabama soft fossil ore:

Analyses of Alabama soft fossil iron ore.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Iron	50.60	51.60	54.88	51.04	51.20
Silica	11.69	19.32	10.60	17.32	17.08
Phosphorus	1.06	.129	.287	.116	.464
Alumina	....	.19	.88	....	1.18

Analyses obtained from the Mary Pratt Furnace Company.

	Iron.	Silica.
	Per cent.	*Per cent.*
Fine red ore	49.00	18.38
Lump red ore	54.42	17.10
Bottom vein	50.00	21.38
Bottom vein	41.24	13.52

A lot of this ore delivered in Chattanooga gave: iron, 53.32 per cent. alumina, 2.10; phosphorus, 0.529; silica, 18.03. Soft red ore mined near Birmingham averages: iron, 46.48; alumina, 2.63; silica, 26.16.

An average of twenty-one analyses of Atalla ore gives: iron, 49.80 per cent.; alumina, 5.57; silica, 12.15. Mr. Fleming states that the Atalla soft fossil ore, as delivered, is generally in medium-sized pieces with about 15 per cent. "fine dirt-ore." It is easily reduced; varying but little and working very well in the furnace. The high phosphorus is the only objection to its use. Birmingham soft ore is similar to the Atalla, only more irregular in composition. Wide variations have been found in different cars received in one day. As delivered, this ore has from 10 to 30 per cent. of "fine dirt-ore" with it.

In discussing this same interesting region Dr. Porter says, "the great importance of the Clinton ore is due to its rapid increase in thickness towards the south. In eastern Tennessee it is little or no thicker than in Virginia and Pennsylvania, being a variable bed of great persistence, but never more than a few feet thick, becoming calcareous very rapidly when mined downward, and almost always pretty high in phosphorus. In Alabama, however, the Clinton ore makes a new departure. Beginning in the northern part of the State or perhaps even in the southern counties of east Tennessee it increases in thickness and splits up into several beds, and as it extends south and west this change is augmented, until at the point where it disappears under the drift of western Alabama it consists of a number of seams, aggregating in some places 30 feet.

In De Kalb county, Alabama, at Valley Head, a fair average locality, Schmitz gives a section from the east side of the valley aggregating 4 feet, as follows: Ore (soft), 9 to 14 inches; shale and sandstone, 2 to 8 feet; ore (soft), 12 to 15 inches; sandstone and shale, 20 to 30 feet; ore (hard), 15 to 24 inches.

At Gadsden, near Atalla, in Etowah county, the ore is very good, and is not only extensively smelted near the mines but also shipped in large quantity to be mixed with harder ores at Chattanooga and other points. This Atalla ore is soft, dark in color, and very easy to mine and use. A sample carefully taken from a large stock pile contained, dried: silica, 3.51; iron, 58.99; phosphorus, 0.313.

From Birmingham to Woodstock and Greenpond, 25 miles down the valley, the Clinton has its maximum size, and has in some places a deposit of good ore 20 feet thick, attaining its maximum at Eureka, where the following section by Schmitz shows its wonderful richness:

1. Limestone and sandstone of indefinite thickness.
2. Sandy red ore (30 to 32 per cent. iron), 10 to 12 feet.
3. Sandstone and shales, 15 feet.
4. Soft red ores (51 to 54 per cent. iron), 15 feet.
5. Hard red ore (40 per cent. iron), 17 to 18 feet.
6. Sandstone, 3 feet.
7. Medium soft ore (50 per cent. iron), 3 feet.
8. Limestone (siliceous).
9. Limestone (good).

Total red ore, 34 to 37 feet.

Southwest of this the ore decreases in thickness quite rapidly, but remains many feet thick to its end. The following are typical analyses of this, the thickest part of the ore. The samples are all from near Eureka.

Analyses of iron ore from Eureka, Alabama.

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Silica	16.31	31.16	31.62
Iron	54.98	41.91	43.71
Phosphorus	.220	.200	.191
Alumina	3.76	4.64	4.14

An interesting confirmation of the theory that lime increases in the red ore as it is mined downward is given by one of the ore properties of the Sloss Furnace Company, near Birmingham, as shown in the accompanying table condensed from the complete analysis given further on. The ore is 13 feet thick and highly tilted, with an outcrop which has been located for many miles. At the time of the analysis the mine was 130 feet deep on the ore, and the following figures give the percentage of carbonate of lime for each 10 feet descent:

Rate of increase of carbonate of lime with the depth, in iron ores from Eureka, Alabama.

Depth.	Carbonate of lime.	Depth.	Carbonate of lime.
Feet.	*Per cent.*	*Feet.*	*Per cent.*
Surface	Trace.	70	25.61
10	Trace.	80	29.92
20	Trace.	90	29.89
30	Trace.	100	23.37
40	21.06	110	28.82
50	23.90	120	21.32
60	37.01	130	30.55

The phosphorus in this ore is not over .1 per cent., and the iron is over 50 per cent. in the soft, and nearly 40 in the hard or lime ore.

A review of a number of analyses of the red fossil ores of Alabama as given by Dr. Porter, shows iron ranging from 25.96 to 59.06, and phosphorus from nothing to .69 per cent.

Analyses of the red fossil iron ores of Alabama.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Silica	11.84	31.83	18.75	12.63	5.20	13.19	15.25
Iron	51.94	42.36	49.36	55.97	33.09	53.95	50.33
Phosphorus	.269	.210	.232	.079	....	.223	.332
Sulphur	....	Trace.	....	....	....	....	....
Lime	....	....	....	Trace.	37.91	1.50	6.25
Alumina	....	4.46	....	3.06	1.45	3.35	2.14

That the State possesses an almost unique arrangement of ores close to coals, both apparently in great quantity, is just reason for encouraging a rapid development of its mineral resources, but in view of the great activity at present in the construction of blast furnace plants it would seem that a somewhat more conservative policy would be for the future advantage of the State. If the blast furnace plants which are at present built, building, and announced to be built are constructed and placed in operation, the State of Alabama will be called upon to supply more ores yearly than the maximum output of the Marquette region, Lake Superior.

This, in view of the irregular character of the ore and a tendency to increase in carbonate of lime under cover and the temptation to apply careless mining methods under the spur of a very active development, may cause this very rich region to have an apparent scarcity of ore sooner than those interested would expect.

TENNESSEE.

The production of iron and the mining of iron ores is not a new industry in Tennessee, although the rapid development in late years has brought this State more prominently before the public. Some of the older iron works of the State have a reputation for their iron, for special purposes, recognized all over the country, and the abundance of the ores of iron and their variety give promise of continued activity in iron production and manufacture. Concerning the iron ores of Tennessee, Mr. J. B. Killebrew, in a monograph entitled "Iron and Coal of Tennessee," says: "There are four distinct belts or areas of iron ores in the State, occupying wholly or in part forty-four counties.

"(1) The Eastern iron-ore belt, extending through the State and lying in front and at the northwestern base of the Unaka mountains, along which range passes the line between Tennessee and North Carolina.

"(2) The Dyestone belt, skirting the southeastern base of the Cumberland table land from Virginia to Georgia, and spreading out laterally for a distance of from 10 to 20 miles into the valley of east Tennessee.

"(3) The Cumberland table land, co-extensive with the Coal Measures of the State, and extending into Kentucky and Alabama.

"(4) The Western belt, lying west of the central basin, generally east of the Tennessee river, in its reflex course through the State, though overleaping that stream and appearing in west Tennessee.

"The Eastern belt is noted for its pockets and seams of brown hematites, and some unique red hematites; the magnetic ore which is strongly developed at the Cranberry mines, North Carolina, also extends into Tennessee. A limited iron-producing industry has been sustained for many years on the ores of the Eastern belt, both as blast furnaces and as Catalan-forge fires. The following are analyses of some of the brown hematites used at the charcoal blast furnaces:

Analyses of brown hematites from the Eastern belt of Tennessee.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Metallic iron	50.41	47.66	49.86	46.56	57.33	56.19
Combined oxygen	21.11	20.07	20.97	19.73	....	....
Silica	8.38	12.05	7.18	13.61	6.15	3.08
Water	12.50	12.50	12.84	12.36	9.13	14.00
Phosphorus	.12	.13	.17	.16	.00	.312
Alumina	6.47	6.84	8.11	6.90	.28	....
Lime	.18	.19	.19	.009	.92	....
Sulphur	....	....	....	.21	....	....
Total	99.17	99.44	99.32	99.539	....	....

Analyses of the same brown hematites after washing and roasting.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Silica	3.06	9.550
Sesquioxide of manganese	.27	....
Peroxide of iron	82.27	77.44
Metallic iron	57.60	54.92
Phosphoric acid	.09	.093
Alumina	1.28	....
Sulphur	.20	....
Phosphorus	.039	.044

The Dyestone or Clinton belt consists of several nearly parallel strikes, extending from 70 to 150 miles through the eastern section of the State, and the ores are found near the northern boundary, as well as close to Chattanooga. The thickness seldom reaches 3 feet, although there are localities where the ore shows 7 feet.

Mr. H. S. Fleming, in a paper on the ores used in the Chattanooga district (Transactions of the American Institute of Mining Engineers, Vol. XV.), says: "Ore mined at Rockwood, Roane county, Tennessee, gives iron, 43.47 per cent.; silica, 9.66; alumina, 5.23; carbonate of lime, 19.14; phosphorus, 0.574."

A sample of this ore mined by the Roane Iron Company and sampled from the stock pile at the furnaces gave iron, 48.36; silica, 14.78; phosphorus, 0.63 per cent.

The ore from Rockwood, Tennessee, is a soft specular hematite. When cleanly and properly mined it averages as shown in the analysis. It is self-fluxing in the furnace, easily reducible, and carries a comparatively low percentage of fine material. The outcrop of this ore shows no lime, but after mining to any considerable depth the lime increases, and finally the iron runs out altogether, and is replaced by lime.

Composition of Tennessee River soft fossil ores.

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Iron	45.35	44.50	43.37
Alumina	11.12	9.89	10.13
Silica	12.51	15.94	14.19
Phosphorus	.610	1.816	1.730

The soft ore, as delivered, is of a rusty, brownish color, and carries from 20 to 60 per cent. of fine dirt ore. In wet weather it contains as much as 30 per cent. of water, and is very sticky and hard to unload. The variation in the ore is mostly due to the moisture, though at times an excessive amount of slate accompanies it.

Analyses by Professor McCreath of ores taken from stock piles at the Chattanooga furnaces show the following composition when dried at 212° F.:

Analyses of red (dyestone) ore, Clinton formation No. V., in Tennessee.

	Soft fossil ore.		Hard fossil ore.
	No. 1.	No. 2.	
	Per cent.	*Per cent.*	*Per cent.*
Metallic iron	44.700	49.150	26.600
Phosphorus	.429	.607	.388
Siliceous matter	19.760	14.480	8.210
Phosphorus in 100 parts of iron	.959	1.235	1.458
Lime (CaO)	....	....	27.070

Dr. John B. Porter, in a contribution upon "The Iron Ores and Coals of Alabama, Georgia, and Tennessee," to the Transactions of the American Institute of Mining Engineers, Vol. XV., gives numerous analyses of the red fossil ores of Tennessee, of which the following are typical:

Analyses of the red fossil iron ores of Tennessee.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Silica	14.81	20.70	9.70	9.64	14.50	4.00
Iron	48.39	40.82	50.29	50.14	50.00	57.04
Phosphorus	.633	.607	.580	.582	Trace.	.042
Carbonate of lime	....	....	5.36	8.14	....	....
Alumina	2.47	9.04	5.86	....	....	....
Water	7.71	6.30	....	9.13	11.90	13.00
Sulphur	....	....	....	....	....	.46

The Cumberland table-land belt produces carbonates, such as kidney or flag ores, but they are used to only a limited extent.

Analyses of the Tennessee River hard fossil ores.

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Iron	33.40	31.42	29.60
Carbonate of lime	31.85	34.68	40.32
Silica	6.79	7.49	5.64
Phosphorus	.614	.520	.438

"The hard river ore, mined in many cases close by the soft, is, as its name indicates, a tough ore, hard to break. The amount of lime it contains is very unreliable; anywhere between 23 and 40 per cent. of carbonate of lime."

Mr. Killebrew says in his report: "In three samples of Rockwood ore, Nos. 1 and 2 from tunnel, No. 3, from the surface, the increase of lime near water level is very apparent."

Analyses of carbonate ores from Rockwood, Tennessee.

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Silica	4.50	5.50	6.50
Water	1.50	2.60	4.00
Alumina	2.80	2.60	3.40
Lime	16.30	16.35	1.60
Metallic iron	41.43	39.00	56.88

The above may be truly taken as a fair showing of the ore of the shin-bone seam throughout its length. On the surface it is rich in iron; near and below water level it contains a large quantity of carbonate of lime and much less iron.

The western iron-ore belt is very interesting as producing large quantities of excellent brown hematite ores. It includes the counties of Stewart, Montgomery, Houston, Humphreys, Dickson, Perry, Hickman, Lewis, Wayne, and Lawrence on the east side of the Tennessee river, and Benton and Decatur on the west side. Its topography is varied, being a slightly rolling plateau, traversed by numerous streams, which cut down through the strata, having an average elevation of about 1,000 feet above the sea level. Mr. Killebrew also remarks that "most of the beds of ore in this belt, taken as a whole, may be classed as limonite, though large bodies of goëthite exist. Turgite is chiefly found in layers or as the interior linings of hollow concretions. Streaks and specimens of red ore are found in many beds of limonite, being a very pure variety of turgite, nearly anhydrous." These ores are smelted largely with charcoal, and the amount of iron so produced is yearly augmented in this district. The following are some analyses of ores from the western iron-ore belt:

Analyses of ores from the western iron-ore belt, Tennessee.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Metallic iron	57.84	59.21
Oxygen with the iron	24.37	24.88
Water	11.96	11.06
Insoluble siliceous matter	3.59	3.21
Soluble silica	.78	.13
Sulphur	None.	None.
Phosphoric acid	(*a*).54	(*b*).36
Alumina	.13	.39
Lime	.05	.17
Magnesia	.03	.06
Manganese, undetermined matter, and loss	.71	.42
Total	100.00	99.89

a Phosphorus, 0.24. *b* Phosphorus, 0.16.

Partial analyses.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Metallic iron	46.49	57.50	53.17	53.72	59.86
Insoluble siliceous matter	18.36	3.90	10.01	3.73	3.35
Sulphur	None.	None.	None.	None.	None.
Phosphorus	.371	.201	.136	.084	.041

The following is ore from White county:

Analysis of iron ore from White county, Tennessee.

	Per cent.
Water	6.09
Silica	9.31
Iron	48.58
Oxygen combined	20.82
Sulphur	.10
Phosphorus	.29

One of the ores employed in the older charcoal iron works, and for the product of which a superior reputation was secured, is represented by the annexed analyses:

Analyses of iron ore from the Cumberland Iron Works, Tennessee.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Metallic iron	57.84	59.22
Oxygen with the iron	24.37	24.88
Water	11.96	11.06
Insoluble siliceous matter	3.50	3.21
Soluble silica	.78	.13
Sulphur	None.	None.
Phosphoric acid	.54	.36
Alumina	.13	.49
Lime	.05	.17
Manganese	.03	.06
Loss	.80	.42
Total	100.00	100.00
Phosphorus	0.24	0.16

KENTUCKY.

The ores of the Hanging Rock region, described under Ohio, extend across the Ohio river into Kentucky, and the district recognized as the Hanging Rock is generally known as embracing the territory in Ohio mentioned above, and about one-half as much in the State of Kentucky, the region extending south of the river 25 to 30 miles. The character and composition of the ores are similar to what has been described in discussing Ohio iron ores, and they have supported an iron industry of moderate proportions. Limonite ores also exist in southwestern Kentucky, a practical extension of the beds in the western iron-ore belt of Tennessee. They are of the same general composition. Carbonates and limonites occur in the Red River district of central Kentucky, where a considerable industry, based upon the smelting of the ores with charcoal, formerly existed, but now is of small importance. These ores yield from 35 to 50 per cent. of iron, and carry from 0.2 to 0.5 per cent. of phosphorus. There is but little activity in iron manufacture in Kentucky, and consequently but a limited amount of ore is mined.

MISSOURI.

Between the Missouri river and the 40th township line there are valuable deposits, mostly of limonite, in Franklin, Osage, Morgan, and Benton counties. This kind of ore also occurs nearly all over the central and southern part of the State. In the southern part, the counties of Stoddard, Bollinger, Wayne, Ozark, Douglas, Christian, and Greene contain considerable deposits of it. But by far the richest portion of the State in iron ores is that between the 30th and 40th township lines. Within this zone iron ores abound in the greater part of the counties situated between the Mississippi on the east and the upper Osage river on the west. Limonite banks are scattered over the whole of this vast region. The specular ores are much more concentrated in certain parts of the State than either the limonites or the carboniferous hematites, and also occur in much larger masses. There are two important specular-ore districts, different, by their geographical positions, mode of occurrence, and geological position, but quite similar in mineralogical character and chemical composition. One of these districts is the Iron Mountain, in Saint François and Iron counties. The second district lies more toward the center of the State, yet mainly in its eastern half. Its principal deposits are concentrated in three counties, Crawford, Phelps, and Dent, and extend into Washington, Franklin, Maries, Miller, Camden, Pulaski, and Shannon. These regions combined form a broad ore belt, running across the State from the Mississippi to the Osage in a direction about parallel to the course of the Missouri river, from southeast to northwest, between the 30th and 40th township lines. The specular ores occupy the middle portion of this belt; the limonites occur in both ends of it. The latter are, besides, spread over the whole southern half of the State. New ore banks are continually being discovered and opened.

Analyses of the Iron Mountain and Pilot Knob ores were given by Mr. Swank. The output of these and other neighboring mines during the last three years has been as follows:

Output of the Iron Mountain, Pilot Knob, and neighboring iron-ore mines in Missouri in 1884, 1885 and 1886 inclusive.

	Long tons.
1884	233,225
1885	169,162
1886	379,776

The total amount mined to the close of 1886 was about 3,627,597 long tons. The central district sustains a number of charcoal blast furnaces, and possesses some mines of considerable magnitude, producing ore of a bluish tint or deep red or earthy in color, and of varying degrees of hardness. The percentage of iron ranges from 44 to 67, and of phosphorus from 0.025 to 0.13.

PRODUCTION EAST OF THE MISSISSIPPI RIVER.

Without full data as to the output of the various districts no proper comparisons of their relative importance can be made, but to give an idea of the resources of some States or mining districts the following table has been prepared from such official data as could be collected. This shows the shipment during 1886 from some of the larger contributors in their order of precedence, and also the importations of foreign ores.

Shipments from certain districts in 1886.

	Long tons.
Marquette region, Lake Superior district	1,621,887
Imported iron ores	1,039,433
Menominee range, Lake Superior district	880,006
Gogebic range, Lake Superior district	756,281
Cornwall ore hills, Pennsylvania	688,054
Lake Champlain magnetites, New York	663,752
New Jersey magnetites	500,501
Missouri mines	379,776
Ohio ores, carbonates and hematites	344,480
Vermilion lake, Minnesota	304,396
Other New York mines	35,728
Cranberry mines, North Carolina	24,106

The following estimates are based upon an average yield of ore and pig iron production in 1886:

Estimated production of iron ores in other sections in 1886.

	Long tons.
Alabama:	
Fossil ores	500,000
Brown hematites	200,000
Tennessee:	
Fossil ores	430,000
Brown hematites	70,000
Virginia	380,000
Georgia:	
Fossil ores	80,000
Brown hematites	25,000

FOREIGN IRON ORES.

Africa, Spain, Italy, Greece, England, France, Canada, Cuba, and other countries have all contributed iron ores to make up the large total of imported ore, most of which enters through the ports of Philadelphia, Baltimore, and New York. The rapid increase of importations may be partly accounted for by the development of the mines in Cuba operated by large American iron and steel companies; another factor of some influence is the opportunity offered by some of the larger coal transportation companies, who are willing to carry foreign ores at low rates as return freights to furnaces located *en route* to the coal-mining regions. The possibility of enriching the furnace mixture, even when a Bessemer grade is not desired, by adding foreign ores or employing them in place of leaner local ores, has also had a tendency to encourage the use of domestic ores from a wider range of territory than was formerly considered possible. The system adopted of selling foreign ores on a unit basis has benefited the iron trade by awakening a better appreciation of the value of ores carrying high percentages of iron. The system almost universally adopted in selling foreign ores is to fix a price per unit of iron in the ore, which is determined by analysis when the ore has been dried at 212° Fahrenheit; the price being dependent upon the amount of iron as well as upon the percentage of phosphorus or other components which may affect its value for specific purposes. This practice caused an effort on the part of the importers to have the duty on foreign ores, which is 75 cents per ton, interpreted as referring to a ton of ore without moisture; but the Treasury Department, upon the advice of the Attorney-General, and after a hearing, decided that in rating duties foreign ores would be estimated upon the same basis as domestic ores.

The percentage of iron in the foreign ores as received will range from about 50 to 64 per cent. The average for 1886 was between 53 and 54 per cent. Fully nine-tenths of the ores imported are hematites, and, if the manganiferous ores destined for making spiegeleisen are included, they may be designated as chiefly of the Bessemer class.

To illustrate the dependence of the United States upon foreign ores, in comparison with other nations, the following table gives such information as is obtainable. No effort has been made to reduce the tons to a common standard, because it was desirable to report the statistics in the original quantities, and because the difference between a metric ton (2,204.6 pounds) and a long ton (2,240 pounds) is not sufficient to affect the result materially.

Iron production and iron-ore imports in different countries.

Countries.	Years.	Pig iron made.	Iron ore imported	Average amount of ore imported per ton of iron produced.
		Tons.	*Tons.*	*Tons.*
United States	1879	2,741,853	284,141	0.104
	1880	3,835,191	493,408	.129
	1881	4,144,254	782,887	.189
	1882	4,623,323	589,655	.128
	1883	4,595,510	490,875	.107
	1884	4,097,868	487,820	.109
	1885	4,044,526	390,786	.096
	1886	5,683,329	1,039,433	.183
Total		33,765,854	4,559,005	0.135

Iron production and iron-ore imports in different countries—Continued.

Countries.	Years.	Pig iron made.	Iron ore imported.	Average amount of ore imported per ton of iron produced.
		Tons.	*Tons.*	*Tons.*
Great Britain	1879	5,995,337	1,083,692	.181
	1880	7,749,233	2,634,401	.340
	1881	8,377,364	2,449,277	.292
	1882	8,493,287	3,282,496	.386
	1883	8,490,224	3,178,310	.321
	1884	7,528,966	2,728,672	.362
	1885	7,250,657	2,817,597	.389
	1886	6,870,665	2,875,176	.418
Total		60,755,733	21,049,621	0.346
France	1879	1,400,286	941,812	.673
	1880	1,733,102	1,168,215	.674
	1881	1,894,861	1,287,870	.680
	1882	2,039,067	1,425,870	.699
	1883	2,069,430	1,601,217	.774
	1884	1,855,247	1,412,724	.762
	1885	1,630,648	1,419,521	.871
	1886	1,507,850	1,158,581	.768
Total		14,130,491	10,415,810	0.737
Germany	1879	2,226,587	380,000	.171
	1880	2,729,038	607,007	.222
	1881	2,914,009	615,490	.211
	1882	3,380,806	785,360	.232
	1883	3,469,719	800,373	.231
	1884	3,600,612	980,442	.272
	1885	3,687,316	852,714	.232
	1886	3,339,803	812,635	.243
Total		25,347,890	5,834,021	0.230
Belgium	1879	448,371	614,534	1.373
	1880	595,704	921,784	1.548
	1881	624,736	1,169,206	1.872
	1882	727,000	1,206,717	1.66
	1883	783,433	1,612,469	2.058
	1884	750,812	1,488,140	1.982
	1885	712,876	1,393,601	1.96
	1886	697,110	1,365,939	1.959
Total		5,340,042	9,772,390	1.83

This table demonstrates that, although our importation of foreign iron ore reached its maximum in 1886, the relative amount of foreign ore used per ton of pig iron made was not as great as in 1881; and that it closely approximated in 1886 the proportion used in Great Britain in 1879, since which date that country has continued to rely upon foreign ores to a much greater extent than the United States. The same remark holds true concerning Germany, and France has been more dependent upon foreign ores than any of the countries named except Belgium, which relies almost entirely upon ores mined outside of its borders.

Taking the average of eight years for the United States, Great Britain, France, Germany, and Belgium, and assuming that the average yield of ore as reported by Mr. Swank holds good for the entire period, we have the following:

Average percentage of foreign ore to total ore used.

	United States.	Great Britain.	France.	Germany.	Belgium.
Tons of ore required to make one ton of pig iron (*a*)	2.03	2.4	2.6	2.6	2.7
Tons of foreign ore imported per ton of pig iron made (see table)	.135	.346	.737	.230	1.83
Average percenage of foreign ore to total ore used	6.65	14.33	28.37	8.85	67.78

a See "Mineral Resources of the United States, 1883-'84," page 262.

While these percentages are of necessity but approximations, they show the comparative dependence of each nation upon its own iron supplies, and in round numbers we may say that in the United States over one-sixteenth, in Germany over one-twelfth, in Great Britain one-seventh, in France over one-fourth, and in Belgium over two thirds of the iron ores used come from foreign countries.

Sources of imported iron ores.—Comparatively little ore from Bilboa, Spain, reaches American furnaces, but the large exports (averaging over 3,000,000 tons annually since 1880) are chiefly to the iron-smelting countries of Europe.

Exports of iron ore from Bilboa, Spain.

	1884.	1885.	1886.
The exports of iron ore from Bilboa were ....metric tons..	3,155.432	3,298.982	3,160.647
Of this amount Great Britain received..........long tons..	1,990.993	2,050.185	2,151.137
The United States received ....do....	2.259	7.304	42.337

The best and most costly ore imported is from the island of Elba, of which there are practically three different kinds: Elba Lavata, Elba Andante (specular), Elba Andante (non-specular). The importers claim that in shipments these last two are not kept separate, but that they come from different openings. The specular is rich in iron and reasonably low in phosphorus. The non-specular is (comparatively speaking) high in phosphorus, while the Lavata can be relied on to be very low in phosphorus, as the following analyses will show. As iron is sold on analyses made after drying at 212° F., the percentage of iron is given when dried and also when the ore is in its natural state.

Analyses of Elba iron ores.

	212° F. Iron.	Natural state.		
		Moisture.	Iron.	Phosphorus.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Elba Andante (specular), average of four cargoes	62.615	2.708	60.916	0.021
Elba Andante (non-specular), average of two cargoes	60.250	5.194	57.127	.040
Elba, Lavata, average of eight cargoes	61.270	7.758	56.504	.0094

Mokta ore, from Bona, Africa, is variable. and later shipments are not so good as the earlier ones, unless they come from the old pillars left standing in the mine. Thus analyses of two carges of lean ore from the new part of the mine are given in Nos. 1 and 2, while two cargoes from the old pillars show as in 3 and 4. Other cargoes are shown in 5, 6, 7, and 8.

Analyses of Mokta iron ores from Bona, Africa.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Silica	6.60							
Lime	2.67							
Magnesia	1.08							
Alumina	2.26							
Manganese	1.69		1.557					
Phosphorus (a)	.024	.026	.02	0.017	0.023		0.021	
Sulphur	.257		.126					
Moisture	4.76	5.346	1.322	1.573	2.705	3.616	4.264	5.272
Iron, natural	54.572	53.67	59.97	60.237	58.207	57.589	56.363	56.006

a The average of the six analyses is 0.022 per cent. of phosphorus.

The Camerata ore from northern Africa yields, when dried at 212°, 54.54 per cent. of iron, 0.025 per cent. phosphorus, and 0.01 per cent. sulphur.

Of the Spanish iron ores, Porman ore (brown hematite) is largely imported; it comes from near Cartagena. The phosphorus in standard Porman ore is 0.044 per cent., but lately it has been delivered containing as low as 0.009 per cent. of phosphorus; it contains about 2 per cent. of lead. In the following table of analyses of Spanish iron ores an average of six cargoes of Porman ore is given, which was lately received at the Durham, Pennsylvania, and Pequest, New Jersey, furnaces; the percentage of phosphorus is very low, ranging from 0.01 to 0.025 per cent. In the analyses, of which this is the average, the range of iron in the undried ore was from 49.1 to 51.88 per cent.

Analyses of Spanish ores.

	Iron, dried at 212°.	Iron in natural state.	Phosphorus.	Sulphur.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Porman	52.812	50.656	0.02	
Camargo:				
Highest		53.70		
Lowest		49.85	.055	
Marbella:				
Selected lump	61.65		.009	.01
Sulphury lump	62.925		.04	.636
Sand ore	59.650		.014	
Alvito, Portugal:				
No. 1	57.625		.010	
No. 2	55.775			
No. 3	56.10		.016	
No. 4	56.20			
Somorostro iron ore from Bilboa, Spain:				
Campanil mines:				
No. 1	54.62		.013	.004
No. 2	57.74		.011	Trace.
No. 3	59.00		Trace.	Trace.
No. 4	53.40		.018	.026

Analyses of Spanish ores—Continued.

	Iron dried at 212°.	Iron in natural state.	Phosphorus.	Sulphur.
Somorostro iron ore from Bilboa, Spain—continued:				
Vena Dulce:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
No. 1	58. 30		0. 006	
No. 2	60. 29		. 021	
No. 3	56. 40		. 018	
Rubio:				
No. 1	55. 85	48. 483	. 013	
No. 2		48. 772	. 0124	
Average of 37 analyses of other Somorostro iron ore:				
Highest	59. 78		56. 20	
Lowest	55. 01		47. 13	
Average	57. 395		51. 665	

The Greek ore from the island of Seriphos, belonging to the Greek government, has the following composition:

Analysis of Greek iron ore from the island of Seraphos.

	Per cent.
Iron	52. 53
Phosphorus	. 033
Sulphur	. 194
Manganese	. 706

The following are analyses of English ores, of which limited amounts are imported:

Analyses of English iron ores.

	Hodbarrow, Cumberland district.	Garlside. (*a*)	
		No. 1.	No. 2.
	Per cent.	*Per cent.*	*Per cent.*
Iron	62. 40	62. 50	66. 70
Phosphorus	. 017	. 018	. 066
Sulphur	. 02	None.	None.

a Above the average; 57 per cent. is all that can be relied upon.

Analyses of imported iron ores not suitable for Bessemer purposes.

	Spanish, Huelva.	Italian, Calabria.		France, Saint Remy fossil ore.	Tinto.	Tefna, Africa.		
		Red.	Yellow.			No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Iron, dried at 212°	47. 20	65. 94	57. 02	55. 20	61. 01	58. 80	59. 35	56. 54
Phosphorus	. 225	. 133	. 272	. 60	. 165		. 03	. 041
Sulphur	. 475	. 026	. 123		. 226			
Manganese								1. 755

For information concerning foreign ores credit is due to Mr. B. F. Fackenthal, of the Durham furnace, Pennsylvania, and to Messrs. Francis Wister and Alfred Earnshaw, of Philadelphia.

GOLD AND SILVER.

According to Dr. James P. Kimball, Director of the Mint, the production of gold from the mines of the United States during the calendar year 1886 approximated 1,881,250 fine ounces, valued at $35,000,000 and of silver 39,445,312 fine ounces, of the commercial value—at the average price of silver during the year, about $1 per ounce fine (strictly $0.99465)—of $39,445,312, or at the coining rate of silver in United States silver dollars, $51,000,000.

The production of the various States and Territories is exhibited in the following table:

Approximate distribution in round numbers, by States and Territories, of the estimated total production of precious metals in the United States during the calendar years 1881 *to* 1886 *inclusive.*

States and Territories.	1881.			1882.		
	Gold.	Silver.	Total.	Gold.	Silver.	Total.
Alaska	$15,000	....	$15,000	$150,000	....	$150,000
Arizona	1,060,000	$7,300,000	8,360,000	1,065,000	$7,500,000	8,565,000
California	18,200,000	750,000	18,950,000	16,800,000	845,000	17,645,000
Colorado	3,300,000	17,160,000	20,460,000	3,360,000	16,500,000	19,860,000
Dakota	4,000,000	70,000	4,070,000	3,300,000	175,000	3,475,000
Georgia	125,000	....	125,000	250,000	....	250,000
Idaho	1,700,000	1,300,000	3,000,000	1,500,000	2,000,000	3,500,000
Maine	....	5,000	5,000	....	....	....
Montana	2,330,000	2,630,000	4,960,000	2,550,000	4,370,000	6,920,000
Nevada	2,250,000	7,060,000	9,310,000	2,000,000	6,750,000	8,750,000
New Mexico	185,000	275,000	460,000	150,000	1,800,000	1,950,000
North Carolina	115,000	....	115,000	190,000	25,000	215,000
Oregon	1,100,000	50,000	1,150,000	830,000	35,000	865,000
South Carolina	35,000	....	35,000	25,000	....	25,000
Tennessee	5,000	....	5,000	....	....	....
Utah	145,000	6,400,000	6,545,000	190,000	6,800,000	6,990,000
Virginia	10,000	....	10,000	15,000	....	15,000
Washington	120,000	....	120,000	120,000	....	120,000
Wyoming	5,000	....	5,000	5,000	....	5,000
Total	34,700,000	43,000,000	77,700,000	32,500,000	46,800,000	79,300,000

	1883.			1884.		
Alaska	$300,000	....	$300,000	$200,000	....	$200,000
Arizona	950,000	$5,200,000	6,150,000	930,000	$4,500,000	5,430,000
California	14,120,000	1,460,000	15,580,000	13,600,000	3,000,000	16,600,000
Colorado	4,100,000	17,370,000	21,470,000	4,250,000	16,000,000	20,250,000
Dakota	3,200,000	150,000	3,350,000	3,300,000	150,000	3,450,000
Georgia	199,000	1,000	200,000	137,000	....	137,000
Idaho	1,400,000	2,100,000	3,500,000	1,250,000	2,720,000	3,970,000
Montana	1,800,000	6,000,000	7,800,000	2,170,000	7,000,000	9,170,000
Nevada	2,520,000	5,430,000	7,950,000	3,500,000	5,600,000	9,100,000
New Mexico	280,000	2,845,000	3,125,000	300,000	3,000,000	3,300,000
North Carolina	167,000	3,000	170,000	157,000	3,500	160,500
Oregon	660,000	20,000	680,000	660,000	20,000	680,000
South Carolina	56,500	500	57,000	57,000	500	57,500
Utah	140,000	5,620,000	5,760,000	120,000	6,800,000	6,920,000
Virginia	6,000	....	6,000	2,000	....	2,000
Washington	80,000	500	80,500	85,000	1,000	86,000
Wyoming	4,000	....	4,000	6,000	....	6,000
Other	17,500	....	17,500	76,000	5,000	81,000
Total	30,000,000	46,200,000	76,200,000	30,800,000	48,800,000	79,600,000

Approximate distribution in round numbers, by States and Territories, of the estimated total production of precious metals in the United States, &c.—Continued.

	1885.			1886.		
Alaska	$300, 000	$2, 000	$302, 000	$446, 000	$2, 000	$448, 000
Arizona	880, 000	3, 800, 000	4, 680, 000	1, 110, 000	3, 400, 000	4, 510, 000
California	12, 700, 000	2, 500, 000	15, 200, 000	14, 725, 000	1, 400, 000	16, 125, 000
Colorado	4, 200, 000	15, 800, 000	20, 000, 000	4, 450, 000	16, 000, 000	20, 450, 000
Dakota	3, 200, 000	100, 000	3, 300, 000	2, 700, 000	425, 000	3, 125, 000
Georgia	136, 000	....	136, 000	152, 500	1, 000	153, 500
Idaho	1, 800, 000	3, 500, 000	5, 300, 000	1, 800, 000	3, 600, 000	5, 400, 000
Montana	3, 300, 000	10, 060, 000	13, 360, 000	4, 425,000	12, 400, 000	16, 825, 000
Nevada	3, 100, 000	6, 000, 000	9, 100, 000	3, 090, 000	5, 000, 000	8, 090, 000
New Mexico	800, 000	3, 000, 000	3, 800, 000	400, 000	2, 300, 000	2, 700, 000
North Carolina	152, 000	3, 000	155, 000	175, 000	3, 000	178, 000
Oregon	800, 000	10, 000	810, 000	990, 000	5, 000	995, 000
South Carolina	43, 000	....	43, 000	37, 500	500	38, 000
Utah	180, 000	6, 750, 000	6, 930, 000	216, 000	6, 500, 000	6, 716, 000
Washington	120, 000	70, 000	190, 000	147, 000	80, 000	227, 000
Texas, Alabama, Tennessee, Virginia, Vermont, Michigan, and Wyoming	90, 000	5, 000	95, 000	5, 000	205, 000	210, 000
Total	31, 801, 000	51, 600, 000	83, 401, 000	34, 869, 000	51, 321, 500	86, 190, 500

Rank of the States and Territories in the production of gold and silver in 1885.

Gold.	Silver.	Total.
1. California.	1. Colorado.	1. Colorado.
2. Colorado.	2. Montana.	2. California.
3. Montana.	3. Utah.	3. Montana.
4. Dakota.	4. Nevada.	4. Nevada.
5. Nevada.	5. Arizona.	5. Utah.
6. Idaho.	6. Idaho.	6. Idaho.
7. Arizona.	7. New Mexico.	7. Arizona.
8. { New Mexico.	8. California.	8. New Mexico.
Oregon.	9. Dakota.	9. Dakota.
9. Alaska.	10. Washington.	10. Oregon.
10. Utah.	11. Oregon.	11. Alaska.
11. North Carolina.	12. "Other."	12. Washington.
12. Georgia.	13. North Carolina.	13. North Carolina.
13. Washington.	14. Alaska.	14. Georgia.
14. "Other."	15. Wyoming.	15. "Other."
15. South Carolina.		16. South Carolina.
16. Wyoming.		17. Wyoming.
17. Virginia.		18. Virginia.

Rank of the States and Territories in the production of gold and silver in 1886.

Gold.	Silver.	Total.
1. California.	1. Colorado.	1. Colorado.
2. Colorado.	2. Montana.	2. Montana.
3. Montana.	3. Utah.	3. California.
4. Nevada.	4. Nevada.	4. Nevada.
5. Dakota.	5. Idaho.	5. Utah.
6. Idaho.	6. Arizona.	6. Idaho.
7. Arizona.	7. New Mexico.	7. Arizona.
8. Oregon.	8. California.	8. Dakota.
9. Alaska.	9. Dakota.	9. New Mexico.
10. New Mexico.	10. "Other."	10. Oregon.
11. Utah.	11. Washington.	11. Alaska.
12. North Carolina.	12. Oregon.	12. Washington.
13. Georgia.	13. North Carolina.	13. "Other."
14. Washington.	14. Alaska.	14. North Carolina.
15. South Carolina.	15. Georgia.	15. Georgia.
16. "Other."	16. South Carolina.	16. South Carolina.

The production of gold in 1886 exceeded that in 1885 by $3,200,000, and was larger than the production of any previous year since 1880. The production of silver fell off slightly from 1885.

In addition to the silver produced from the mines of the United States there has been a large importation of silver products from the mining districts of Mexico, which have recently become accessible to the new trunk lines of railway, consisting of silver ores for smelting and of silver bullion for refining shipped to private refineries in the United States. The value of the silver in these Mexican products refined in the United States during the calendar year 1886 was nearly $7,000,000.

During the year 1886 the fluctuations in the price of silver were very marked. At the beginning of the year the price in London was $46\frac{15}{16}$ pence per ounce, British standard. In April commenced a rapid decline, reaching the lowest point July 31, 42 pence, at which price silver remained until August 10, when an advance commenced and continued until November 20. The price then reached 47 pence. The closing quotation on December 31 was $46\frac{1}{4}$ pence. The average price of silver bullion during the year was $45\frac{3}{8}$ pence per ounce, British standard (.925 fine), equal, in United States money, to $0.99465. The price at the present time (May 17, 1887) is $43\frac{5}{8}$ pence, equivalent to $0.956 per ounce fine.

The following table shows the production of gold and silver in the United States since 1804, silver being valued at the coining rate in silver dollars, equivalent to $1.2929 per troy ounce fine:

Production of gold and silver in the United States to December 31, 1886.

Periods.	Gold.	Silver.	Total.
Output of the southern States from 1804 to the discovery of gold in California in 1848 (based on estimates of Prof. J. D. Whitney)	$13, 243, 475	....	$13, 243, 475
Product from 1848 to 1879, inclusive, by fiscal years	1, 484, 041, 532	$422, 722, 260	1, 906, 763, 792
Fiscal year ending June 30, 1880 (census figures, covering a period one month earlier, assumed)	33, 379, 663	41, 110, 957	74, 490, 620
July 1, 1880, to December 31, 1880 (estimated on the basis of half the product of the fiscal year 1881, as reported by Hon. Horatio C. Burchard, Director of the Mint)	18, 250, 000	21, 050, 000	39, 300, 000
Calendar years 1881 to 1884, inclusive (as reported by Hon. Horatio C. Burchard, Director of the Mint)	128, 000, 000	184, 800, 000	312, 800, 000
Calendar years 1885 and 1886 (as reported by Dr. James P. Kimball, Director of the Mint)	66, 801, 000	101, 600, 000	169, 401, 000
Total product of the United States to close of 1886	1, 743, 715, 670	773, 283, 217	2, 516, 998, 887

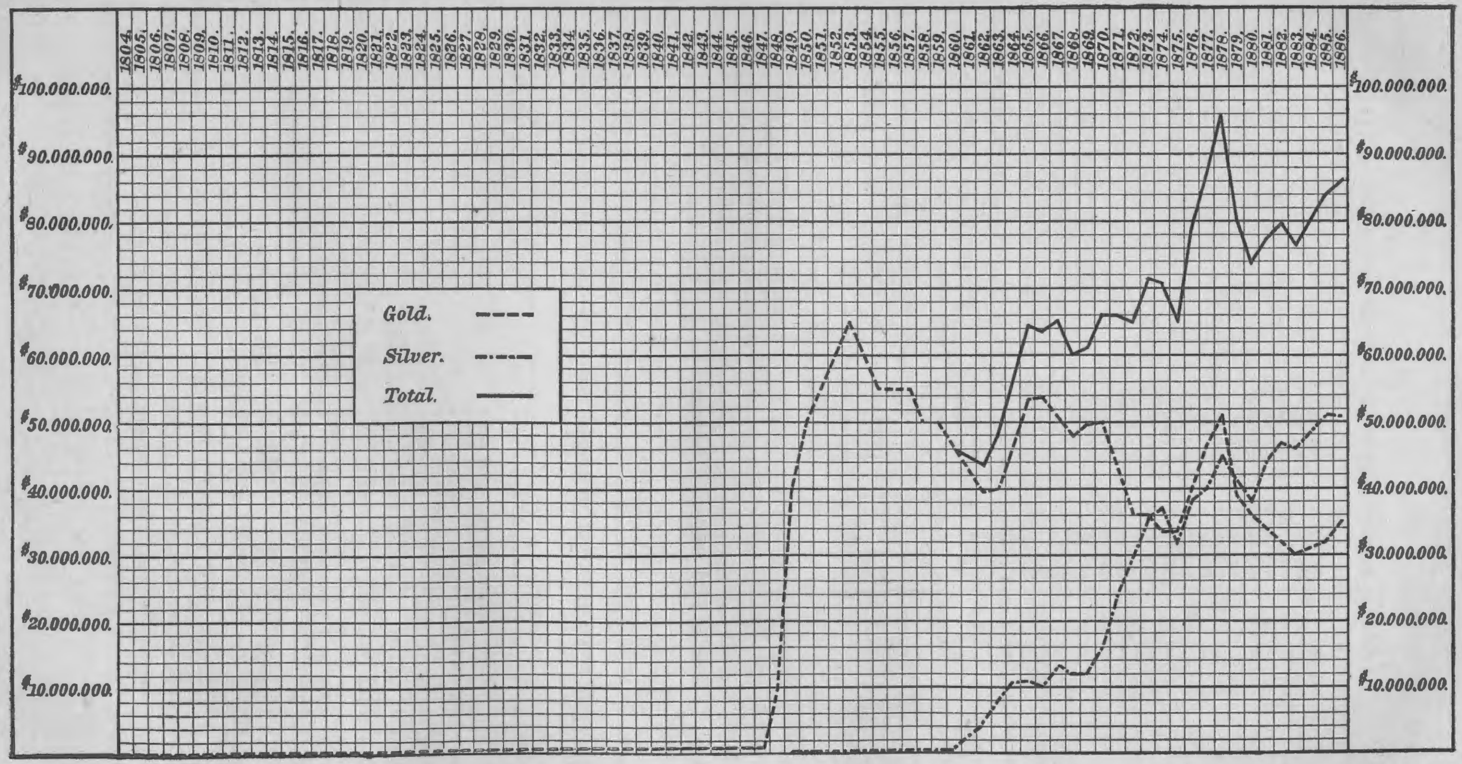


FIG. 1.—Production of gold and silver in the United States to December 31, 1886.

Imports of gold and silver, 1868 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Gold.			Silver.	
	Dust. (*a*)	Bullion.	Coin.	Bullion.	Coin.
1868	....	$1,909,503	$6,558,602	$151,238	$5,304,835
1869	....	890,064	13,240,191	54,267	5,622,548
1870	....	697,904	11,452,414	161,932	14,217,406
1871	....	1,177,387	5,704,298	69,836	11,591,875
1872	$258,329	1,101,617	7,339,572	405,631	4,647,034
1873	7,771	1,549,899	7,092,011	476,608	12,318,911
1874	20,842	1,349,346	18,089,155	830,639	8,153,087
1875	15,222	1,562,767	12,018,537	1,294,763	5,913,474
1876	28,802	1,167,102	6,596,692	1,057,377	6,885,795
1877	85,858	2,032,997	24,131,925	4,693,605	9,829,666
1878	17,602	1,955,005	11,365,656	6,971,849	9,512,704
1879	17,949	1,275,749	4,373,168	2,424,675	12,203,871
1880	883,690	19,453,755	60,420,951	1,981,425	10,294,489
1881	697,467	30,301,452	69,032,340	2,303,472	8,240,766
1882	647,551	8,758,502	24,971,001	2,121,833	5,973,603
1883	....	3,331,708	14,399,441	2,475,968	8,279,274
1884	....	4,997,571	17,833,746	2,910,451	11,684,494
1885	....	8,849,237	17,842,459	4,530,384	12,020,243
1886	....	4,073,458	16,669,891	4,151,438	13,698,869

a In 1868–1871, and 1883–1886, included under head of gold bullion.

Exports of gold and silver of domestic production, 1851 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Gold and silver coin. (*a*)	Gold.		Silver.	
		Bullion.	Coin.	Bullion.	Coin.
1851	$18,069,580	....	....	....	....
1852	37,437,837	....	....	....	....
1853	23,548,535	....	....	....	....
1854	38,062,570	....	....	....	....
1855	19,842,423	$34,114,995	....	....	....
1856	15,458,333	28,689,946	....	....	....
1857	28,777,372	31,300,980	....	....	....
1858	19,474,040	22,933,206	....	....	....
1859	24,172,442	33,329,863	....	....	....
1860	26,033,678	30,913,173	....	....	....
1861	10,488,590	13,311,280	....	....	....
1862	....	13,267,739	$17,776,912	....	....
1863	44,608,529	11,385,033	....	....	....
1864	....	10,985,703	86,148,921	$836,387	$2,502,551
1865	....	21,145,055	35,413,651	6,311,986	1,747,432
1866	....	20,731,473	49,395,993	10,832,849	1,683,059
1867	....	13,867,641	22,362,035	15,853,530	2,892,990
1868	....	23,841,155	44,390,003	12,978,311	2,536,506
1869	....	13,584,407	14,858,369	13,573,427	899,763
1870	....	15,812,108	12,768,501	11,748,864	3,554,329
1871	....	9,089,959	55,491,719	17,285,916	2,535,765
1872	....	7,986,145	40,391,357	22,729,657	1,691,081
1873	....	8,810,175	35,661,863	27,759,066	1,674,442
1874	....	3,878,543	28,766,943	22,498,782	4,555,418
1875	....	2,233.775	59,309,770	17,197,914	5,115,670
1876	....	1,888,896	27,542,861	15,240,344	5,366,590
1877	....	1,084,536	21,274,565	11,482,894	9,292,743
1878	....	205,319	6,427,251	15,035,045	5,394,270
1879	....	24,774	4,120,311	11,883,064	1,526,886
1880	....	87,066	1,687,973	6,912,864	659,990
1881	....	84,943	1,741,364	11,852,995	547,642
1882	....	1,598,336	29,805,289	11,653,547	423,099
1883	....	4,118,455	4,802,454	12,551,378	150,894
1884	....	23,052,183	12,242,021	14,241,050	690,381
1885	....	395,750	2,345,809	20,422,924	1,211,627
1886	....	27,365,090	5,400,769	18,693,313	463,738

a In 1862 and 1864–1886 segregated, appearing in the other columns.

COPPER.

By C. Kirchhoff, Jr.

The long period of depression in the copper trade of the world continued into 1886, and in spite of a temporary reaction carried the average price realized in this country and abroad below the lowest figures yet reached. The result has been a decided check to the rapid increase in the production which had characterized the industry of the United States during the past few years. Although the most striking decrease has occurred here and in Chili, the output has increased in some other countries, and taking it as a whole the production of the world has not fallen off as much as the necessarily great strain of unremunerative prices on many mines would appear to justify. So many considerations, having no apparent direct connection with the supply and demand of the metal, tell upon copper, that it is a difficult matter to gauge the effect of low prices upon the metal. Collateral industries influence the output in some countries which do not have the slightest bearing upon it in others. A large demand for Leblanc soda and for fertilizers in Europe, by increasing the consumption of sulphuric acid, aids the revenues of the Spanish pyrites mines. A decline in the price of silver bears heavily on the principal German mine, while it to some extent helps the copper interests of Chili.

The principal effect of the falling off in the make in this country was dissipated through such causes, since the decline in output was principally in those sections of the country the produce of which has been seeking a market abroad. An effort to obtain a greater foothold at home led to a sudden decline, and the pressure upon foreign markets was transferred to our own. Consumption in the United States cannot cope with the quantities produced in this country. A certain surplus must go abroad. The question is which producers must export. As prices which can be realized in Europe are usually considerably lower than they are here, export sales mean a sacrifice, relatively speaking. Formerly, when the lake companies controlled the bulk of the output, the surplus only was marketed by them, leaving an ample supply at remunerative prices for home consumption. Now heavy export sales by one producer redound to the benefit of others. It was supposed that the acknowledged unequaled quality of Lake Superior copper would protect it in any case against the encroachments of cheaper brands approaching it in quality; but it appears certain that the aggregate wants of consumers who must have the best copper obtainable is considerably less than the output of that grade, or, in other words, the make of the Lake Superior district. The result is that for other purposes than those calling for exceptional quality the inducement of even a slight reduction in price will cause the manufacturer to take other than lake copper. The lake companies must, therefore, either be content to practically waive the advantage of higher quality, or they must export a part of their product. Arizona brands have now been known long enough to possess a recognized standing not much inferior to that of lake, and other grades have decidedly improved during the past years. Manufacturers, too, have learned to depart from time-honored practice and have been taught to employ to advantage, for a variety of work, grades of the metal which hasty trials would formerly have promptly condemned.

This movement has progressed slowly, but it has been the underlying cause of apparent sudden changes in the policy of leading sellers, and will furnish an explanation for abrupt fluctuations in prices. It has to some extent obscured the influence of foreign markets upon our own, and seems destined to play an important part in the development of the copper industry in the near future, especially since the Montana companies show a growing tendency to refine at home.

Generally speaking, the cost of production has been reduced during the year 1886, and the principal mines in the leading districts have considerably improved their position in this respect. With few exceptions, the mines do not, however, realize a fair return for the capital invested, if the exhaustion of ore reserves and other risks incident to mining are taken into account. A number of them have shown a determination to close down as soon as values reached a price which has ruled at times during the year. Others run slowly, to keep equipment employed and working force together.

Comparatively few and unimportant additions have been made to the plant of existing mines during the year 1886, except in Arizona and Montana. In 1887, however, preparations have begun, notably by the Calumet and Hecla Company, and by the Anaconda in Montana, to make very important additions to capacity. Considerable development work has been done in some of the principal districts during the year 1886, but it is not believed that at present prices the properties thus being opened out will be made productive to an extent likely to affect the aggregate output materially. Any notable advance in values would be promptly followed by a rapid increase in output by some of the works now running only up to a portion of their capacity and by the resumption of mines now idle. A continuance of the depression is likely to lead to a further moderate decline in the production of copper, with the possible exception of Montana. During the year 1886 only one new producer of consequence, in New Mexico, has entered the list.

Except through its influence in partly contributing toward the increase in the cost of fuel for some sections, the labor agitation, which was one of the leading features of the industrial development of 1886, did not touch the copper trade directly. It slightly decreased the output in Montana, but did not affect manufacturers of copper beyond the general influence which it exerted upon business all over the country.

The dividends paid by public companies during 1886 compare as follows with the profits paid out in previous years.

Dividends of copper-mining companies.

Name of mine.	1882.	1883.	1884.	1885.	1886.
Calumet and Hecla (Lake Superior)	$2,000,000	$2,000,000	$1,300,000	$1,700,000	$1,500,000
Quincy (Lake Superior)	440,000	380,000	280,000	180.000	240,000
Osceola (Lake Superior)	200,000	200,000	62,500	....	....
Atlantic (Lake Superior)	80,000	80,000	40,000	20,000	40,000
Central (Lake Superior)	60,000	60,000	40,000	(a) 30,000	40,000
Franklin (Lake Superior)	....	80,000	80,000	40,000	80,000
Copper Queen (Arizona)	325,000	500,000	200,000	....	....
San Francisco (California)	....	2,500	....	....	....
United Verde (Arizona)	....	37,500	60,000	....	....

a By sale of timber lands.

It should be stated that some of the Lake Superior mining companies declare their dividends in the beginning of the year out of the earnings of the year before, so that the date of the dividend does not in some cases reflect the earning capacity of the mine in that year. The Copper Queen of Arizona has passed into private ownership practically, while the United Verde has not been worked in 1886, although it resumed operations in 1887. Not one of the leading Montana mines is controlled by public companies who announce their dividends, but it is understood that some of them earned a moderate profit.

DOMESTIC PRODUCTION.

The growth in the production of copper in the United States, compiled up to 1886, inclusive, from the best data available, is shown in the following table. It proves in a striking manner how preponderating was, until the past few years, the influence of the Lake Superior district; and again of one great mine in it, the Calumet and Hecla, for more than a decade. In order to point out more clearly how the influence of the Lake district has declined, a column has been added giving its percentage of the total product from year to year. It should be stated that the yield of copper from pyrites is not here included.

Production of copper in the United States from 1845 to 1886 inclusive.

Years.	Total production.	Lake Superior.	Calumet and Hecla.	Percentage of Lake Superior of total product.	Years.	Total production.	Lake Superior.	Calumet and Hecla.	Percentage of Lake Superior of total product.
	Long tons.	*Long tons.*	*Long tons.*			*Long tons.*	*Long tons.*	*Long tons.*	
1845...	100	12	....	12.0	1866...	8,900	6,138	....	68.8
1846...	150	26	....	17.0	1867...	10,000	7,824	603	78.2
1847...	300	213	....	71.0	1868...	11,600	9,346	2,276	80.6
1848...	500	461	....	92.5	1869...	12,500	11,886	5,497	95.1
1849...	700	672	....	96.0	1870...	12,600	10,992	6,277	87.2
1850...	650	572	....	88.0	1871...	13,000	11,942	7,242	91.9
1851..	900	779	....	86.6	1872...	12,500	10,961	7,215	95.7
1852...	1,100	792	....	72.0	1873...	15,500	13,433	8,414	87.3
1853...	2,000	1,297	....	64.9	1874...	17,500	15,327	8,984	87.6
1854...	2,250	1,819	....	71.1	1875...	18,000	16,089	9,586	89.4
1855...	3,000	2,593	....	86.4	1876..	19,000	17,085	9,683	88.9
1856...	4,000	3,666	....	91.6	1877...	21,000	17,422	10,075	82.9
1857...	4,800	4,255	....	88.7	1878..	21,500	17,719	11,272	82.4
1858...	5,500	4,088	....	74.3	1879..	23,000	19,129	11,728	83.2
1859...	6,300	3,985	....	63.3	1880...	27,000	22,204	14,140	82.2
1860...	7,200	5,388	....	74.8	1881...	32,000	24,363	14,000	76.1
1861...	7,500	6,713	....	89.1	1882...	40,467	25,439	14,309	62.1
1862...	9,000	6,065	....	67.4	1883...	51,574	26,653	14,788	50.1
1863...	8,500	5,797	....	67.0	1884...	63,555	30,916	17,812	48.4
1864...	8,000	5,576	....	69.7	1885...	74,053	32,206	21,093	43.5
1865...	8,500	6,410	....	75.4	1886...	69,971	35,666	25,259	50.1

For the western States and Territories the geographical distribution of the product is becoming more and more difficult.

Territorially distributed, the production of the United States in 1886 has been as follows as compared with previous years:

Total copper production in the United States, 1882 to 1886.

Source.	1882.	1883.	1884.	1885.	1886.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Lake Superior..................	56,982,765	59,702,404	69,353,202	72,148,172	79,890,798
Arizona.........................	17,984,415	23,874,963	26,734,345	22,706,366	15,657,035
Montana	9,058,284	24,664,346	43,093,054	67,797,864	57,611,621
New Mexico	869,498	823,511	59,450	79,839	558,385
California......................	826,695	1,600,862	876,166	469,028	430,210
Colorado	1,494,000	1,152,652	2,013,125	1,146,460	409,306
Utah............................	605,880	241,885	265,526	126,199	500,000
Wyoming	100,000	962,468	....	....	....
Nevada	350,000	288,077	100,000	8,871	50,000
Idaho	....	....	46,667	40,381	....
Missouri........................	294,695	260,306	230,000	....	....
Maine and New Hampshire...	290,000	212,124	249,018	211,602	815,719
Vermont.........................	1,265,000	400,000	655,405		
Southern States.................	400,000	395,175	317,711	40,199	29,811
Middle States	....	64,400	2,114	190,641	....
Lead desilverizers, etc	125,000	782,880	950,870	910,144	1,282,496
Total domestic copper...	90,646,232	115,526,053	144,946,653	165,875,766	156,735,381
From imported pyrites and ores	1,000,000	1,625,742	2,858,754	5,086,841	4,500,000
Total (including copper from imported pyrites).	91,646,232	117,151,795	147,805,407	170,962,607	161,235,381

The figures given under "lead desilverizers" in the above table are the closest approximation obtainable by a study of the returns from the lead-desilverizing works, which usually report to this office separately their make of bluestone and of matte. The total stated under "imported pyrites and ores" may include some copper from domestic pyrites, since it is impossible to separate them in some cases.

The following is, in detail, the output of the Lake Superior mines. In the majority of cases it is the official product based on smelting-works returns; in a few instances it is an official estimate of the ingot product based on the known output of mineral. The total is accurate, therefore, within a few thousand pounds.

The production of Lake Superior copper mines, 1880 to 1886.

Mines.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Calumet and Hecla	31, 675, 239	31, 360, 781	32, 053, 539	33, 125, 045	40, 473, 585	47, 247, 990	50, 518, 222
Quincy	3, 696, 263	5, 506, 848	5, 665, 796	6, 012, 239	5, 650, 436	5, 848, 530	5, 888, 517
Osceola	3, 383, 537	4, 179, 976	4, 176, 782	4, 256, 409	4, 247, 630	1, 945, 208	3, 560, 786
Franklin	2, 336, 466	2, 677, 932	3, 264, 120	3, 488, 708	3, 748, 652	4, 007, 105	4, 264, 297
Allouez	1, 318, 471	1, 473, 007	1, 683, 557	1, 751, 377	1, 928, 174	2, 170, 476	1, 725, 463
Atlantic	2, 341, 195	2, 528, 009	2, 631, 708	2, 682, 197	3, 163, 585	3, 582, 633	3, 503, 670
Pewabic	970, 509	1, 876, 244	1, 482, 666	1, 171, 847	227, 834	....	....
Central	2, 026, 078	1, 418, 465	1, 353, 597	1, 268, 556	1, 446, 747	2, 157, 408	2, 512, 886
Grand Portage	67, 860	26, 264	757, 080	735, 598	255, 860	....	....
Conglomerate	233, 814	386, 091	734, 249	222, 117	1, 198, 691	....	....
Mass	517, 159	467, 684	737, 440	659, 474	481, 396	365, 000	200, 000
Copper Falls	6, 615	669, 121	587, 500	804, 000	891, 168	1, 168, 000	1, 400, 000
Phœnix	436, 010	409, 357	537, 177	512, 291	631, 004	344, 355	100, 000
Hancock	3, 032	571, 897	540, 575	484, 906	562, 636	203, 037	150, 000
Huron	70, 285	254, 515	364, 579	720, 213	1, 927, 660	2, 252, 484	1, 992, 695
Ridge	223, 353	235, 606	102, 936	60, 155	74, 030	63, 390	158, 272
Saint Clair	13, 195	135, 493	87, 126	125, 225	139, 407	....	....
Cliff	78, 962	79, 382	66, 053	10, 374	28, 225	....	22, 342
Wolverine	....	....	25, 623	699, 622	751, 763	328, 610	3, 125
Nonesuch	55, 584	119, 061	46, 450	....	23, 867	28, 484	....
Isle Royal	79, 469	47, 308	35, 447	....	16, 074	....	....
Minong	27, 407	15, 397	21, 380	3, 582	....	....	....
National	....	....	17, 060	26, 006	87, 368	162, 252	184, 706
Minesota	26, 033	24, 227	10, 672	6, 226	1, 144	12, 608	....
Belt	....	....	5, 625	16, 402	130, 851	27, 433	7, 300
Sheldon and Columbia	26, 931	10, 031	3, 299	....	9, 828	....	....
Aztec	3, 757	....	3, 129	....	....	....	....
Adventure	2, 951	7, 500	429	....	4, 333	4, 000	1, 000
Peninsula	....	....	....	849, 400	1, 225, 931	....	....
Tamarack	....	....	....	7, 435	....	181, 669	3, 646, 517
Ogima	5, 885	16, 776	4, 207	3, 000	1, 106	12, 000	....
Concord	10, 464	28, 849	....	....	....	....	....
Evergreen Bluff	10, 651	968	....	....	954	1, 500	1, 000
Flint Steel River	28, 080	4, 140	....	....	....	....	....
Madison	....	1, 534	....	....	....	....	....
Northwestern	916	....	....	....	....	....	....
Ash Bed	....	24, 804	72, 636	....	1, 517	....	....
Centennial	....	....	83, 554	....	....	....	....
Sundry companies—tributers	6, 166	1, 642	....	....	21, 696	34, 000	50, 000
Total	49, 682, 337	54, 558, 909	57, 155, 991	59, 702, 404	69, 353, 202	72, 148, 172	79, 890, 798

THE COPPER DISTRICTS OF THE UNITED STATES.

Lake Superior.—The prices for copper realized in 1886 were a little lower than those of the preceding year, and therefore bore heavily on a number of the smaller mines, leading to the practical suspension of operations at some of them. But the increase in the production of the Calumet and Hecla and the larger output of the Tamarack mine more than compensated for the falling off thus brought about. At nearly all of the larger mines further economies and improved equipment brought about another lowering of costs in spite of higher prices for fuel.

The following table gives the cost of production of the principal mines in the years 1875 and 1881 to 1886:

Cost of production of Lake copper per pound.

Mines.	Cost of production (in cents per pound).							Yield (per cent.).						
	1886.	1885.	1884.	1883.	1882.	1881.	1875.	1886.	1885.	1884.	1883.	1882.	1881.	1875.
Quincy	6.78	7.50	8.63	9.00	9.55	10.03	15.79	2.54	2.51	2.70	2.86	3.21	2.62	.....
Osceola	8.67	10.90	11.24	12.21	12.97	......	......	1.29	......	1.17	1.21	.....	1.29	......
Atlantic	9.52	9.37	10.88	12.56	13.80	13.68	22.12	.71	.74	.75	.68	.69	.72	.78
Central	8.74	8.83	15.10	15.40	14.76	14.24	15.81	......	3.37	2.48	1.90	2.20	1.58	2.65
Allouez	......	11.29	13.46	15.98	17.38	19.32	......	......	.84	.85	.86	.85	.95	......
Franklin	9.34	10.03	11.62	12.96	13.00	......	......	1.88	1.46	1.45	1.38	1.10	.....	......
Pewabic	......	......	......	21.47	17.00	10.36	......	......	.....	......	1.01	1.00	1.38	......
Huron	13.59	11.75	14.78	......	......	......	......	1.54	1.18	1.45	......	.....	.....	......
Tamarack	7.49	......	......	......	......	......	......	......	.....	......	......	......	.....	......

So far as developments at the mines of the Calumet and Hecla are concerned, the only important fact is the notable improvement in the grade of the rock in the Black Hills ground, approaching as it does now close to 3 per cent. This, the west end of the lode, has been opened out for a number of levels, but up to the close of 1866 little or no extraction has gone on; that part of the territory constituting practically a new mine, untouched till recently. It is understood that further changes and additions are about to be made in the machinery plant, the large engine now used for driving hoisting drums and compressors at the Calumet to be applied to the latter purpose only, while new triple-expansion engines are to be used for hoisting. Early in 1887 the company decided to add further to its crushing plant, and in May the foundations were being laid for six new Leavitt stamps, thus increasing the crushing capacity 50 per cent. Provided that the same grade of rock be treated, this would mean a capacity after 1888 of 75,000,000 pounds of ingot, but if the new stamps are to crush West End rock, the total possible output would be 60,000,000 to 62,000,000 pounds. The company, in co-operation with the owners of the Detroit and Lake Superior Copper Company, has built a refinery at Torch Lake, started in May, 1887. The starting of these works of the Calumet and Hecla Smelting Company will tend to lower costs.

According to official advices, under date of April 26, 1887, No. 1 shaft of the Tamarack mine is 2,510 feet deep, or 10 feet below the seventh level, from which stoping and hoisting will be begun in May. The sixth level, which is 300 feet in length and has been opened on the conglomerate, has proved richer ground than any seen elsewhere in the mine, the stopes showing a width of from 15 to 16 feet. On the seventh level the foot-wall part only of the lode has been opened for about 50 feet, its width not having been proven thus far. The work at the Tamarack, therefore, confirms the general conviction concerning the persistency of the lode and the highly metalliferous character of the ground within the limits of the ore chute. The property of the company is such that in its upper levels it controls only a narrow strip of this chute, widening as depth is reached. It has now reached a level which will give it a working length of 1,100 feet. A second shaft is now being sunk. It has reached a depth of 500 feet, and it is expected that in about two years the mine workings will be communicated with. Early in May the new Tamarack mill was started. It has two stamps, and the foundations are laid for a third, the building being so designed that further additions to it may be made in the future. Its present capacity is rated at 10,000 tons of rock a month, which, it is expected, will yield 250 tons of ingot copper monthly.

Parties identified with the Osceola and Tamarack mines have begun work at the Kearsarge, north of the Calumet and Hecla, on what is known as the Kearsarge amygdaloid. In May, 1887, it had two shafts, 400 feet apart, down below the third level and connected at the second level. The developments thus far are reported to be very encouraging. The intention of the management is to open a good block of ground, and in the summer of 1887 to begin stamping at the Osceola mill. Under the same management ground north of the Kearsarge has been opened by what is known as the Iroquois Company. Late in the fall of 1886 the Kearsarge amygdaloid was found, but it has been decided to await developments at the Kearsarge mine before actively going to work.

The year 1886 has been an uneventful one for the Franklin mine. It has further increased its product to 4,264,297 pounds by handling a larger amount of rock and through an improvement in the grade of the ore crushed. The mine has needed and has expended little for construction account, and will do nothing of any consequence in that direction. The profit in 1886 amounted to $58,454.47. The Huron, a neighbor of the Atlantic, is under the management controlling the Franklin. It has been struggling against adverse circumstances. Through stoppage on account of low prices in the spring, and by reason of accident, its output has been somewhat lessened and it has been working at a loss. The amount of rock hoisted was 129,437 tons, of which 38,943 tons, or 30.1 per cent., was rejected, the total cost of manipulating a ton of rock being $1.70, against $1.59 on 139,129 tons in 1885. Early in 1887 its stamp mill was destroyed by fire.

The Atlantic mine has, in 1886, further reduced expenses, although its profits have been less per ton of rock, principally because the copper contents fell from 0.743 per cent. in 1885 to 0.709 per cent. in 1886.

Cost at the Atlantic mine.

Items of cost.	1885.	1886.
	Cents.	*Cents.*
Mining, selecting, breaking, and all surface expenses, including taxes	78.62	80.88
Transportation to mill	4.80	3.48
Stamping and separating	30.36	26.53
Freight, smelting, marketing, and New York expenses	25.45	24.25
Total working expenses	139.23	135.14
Total expenditures	143.60	138.01
Net profit	22.05	15.29

The total amount of rock treated was 247,035 tons, obtained from 14,724 cubic fathoms of ground, broken in openings and stopes. The mining profit amounted to $48,497.78, the net surplus at the end of the year being $304,100.09.

The Central mine is the only prominent "mass" mine which has survived. Out of its total product of 3,200,755 pounds, about one-quarter, or 832,495 pounds, was obtained in the form of 324 masses of copper, each of which, therefore, averaged considerably over one ton. In addition to this, 689,125 pounds of "barrel copper" was obtained. The mine has considerable stoping ground which is too poor to pay at present prices, but has worked principally in some more productive stopes. The mining profit for 1886 footed up to $51,839.34, after paying $21,540.05 for construction account. The new hoisting engine was being put up in the beginning of 1887. Out of its income the company purchased two adjoining tracts of 2,520 acres, formerly belonging to the Northwestern and Madison mines, for $24,017.01, leaving its surplus at the end of the year $256,104.31.

Arizona.—The output of Arizona declined again in 1886, partly because of the cessation of operations at all of the smaller mines, and the running at a moderate rate of the four principal producers, the Copper Queen, Old Dominion, Detroit, and Arizona. The Old Dominion mine was worked only to its minimum capacity, one smelting furnace being run with the purpose of keeping the force together. No increase in the plant is contemplated, and the only work of consequence to be done will be to sink a new shaft during the year. During 1886 a large vein of ore 18 feet wide has been opened the length of which had not yet been ascertained in April. As it is considered the most valuable discovery yet made since the opening of the mine, a continuance of the production of the mine is assured. Costs generally have been somewhat reduced and wagon and railroad freights have been lowered somewhat. The average grade of the ore has remained the same, the percentage during the fiscal year being 15.7 per cent.

The Copper Queen built a new concentrating and smelting plant in 1886 and 1887 and acquired a number of adjoining properties. In 1886 the company smelted 23,265 tons of ore yielding 1,978 tons of black copper, 96 per cent. fine, equal to 8.5 per cent. copper yield. The Arizona Copper Company at Clifton has opened several claims and has made some improvements in the shape of tramways which should materially add to output. It is not expected by the management that the amount mined will be so large as these improvements would justify, since the low price of copper does not warrant any special expenditure. The cost of mining has declined during 1886, partly owing to a reduction in wages and partly to improvements in plant. Nothing calculated to lead to a heavier output is reported from the Detroit Company in the same district. Of all the other copper mines in

Arizona none have been producers in 1886, and with low values for the metal, a further decline in the product of the territory is looked forward to.

Montana.—Through the temporary and in some cases long-continued closing down of some of the works, the product of Butte has not been up to the capacity of its mines and smelting plant. Generally speaking it may be stated that costs have been lowered somewhat, and there is evidence enough to assert that at the average prices realized in 1886 the majority of the mines have not run at a loss. The published financial statement of one proves this and confidential returns from others confirm it. On the other hand, while the mines can live and will continue to produce at such figures, it must be conceded that the returns have not been adequate earnings on capital invested or allowed for exhaustion of deposits. The price of fuel, now $6.50 to $7 a ton for coal, and $18 for coke, will probably be lowered during the current year, and freights from Butte to Chicago have been reduced from $15 to $12 per ton of matte, but labor still remains comparatively much higher than it is in competing districts. An unsuccessful effort has been made to bring about a reduction. The probabilities point to a cheapening of the cost of production which will enable the mines of this district to hold their position in domestic and foreign markets against the competition of other sections. More attention has been paid during 1886 to the smelting of argentiferous ores, the copper veins carrying the precious metal lying outside of the main belt, and being much smaller. True silver ores are purchased or extracted by parties controlling copper works from their own mines to carry the average silver contents of the matte above the limit at which separation pays. This lies at about 30 ounces. For the silver above that minimum the precious metal is paid for at the rate of 92½ per cent. of its value, the copper being sold for a given sum per pound regardless of the silver contents of the matte. The bulk of the matte made by the Anaconda Company does not carry sufficient silver to pay for cost of separation. The same is true of the Mountain View ores and of the bulk of the product of the Parrot, Montana, and Clark's Colusa mines. When smelting ordinary copper and silver ores together the output of a plant is considerably smaller than it is for copper ores alone.

The Anaconda Company has considerably enlarged its concentrating capacity during 1886, by the erection of Ball stamps, so that its plant can now handle close up to 1,500 tons of ore a day, making its annual capacity, with twenty-two furnaces, about 60,000,000 pounds, at which rate it has produced for months during the first half of 1887. There has been some talk of finishing the second concentrating mill during the season of 1887. Branches are now being built to a number of other mines controlled by the Anaconda Company, where considerable quantities of 14 to 15 per cent. ore are stored. When they become available the output of the plant will be greater, since their average is higher than that of the ores worked lately. The cost of production at the Anaconda has been considerably reduced during 1886.

The Montana Copper Company produced only during the first few months of the year 1886. Since then work has been devoted exclusively to further development of the mines, which are reported to show large reserves of a good grade of ore. In 1887 a consolidation with parties interested in the Tamarack and Osceola mines, Lake Superior, took place, and more active working will follow.

The Parrot Company has run quite steadily during 1886, and during the year has replaced one of its older blast furnaces by a new one, its Manhès plant running regularly and satisfactorily. The output is not likely to be much greater in 1887 than it was in 1886, when the operations of the company were conducted at a profit.

Some improvements have been made in 1886 in the plant belonging to W. A. Clark. The concentrating works have now a capacity of 125 tons per day. The two O'Harra calciners are capable of handling 54 tons per day, and the smelting capacity of two blast furnaces and two reverberatory furnaces is equal to 175 tons per day. When smelting copper ores only, the works can turn out 1,000,000 pounds of fine copper monthly, but when making only argentiferous mattes, the monthly product is about 600,000 pounds.

California.—Mining operations at the largest mine in California, at Spenceville, have been stopped during the year, and leaching of the ore on the dumps only has been continued. The same company has begun work at Campo Seco, but leaching operations have not been satisfactory.

Refineries.—An enterprise which is significant in connection with the tendency to treat copper furnace material at home is the project of building a large plant at Duluth to refine Montana mattes. The Baltimore refinery has been engaged in adding to its capacity during 1887, which will enable it to handle increased quantities of Montana mattes in the future. The effect of the venture is expected to be to increase the pressure on our home markets and keep them more closely on a parity with foreign values. The Pueblo Smelting and Refining Company, at South Pueblo, Colorado, is experimenting with a process to work argentiferous copper mattes with lead to extract their silver.

IMPORTS.

The imports of fine copper contained in ores, and regulus and black copper, and of ingot copper, old copper, plates not rolled, rolled plates, sheathing metal, and manufactures not otherwise specified, and of brass, are given in the following tables:

Fine copper contained in ores, and regulus and black copper imported and entered for consumption in the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Fine copper contained in ores.		Regulus and black copper. (*a*)		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		
1867		$936,271			$936,271
1868	3,496,994	197,203			197,203
1869	24,960,604	448,487			448,487
1870	1,936,875	184,736			134,736
1871	411,315	42,453	499	$60	42,513
1872	584,878	69,017	4,247	1,083	70,100
1873	702,086	80,132	1,444,239	279,631	359,763
1874	606,266	70,633	28,880	5,397	76,030
1875	1,337,104	161,903	12,518	2,076	163,979
1876	538,972	68,922	8,584	1,613	70,535
1877	76,637	9,756	1,874	260	10,016
1878	87,039	11,785			11,785
1879	51,959	6,199			6,199
1880	1,165,283	173,712	2,201,394	337,163	510,875
1881	1,077,217	124,477	402,640	51,633	176,110
1882	1,473,109	147,416	224,052	30,013	177,429
1883	1,115,386	113,349			113,349
1884	2,204,070	219,957	2,036	204	220,161
1885	3,665,739	343,793	285,322	20,807	364,600
1886	4,123,842	413,276	186,887	14,962	428,238

a Not enumerated till 1871.

Copper imported and entered for consumption in the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Bars, ingots, and pigs.		Old, fit only for remanufacture.		Old, taken from bottoms of American ships abroad. (*a*)		Plates not rolled.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*		*Pounds.*		*Pounds.*	
1867	1,635,953	$287,831	569,732	$81,930				
1868	61,394	6,935	318,705	42,652				
1869	13,212	2,143	290,780	34,820				
1870	5,157	418	255,386	31,931				
1871	3,316	491	369,634	45,672			430	$129
1872	2,638,589	578,965	1,144,142	178,536			148,192	33,770
1873	9,697,608	1,984,122	1,413,040	255,711	32,307	$4,913	550,431	97,888
1874	718,935	134,326	733,326	137,087	9,500	930		
1875	58,475	10,741	396,320	55,564	11,636	1,124	8	4
1876	5,281	788	239,987	35,545	10,304	1,981	5,467	600
1877	230	30	219,443	28,608	41,482	5,136		
1878	1		198,749	25,585		6,004		
1879	2,515	352	112,642	11,997	11,000	1,107	27,074	4,496
1880	1,242,103	206,121	695,255	91,234			120	11
1881	219,802	36,168	541,074	63,383	14,680	1,504	20	3
1882	6,200	836	508,901	59,629	16,075	1,629		
1883			330,495	36,166	9,415	666		
1884	(*b*)542	107	149,701	12,099		554		
1885	914	172	81,312	6,658		1,160		
1886	159	24	41,025	2,647		374		

a Not enumerated until 1873. *b* Includes "Plates not rolled" since 1884.

Copper imported and entered for consumption in the United States, &c.—Continued.

Fiscal years ending June 30—	Plates rolled; sheets, pipes, &c.		Sheathing metal, in part copper. (a)		Manufactures not otherwise specified.	Total value.
	Quality.	Value.	Quality.	Value.	Value.	
	Pounds.		*Pounds.*			
1867	....	$1,101	220,889	$37,717	$15,986	$424,565
1868	....	1	101,488	18,852	21,492	89,932
1869	....	39	43,669	6,592	43,212	86,806
1870	....	2,039	....	....	485,220	519,608
1871	....	7,487	....	....	668,894	722,673
1872	....	18,895	....	....	1,007,744	1,817,010
1873	....	4,514	....	....	869,281	3,216,429
1874	....	27	282,406	50,174	125,708	448,252
1875	....	617	136,055	23,650	35,572	127,272
1876	....	326	18,014	2,903	29,806	71,949
1877	....	203	110	22	41,762	75,761
1878	....	1,201	647	55	35,473	68,318
1879	....	786	300	20	39,277	58,035
1880	....	4,134	6,044	693	130,329	432,522
1881	....	82	39,520	4,669	284,509	390,318
1882	5,855	1,551	....	....	77,727	141,372
1883	2,842	379	6,791	1,047	40,343	78,601
1884	6,529	2,330	19,637	926	55,274	71,290
1885	470	120	86,619	9,894	61,023	79,027
1886	374	21	662,466	78,572	19,093	100,731

a Does not include copper sheathing in 1867, 1868, and 1869.

Brass imported and entered for consumption in the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Bars and pigs.		Old, fit only for remanufacture.		Not otherwise provided for.	Total value.
	Quantity.	Value.	Quantity.	Value.	Value.	
	Pounds.		*Pounds.*			
1867	....	$3,099	....	$26,468	$170,873	$200,440
1868	31,104	2,071	129,913	11,699	181,114	194,884
1869	33,179	2,457	131,640	10,838	198,310	211,605
1870	54,108	3,791	98,825	6,918	49,845	60,554
1871	28,453	2,803	438,085	37,922	13,659	54,384
1872	17,963	1,664	829,964	73,098	23,738	98,500
1873	56,656	7,147	699,478	71,494	114,767	193,408
1874	253	19	682,151	64,848	350,266	415,133
1875	370,273	38,867	124,285	12,786	273,873	325,526
1876	....	....	618,191	54,771	232,870	287,641
1877	....	....	689,633	59,402	207,642	267,044
1878	....	....	713,171	57,551	205,209	262,760
1879	950	49	485,354	32,278	232,030	264,357
1880	....	....	958,590	75,093	339,131	414,224
1881	85,370	11,202	1,615,402	151,541	331,506	494,249
1882	30,769	3,168	2,954,148	263,891	400,477	667,536
1883	6,380	559	1,015,345	84,786	485,321	570,666
1884	1,611	445	508,923	40,766	429,224	470,435
1885	2,305	532	166,317	15,717	400,175	416,424
1886	1,956	91	173,511	30,076	363,934	394,101

EXPORTS.

The wide fluctuations in the quantities of copper, copper ore, and manufactured copper exported for a series of years are exhibited in the following tables:

Value of copper, brass, and manufactured copper exported from the United States, 1791 *to* 1863, *inclusive.*

Fiscal years ending September 30 until 1842, and June 30 since.	Value.	Fiscal years ending September 30 until 1842, and June 30 since.	Value.
1791	$493	1833	$203, 880
1803	6, 233	1834	198, 273
1804	8, 654	1835	69, 791
1805	12, 977	1836	72, 991
1806	25, 340	1837	91, 724
1807	12, 742	1838	81, 363
1808	4, 061	1839	81, 334
1809	3, 095	1840	86, 954
1810	17, 426	1841	72, 932
1811	9, 282	1842	97, 021
1812	2, 644	1843 (nine months)	79, 234
1813	....	1844	91, 446
1814	....	1845	94, 736
1815	366	1846	62, 088
1816	16, 152	1847	64, 980
1817	8, 765	1848	61, 468
1818	33, 379	1849	66, 203
1819	12, 721	1850	105, 060
1820	18, 547	1851	91, 871
1821	26, 694	1852	103, 039
1822	36, 974	1853	108, 205
1823	16, 768	1854	91, 984
1824	26, 981	1855	690, 766
1825	30, 472	1856	534, 846
1826	60, 083	1857	607, 054
1827	52, 341	1858	1, 985, 223
1828	60, 452	1859	1, 048, 216
1829	129, 647	1860	1, 664, 122
1830	36, 601	1861	2, 375, 029
1831	55, 755	1862	1, 098, 546
1832	105, 774	1863	1, 026, 038

Copper and copper ore of domestic production exported from the United States, 1864 *to* 1886 *inclusive.*

[Cwts. are long hundredweights of 112 pounds.]

Fiscal years ending June 30—	Ore.		Pigs, bars, sheets, and old.		Value of manufactured.	Total value.
	Quantity.	Value.	Quantity.	Value.		
	Cwts.		*Pounds.*			
1864	109, 581	$181, 298	102, 831	$43, 229	$208, 043	$432, 570
1865	225, 197	553, 124	1, 572, 382	709, 106	282, 640	1, 544, 870
1866	215, 080	792, 450	123, 444	33, 553	110, 208	936, 211
1867	87, 731	317, 791	(a)4, 637, 867	303, 048	171, 062	791, 901
1868	92, 612	442, 921	1, 350, 896	327, 287	152, 201	922, 409
1869	121, 418	237, 424	1, 134, 360	233, 932	121, 342	592, 698
1870	(a)19, 198	537, 505	2, 214, 658	385, 815	118, 926	1, 042, 246
1871	(a)54, 445	727, 213	581, 650	133, 020	55, 198	915, 431
1872	35, 564	101, 752	267, 868	64, 844	121, 139	287, 735
1873	45, 252	170, 365	38, 958	10, 423	78, 288	259, 076
1874	13, 326	110, 450	503, 160	123, 457	233, 301	467, 208
1875	(a)51, 305	729, 578	5, 123, 470	1, 042, 536	43, 152	1, 815, 266
1876	15, 304	84, 471	14, 304, 160	3, 098, 395	343, 544	3, 526, 410
1877	21, 432	109, 451	13, 461, 553	2, 718, 213	195, 730	3, 023, 394
1878	32, 947	169, 020	11. 297, 876	2, 102, 455	217, 446	2, 488, 921
1879	23, 070	102, 152	17, 200, 739	2, 751, 153	79, 900	2, 933, 205
1880	21, 623	55, 763	4, 206, 258	667, 242	126, 213	849, 218
1881	9, 958	51, 499	4, 865, 407	786, 860	38, 036	876, 395
1882	25, 936	89, 515	3, 340, 531	565, 295	93, 646	748, 456
1883	112, 923	943, 771	8, 221, 363	1, 293, 947	110, 286	2, 348, 004
1884	386, 140	2, 930, 895	17, 044, 760	2, 527, 829	137, 135	5, 595, 859
1885	432, 300	4, 739, 601	44, 731, 858	5, 339, 887	107, 536	10, 187, 024
1886	544, 020	3, 068, 879	24, 292, 393	2, 493, 898	108, 971	5, 671, 748

a Evidently errors in quantities.

Value of brass, and manufactures of, exported from the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Value.	Fiscal years ending June 30—	Value.
1867	$12,864	1877	$327,817
1868	16,841	1878	589,451
1869	40,063	1879	200,871
1870	169,997	1880	183,468
1871	210,816	1881	216,057
1872	229,458	1882	322,439
1873	494,575	1883	287,847
1874	503,531	1884	301,014
1875	1,000,629	1885	538,118
1876	256,974	1886	150,807

In all the above tables the fiscal year, being that adopted by the Bureau of Statistics, is chosen. For the calendar years, with which the trade deals almost exclusively, the figures are:

Exports of copper—calendar years.

	1885.	1886.
Pig, bars, and ingot ... pounds	36,221,931	19,504,087
Sheets ... do	63,101	49,334
Ore and matte ... long tons (*a*)	34,767	50,876

a It is not usual to state ore and matte exports in pounds.

Through the courtesy of the principal exporting refineries and mining companies, it has been possible to trace no less than 18,424,188 pounds of the above 19,504,087 pounds of ingot copper exported in 1886, leaving a little more than 1,000,000 as the export of second hands. On the basis of these returns it may be stated roughly that between 15,000,000 and 15,500,000 pounds of the export were lake copper, and 4,000,000 to 4,500,000 pounds were other brands, the origin of which it is, of course, impossible to trace, though it may be stated in a general way that a large proportion of it was undoubtedly Montana produce.

It is a far more difficult matter to trace the quantity of the copper exported in the form of mattes or ore, the Bureau of Statistics not giving the fine copper contents thereof. Considerable quantities are always in transit, so that it is not safe to simply deduct from the product of Montana the quantities refined in this country. Besides, an unknown quantity is shipped abroad in the form of ingots after being refined here. Then some works which smelt foreign ores re-export in the form of matte. The total quantity of Montana product refined at home aggregated 22,551,013 pounds, a part of it, however, being shipped to bluestone works in the form of oxide. A small quantity smelted at a refinery started in 1886 is not included. This would apparently leave 35,000,000 as the quantity exported in the form of matte. But as the total quantity of the latter was only 20,876 long tons, which, at 65 per cent. would amount to only 27,000,000 pounds, and as this includes close upon 2,000,000 pounds of copper in mattes from other sources, there is an apparent discrepancy of 10,000,000 pounds. The English imports do not furnish a cue, since the total of fine copper reported from there is only 25,350,000 pounds, in connection with which the fact must be considered that they include probably a large quantity of 1885 product, the arrival of which is credited in 1886, while the amounts afloat towards the end of 1886 were small. On the other hand, it is true that some matte went to the continent, but that quantity cannot have been more than a few millions of pounds. The natural inference is that a considerable quantity of Montana matte, credited in 1886 production, must have been carried in stock either at the smelting works at the West, or at Eastern refineries, or must have been in transit.

In the absence of any statement concerning stocks a balance cannot be struck between product, quantity retained for home consumption, and amounts exported.

Consumption.

As in the past year, this office has again received, confidentially, a statement from the majority of the leading manufacturers of copper and brass in its different forms, the following firms sending replies:

American Tube Works, Boston, Massachusetts.

Ansonia Brass and Copper Company, Ansonia, Connecticut.

Baltimore Copper Smelting and Rolling Mill Company, Baltimore, Maryland.

Bridgeport Brass Company, Bridgeport, Connecticut.

Bristol Brass and Clock Company, Bristol, Connecticut.

Cheshire Brass Manufacturing Company, West Cheshire, Connecticut.

Coe Brass Manufacturing Company, Torrington, Connecticut.

Detroit Copper and Brass Rolling Mills, Detroit, Michigan.

De Witt Wire Cloth Company, New York.

Haydenville Manufacturing Company, Haydenville, Massachusetts.

Hendricks Brothers, New York.

Holmes, Booth & Haydens, Waterbury, Connecticut.

C. G. Hussey & Co., Pittsburgh, Pennsylvania.

Landers, Frary & Clark, New Britain, Connecticut.

Manhattan Brass Company, New York.

E. Miller & Co., Meriden, Connecticut.

New Bedford Copper Company, New Bedford, Massachusetts.

New Haven Copper Company, Seymour, Connecticut.

Peck Brothers & Co., New Haven, Connecticut.

Peck, Stow and Wilcox Company, Southington, Connecticut.

Plume and Atwood Manufacturing Company, Thomaston and Waterbury, Connecticut.

J. A. Roebling's Sons Company, Trenton, New Jersy.

Russell and Erwin Manufacturing Company, New Britain, Connnecticut.

Rome Iron Works, Rome, New York.

Scovill Manufacturing Company, Waterbury, Connecticut.

Seymour Manufacturing Company, Seymour, Connecticut.

Taunton Copper Manufacturing Company, Taunton, Massachusetts.

United Brass Company, Lorain, Ohio, and Haydenville, Massachusetts.

Wallace & Sons, Ansonia, Connecticut.

Washburn and Moen Manufacturing Company, Worcester, Massachusetts.

Waterbury Brass Company, Waterbury, Connecticut.

Yale and Towne Manufacturing Company, Stamford, Connecticut.

In the aggregate these works consumed, in 1886, 65,414,429 pounds of ingots, slabs, cakes, and bars, against 52,607,922 pounds in 1885. This would indicate an increase of 24.3 per cent. It should be stated, however, that the returns include a number of wire drawers whose consumption has developed in a phenomenal manner, thus probably making the rate of increase appear considerably larger than it would be if the figures were available for the entire trade. It is impossible to go into details without revealing confidential data, but it may be stated that, deducting some works known to be almost exclusively rollers of wire bars and drawers of wire, the balance shows a rate of increase of about 17.7 per cent., or a little more than the year 1885, when it was 16 per cent. It is safe, therefore, to assume that the increase in the consumption was equal, at least, to 20 per cent., which would carry the consumption close to 108,000,000 pounds as compared with 90,000,000 pounds in 1885. This would indicate an increase of stocks of about 6,900,000 pounds, or less than the apparent discrepancy between the output of Montana reported and amounts thereof refined and exported. It might well be possible therefore, that the stocks of ingot throughout the country might be lower, while the supply of copper in the form of furnace products might be much greater.

THE COPPER MARKETS.

The following table summarizes the highest and lowest prices obtained for lake copper monthly in the New York market from 1860 to 1886, both inclusive:

Highest and lowest prices of Lake Superior ingot copper, by months, from 1860 *to* 1886.

[Cents per pound.]

Years.	January.		February.		March.		April.		May.		June.	
	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
1860	24	23½	24	23¾	23¾	23	23½	23	23¼	22½	22½	21¾
1861	20	19	19½	19	19¾	19¼	19¾	19	19¾	19¼	19	18
1862	28	27	28	25	25	23	23	21½	21½	20¾	23	20¾
1863	35	31	37	35	37	31	31	30	30½	30	30½	30
1864	41¼	39	42	41¼	42½	41⅛	44	42½	44	43	49	44
1865	50½	46	46	44	44½	34	35	34	34	30	30½	28½
1866	42	38	38	35½	35½	29½	30	28½	31	29	33	31
1867	29¼	27	27¾	27½	27½	24	24½	23½	24¼	24	24½	24
1868	23½	21½	24	22½	24	23¼	24¼	23¼	24¼	24	24	23⅛
1869	26¼	23¾	27	26	26¾	24	24	23¼	24¼	23¾	23¾	22
1870	22	21⅛	21¼	20⅞	20¾	19	19¾	19¼	19½	19	20⅝	19
1871	22⅞	22	22⅜	21⅞	22	21½	21¾	21¼	21¾	21⅜	21½	21¼
1872	28½	27⅛	28⅜	28¼	30½	28⅜	44	30½	42	36	34¾	33
1873	35	32½	35	34	35	34½	34½	33½	33½	32	31½	29⅛
1874	25	24⅛	25	24⅛	24¾	24	25	24¾	25	24½	24¾	24¼
1875	23½	21½	22¾	21¾	21¾	21½	21¾	21½	23¼	22⅝	23	23
1876	23¼	23	22⅞	22½	22¼	22	22⅝	22	22⅛	21	21	19¼
1877	19½	19	20½	19½	19½	19	19½	19¼	19¼	19	19⅜	19
1878	17⅝	17¼	17½	17⅛	17⅛	16⅞	17	16⅞	16¾	16¼	16⅜	16¼
1879	16	15½	15½	15½	15¾	15¾	16	15¾	16¼	16	16¼	16⅛
1880	25	21⅜	24½	24	24	22¾	22½	21	21	18	18½	17⅞
1881	19⅜	19⅛	19⅜	19⅛	19⅜	19	19	18¾	18⅞	18½	18¼	16⅜
1882	20⅜	20¼	20	19	19¼	18⅞	18⅞	17⅞	18¼	18	18¼	18
1883	18⅛	18	17⅞	17¾	17⅝	17⅛	16	15¾	16	15⅞	15⅞	15
1884	15	14⅞	15	14⅞	15	14⅞	15	14½	14¼	14⅛	14¼	14
1885	11½	10⅜	11⅛	10⅘	11⅛	10⅖	11¼	10.1	11½	9⅘	11½	11
1886	11⅝	11⅜	11⅝	11⅜	11¼	11⅜	11½	11⅜	11⅛	10	10⅛	10

Years.	July.		August.		September.		October.		November.		December.	
	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
1860	21¾	21½	21½	21½	22	21¼	22	21½	21½	20¼	20¼	19¾
1861	18	17½	19	17¾	20¼	19	20¼	20	22½	20¼	27	22½
1862	24½	22½	24½	24	27	24¼	32⅞	27	32⅞	30½	31½	30½
1863	32	29	31	29	32¼	31	34½	32¼	38½	34½	38¾	38½
1864	55	49	52½	50	52½	47½	48	47	49	47	50	48½
1865	30¼	28	32	30½	32¾	31½	33	32½	45½	33	45½	39¼
1866	33½	31	31	30	31½	30¾	31	30¾	30¾	26½	29	26½
1867	26	24	26¼	25¾	27¼	26¼	26¾	22¾	23	22¾	23	21½
1868	24½	23⅛	24¼	24	24	23¾	24	23	24	22½	24½	23¾
1869	22¼	21⅞	23⅛	21⅞	23	22	22¾	22	22½	22	22	21½
1870	20½	20⅜	21⅜	20⅛	21½	20¾	21¾	21½	23⅜	21¾	22⅝	22¼
1871	22¼	21⅝	23	22⅜	23⅞	22⅞	23⅞	23¼	24¼	23¼	27	24½
1872	34	33	35	32½	35¼	33	34¾	31¼	32¼	30¾	32½	30½
1873	29	26⅝	27½	27	27	25½	25½	24	24	21	25	23
1874	24¼	20	21	19	21¼	21	22¼	21¼	23¾	22¼	23¼	23¼
1875	23	22⅝	23⅜	23	23⅞	23⅛	23¼	23	23¼	23	23⅜	23⅜
1876	20	19½	19½	18¾	21	18¾	21¼	20½	20½	20	20	19⅝
1877	19¼	19	19	17⅞	18½	17⅞	18	17¾	17¾	17⅝	17¾	17½
1878	16¼	16	16	16	16¼	16	16	15½	15⅞	15½	16	15⅞
1879	16⅛	16	16⅜	16	17	16¼	21½	18	21¾	21	21½	21
1880	18⅞	18½	19⅛	19	18⅞	18¾	18⅞	18¾	18⅞	18¾	19⅛	18⅞
1881	16½	16	16⅝	16⅜	18⅛	16¾	18⅜	18	19	18⅛	20⅜	19¼
1882	18¼	18⅛	18¼	18⅛	18¼	18	18¼	18	18⅛	18	18	17⅞
1883	15⅛	15	15	15	15¼	15⅛	15¼	15⅛	15	14⅞	15	14⅞
1884	14⅛	13⅞	14	13⅞	13⅛	13	13⅛	12⅞	13	12½	12⅛	11
1885	11¼	10⅞	11¼	11	11⅛	10.95	11⅛	10⅘	11⅛	10⅘	11½	11.1
1886	10⅛	10	10¼	10	11⅛	10¼	11¾	11⅛	12	11¾	12⅛	11⅞

The following shows the fluctuations of Lake copper and ordinary Baltimore, or its equivalent, in the open market, during 1885 and 1886:

Prices of copper in 1885 *and* 1886.

[Cents per pound.]

Months.	1885.				1886.			
	Lake copper.		Casting copper.		Lake copper.		Casting copper.	
	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
January	11.50	(a)10.60	10.75	10.25	11.62	11.37	10.75	10.25
February	11.12½	(a)10.80	10.75	10.50	11.62	11.37	10.37	10.12
March	11.12½	(a)10.40	10.62½	10.12½	11.50	11.37	10.37	10.00
April	11.25	(a)10.10	10.75	10.25	11.50	11.37	10.12	9.75
May	11.50	(a) 9.80	10.89½	10.60	11.12	10.00	10.00	9.50
June	11.50	11.00	10.62½	10.20	10.12	10.00	9.50	9.25
July	11.25	10.87½	10.35	10.20	10.12	10.00	9.25	9.00
August	11.25	11.00	10.35	10.15	10.25	10.00	9.50	9.25
September	11.12½	10.95	10.25	10.10	11.12	10.25	10.12	9.37
October	11.12½	10.80	10.12	9.90	11.75	11.12	10.50	10.00
November	11.12½	10.80	10.00	9.80	12.00	11.75	10.75	10.50
December	11.50	11.10	10.50	10.00	12.12	11.87	10.75	10.62

a Under Chili bar sliding-scale contracts.

The best data to compute an average of the prices of the year are obtained from the reports of a number of the Lake companies. The following table, not including the Calumet and Hecla sales, is compiled from these reports:

Prices realized for Lake Superior copper in 1883, 1885, *and* 1886.

Mines.	1883.		1885.		1886.	
	Sales.	Average price.	Sales.	Average price.	Sales.	Average price.
	Pounds.	*Cts. per lb.*	*Pounds.*	*Cts. per lb.*	*Pounds.*	*Cts. per lb.*
Allouez	1,751,377	15.13	(a)1,050,546	11.03	....	....
Franklin	3,418,456	15.66	3,291,806	11.04	2,943,794	10.71
Atlantic	2,385,585	15.08	(b)2,729,588	11.08	(b)3,488,790	10.92
Pewabic	1,239,740	15.91	....	....	....	....
Central	1,125,910	15.08	(b)1,600,899	11.02	2,033,922	10.67
Huron	647,787	15.69	2,729,588	10.92	2,059,206	10.99
Osceola	....	....	1,639,169	10.75	....	....

a First five months. *b* Not including copper on hand sold.

It is unnecessary to add that the large companies which did a considerable amount of exporting did not, in all likelihood, secure so good an average price. It is likely, in fact, that the average of the Calumet and Hecla was not much, if any, above 10¼ cents on its total sales of the year.

Since the English quotations have become of such direct importance to American copper miners, the following table, showing a comparison of values in 1886 with former years, is of interest:

Average values in England.

Years.	Chili bars.	Ore, 25 per cent.	Precipitate.
	Long ton.	*Per unit.*	*Per unit.*
1880	£62 10 0	£0 12 9	£0 12 11
1881	61 10 0	12 6	13 $8\frac{3}{16}$
1882	66 17 0	13 6¾	13 $10\frac{1}{16}$
1883	63 5 10	12 4½	12 $10\frac{1}{16}$
1884	54 9 1	10 5½	11 1
1885	44 0 10	8 4	9 0⅛
1886	40 9 3	7 9	8 3⅝

In detail the average prices monthly during 1885 and 1886 were as follows:

Monthly averages of values in England in 1885 *and* 1886.

Months.	1885.					1886.				
	Chili bars, per long ton.			Precipitate, per unit.		Chili bars, per long ton.			Precipitate, per unit.	
	£	*s.*	*d.*	*s.*	*d.*	£	*s.*	*d.*	*s.*	*d.*
January	48	14	7	9	11½	40	5	8	8	3⅛
February	47	13	6	9	8⅞	40	5	3	8	3⅛
March	46	4	9	9	5½	42	6	9	8	8⅛
April	44	9	2	9	1¼	41	15	9	8	6¾
May	44	13	6	9	1⅝	40	9	10	8	3⅝
June	44	18	3	9	2½	39	18	0	8	2¼
July	44	4	9	9	0⅝	39	7	5	8	1
August	43	5	11	8	10½	39	10	0	8	1¼
September	41	17	6	8	7	40	5	10	8	3¼
October	39	18	6	8	2⅜	41	9	11	8	6⅛
November	41	3	0	8	5¼	40	12	4	8	4
December	41	6	6	8	5⅝	39	4	3	8	0⅝

Early in the year consumers were being supplied at 11½ cents for Lake, while the leading Montana mine closed a contract for the delivery of 10,000 tons of matte to England, from January to June, at a fixed price. During February, March, and April Lake copper was very dull, the only prominent feature in the market, developing greater significance as the year went on, being the growing pressure to sell other brands. Prices were lowered until at last they were fully 1¼ cents below the nominal quotation for Lake copper. The leading Lake companies met this competition by selling close up to 10,000,000 pounds in the middle of May, for June and July delivery, at 10 cents, which was followed in June by sales for export of nearly 15,000,000 pounds. Other brands followed the decline, but with low foreign markets and a discouraging outlook at home some of the Arizona companies, like the Copper Queen, closed down entirely, while in Montana a number of the works reduced output. This brought relief after further sales of Lake copper up to October had been made in August, at 10 cents. The market rallied steadily until, in September, the Lake companies were enabled to contract with consumers at 11 cents for October and November delivery. Later the closing down of the Anaconda mine and works, through labor troubles, caused further rallying, the market touching 12 cents for Lake and close upon 11 cents for casting brands in November and December. Toward the end of the year the resumption of work by the Anaconda and renewed pressure of outside brands caused some uneasiness.

THE PRINCIPAL FOREIGN PRODUCERS.

The copper production of the world, 1879 *to* 1886 *inclusive.*

Countries.	1886.	1885.	1884.	1883.	1882.	1881.	1880.	1879.
EUROPE.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Great Britain	(*a*)1, 471	2, 773	3, 350	2, 620	3, 464	3, 875	3, 662	3, 462
Spain and Portugal:								
Rio Tinto	24, 700	23, 484	21, 564	20, 472	17, 389	16, 666	16, 215	13, 751
Tharsis	11, 000	(*a*)11, 500	(*a*)10, 800	9, 800	9, 000	10, 203	9, 151	11, 324
Mason & Barry	7, 000	(*a*)7, 000	(*a*)7, 500	8, 000	8, 000	8, 170	6, 603	4, 692
Sevilla	2, 135	1, 800	2, 000	2, 026	1, 885	1, 340	1, 705	1, 360
Portugueza	1, 258	1, 665	(*a*)2, 300	2, 357	1, 700	1, 410	1, 000	770
Poderosa	3, 560	2, 424	2, 251	1, 000	800	800	800	800
Germany:								
Mansfeld	12, 595	12, 450	12, 582	12, 634	11, 536	10, 999	9, 800	8, 400
Other German	1, 870	(*a*)2, 800	(*a*)2, 200	3, 568	3, 552	1, 743	1, 000	600
Austria	550	585	670	572	474	474	500	255
Hungary	500	504	614	661	661	800	900	1, 019
Sweden	600	775	662	732	798	995	1, 074	800
Norway	2, 220	2, 560	2, 706	2, 630	2, 590	2, 640	2, 426	2, 412
Italy	900	835	1, 325	1, 600	1, 400	1, 480	1, 380	1, 140
Russia	4, 875	(*a*)5, 100	4, 700	3, 500	3, 537	3, 411	3, 154	3, 081
Total Europe	75, 234	76, 255	75, 224	72, 172	66, 786	65, 006	59, 370	53, 866
NORTH AMERICA.								
United States	69, 971	74, 053	63, 555	51, 574	40, 467	32, 000	27, 000	23, 000
Canada	1, 440	2, 500	236	1, 055	500	500	50	50
Newfoundland:								
Bett's Cove	1, 125	778	668	1, 053	1, 500	1, 718	1, 500	1, 500
Mexico	850	375	291	489	401	333	400	400
Total North America	73, 386	77, 706	64, 750	54, 171	42, 868	34, 551	28, 950	24, 950
SOUTH AMERICA.								
Chili	35, 025	38, 500	41, 648	41, 099	42, 909	37, 989	42, 916	49, 318
Bolivia:								
Corocoro	1, 100	(*a*)1, 500	(*a*)1, 500	1, 680	3, 259	2, 655	2, 000	2, 000
Peru	75	229	362	395	440	615	600	600
Venezuela:								
New Quebrada	3, 708	4, 111	4, 600	4, 018	3, 700	2, 823	1, 800	1, 597
Argentine Republic	180	233	159	293	800	307	300	300
Total South America	40, 088	44, 573	48, 269	47,485	51, 108	44, 389	47, 616	53, 815
AFRICA.								
Algiers	110	250	260	600	600	600	500	500
Cape of Good Hope	6, 015	5, 450	5, 000	5, 975	5, 716	3, 467	4, 739	4, 328
Total Africa	6, 125	5, 700	5, 260	6, 575	6, 316	4, 067	5, 239	4, 828
ASIA.								
Japan	10, 000	(*a*)10, 000	(*a*)10, 000	7, 600	4, 800	3, 900	3, 900	3, 900
Total Asia	10, 000	10, 000	10, 000	7, 600	4, 800	3, 900	3, 900	3, 900
AUSTRALIA.								
Australia	9, 700	11, 400	14, 100	12, 271	8, 512	10,000	9, 700	9, 500

a Estimated.

The copper production of the world, 1879 *to* 1886 *inclusive*—Continued.

RECAPITULATION.

	1886.	1885.	1884.	1883.	1882.	1881.	1880.	1879.
Europe	75,234	74,839	73,959	72,172	66,786	65,006	59,370	53,866
North America	73,386	77,706	64,750	54,171	42,868	34,551	28,950	24,950
South America	40,088	44,573	48,269	47,485	51,108	44,389	47,616	53,815
Africa	6,125	5,700	5,260	6,575	6,316	4,067	5,239	4,828
Asia	10,000	10,000	10,000	7,600	4,800	3,900	3,900	3,900
Australia	9,700	11,400	14,100	12,271	8,512	10,000	9,700	9,500
Total	214,533	224,218	216,338	200,274	180,390	161,913	154,775	150,859

Great Britain.—The following are the official returns of the quantity of ore and precipitate produced by English mines, and their copper contents, or, as the last report puts it, "metallic copper obtainable by smelting":

Production of copper in Great Britain.

Years.	Ore.	Copper.	Years.	Ore.	Copper.
	Long tons.	*Long tons.*		*Long tons.*	*Long tons.*
1860	362,696	15,968	1878	56,094	3,952
1865	198,298	11,888	1879	51,035	3,462
1870	106,698	7,175	1880	52,118	3,662
1871	97,129	6,280	1881	52,556	3,875
1872	91,893	5,703	1882	52,810	3,464
1873	80,188	5,240	1883	46,820	2,620
1874	78,521	4,981	1884	42,149	3,350
1875	71,528	4,323	1885	36,379	2,773
1876	79,252	4,694	1886	18,617	1,471
1877	73,143	4,486			

According to the official returns of the Board of Trade the British imports and exports of copper have been as follows for a series of years:

British imports and exports of copper.

Years.	Imports of— Bars, cakes, and ingots.	Imports of— Copper in ores and furnace products.	Total imports.	Exports.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*
1860	13,142	13,715	26,857	26,117
1865	23,137	23,922	47,059	41,398
1870	30,724	27,025	57,749	53,006
1871	33,228	23,671	56,899	56,633
1872	49,000	21,702	70,702	53,195
1873	35,840	26,756	62,596	55,716
1874	39,906	27,894	67,800	59,742
1875	41,931	29,483	71,414	51,870
1876	39,145	36,191	75,336	52,468
1877	39,743	53,582	93,325	54,088
1878	39,360	48,212	87,572	55,001
1879	46,670	50,421	97,091	62,412
1880	36,509	56,225	92,734	59,482
1881	32,170	54,057	86,227	61,689
1882	35,509	58,366	93,875	55,683
1883	35,653	63,493	99,146	59,350
1884	39,767	69,623	109,390	64,692
1885	41,993	81,616	123,609	62,050
1886	43,069	65,046	108,115	60,510

The following figures from the Board of Trade returns for the past nine years show in detail the form in which the copper is brought into Great Britain and in what form it is exported:

Imports of copper into Great Britain from 1878 to 1886 inclusive.

Character.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Pure in pyrites	14, 443	12, 040	16, 446	13, 551	15, 672	15, 016	14, 077	16, 333	13, 905
Pure in precipitate	13, 173	18, 159	18, 205	18, 619	17, 935	23, 645	19, 688	21, 398	19, 323
Pure in ore	15, 441	13, 173	14, 976	15, 396	15, 489	15, 880	24, 677	15, 683	13, 749
Pure in regulus	5, 155	7, 049	6, 598	6, 491	9, 270	8, 952	11, 181	28, 202	18, 069
Bars, cakes, etc	39, 360	46, 670	36, 509	32, 170	35, 509	35, 653	39, 767	41, 993	43, 069
Total	87, 572	97, 091	92, 734	86, 227	93, 875	99, 146	109, 390	123, 611	108, 115

Turning first to the imports of pyrites, we find the following table of the imports and their source since 1873 in the volume of the "Mineral Statistics of Great Britain:"

Imports of pyrites into Great Britain.

Years.	Norway.	Portugal.	Spain.	Germany.	Other countries.	Total.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
1873	67, 462	199, 559	246, 692	....	6, 634	520, 347
1874	41, 044	162, 569	294, 117	....	907	498, 637
1875	21, 820	165, 433	344, 019	....	6, 283	537, 555
1876	7, 688	56, 579	419, 068	....	21, 417	504, 752
1877	8, 564	149, 562	498, 977	....	22, 209	679, 312
1878	5, 773	136, 705	419, 561	....	12, 318	574, 357
1879	8, 485	82, 529	374, 505	....	15, 783	481, 302
1880	10, 952	166, 519	463, 199	8, 695	8, 684	658, 049
1881	6, 009	140, 079	379, 216	8, 412	8, 662	542, 378
1882	....	114, 132	497, 807	....	15, 761	627, 700
1883	1, 271	121, 137	473, 343	....	5, 537	601, 288
1884	522	85, 454	471, 556	....	5, 541	563, 073
1885	2, 608	28, 899	619, 523	....	3, 491	654, 521
1886	4, 117	28, 656	521, 718	....	2, 497	556, 988

The following table, compiled by John Arthur Phillips, exhibits the quantity of burned pyrites treated at the twenty-two metal-extraction works, together with the quantities of metallic copper and gold and silver extracted by the Claudet process:

Metals extracted from burned cupriferous pyrites.

Years.	Ore.	Copper.	Gold.	Silver.
	Long tons.	*Long tons.*	*Ounces.*	*Ounces.*
1880	415, 567	15, 000	1, 043	246, 981
1881	396, 737	14, 000	1, 490	258, 463
1882	434, 427	15, 300	1, 500	400, 000
1883	439, 156	15, 370	1, 511	348, 210
1884	416, 412	15, 200	1, 900	335, 000
1885	407, 700	14, 880	1, 840	328, 000
1886	393, 699	14, 370	1, 780	316, 000

Another great source of supply of the English metallurgical works is ore. The following table gives the Board of Trade returns, the average values being computed by this office:

Imports of copper ore into Great Britain.

Countries.	Quantities.				Average value per ton.			
	1883.	1884.	1885.	1886.	1883.	1884.	1885.	1886.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*				
Italy	9, 403	11, 100	7, 405	6, 262	£7. 11	£4. 79	£5. 42	£4. 65
Venezuela	31, 844	25, 900	38, 613	27, 318	6. 73	6. 16	4. 46	3. 72
Bolivia	1, 029	2, 067	4, 642	508	12. 98	8. 81	8. 22	7. 65
Chili	1, 062	245	529	331	13. 17	19. 92	17. 10	10. 71
Cape of Good Hope	19, 917	22, 330	20, 875	24, 613	17. 71	15. 35	11. 80	11. 48
British North America	10, 876	2, 067	5, 002	5, 167	6. 04	4. 35	2. 02	4. 41
United States	....	31, 316	5, 970	2, 035	....	18. 94	14. 27	12. 99
Other countries	31, 748	29, 189	18, 941	18, 896	11. 65	6. 76	6. 79	5. 95
Total ore and average value	105, 879	124, 214	101, 977	85, 130	10. 35	11. 09	7. 07	6. 84
Total fine copper	15, 880	24, 842	15, 683	13, 749	....	....	....	....
Average percentage	15. 00	20. 00	14. 43	16. 15	....	....	....	....

The most striking fact shown in this table is the rapid decline from the high figures reached in 1884 of the receipts in England of ore from the United States.

Imports of precipitate and regulus into Great Britain.

Countries.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	Fine copper.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Portugal	5, 358	8, 144	7, 301	8, 873	7, 161	8, 283	6, 657	24, 032
Spain	20, 482	21, 647	21, 398	28, 962	27, 621	38, 267	38, 666	
Chili	14, 659	8, 116	10, 882	6, 384	10, 699	5, 255	1, 637	737
United States	....	....	....	....	5, 805	29, 861	16, 105	10, 853
Other countries	4, 502	6, 309	9, 716	13, 509	11, 124	6, 000	5, 240	1, 770
Total	45, 001	44, 216	49, 297	57, 728	62, 410	87, 666	68, 305	....
Fine copper	24, 772	25, 110	27, 205	32, 597	34, 172	49, 600	....	37, 392

The chief sources of the receipts of ingot copper and of bars are Australia, furnishing the former, and Chili, which sends the latter. A comparatively small quantity is received from the United States.

Imports of copper, wrought and unwrought, into Great Britain.

Countries.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Chili	24, 258	21, 019	22, 585	22, 799	22, 843	24, 832	24, 748
Australia	9, 406	9, 150	8, 152	9, 531	9, 329	8, 564	9, 933
United States	....	....	....	1, 866	3, 408	3, 259	2, 121
Other countries	2, 845	2, 001	4, 772	1, 457	4, 235	5, 338	6, 328
Total	36, 509	32, 170	35, 509	35, 653	39, 815	41, 993	43, 130

Messrs. James Lewis & Son, of Liverpool, estimate as follows the imports of other than Chili copper into Liverpool, London, and Swansea during the years 1882, 1883, 1884, 1885, and 1886, which represents the total imports, with the exception of precipitate, into Newcastle and Cardiff, reliable returns of which cannot be obtained, but which is estimated to vary from 10,000 to 12,000 tons fine per annum:

Imports of copper produce into Liverpool, Swansea, and London.

Countries.	1882.	1883.	1884.	1885.	1886.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Chili	30,112	27,504	31,298	28,985	27,191
United States	745	9,410	17,309	24,037	13,483
Spain and Portugal	464	2,788	2,359	4,655	5,721
Spain (precipitate)	8,757	11,249	10,009	9,186	10,038
Spain (pyrites)	15,673	15,017	14,077	16,333	13,905
Australia	9,847	9,694	9,685	8,951	10,096
Cape of Good Hope	5,298	5,670	6,042	5,405	7,073
New Quebrada	3,164	3,960	3,675	4,074	3,055
Japan	....	....	1,064	3,010	3,572
Italy	1,386	1,091	1,310	835	889
Norway	446	296	289	27	....
Canada	347	448	266	....	8
Newfoundland	1,362	1,185	224	723	891
Mexico	372	489	291	374	243
Peru	821	426	408	229	68
River Platte	260	319	131	233	179
Other countries	925	946	284	325	1,049
Total tons fine	79,979	90,492	98,721	107,382	97,461

The exports of copper from Great Britain, in different forms, were as follows:

Exports of copper from Great Britain from 1878 to 1886 inclusive.

Character.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Raw English	17,319	16,370	15,202	18,737	12,776	16,777	17,943	18,766	19,036
Sheets	12,769	15,402	16,580	15,960	15,698	16,071	20,669	21,108	17,927
Yellow metal, at 60 per cent.	8,744	10,042	10,128	9,939	10,892	11,918	11,602	12,551	11,958
Brass, at 70 per cent	3,450	2,761	2,677	3,263	3,499	3,381	3,735	3,233	3,001
	42,282	44,575	44,587	47,899	42,865	48,147	53,949	55,658	51,922
Fine foreign	12,719	17,837	14,895	13,790	12,818	11,203	10,742	6,422	8,589
Total	55,001	62,412	59,482	61,689	55,683	59,350	64,691	62,080	60,511

Chili.—The following table gives the record of the exports of copper from Chili for a long series of years, no official statements of the production being available:

Exports of copper from Chili.

Years.	Tons.	Years.	Tons.
1855	20,250	1871	41,200
1856	21,938	1872	46,337
1857	25,498	1873	42,165
1858	30,470	1874	48,240
1859	28,250	1875	45,430
1860	36,289	1876	50,740
1861	38,371	1877	45,400
1862	43,109	1878	46,770
1863	32,540	1879	49,560
1864	47,500	1880	43,135
1865	48,327	1881	38,160
1866	44,820	1882	43,129
1867	44,654	1883	41,229
1868	43,669	1884	43,780
1869	54,867	1885	38,636
1870	49,130	1886	35,138

Relative proportion of different descriptions of copper exported from Chili.

Years.	Bar copper.	Regulus.	Ore.
	Per cent.	*Per cent.*	*Per cent.*
1879	80.10	17.20	2.70
1880	80.76	16.29	2.95
1881	82.28	15.82	1.90
1882	84.61	13.77	1.62
1883	87.67	11.65	.68
1884	79.37	18.78	1.85
1885	89.19	9.85	.96
1886	92.92	6.77	.31

One of the few mines in Chili controlled by a foreign public company is the Panulcillo Copper Company, which in 1886 showed only a profit of £3,329 on a product of 4,727 tons of regulus, containing 2,193 long tons of copper; a decrease of 502 tons as compared with the preceding year. As indicating how slightly, comparatively speaking, prices have varied in Chili, it may be stated that the average price realized for the company's regulus in 1886 was $14.27 per metrical quintal (110 pounds) as against $14.22 in 1885. The company has secured a supply of carbonate ores from adjacent mines, and is experimenting with water-jacket furnaces to reduce costs.

Spain.—An interesting estimate of the actual output of copper in the Peninsula, including the fine copper both in precipitate and pyrites, has been made by Messrs. H. R. Merton & Co., of London, who place the product as follows:

Copper production of Spain and Portugal.

Mines.	1886.	1885.	1884.	1883.	1882.	1881.	1880.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Rio Tinto (Spain)	24,700	23,484	21,564	20,472	17,389	16,666	16,215
Tharsis (Spain)	11,000	11,500	11,800	9,800	9,000	10,203	9,151
Mason & Barry (Port.)	7,000	7,000	7,500	8,000	8,000	8,170	6,603
Sevilla (Spain)	2,135	1,800	2,000	2,026	1,885	1,340	1,705
Portugueza (Port.)	1,258	1,665	2,300	2,357	1,700	1,410	1,000
Poderosa (Spain)	3,560	2,424	2,251	1,000	800	800	800
Total	49,653	47,873	47,415	43,655	38,774	38,589	35,474

The Rio Tinto mines continue to excite the greatest interest as among the greatest of the world. Their production for a series of years has been as follows:

Production of the Rio Tinto mines.

Years.	Pyrites for shipment.	For extraction of copper by local treatment.	Total.	Actual consumption of pyrites in England, Germany, etc.	Average copper contents of ore mined.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Per cent.*
1877	251,360	520,391	771,751	....	....
1878	218,818	652,289	871,107	....	....
1879	243,241	663,359	906,600	236,849	....
1880	277,590	637,567	915,157	274,201	2.619
1881	249,098	743,949	993,047	256,827	2.750
1882	259,924	688,307	948,231	292,826	2.805
1883	313,291	786,682	1,099,973	288,104	2.956
1884	312,028	1,057,890	1,369,918	314,751	3.234
1885	406,772	944,694	1,351,466	354,501	3.102
1886	336,548	1,041,833	1,378,381	347,024	3.046

The production of copper by local treatment at the Rio Tinto mines, not including that in pyrites delivered, was as follows since 1876:

Production of metallic copper at Rio Tinto.

Years.	Long tons.
1876	946
1877	2,495
1878	4,184
1879	7,179
1880	8,559
1881	9,466
1882	9,740
1883	12,295
1884	12,668
1885	14,593
1886	15,863

The net profit available for dividends to the shareholders of the Rio Tinto Company for the year 1886 was £105,103, out of which a dividend of 3 per cent., or £97,500, was paid. Considerable progress has been made with the Doetsch process for treating the pyrites locally without previous roasting. Of the 1,041,833 tons laid down at Rio Tinto for working on the spot, about two-thirds were put down for extraction by the method named. The policy of the company is in the direction of increasing the product of copper in Spain. At the last meeting of the stockholders the directors brought up for discussion the question of providing funds for the payment of the floating debt, about £300,000, and additional working capital, about £200,000, to carry the make "on the spot," from 16,500 tons in 1886 to 20,000 tons, and "eventually" to 25,000 long tons.

The Tharsis Sulphur and Copper Company, the second largest on the Peninsula, has, too, keenly felt the effect of low prices. Its dividend for 1886 was only 7½ per cent., as compared with 10 per cent. for 1885 and 20 per cent. for 1884. The product fell off somewhat, chiefly owing to the small rainfall of 1886, which was only 21.44 inches in 77 days, as compared with 41.19 inches in 108 days in 1885, thus reducing considerably the quantity of water available for leaching. Drought in Spain, especially in former years, has always had a serious influence upon the local copper extraction, although the Rio Tinto Company, for instance, has aimed to overcome the difficulty by extensive and costly water service. The most important work going on at the Tharsis mines is the building of the extension of its railroad to the Calañas mines now being developed. It is expected that this road will be finished in 1888, and that then the product will be considerably increased. In order to meet this expenditure an issue of £400,000 of debentures was authorized, of which, however, only £192,600 have been issued thus far. The company has its own metal-extraction works, to which there has been added recently a plant for bricking the residue from extracting the copper, the "blue billy," or oxide of iron, which is used in pig-iron manufacture.

The following table gives an epitome of the business of the Tharsis company for a number of years:

Operations of the Tharsis Company.

Years.	Ore raised.	Pyrites shipped.	Precipitate shipped.	Net profits.	Dividends.
	Long tons.	*Long tons.*	*Long tons.*		
1882	486, 860	218, 218	5, 534	(?)	(?)
1883	490, 033	202, 318	6, 717	334, 491	£323, 032
1884	518, 552	206, 939	7, 095	(?)	(?)
1885	587, 303	311,151	(*a*) 6, 110	104, 211	117, 466
1886	573, 446	273, 298	6, 463	91, 240	88, 099

The average of the dividends during the last twenty years was 19¼ per cent., the lowest on record being 5 per cent. in 1869.

The council of state of Spain has recently confirmed the action of the city council of Calañas in prohibiting the roasting of pyrites in open heaps, and has rebuked the governor of Huelva for exceeding his authority in interfering in this matter. Should this method of treating the Spanish pyrites be prohibited as a nuisance, a very heavy decline in the local output would follow, since thus far the Doetsch process of leaching raw ore has only been partially introduced by the Rio Tinto Company, while the Tharsis Company uses the old methods exclusively.

Germany.—The following table shows the production of copper in Prussia and in the Mansfeld district, from 1875 to 1885 inclusive:

Production of copper in Prussia and in the Mansfeld district.

Years.	Prussia.	Mansfeld district.
	Metric tons.	*Metric tons.*
1875	7, 212	6, 046
1876	8, 235	6, 287
1877	8, 412	6, 908
1878	9, 096	8, 007
1879	9, 610	8, 526
1880	13, 605	9, 814
1881	14, 626	11, 000
1882	16, 653	11, 691
1883	18, 194	12, 836
1884	16, 825	12, 744
1885	(*a*) 17, 595	12, 832

a Assuming matte produced to carry 50 per cent. of copper.

A preliminary statement issued in April places the product in 1886 at 19,998 metric tons of ingot and 423 tons of matte, as compared with 20,628 and 343 tons, respectively, in 1885 for the whole German Empire. It is probable that the greater part of the excess of these figures above those in the above table is due to the fact that the metal extracted from imported ore and furnace material is included.

During 1886 those in charge of the management of the greatest German copper producer, the Mansfeldsche Kupferschieferbauende Gewerkschaft, made persistent efforts to bring about higher duties on copper, largely on the ground that that important industry was jeopardized by foreign competition. The proposal met with strong opposition on the part of copper manufacturers. The elaborate report for the fiscal year 1886 fails to show that the company is in as bad a way as it was represented to be. A reduction in the costs, chiefly of mining, was effected, which went far toward counterbalancing low prices, the average returns for the years 1885 and 1886 being 102.24 and 86.90 marks, respectively. Per metric ton of refined copper the costs were:

Costs at Mansfeld.

	Mining.	Total cost.
	Marks.	*Marks.*
1885	1,379.98	1,919.27
1886	1,197.22	1,702.48

These figures, of course, include the cost of obtaining the silver, which in 1886, at an average of 133.74 marks per kilogram on 75,075.62 kilograms produced, is equal to 785.27 marks per metric ton of copper made. Assuming that the whole profit was in the copper, and none in the silver, this would make the cost of the copper 917.21 marks per metric ton, or £45.86. But revenues are obtained from the manufacture of other by-products, like sulphuric acid, etc., which reduce the cost. The latter may be computed as follows, assuming that no profit is made on the silver and on by-products: The total outlay in 1886 at Mansfeld was:

Expenses of copper production at Mansfeld in 1886.

Items.	Amount.
	Marks.
Mining	13,751,290.13
Smelting, roasting, and matting	4,728,749.31
Desilverizing	523,649.90
Copper refining	367,486.23
Purchase of and treating outside ores	52,992.85
Taxes	294,739.39
General expenses	184,848.08
Cost of marketing	82,414.62
Miscellaneous	255,849.34
Total	20,242,019.85

The receipts for silver were 10,066,702.61 marks, for sulphuric acid and sulphate 477,924.94 marks, and a variety of other products 596,699.99 marks. Deducting these from the above, and dividing by the product of copper for the year, we reach a cost of 711.07 marks, or £35.55. This figure, at the 1886 prices for silver, sulphuric acid, etc., represents the point at which Mansfeld begins to lose money in making from 24,000,000 to 25,000,000 pounds of copper annually.

Since the elaborate annual report of this large company is rarely accessible to those in the American copper trade, a more lengthy review is appropriate. The Mansfeld deposit is a thin bituminous shale, the dimensions and copper contents of which may be gathered from the following table of assays made at different points opened up during the year. The terms "Feine Lette" (I.), "Grobe Lette" (II.), and "Kammschale" (III.), are local subdivisions of the cupriferous parts of the bed. The copper contents are given after deducting 25 per cent. for waste in mining and smelting.

Character of the Mansfeld copper beds.

Locality.	Subdivision.	Copper.	Thickness.
		Per cent.	*Centimeters.*
II. Level	I.	4.0	3.5
	II.	2.2	4.5
	III.	1.3	2.6
III. Level	I.	2.7	3.0
	II.	7.2	3.5
	III.	10.1	2.5
IV. Level crosscut	I.	4.1	3.5
	II.	4.4	4.5
	III.	3.7	2.6
III. Level	I.	0.7	5.0
	II.	5.0	6.0
	III.	2.0	4.0
III. Level	I.	....	5.0
	II.	7.6	6.0
	III.	1.8	4.0
II. Level	I.	0.5	5.0
	II.	6.0	6.0
	III.	1.2	4.0

The thickness of the deposit fluctuates considerably, in some cases going up to 24 centimeters, or about three-quarters of a foot, but falling, too, to 10 centimeters, or less than 4 inches. In 1886, 441,367 tons of ore were mined, at a cost of 31.15 marks per ton, against 542,162 tons in 1885, at a cost of 33.18 marks; the decline in the output being partly due to a lessened number of men, many of whom left on account of the lowering of wages, and partly to the system of closer sorting of the ore to carry up the average contents of the ore hoisted and treated. The result has been, on the one hand, that the average quantity produced per miner in an eight-hour shift fell in the two principal districts from 5.89 and 4.31 cwts., respectively, to 5.44 and 3.71 cwts.

The average wages per miner per shift declined in the first district from 3.11 marks, or 75 cents, to 2.73 marks, or 65.5 cents, and in the second district from 2.76 marks, or 66 cents, to 51 cents. When it is considered that the work consists of undercutting a narrow bed, in which sitting upright is utterly impossible, the inadequacy of such wages will be understood.

On the other hand, the average copper contents of the ore smelted has been increased by more closely rejecting lower-grade material.

The following statement shows the quantity of shale treated at the different works in 1886 and the average yield for a series of years:

Average yield of copper at Mansfeld.

Works.	Smelted, 1886.	Silver contents, per ton ore, 1886.	Copper contents.			
			1886.	1885.	1884.	1883.
	Tons.	*Kilos.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Kong	121,250	0.164	2.544	2.112	2.429	2.671
Koch	140,000	0.180	3.022	2.589	2.785	2.707
Eckardt	97,550	0.198	3.123	2.593	2.703	2.491
Kupferkammer	87,450	0.191	3.104	2.604	2.567	2.554
Sangerhausen	7,170	0.053	1.757	....	....	....
Totals	453,420	....	2.912	2.457 (*a*)		

a 0.0180 of silver.

During 1886, 1,156,300 square meters of the bed were mined, against 1,185,840 square meters in 1885, the reserves developed being reduced to 5,024,000 square meters from 5,643,400 square meters, so that practically development work was allowed to fall six months behind. The total outlay for sinking shafts and driving levels was 1,958,004.74 marks; for timbering, 230,341.31 marks; for pumping and water supply, 261,531.76 marks; for hoisting, 2,175,012.33 marks; and for surface expenses and machinery, 686,772.19 marks.

Besides its Mansfeld copper mines the company has two small copper-rolling mills, lignite mines, a colliery and coking plant in Westphalia, large tracts of timber lands, etc., from which the gross increase, including interest account, was 13,674,284.14 marks, while the expenses, including interest, were 12,198,594.98, leaving a profit of 1,475,689.16 marks. While the company had been evidently holding copper in 1885, selling only 10,404.5 tons in that year, they sold more than the year's make in 1886, or 13,785.8 metric tons. This added 867,500 marks to the gross revenue. On the other hand, 330,000 marks of bonds were paid off. The gross profit was 4,024,334.64 marks; but stocks of supplies, products, etc., were reduced by 2,846,005.99, leaving the net profit at 1,178,328.65 marks. The assets at the close of 1886 were estimated at 28,678,164.32 marks, against 28,277,690.83 in 1885, the bonded debt being 9,103,500 and 9,433,500 marks, respectively.

It was only by an avowedly large restriction of development work and of new construction, by sharp reductions in labor, by the sale of 3,381 tons of copper on which the costs had been paid during the previous year, when the loss was 653,338.25 marks, that a profit was realized. Although the latter amounted in reality to only 1,178,328.65 marks, a dividend of 30 marks a share, or 2,073,600 marks, was paid.

France.—The following is an official statement of the quantity of copper produced in French works from imported ores and furnace material, with the exception of a trifling quantity:

Production of copper in France from 1870 to 1883 inclusive.

Years.	Metric tons.	Years.	Metric tons.
1870	2,100	1877	2,330
1871	2,720	1878	3,500
1872	2,600	1879	3,350
1873	2,140	1880	3,300
1874	2,000	1881	3,395
1875	2,300	1882	3,627
1876	2,230	1883	3,255

The following figures, compiled by English authorities, show the magnitude of the French copper trade:

Imports of copper into France from 1876 to 1886 inclusive.

Years.	All kinds direct.	America.	Other countries.	Chili.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*
1876	16,418	4,220	....	12,198
1877	13,015	4,030	....	8,985
1878	13,094	4,016	....	9,078
1879	10,402	4,675	....	5,727
1880	11,818	320	....	11,498
1881	16,436	3,205	....	13,231
1882	13,573	1,035	344	12,194
1883	20,894	4,355	475	16,064
1884	18,683	7,205	392	11,086
1885	16,587	9,235	995	6,357
1886	14,024	4,167	1,600	8,257

The bulk of the American copper which goes to France is Lake ingot, the quality of which is much appreciated for art bronze castings, while the Government calls for Lake copper in its specifications for cartridges.

Venezuela.—The principal work at the New Quebrada was the building of a new smelting plant after American models, under the superintendance of Mr. George Thomson, of New York.

New Caledonia.—According to a report in the *Annales des Mines* the low prices of copper have led to rapid decline in the product of the mines at Ouéga, worked by the Compagnie de la Balade. The output of ore, carrying about 16 per cent. of copper, was as follows for a series of years:

Output of ore at the Ouéga mines, New Caledonia.

Years.	Metric tons.	Years.	Metric tons.
1877	4,622	1881	5,208
1878	6,024	1882	3,385
1879	7,741	1883	2,991
1880	3,441	1884	2,060

Australia.—The English and Australian Copper Company, limited, a concern prosperous for nearly a generation, has reduced its capital from £210,000 to £140,000 in order to provide for depreciation of its property.

Africa.—The Cape Copper Company has entered into an agreement with the Briton Ferry Chemical and Guano Company, by which the latter is to utilize the sulphurous acid from roasting Cape copper ores at their Swansea smelting works, being secured one-half the profits after thec apital invested, £25,000, has been recouped.

LEAD.

BY C. KIRCHHOFF, JR.

Generally speaking, the year 1886 has been quite a prosperous period for the lead industry of the United States, prices having been in general fairly remunerative to moderately rich, well-located mines. The result has been a recovery from the tendency towards restricted production of the three preceding years, and, while the output of 1883 and 1884 has not been reached, the impetus given in 1886 is likely to bring about a further increase in 1887. The events of the first four months of the latter year do not, however, indicate that it will assume unmanageable proportions, especially because some of the preparations for a larger make will not come into play until later in the year. A larger output is expected in Missouri, where mining was quite active in 1886, and where the largest producer, the Saint Joe Lead Company, has considerably increased its capacity. In Colorado a moderate growth in the output is expected, and Utah is likely to do as well in 1887 as in 1886, if not better. In Idaho there may be quite a considerable development, and in Montana the principal works have been enlarged. In Dakota a little smelting was done in 1886, and a slight increase is likely during the current year. It is expected that California, Nevada, and Arizona will not contribute much more than the recent very moderate quota to the general total, but in New Mexico a higher output is looked forward to. There and at El Paso, Texas, the smelting of silver ores brought in from Mexico duty free, but often carrying considerable quantities of lead, will become an important industry.

During the year no very startling discoveries of new districts have been made. Progress has been rather in the perfection and in the growing number of concentrating plants, which, with the improvements in smelting practice, in the direction of handling smelting charges lower in lead, have the tendency of making available lower grades of ore. This means greater steadiness in the supply, and moderates the danger of sudden fluctuations in the quantities of metal available for the market, which have characterized the past history of the industry in this country. The year 1886 has witnessed a revival in the construction of new railroads in some sections of the Rocky mountains. By extending the territory from which ores may be drawn, by cheapening fuel and supplies, it will tend toward increasing the output, especially since the magnitude of the latter is becoming more and more independent of the prosperity of a few mines widely scattered.

To the mine owners in some of the principal districts the advantages of higher prices for lead have been partially or wholly lost through higher smelting charges. This, however, must be regarded rather as a return to a normal condition than a circumstance of which ore sellers have much right to complain, since the smelting industry was not fairly remunerative at the old rates. The improvement in this direction has extended also to the desilverizing works, which have been enabled to occupy a more independent position than they did during previous years.

Special efforts were made to ascertain whether the low price for silver had operated to materially curtail the output of lead. The indications received do not point in that direction, although lead is becoming more and more simply the carrier of the precious metal.

An important and growing source of supply of the metal is Mexico, from which silver ores carrying heavy percentages of lead are imported. The Bureau of Statistics has no records to show the quantity of the lead thus brought in duty free.

Up to the year 1873 no specific data concerning the relative output of the different producing districts were available. For the succeeding years the quantities of desilverized lead and of non-argentiferous lead and the former's percentage of the total have been added because they reveal clearly the growing importance of the former industry, which has its seat in the Rocky mountains; while almost the whole of the non-argentiferous lead is produced in Missouri, Kansas, Illinois, and Wisconsin, only a small quantity being made in Virginia. In this table, and throughout this paper, the tons are short tons of 2,000 pounds.

Production of lead in the United States.

Years.	Total production.	Desilverized lead.	Non-argentiferous lead.	Percentage of desilverized lead.
	Short tons.	*Short tons.*	*Short tons.*	*Per cent.*
1825	1,500			
1830	8,000			
1831	7,500			
1832	10,000			
1833	11,000			
1834	12,000			
1835	13,000			
1836	15,000			
1837	13,500			
1838	15,000			
1839	17,500			
1840	17,000			
1841	20,500			
1842	24,000			
1843	25,000			
1844	26,000			
1845	30,000			
1846	28,000			
1847	28,000			
1848	25,000			
1849	23,500			
1850	22,000			
1851	18,500			
1852	15,700			
1853	16,800			
1854	16,500			
1855	15,800			
1856	16,000			
1857	15,800			
1858	15,300			
1859	16,400			
1860	15,600			
1861	14,100			
1862	14,200			
1863	14,800			

Production of lead in the United States—Continued.

Years.	Total production.	Desilverized lead.	Non-argentiferous lead.	Percentage of desilverized lead.
	Short tons.	*Short tons.*	*Short tons.*	*Per cent.*
1864	15,300			
1865	14,700			
1866	16,100			
1867	15,200			
1868	16,400			
1869	17,500			
1870	17,830			
1871	20,000			
1872	25,880			
1873	42,540	20,159	22,381	47.7
1874	52,080			
1875	59,640	34,909	24,699	58.5
1876	64,070	37,649	26,421	58.8
1877	81,900	50,748	31,152	62.0
1878	91,060	64,290	26,770	70.6
1879	92,780	64,650	28,130	69.7
1880	97,825	70,135	27,690	71.7
1881	117,085	86,315	30,770	73.7
1882	132,890	103,875	29,015	78.3
1883	143,957	122,157	21,800	84.8
1884	139,897	119,965	19,932	86.4
1885	129,412	107,437	21,975	83.0
1886	135,629	114,829	20,800	85.0

LEAD-PRODUCING REGIONS OF THE UNITED STATES.

Utah.—For a series of years the production of the Territory has been estimated as follows:

Production of lead in Utah.

Years.	Short tons.	Years.	Short tons.
1871	5,000	1879	14,000
1872	8,000	1880	15,000
1873	15,000	1881	24,000
1874	20,000	1882	30,000
1875	19,000	1883	29,000
1876	25,000	1884	28,000
1877	27,000	1885	23,000
1878	21,000	1886	20,000

According to the statement of Messrs. Wells, Fargo & Co. the product of Utah was as follows:

Wells, Fargo & Co.'s statement of the product of Utah for 1885 *and* 1886.

Base bullion.	1885.			1886.		
	Unrefined lead.	Fine silver.	Fine gold.	Unrefined lead.	Fine silver.	Fine gold.
	Pounds.	*Ounces.*	*Ounces.*	*Pounds.*	*Ounces.*	*Ounces.*
Germania Lead Works	7,975,400	629,754	1,404	9,834,700	663,106	1,853
Hanauer	9,352,644	666,685	2,158	11,741,763	903,302	2,374
Horn Silver Mining Company (three months)	4,905,932	123,062				
Mingo Furnace Company	11,744,000	403,081	1,586	11,743,749	380,440	1,646
Other smelters				523,631	23,845	55
Net product base bullion	33,977,976	1,822,582	5,148	33,843,843	1,970,693	5,922
Lead, silver, and gold in ores shipped	20,340,800	1,366,994	2,141	14,612,417	867,560	2,447
Total	54,318,776	3,189,576	7,289	48,456,260	2,838,263	8,369

In addition thereto 104 tons of refined lead were made. Now much of the lead product of the Utah smelters is from Idaho ores, and is not stated, so that it is not possible to estimate the quantity which ought to be credited to the Territory.

There have been but few striking developments in the lead mines of Utah during 1886. The Stockton mines produced heavily, and Bingham did fairly well. The Lead Mine Company of Bingham has exposed a very large body of ore, carrying 30 per cent. of lead, 9 ounces of silver, and 0.2 ounce of gold per ton, and estimated to contain 18,000 tons of ore down to the 600-foot level, where the deposit is thicker than at any other point. For the present, however, this body will not affect the lead market, but is only referred to as showing the possibilities of Bingham after the carbonates and sulphates have been worked out. The Ontario and Daly and Crescent mines, at Park City, continued their shipments of smelting ore. The first sold 9,565 short tons, averaging 19.68 per cent. of lead, or a total of 1,882 tons of lead, 2,000 tons of the ore going to Utah smelters and the remainder to Omaha and Denver. The Daly shipped 3,288 short tons of ore, carrying an average of 18.51 per cent. of lead, or 609 short tons of lead, the greater part of it being reduced in Utah. The continued heavy production of smelting ore from these two mines is assured, and there are several promising prospects in Park City besides. It is believed that the completion of the Colorado Midland railroad to Salt Lake City will cheapen coke and thus aid in reducing costs. Nothing in the present mining development warrants the expectation of any material change in the lead product of the Territory in the near future.

Nevada.—During the year there have been no developments in Nevada pointing to any sudden increase in the output through the opening of new districts. In the Eureka district the old ore bodies of Ruby hill have been practically worked out, and it is likely that the small output of 1886 will be even further reduced in quantity in 1887 unless the latest find in the upper levels of the Richmond mine proves important. The Richmond Consolidated Mining Company produced about 2,000 tons in 1886, and the Eureka Company 1,200 tons. A small quantity was turned out at the Reno Reduction Works from ore from miscellaneous mines. Since 1877 the production of lead in the State has been as follows:

Production of lead in Nevada since 1877.

Years.	Short tons.	Years.	Short tons.
1877	19,724	1882	8,590
1878	31,063	1883	6,000
1879	22,805	1884	4,000
1880	16,659	1885	3,500
1881	12,826	1886	3,400

Colorado.—This State continues to be the principal source of the lead supply of the country, Leadville ranking far beyond all others. During 1886, so far as it is possible to trace the facts, there was a slight increase in the total product of the State. The following table gives the output of its leading smelters, with the exception of the Omaha and Grant whose total product is given as including smelting operations at Omaha. In the table below that part of its make is reported which is credited to Colorado ores.

Production of lead by Colorado smelting works.

	Short tons.
American Smelting Works	6,134
Arkansas Valley Smelting Company	8,613
Harrison Reduction Works	4,020
La Plata Smelting Company	4,370
Manville Smelting Works	2,826
Colorado Smelting Company	9,327
Pueblo Smelting and Refining Company	9,250
San Juan and New York Smelting Company	2,006
Royal George Smelting Works	2,342
Golden Smelting Company	1,020
Holden Smelting Company	1,454
Omaha and Grant (Colorado ores)	8,645
Miscellaneous	1,282
	61,289

From this total must be deducted about 2,250 tons of lead, the product from ores from other States and Territories, leaving the lead product of Colorado about 59,000 short tons, of which 48,500 are the product of Leadville.

The following figures relate to Leadville:

Leadville bullion product.

Years.	Lead.	Silver.	Gold.	Ore.	Value of ore shipments.
	Short tons.	*Ounces.*	*Ounces.*	*Short tons.*	
1877	175	376,827	3,750	3,300	$400,000
1878	2,324	450,476	897	15,840	2,360,503
1879	17,650	6,004,416	1,100	18,549	2,851,850
1880	33,551	8,999,399	1,687	12,410	1,460,363
1881	38,101	7,162,909	12,192	15,630	1,016,044
1882	39,864	8,376,802	12,615	22,416	1,872,604
1883	36,870	5,057,990	22,330	(?)	6,420,692
1884	35,296	5,720,904	22,626	(?)	(?)
1885	19,128	5,099,271	8,262	137,869	(?)
1886	25,963	4,569,013	22,504	138,335	6,135,585

The lead contents of the ore shipments are estimated at 22,526 short tons. Leadville is, however, credited with considerable ore derived from tributary camps, notably Red Cliff. Mining developments in Leadville have been, generally speaking, favorable to a continuance of a heavy lead output, the principal feature being the looming up as lead mines of the Maid of Erin and the Henriette, which have been struggling against heavy flows of water.

A good deal of progress has been made during 1886 in the direction of concentrating low-grade ores, a number of plants having been built, to which others are to be added during the current year. The sulphurets continue to be troublesome to smelters on account of their high percentage of zinc. Roasting in stalls, as predicted by the best authorities, has proved very inadequate and has been quite generally abandoned. Even ore roasted in reverberatory furnaces, at a cost of $3.50 per ton, occasions losses and mechanical difficulties in smelting.

In other districts in Colorado there has been little development likely to encourage the belief of greater output. The Madonna, one of the leading lead mines outside of Leadville, has not been producing as heavily as it did in the past, but the falling off has been largely covered from the Sierra Mojada, Mexico, where the Esmeralda and San Salvador mines are reported to be shipping as much as 1,000 tons of ore a week.

Aspen produced very little lead bullion in 1886, and a comparatively small amount of ore. Between 5,000 and 6,000 tons were marketed. This was due to a number of causes. The bringing of suits by apex claims, and the consequent injunction placed upon claims below the apex, operated to stop production on several of the most important mines. These injunctions are still in force, and there is no prospect of a final settlement during the year 1887. Then the building of the Colorado Midland railroad has tended to stop shipments of all ores except those of the very highest grade, because they will be much more valuable as soon as the railroad reaches Aspen in the fall. When railway transportation has been secured it is probable that there will be great activity both in developing and working low-grade mines, and a large output of lead is looked for from Aspen in the latter part of 1887 and in 1888. A large amount of development work is being done in opening up productive territory and in getting ready to ship. It is probable that supplies will be considerably cheapened, and fuel will be available at a low price.

Rico has shipped only a small quantity of lead—346 short tons in 1886—and it is not expected that the 1887 shipment will exceed 500 tons, there having been but little development in that section in 1886, which will materially affect its lead production. The San Barnado mine of Trout Lake, San Miguel county, has recently opened new workings in heavy lead ore, carrying 45 to 60 per cent. of lead, and the Union mine at Rico has exposed during the winter a considerable body of ore carrying 50 per cent. These developments are offset, however, by the greatly diminished output of the "C. H. C." and Ethlene mines, which have until lately been the principal source of lead. The question of railroad transportation to Rico is being vigorously agitated, and it is possible that at no distant date cheap transportation to valley smelters may be secured. But even now all lead ores containing sufficient silver to warrant it are being treated, the Grand View Mining and Smelting Company having worked lead ores running only 12 to 20 ounces of silver. The proximity of coking coal and the fact that labor, charcoal, and fluxes would be little if any cheaper with railroad communication established, does not make it likely that the lead output would be much stimulated by improved facilities for transportation.

Idaho.—A very large proportion of the ores mined in this Territory is shipped to smelting works in Utah, Colorado, and elsewhere, where their identity is lost, so that it is very difficult to trace the lead product of the Territory. Thus, according to a published statement, the Omaha and Grant Smelting and Refining Company produced 6,344 tons of lead and 892,147 ounces of silver from Idaho ores, and no inconsiderable proportion of the bullion made at Utah works was from Idaho ores, principally from the Wood River region. The Viola Company, at Nicholia, now controlled by an English corporation, produced in 1886 a little over 7,000 tons of lead, a part of it being derived from ores from the Texas and Little Lost River districts. The Philadelphia, Clayton, and Bay Horse smelters turned out about 1,350 tons of base bullion, so that thus alone 14,700 tons are accountedf or, not taking into consideration the lead contents of ores which went to Utah smelters. In addition thereto, some ore was smelted in Montana, so that an estimate of at least 16,000 tons of lead is conservative, with the probability that it reached 17,000 tons. So far as can be ascertained now the older Idaho districts can be counted upon to furnish their quota. The Viola will probably make more in 1887, and it seems certain that the mines at Wardner, in the Cœur d'Alène district, will this year heavily increase their output.

Considerable development work has been done in this section, and during the latter half of the year shipments of high grade galena ore and concentrates aggregating several thousand tons have been made, the leading producing mines being the Sullivan and Bunker Hill. Other mines have been preparing ore for shipment, and from present prospects it seems likely that the district will largely add to the lead product of the Territory.

New Mexico.—The lead production in this Territory has not increased in 1886, as compared with former years, so far as metal originating in the mines of New Mexico is concerned, although there have been heavier ore shipments from Mexico. The latter have been growing, and among the newest refineries established recently, dependent principally upon lead ores from that country, are the El Paso Smelting Works, at El Paso, Texas, at which three large furnaces are now being put up, with the expectation of doubling the number as the trade increases. In New Mexico the principal producer continues to be the smelting works at Socorro, belonging to Mr. Gustav Billing, which obtains its lead supply from the Kelly mine and tributary camps. The Graphic Smelting Works in the same locality has been turning out quantities of lead during 1886, depending largely upon the same district for its supply of lead ores. At Nogales the works treat largely Mexican ores.

California.—The lead output is estimated by competent authorities at 1,000 tons. While California produces so little lead, the shipments from the port of San Francisco are large, the bulk of it being the product of the Selby Smelting Works. This refinery made 5,602,929 pounds, of which 2,317,765 pounds were sold, the balance being marketed in the form of lead pipe, sheet lead, and shot, manufactured at their San Francisco works.

Missouri and Kansas.—Messrs. John Wahl & Co., of Saint Louis, estimate the output of non-argentiferous lead at 20,800 tons, of which they credit 13,800 tons to southeast Missouri and 7,000 tons to southwest Missouri and Kansas. The principal producer in the former section, the Saint Joe Lead Company, has considerably increased its capacity during 1886, and is likely to add a few thousand tons to its output in 1887 over that of the previous year. Mine la Motte, the second large company, turned out its usual amount in 1886, and, as no preparations have been made to enlarge operations, will not, in all likelihood, vary much in 1887 from 1886. New territory is to be opened by the Doe Run Company, in which parties identified with the Saint Joe Lead Company are interested.

A special report by John N. Wilson, of Carthage, Missouri, made at the instance of the Joplin Board of Trade, gives statistics of the lead ore product of southwest Missouri for the year ending March 1, 1887. It is accompanied by a geological sketch by F. L. Clerc, and a brief account of the mining machinery used in the district by J. N. Dasey. Although the figures do not cover the calendar year, they are valuable because they constitute the first official statement available for many years of the output of the different mines, the data of this office being based on the reports from the smelting works. A part of the lead ore mined is converted directly into paint, and does not, therefore, appear in output of the metal. The following is the recapitulation of the figures given in the report:

Production of lead ore in the Joplin district for the year ending March 1, 1887.

Companies.	Quantity.	Value.
	Pounds.	
Oswego Mining Company, Joplin	2,285,580	$58,519.64
Guinn & Lloyd, Joplin	2,063,540	51,617.85
Dittmar Company, Joplin	348,743	8,743.48
Turkey Creek Mining Company, Joplin	196,140	4,770.83
Globe Zinc Company, Joplin	1,202,560	12,020.74
Byers, Murphy & Connor, Joplin	1,119,120	11,347.67
Paxton Lead and Zinc Company, Joplin	649,873	15,830.09
Penn Mining and Drainage Company, Joplin	314,334	7,535.27
Murphy & Byers' Tanyard Company, Hollow	18,960	426.40
Stephens Mining Company, East Hollow	7,535	168.27
William Johnson Mining Company, West Hollow	55,000	1,265.00
P. Murphy, Belleville	150,000	3,600.00
G. W. Bruce, Belleville	2,780	63.40
S. B. Holden, Belleville	93,106	2,340.15
North Belleville Lead and Zinc Company, Belleville	63,359	1,583.97
Johnson Mines, near Thurman	162,733	3,742.86
Murdock & Smith	120,000	2,700.00
McClelland & Maupin, Grant Falls	70,000	1,610.00
Total	6,601,683	164,577.21

Production of lead ore in the Webb City and Carterville district for the year ending March 1, 1887.

Companies.	Quantity.	Value.
	Pounds.	
Center Creek Mining and Smelting Company, Webb City	1,993,150	$51,308.08
Garrison Lead and Zinc Company, Webb City	124,595	2,829.11
Nevada Mining Company, Webb City	283,130	6,785.29
Daugherty & Davay, Carterville	3,031,680	73,434.28
Motley Mining Company, Carterville	51,460	1,194.56
Tracey Lead and Zinc Company, Webb City	23,930	529.70
Weston Land and Mining Company, Webb City	281,558	6,650.86
McCorkee & Aylor, Webb City	120,000	2,760.00
Aylor Brothers, Webb City	50,000	1,250.00
Total	5,959,503	146,741.88

Production of lead ore at Oronogo, Granby, and Short Creek.

Companies.	Quantity.	Value.
	Pounds.	
North Oronogo Mining Company, Oronogo	796,000	$19,104.00
Granby Mining and Smelting Company, Oronogo	345,120	7,937.76
West Joplin Lead and Zinc Company, Sherwood	50,000	1,150.00
Alba Mining and Smelting Company, Alba	10,000	230.00
Granby Mining and Smelting Company, Granby	3,120,000	71,760.00
Mosely mines, Neosho	50,000	1,000.00
Aurora Mining and Smelting Company, Aurora	3,290,000	65,800.00
Elliott lands, Aurora	246,000	3,700.00
Short Creek mines, Cherokee county, Kansas	5,924,294	142,183.05
Total	13,831,414	312,864.81

The following is a summary by counties:

Counties.	Quantity.	Value.
	Pounds.	
Jasper, Missouri	13,409,573	$331,627.99
Newton, Missouri	3,522,733	80,872.86
Lawrence, Missouri	3,536,000	69,500.00
Cherokee, Kansas	5,924,294	142,183.05
Total	26,392,699	624,183.90

With a yield of 70 per cent. of metal this would represent a total of 9,237 tons of lead, the average value of the ore being $47.30 per short ton.

Wisconsin.—Mr. Thomas H. McElroy, editor of the *Southwestern Local*, of Shullsburgh, has collected for this office some statistics on the output of the mines of Wisconsin. The lead ore mined in the vicinity of Shullsburgh was nearly all smelted at T. A. Leckley's furnace, 6 miles south of that point, the quantity treated being 1,225,000 pounds of ore, nearly all of which was mined at Shullsburgh, New Diggings, and Benton. At Mineral Point James Sprusley worked 1,000,000 pounds of ore; Rich & Bowden, at Galena, Illinois, treating about 100,000 pounds. In May, 1887, lead ore was selling at Shullsburgh, delivered at the furnace, at $24 per 1,000 pounds. There has been quite a revival of mining in the region. It is proposed to sink a test shaft to determine the possibility of profitable deep mining, the greatest depth reached thus far being about 160 feet. The average depth of the mines being worked in the Wisconsin lead and zinc region is not over 50 feet, and there are still 300 feet of the upper lead-bearing magnesian limestone unexplored.

IMPORTS.

Since the temporary shortage in the supply of domestic lead, the imports have again assumed significance. The following tables give in detail the quantities of ore and dross, pigs and bars, sheets, pipe, and shot, and other manufactures not specified, imported since 1867:

Lead imported and entered for consumption in the United States, 1867 to 1886 inclusive.

Fiscal years ending June 30—	Ore and dross.		Pigs and bars.		Sheets, pipe, and shot.		Shot.		Not otherwise specified.	Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.		
	Pounds.		*Pounds.*		*Pounds.*		*Pounds.*			
1867	611	$25	65, 322, 923	$2, 812, 668	185, 825	$9, 560			$6, 222	$2, 828, 475
1868	6, 945	239	63, 254, 677	2, 668, 915	142, 137	7, 229			6, 604	2, 682, 987
1869			87, 865, 471	3, 653, 481	307, 424	15, 531			18, 885	3, 687, 897
1870	5, 973	176	85, 895, 724	3, 530, 837	141, 681	6, 879			10, 444	3, 548, 336
1871	316	10	91, 496, 715	3, 721, 096	86, 712	4, 209			8, 730	3, 734, 045
1872	32, 331	1, 425	73, 086, 657	2, 929, 623	12, 518	859			20, 191	2, 952, 098
1873			72, 423, 641	3, 233, 011	105	12	420	$50	21, 503	3, 254, 576
1874			46, 205, 154	2, 231, 817			30, 219	1, 349	36, 484	2, 269, 650
1875	13, 206	320	32, 770, 712	1, 559, 017			58	4	25, 774	1, 585, 115
1876			14, 329, 366	682, 132			20, 007	1, 204	27, 106	710, 442
1877	1, 000	20	14, 583, 845	671, 482			16, 502	1, 242	1, 041	673, 785
1878			6, 717, 052	294, 233			15, 829	963	113	295, 309
1879			1, 216, 500	42, 983			3, 748	209	930	44, 122
1880			6, 723, 706	246, 015			1, 120	54	371	246, 440
1881	5, 981	97	4, 322, 068	189, 129			900	65	1, 443	160, 734
1882	21, 698	500	6, 079, 304	202, 603			1, 469	99	2, 449	205, 651
1883	600	17	4, 037, 867	130, 108			1, 510	79	8, 030	138, 234
1884	419	13	3, 072, 738	85, 395	15, 040	630			1, 992	88, 030
1885	4, 218	57	5, 862, 474	143, 103	971, 951	22, 217			1, 372	166, 749
1886			11, 005, 083	294, 856	24, 087	1, 023			1, 698	297, 577

Old and scrap lead imported and entered for consumption in the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Quantity.	Value.	Fiscal years ending June 30—	Quantity.	Value.
	Pounds.			*Pounds.*	
1867	1, 256, 233	$53, 202	1877	249, 645	$8, 383
1868	2, 465, 575	101, 586	1878	106, 342	3, 756
1869	2, 983, 272	123, 068	1879	42, 283	1, 153
1870	3, 756, 785	150, 379	1880	213, 063	5, 262
1871	2, 289, 688	94, 467	1881	123, 018	2, 729
1872	4, 257, 778	171, 324	1882	220, 702	5, 949
1873	3, 545, 098	151, 756	1883	1, 094, 133	31, 724
1874	395, 516	13, 897	1884	160, 356	4, 830
1875	382, 150	13, 964	1885	4, 866	106
1876	265, 860	9, 534	1886	17, 943	666

Lead ashes imported and entered for consumption in the United States, 1869 *to* 1881 *inclusive.*

Fiscal years ending June 30—	Value.	Fiscal years ending June 30—	Value.
1869	$1, 461	1875	$503
1870	8, 892	1876	4, 241
1871	8, 852	1877	33, 297
1872	1, 315	1878	4, 886
1873	254	1879	69
1874	1, 583	1881 (*a*)	67

a Not separately classified since 1881.

EXPORTS.

Except during the period of 1842 to 1846, both fiscal years included, and in the years 1878 and 1879, when considerable quantities of lead were sent to China, the export movement of lead has always been insignificant as compared with the home production.

Lead and manufactures of lead, of domestic production, exported from the United States.

Fiscal years ending September 30 until 1842, and June 30 since.	Manufactures of— Lead.		Manufactures of— Pewter and lead.	Bars, shot, etc.		Total value.
	Quantity.	Value.	Value.	Quantity.	Value.	
	Pounds.			*Pounds.*		
1790	13,440	$810				$810
1803 (barrels)	900					
1804	19,804					
1805	8,000					
1808	40,583					
1809	126,537					
1810	172,323					
1811	65,497					
1812	74,875					
1813	276,940					
1814	43,600					
1815	40,245					
1816	35,844					
1817	111,034	9,993				9,993
1818	281,168	22,493				22,493
1819	94,362	7,549				7,549
1820	25,699	1,799				1,799
1821	56,192	3,512				3,512
1822	66,316	4,244				4,244
1823	51,549	3,098				3,098
1824	18,604	1,356				1,356
1825	189,930	12,697				12,697
1826	47,337	3,347				3,347
1827	50,160	3,761				3,761
1828	76,882	4,184				4,184
1829	179,952	8,417				8,417
1830	128,417	4,831				4,831
1831	152,578	7,068				7,068
1832	72,439	4,483				4,483
1833	119,407	5,685				5,685
1834	13,480	805				805
1835	50,418	2,741				2,741
1836	34,600	2,218				2,218
1837	297,488	17,015				17,015
1838	375,231	21,747				21,747
1839	81,377	6,003				6,003
1840	882,620	39,687				39,687
1841	2,177,164	96,748				96,748
1842	14,552,357	523,428				523,428
1843 (nine months)	15,366,918	492,765				492,765
1844	18,420,407	595,238				595,238
1845	10,188,024	342,646				342,646
1846	16,823,766	614,518				614,518
1847	3,326,028	124,981				124,981
1848	1,994,704	84,278				84,278
1849	680,249	30,198				30,198
1850	261,123	12,797				12,797
1851			$16,426	229,448	$11,774	28,200
1852			18,469	747,930	32,725	51,194
1853			14,064	100,778	5,540	19,604
1854			16,478	404,247	26,874	43,352
1855			5,233	165,533	14,298	19,531
1856			5,628	310,029	27,512	33,140
1857			4,818	870,544	58,624	63,442
1858			27,327	900,607	48,119	75,446
1859			28,782	313,988	28,575	57,357
1860			56,081	903,468	50,446	106,527
1861			30,534	109,023	6,241	36,775
1862			28,832	79,231	7,334	36,166
1863			30,609	237,239	22,634	53,243
1864			30,411	223,752	18,718	49,129

Lead and manufactures of lead, &c.—Continued.

Fiscal years ending September 30 until 1842, and June 30 since.	Manufactures of.			Bars, shat, etc.		Total value.
	Lead.		Pewter and lead.			
	Quantity.	Value.	Value.	Quantity.	Value.	
	Pounds.			*Pounds.*		
1865	....	....	$29,271	852,895	$132,666	$161,937
1866	....	....	44,483	25,278	2,323	46,806
1867	....	....	27,559	99,158	5,300	32,859
1868	....	....	37,111	438,040	34,218	71,329
1869	....	....	17,249	....	....	17,249
1870	....	$28,315	....	....	....	28,315
1871	....	79,880	....	....	....	79,880
1872	....	48,132	....	....	....	48,132
1873	....	13,392	....	....	....	13,392
1874	....	302,044	....	....	....	302,044
1875	....	429,309	....	....	....	429,309
1876	....	102,726	....	....	....	102,726
1877	....	49,835	....	....	....	49,835
1878	....	314,904	....	....	....	314,904
1879	....	280,771	....	....	....	280,771
1880	....	49,899	....	....	....	49,899
1881	....	39,710	....	....	....	39,710
1882	....	178,779	....	....	....	178,779
1883	....	43,108	....	....	....	43,108
1884	....	135,156	....	....	....	135,156
1885	....	123,466	....	....	....	123,466
1886	....	114,098	....	....	....	114,098

REVIEW OF THE LEAD MARKET.

The following table gives the highest and lowest prices monthly for a series of years:

Highest and lowest prices of lead at New York City, monthly, from 1870 *to* 1886 *inclusive.*

[Cents per pound.]

Years.	January.		February.		March.		April.		May.		June.	
	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
1870	(a)6.30	6.20	6.25	6.17	6.20	6.10	6.25	6.15	6.25	6.20	6.25	6.20
1871	(a)6.30	6.15	6.25	6.20	6.20	6.15	6.20	6.10	6.18	6.10	6.15	6.12
1872	(a)6.00	5.90	6.00	5.87	6.00	5.87	6.12	5.90	6.62	6.25	6.62	6.40
1873	(a)6.37	6.25	6.50	6.40	6.50	6.25	6.50	6.25	6.62	6.35	6.55	6.12
1874	(a)6.00	5.90	6.25	6.00	6.25	6.12	5.25	5.90	6.00	5.75	6.00	5.62
1875	(a)6.20	6.00	5.90	5.85	5.75	5.62	5.87	5.80	5.95	5.90	5.90	5.75
1876	(a)6.00	5.87	6.37	6.00	6.50	6.40	6.40	6.12	6.50	6.10	6.50	6.25
1877	(b)6.15	6.12	6.40	6.20	6.75	6.50	6.50	6.25	6.00	5.55	5.70	5.60
1878	4.35	4.00	3.87	3.65	3.87	3.62	3.75	3.50	3.50	3.25	3.50	3.12
1879	4.50	4.00	4.50	4.50	4.50	3.25	3.25	2.87	3.12	2.87	3.80	3.12
1880	6.10	5.50	6.00	5.87	5.95	5.30	5.75	5.40	5.25	4.40	4.75	4.50
1881	5.00	4.30	5.10	4.80	4.85	4.62	4.85	4.37	4.70	4.25	4.50	4.25
1882	5.15	4.95	5.20	5.00	5.12	4.85	5.00	4.90	4.85	4.60	4.90	4.55
1883	4.70	4.60	4.60	4.50	4.65	4.50	4.62	4.40	4.55	4.40	4.45	4.40
1884	4.50	3.75	4.10	3.75	4.15	4.10	4.05	3.62½	3.75	3.52½	3.65	3.57½
1885	3.70	3.55	3.70	3.60	3.70	3.62½	3.70	3.62½	3.75	3.60	3.85	3.62½
1886	4.70	4.50	4.90	4.60	4.95	4.85	4.90	4.65	4.75	4.65	4.90	4.65

a Gold. *b* Currency.

Highest and lowest prices of lead at New York City, &c.—Continued.

Years.	July.		August.		September.		October.		November.		December.	
	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
1870	6.30	6.20	6.37	6.32	6.37	6.30	6.37	6.25	6.35	6.25	6.35	6.25
1871	6.15	6.10	6.12	6.00	6.10	6.00	6.00	5.87	6.00	5.90	6.00	5.75
1872	6.02	6.40	6.50	6.40	6.50	6.30	6.62	6.40	6.60	6.50	6.60	6.42
1873	6.12	6.00	6.25	6.00	6.62	6.37	6.75	6.25	6.50	6.00	6.12	6.00
1874	5.80	5.62	5.80	5.65	6.10	5.65	6.35	6.10	6.50	6.25	6.40	6.12
1875	6.00	5.95	5.95	5.87	5.87	5.70	5.65	5.60	5.87	5.65	5.95	5.87
1876	6.35	6.20	6.37	6.25	5.25	6.00	6.00	5.80	5.80	5.70	5.70	5.65
1877	5.60	5.37	5.12	4.90	4.85	4.75	4.85	4.25	4.75	4.50	4.60	4.50
1878	3.62	3.25	3.50	3.20	3.45	3.25	3.60	3.37	3.95	3.60	4.00	3.90
1879	4.10	3.90	4.05	4.00	4.00	3.75	5.50	4.00	5.62	5.00	5.60	5.50
1880	4.75	4.25	5.00	4.30	4.90	4.80	4.87	4.65	4.85	4.75	4.75	4.25
1881	4.90	4.50	4.95	4.75	5.37	4.95	5.25	4.87	5.25	4.90	5.25	5.00
1882	5.15	4.90	5.10	4.95	5.15	4.95	5.15	4.85	4.90	4.50	4.75	4.50
1883	4.40	4.30	4.30	4.20	4.32	4.30	4.32	4.12	4.05	3.65	3.75	3.60
1884	3.70	3.55	3.70	3.52½	3.75	3.55	3.75	3.60	3.55	3.37½	3.75	3.50
1885	4.15	3.87½	4.25	4.12	4.25	4.00	4.25	4.00	4.60	4.00	4.67½	4.50
1886	4.90	4.75	4.80	4.75	4.70	4.45	4.30	4.00	4.40	4.10	4.35	4.25

In order to arrive at an average of the market price of lead at New York, the reported sales at the three principal markets—New York, Saint Louis, and Chicago—in lots above 100 tons, have been traced, converting the transactions at the two latter points into their equivalent at New York.

Average market price of lead at New York.

Periods.	Price per pound.
First half, 1883	4.51
Second half, 1883	4.07
Average, 1883	4.28
First half, 1884	3.82
Second half, 1884	3.63
Average, 1884	3.77
First half, 1885	3.78
Second half, 1885	4.28
Average, 1885	4.04
Average, 1886	4.67

The average price in 1886 was therefore a little over 14 per cent. greater than in 1885.

Early in January the market, particularly in New York, showed indications of gaining in strength, but towards its close relapsed into quietude. A firmer tone prevailed in the first days of February, the impetus first coming from the West developing great activity in a short time and reaching the importing point. In spite of orders taken for foreign, sales of domestic were very heavy, with an advancing tendency, 4.90 cents being reached in that month. This stimulated considerable speculative purchasing of foreign, a heavy proportion of which, however, came too late to be marketed, and was ultimately returned. The middle of March witnessed the general check in business due to the labor troubles, which, with the heavy importations, caused a cessation of the upward movement, and later brought about a weakening in prices in April. The latter became more pronounced toward the end of that month, under the reselling of foreign lead bought for western account earlier in the year. In May supplies of domestic lead became more ample, while the pressure to sell foreign lead grew heavier. In June, however, a better feeling developed, and the metal again became active, with a rising tendency, the Richmond company disposing of about 3,000 tons of its stock of lead. July opened with a quiet though firm market, but it gradually weakened under free offerings of foreign lead and greater reserve on the part of buyers. Under these influences, which were potent throughout August, the metal was dull and showed a declining tendency, which developed into more decided weakness in September. It began to be understood that in some lines, notably in white lead, the business done during the season had been disappointing. It was asserted on good authority that the corroders' consumption of lead indicated a falling off in demand for 1886 of about 10,000 tons as against the previous year. These facts began to tell in October, the market declining to 4 cents. During all this time about 2,000 tons of foreign lead were still being held in bond, nearly all of which went back in November. In that month there was a temporary flurry in the West, the metal, however, falling back, although not to the low evel of the latter part of October. December was dull, though fairly firm.

ZINC.

By C. Kirchhoff, Jr.

Quiet development, with very few noteworthy incidents, characterized the zinc industry of the United States in 1886. Production increased somewhat, notably in the West, in spite of some disturbing influences, but on the other hand consumption must have developed considerably. This must have been particularly the case with that part of the output of the metal which goes to brass manufacturers, the long-continued low prices in copper having considerably stimulated the consumption of the alloy and its manufactures. The demand for galvanized wire and sheets, too, was greater in 1886 than it was in 1885. The markets during the year were quite steady, and the increased make was absorbed with only occasional pressure to sell. Some preparations were made in 1886, and others are still going forward to increase the capacity of existing works, notably in the South. Unless untoward circumstances operate adversely, the output will be further increased in 1887.

PRODUCTION.

The records of the production of spelter and zinc in previous years are incomplete, the following figures being the only ones available which are worthy of consideration:

Production of spelter in the United States.

Years.	Short tons.
1873	7,343
1875	15,833
1880 (census year ending May 31)	23,239
1882	33,765
1883	36,872
1884	38,544
1885	40,688
1886	42,641

Grouped by States, the product has been as follows:

Production of spelter in the United States, 1881 to 1886, inclusive by States.

States.	1881.	1882.	1883.	1884.	1885.	1886.
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
Illinois	16,250	18,201	16,792	17,594	19,427	21,077
Kansas	5,000	7,366	9,010	7,859	8,502	8,932
Missouri	2,750	2,500	5,730	5,230	4,677	5,870
Eastern and southern States	....	5,698	5,340	7,861	8,082	6,762
Total	....	33,765	36,872	38,544	40,688	42,641

In the East tne output declined, the works of the Bergenport Zinc Company having been closed down during the year, while the make of the Lehigh Zinc and Iron Company at Bethlehem fell off somewhat as compared with 1885. In the South the plant of the Bertha Zinc Company at Pulaski City, Virginia, stood idle a large portion of the time, from the fact that the Norfolk and Western Railroad was building the Cripple Creek extension, which runs through the mining property of the company. As previous to its completion the ore required to be hauled 16 miles by wagon, the works were stopped. Since the railroad has been built two furnaces have been started, followed by two more later in the year. The company is building six new furnaces which will be in blast during the second half of the year, and will bring the capacity of the works up to 10 tons per day. Early in 1887 the company sold 200 tons of Bertha zinc to be shipped to Russia for cartridge metal. The Edes, Mixter and Heald Zinc Company, with works at Knoxville, Tennessee, made a moderate amount of metal in 1886. The company purchased the Richburg mines and zinc works. During the current year the company will put up a concentrating plant at its mines. The East Tennessee Valley Zinc Works were idle in 1886.

In Illinois, the Illinois Zinc Company at Peru increased its output in 1886 over 1885. The Collinsville Zinc Works, Otto F. Meister & Co., Collinsville, Illinois, ran 260 retorts from January 1 to April 1, increasing to 360 during the two quarters following, and had in operation during the last quarter of the year 616 retorts, which were 48 inches long by 8 inches in diameter. They contemplate a further increase of capacity during the current year (1887), and will add 256 retorts during the first half. In Kansas the production was considerably interfered with by the great railroad strikes early in the year. No recent additions to capacity or contemplated enlargement of works are reported.

In Missouri the status of the Glendale Zinc Company is unknown. In the absence of a return, the only one missing, the product of the works has been estimated at 3,250 tons. The Joplin Zinc Company, which had been idle for eighteen months, started up on October 1, 1886.

THE SUPPLY OF ZINC ORES IN THE WEST.

Southwest Missouri.—In a pamphlet issued by John N. Wilson, of Carthage, Missouri, valuable statistics are given concerning the product of zinc ores of southwest Missouri. They embrace, however, the period from March, 1886, to March, 1887. According to the detailed statements furnished, the product of Joplin and vicinity during that period was 18,758 short tons of zinc ore, valued at $445,431.40, the principal producers being:

Name.	Short tons.
Oswego Company, Joplin	1,226
Guinn & Lloyd, Joplin	1,144
Dittmar Company, Joplin	1,180
Turkey Creek Mining and Smelting Company, Joplin	2,574
W. Johnson Mining Company, West Hollow	2,797
P. Murphy, Belleville	4,350
G. W. Bruce, Belleville	1,848
S. B. Holden, Belleville	1,909

The product of the Webb City and Carterville district is placed at 24,019 short tons, valued at $462,768.73, with the following leading producers:

Name.	Short tons.
Center Creek Mining and Smelting Company, Webb City..	14, 095
Daugherty & Davey, Carterville....	5, 617
Garrison Lead and Zinc Company, Webb City	1, 422
Nevada Mining Company	1, 704

In addition to the districts enumerated, the Granby mines produced 8,892 short tons of principally calamine, and the Lehigh Drainage and Mining Company, which mined the territory heretofore known as the Lehigh mines, turned out 2,172 short tons. These mines were flooded in July, but resumed in the spring of 1887. The Moseley mines, northward of Neosho, in Newton county, produced about 1,500 tons of silicate. By counties the product is reported as follows:

	Short tons.	Value.
Jasper county	46, 889	$995, 551. 04
Newton county	10, 912	155, 532. 00
Lawrence county	239	2, 022. 00
Total	58, 040	1, 153, 105. 04

According to a report received from an authoritative source, it is probable that Belleville and the Stephens diggings will sufficiently increase their output to make up for deficiencies which are likely to take place in the supply of Webb City and other districts.

Kansas.—Practically forming a part of the Southwest Missouri region, the Short Creek district, Kansas, has been a heavy producer. Mr. W. B. Stone, of Galena, estimates the 1886 production at 31,768 tons of zinc ore, valued at $508,207. The figures for Missouri and Kansas show an average value per short ton of $18.50. A part of the output is silicate of zinc, which sold in some cases at only $10 per ton, while the other class of ore sold at $20 and $21.50 per ton. The entire output of the Moseley mines, near Neosho, and the greater part of that of the Granby mines, was the former.

Wisconsin.—Mr. Thomas H. McElroy, editor of the *Southwestern Local*, Shullsburgh, Wisconsin, reports to this office that the shipments of zinc ore by rail from Shullsburgh in 1886 were 506 short tons of "dry bone" to Saint Louis, and 209 short tons of "black jack" to Mineral Point, Wisconsin, and La Salle, Illinois. The shipments of both classes of ore from Benton during 1886 were 2,275 short tons. In addition to the shipments there were about 500 short tons of ore on the dumps of the different mines at the close of the year. Early in 1887 "dry bone" was selling in the Shullsburgh district at $12 and $19 per ton, and "black jack" at $18 and $22 per ton, zinc ore having advanced $2 a ton in 1886. Reports from Wisconsin indicate considerable activity in mining in that section.

IMPORTS AND EXPORTS.

Zinc imported and entered for consumption in the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Blocks or pigs.		Sheets.		Value of manufactures.	Total value.
	Quantity.	Value.	Quantity.	Value.		
	Pounds.		*Pounds.*			
1867	5,752,611	$256,366	5,142,417	$311,767	$1,835	$569,968
1868	9,327,968	417,273	3,557,448	203,883	1,623	622,779
1869	13,211,575	590,332	8,306,723	478,646	2,083	1,071,061
1870	9,221,121	415,497	9,542,687	509,860	21,696	947,053
1871	11,159,040	508,355	7,646,821	409,243	26,366	943,964
1872	11,802,247	522,524	10,704,944	593,885	58,668	1,175,077
1873	6,339,897	331,399	11,122,143	715,706	56,813	1,103,918
1874	3,593,570	203,479	6,016,835	424,504	48,304	676,287
1875	2,034,252	101,766	7,320,713	444,539	26,330	572,635
1876	947,322	56,082	4,611,360	298,308	18,427	372,817
1877	1,266,894	63,250	1,341,333	81,815	2,496	147,561
1878	1,270,184	57,753	1,255,620	69,381	4,892	132,026
1879	1,419,791	53,294	1,111,225	53,050	3,374	109,718
1880	8,092,620	371,920	4,069,310	210,230	3,571	585,721
1881	2,859,216	125,457	2,727,324	129,158	7,603	262,218
1882	18,408,391	736,964	4,413,042	207,032	4,940	948,936
1883	17,067,211	655,503	3,309,239	141,823	5,606	802,932
1884	5,869,738	208,852	952,253	36,120	4,795	249,767
1885	3,515,840	113,268	1,839,860	64,781	2,054	180,103
1886	3,616,462	115,813	1,037,951	38,359	10,650	164,822

Exports of zinc and zinc ore of domestic production, 1864 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Ore or oxide.		Plates, sheets, pigs, or bars.		Value of manufactures.	Total value.
	Quantity.	Value.	Quantity.	Value.		
	Cwt.		*Pounds.*			
1864	14,810	$116,431	95,738	$12,269	....	$128,700
1865	99,371	114,149	184,183	22,740	....	136,889
1866	4,485	25,091	140,798	13,290	....	38,381
1867	3,676	32,041	312,227	30,587	....	62,628
1868	8,344	74,706	1,022,699	68,214	....	142,920
1869	....	65,411	....	....	....	65,411
1870	15,286	81,487	110,157	10,672	....	92,159
1871	9,621	48,292	76,380	7,823	....	56,115
1872	3,686	20,880	62,919	5,726	....	26,606
1873	234	2,304	73,953	4,656	....	6,960
1874	2,550	20,037	43,566	3,612	....	23,649
1875	3,083	20,659	38,090	4,245	$1,000	25,904
1876	10,178	66,259	134,542	11,651	4,333	82,243
1877	6,428	34,468	1,419,922	115,122	1,118	150,708
1878	16,050	83,831	2,545,320	216,580	567	300,978
1879	19,660	40,399	2,132,949	170,654	....	211,053
1880	13,024	42,036	1,368,302	119,264	....	161,300
1881	11,390	16,405	1,491,786	132,805	168	149,378
1882	10,904	13,736	1,489,552	124,638	....	138,374
1883	3,045	11,509	852,333	70,981	734	83,224
1884	4,780	16,685	126,043	9,576	4,666	30,927
1885	6,840	22,824	101,685	7,270	4,991	35,085
1886	8,740	24,951	770,558	64,410	12,749	102,110

PRICES OF ZINC.

The following table summarizes the prices of spelter since 1875:

Prices of common western spelter in New York City, 1875 *to* 1886 *inclusive.*

[Cents per pound. Figures in parentheses are combination prices.]

Years.	January.		February.		March.		April.		May.		June.	
	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
1875	6.75	6.37	6.67	6.25	6.50	6.20	(7.00)	6.50	(7.25)	7.15	(7.25)	7.15
1876	(7.60)	7.40	(7.75)	7.50	(7.75)	7.62	(8.00)	7.60	(8.00)	7.75	(8.00)	7.25
1877	6.50	6.25	6.62	6.50	6.50	6.37	6.37	6.25	6.25	6.00	6.12	5.87
1878	5.75	5.50	5.62	5.25	5.62	5.25	5.25	5.00	5.00	4.62	4.62	4.25
1879	4.50	4.25	4.62	4.40	4.62	4.37	4.75	4.25	4.50	4.25	4.37	4.12
1880	6.50	5.87	6.75	6.37	6.75	6.50	6.50	6.12	6.00	5.62	5.50	5.12
1881	5.25	4.87	5.25	5.12	5.00	4.87	5.12	4.75	5.00	4.87	5.00	4.75
1882	6.00	5.75	5.75	5.62	5.62	5.37	5.50	5.25	5.62	5.25	5.37	5.25
1883	4.62	4.50	4.62	4.50	4.75	4.62	4.75	4.60	4.75	4.50	4.62	4.37
1884	4.37	4.20	4.40	4.25	4.60	4.40	4.65	4.50	4.60	4.45	4.60	4.45
1885	4.50	4.12	4.30	4.25	4.30	4.12	4.30	4.12	4.25	4.10	4.10	4.00
1886	4.50	4.30	4.55	4.30	4.60	4.50	4.60	4:50	4.60	4.40	4.40	4.35

Years.	July.		August.		September.		October.		November.		December.	
	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
1875	(7.35)	7.25	(7.25)	7.10	(7.25)	7.10	(7.40)	7.15	(7.40)	7.15	(7.40)	7.15
1876	7.25	7.12	7.25	7.00	7.12	6.80	6.75	6.62	6.62	6.37	6.50	6.37
1877	5.87	5.62	5.90	5.80	5.87	5.75	5.90	5.70	5.87	5.62	5.75	5.50
1878	4.75	4.50	4.87	4.50	4.87	4.75	4.82	4.50	4.75	4.50	4.37	4.25
1879	4.75	4.37	5.62	4.80	6.00	5.62	6.37	6.00	6.25	5.87	6.25	6.00
1880	5.00	4.87	5.25	4.87	5.12	4.75	5.00	4.87	4.90	4.65	4.75	4.65
1881	5.00	4.75	5.12	5.00	5.25	5.00	5.37	5.25	5.87	5.50	6.00	5.87
1882	5.37	5.12	5.50	5.12	5.37	5.12	5.37	5.12	5.12	4.87	4.87	4.50
1883	4.50	4.30	4.40	4.30	4.50	4.40	4.45	4.35	4.40	4.37	4.37	4.35
1884	4.55	4.45	4.62	4.52	4.62	4.50	4.55	4.40	4.40	4.30	4.25	4.00
1885	4.40	4.10	4.60	4.40	4.62	4.50	4.62	4.50	4.60	4.45	4.60	4.45
1886	4.40	4.30	4.40	4.30	4.40	4.25	4.30	4.25	4.30	4.25	4.50	4.35

During the year 1886 the market ruled fairly steady. It opened quietly, but gathered strength in February, and developed a further advancing tendency in March. In April the western railroad strikes, it is true, restricted the output by closing some works which could not get a sufficient supply of ores. But, on the other hand, lines of business representing a large consumption of spelter suffered keenly, which caused a weakening of the market to 4.35 and 4.40 cents. During the second half of the year the metal was steady at the range of 4.35 to 4.40 cents, closing, however, with higher figures generally prevailing. Early in 1887 foreign spelter again came into this market, one lot of 1,000 tons being sold to an eastern wire mill at 4.65 cents. During 1886 the imports were moderate, the American producers controlling the home market. Somewhat larger exports of American ores were made to Europe during the year.

Messrs. Henry Merton & Co., of London, make the world's production as follows:

Merton's estimate of the world's production of zinc.

Countries.	1886.	1885.	1884.	1883.	1882.	1881.	1880.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Rhine district and Belgium ..	129, 020	129, 754	130, 522	123, 891	119, 193	110, 989	98, 830
Silesia	81, 630	79, 623	76, 116	70, 405	68, 811	66, 497	64, 459
Great Britain	20, 730	23, 099	29, 259	28, 661	25, 581	24, 419	(*a*)22, 000
France and Spain	15, 305	14, 847	15, 341	14, 671	18, 075	(*a*)18, 358	15, 000
Poland	4, 145	5, 019	4, 164	3, 733	4, 400	(*a*) 4, 000	(*a*)4, 000
Austria	3, 760	3, 890	4, 470	4, 672	5, 094	4, 270	(*a*)2, 520
Total, Europe	254, 590	256, 232	259, 872	246, 033	241, 154	228, 533	206, 809
Total, United States ...	38, 072	36, 339	34, 414	32, 921	30, 148	(*a*)30, 000	20, 749
Grand total	292, 662	292, 571	294, 286	278, 954	271, 302	258, 533	227, 558

a Estimated.

QUICKSILVER.

The production of quicksilver in the United States has always been limited practically to California, and this will probably continue for many years, although a small establishment inaugurated the production of quicksilver in Utah late in 1886, and promises to produce steadily if only in small amount. The production in 1886, amounting to 29,981 flasks, was slightly less than in 1885, when 32,073 flasks were produced, but nevertheless this was fully equal to the demand, which is limited and entirely beyond the control of American producers. Much more could have been produced on any encouragement in the demand. The total value of the product increased to $1,060,000 on account of a rise in the average price to $35.35 per flask. The production from the various mines in California is shown in the following table, compiled by Mr. J. B. Randol, director of the New Almaden mines in California:

Production of quicksilver in the United States to the close of 1886.

Years.	New Almaden.	New Idria.	Redington.	Sulphur Bank.	Guadalupe.	Great Western.	Pope Valley.	Napa Consolidated. (a)	St. John.	Altoona.	Oceanic.	Oakland.	California.	Great Eastern.	Sunderland.	Cloverdale.	Abbott.	Manhattan.	Various mines.	Total yearly production of California mines.
	Flasks.	Flasks.	Flasks.	Flasks.	Flasks.	Flasks.	Flasks.	Flasks.	Fl'ks.	Flasks.	Fl'ks.	Fl'ks.	Fl'ks.	Fl'ks.	Fl'ks.	Fl'ks.	Fl'ks.	Flasks.	Flasks.	Flasks.
1850	7,723	Production from 1858 to 1866, 17,455 flasks—no yearly details obtainable—included in production of various mines	...	...	Yearly production previous to 1875 not obtainable (estimated at 20,000 flasks), included in production of various mines.	...	...	...	...	Some was produced prior to 1875, but no record kept (estimated production previous to 1875, 1,000 flasks), included in production of various mines.	...	...	...	...	...	...	...	Yearly production previous to 1876 not obtainable (estimated at 3,594 flasks), included in production of various mines.	...	7,723
1851	27,779		...	...		...	...	...	...		...	...	...	...	...	...	...		...	27,779
1852	15,901		...	...		...	...	...	...		...	...	...	...	...	...	...		4,099	20,000
1853	22,284		...	...		...	...	...	...		...	...	...	...	...	...	...		...	22,284
1854	30,004		...	...		...	...	...	...		...	...	...	...	...	...	...		...	30,004
1855	29,142		...	...		...	...	...	...		...	...	...	...	...	...	...		3,858	33,000
1856	27,138		...	...		...	...	...	...		...	...	...	...	...	...	...		2,862	30,000
1857	28,204		...	...		...	...	...	...		...	...	...	...	...	...	...		...	28,204
1858	25,761		...	...		...	...	...	...		...	...	...	...	...	...	...		5,239	31,000
1859	1,294		...	...		...	...	...	...		...	...	...	...	...	...	...		11,706	13,000
1860	7,061		...	...		...	...	...	...		...	...	...	...	...	...	...		2,939	10,000
1861	34,429		...	...		...	...	...	...		...	...	...	...	...	...	...		571	35,000
1862	39,671		444	...		...	...	...	...		...	...	...	...	...	...	...		1,885	42,031
1863	32,803		852	...		...	...	...	...		...	...	...	...	...	...	...		6,876	40,589
1864	42,489		1,914	...		...	800	...	...		...	...	...	...	...	...	...		2,286	47,400
1865	47,194		3,545	...		...	...	...	...		...	...	...	...	...	...	...		2,261	53,000
1866	35,150	6,525	2,254	...		...	...	...	...		...	...	...	...	...	...	...		2,621	46,550
1867	24,461	11,493	7,862	...		...	...	...	...		...	...	...	...	...	...	...		3,184	47,000
1868	25,628	12,180	8,686	...		...	1,122	...	...		...	...	...	...	...	...	...		112	47,728
1869	16,898	10,315	5,018	...		...	1,580	...	...		...	...	...	...	...	...	...		...	33,811
1870	14,423	9,888	4,546	...		...	1,220	...	...		...	...	...	...	...	...	...		...	30,077
1871	18,568	8,180	2,128	...		...	1,970	...	...		...	...	...	...	...	...	...		840	31,686
1872	18,574	8,171	3,046	...		...	1,830	...	...		...	...	...	...	...	...	...		...	31,621
1873	11,042	7,735	3,294	...		340	1,955	...	...		...	...	...	...	...	...	...		3,276	27,642
1874	9,084	6,911	6,678	573		1,122	1,645	...	1,743		...	...	...	...	...	...	...		...	27,756
1875	13,648	8,432	7,513	5,372	3,342	3,384	1,940	...	1,927	533	...	...	...	412	...	...	...		3,747	50,250
1876	20,549	7,272	9,183	8,367	7,381	4,322	300	573	1,683	1,979	2,358	2,150	965	387	1,570	1,028	1,436	976	2,595	75,074
1877	23,996	6,316	9,399	10,993	6,241	5,856	1,060	2,229	1,463	1,317	2,575	1,395	1,516	505	735	1,291	836	439	1,234	79,396
1878	15,852	5,138	6,686	9,465	9,072	4,963	1,075	3,049	...	1,534	1,679	1,615	1,640	1,366	472	116	...	...	158	63,880
1879	20,514	4,425	4,516	9,249	15,540	6,333	1,325	3,605	1,290	1,919	779	1,505	1,110	1,455	...	18	...	...	101	73,684
1880	23,465	3,209	2,139	10,706	6,670	6,442	275	4,416	492	245	...	166	422	1,279	...	...	...	...	...	59,926
1881	26,060	2,775	2,194	11,152	5,228	6,241	...	5,552	...	...	...	...	...	1,065	...	208	...	...	376	60,851
1882	28,070	1,953	2,171	5,014	1,138	5,179	...	6,842	...	...	...	...	...	2,124	...	...	...	...	241	52,732
1883	29,000	1,606	1,894	2,612	84	3,869	...	5,890	...	...	...	...	...	1,669	...	...	...	...	101	46,725
1884	20,000	1,025	881	890	1,179	3,292	...	4,307	...	...	...	...	...	332	...	...	...	...	7	31,913
1885	21,400	1,144	385	1,296	35	3,469	...	3,506	...	...	...	...	...	446	...	...	...	...	392	32,073
1886	18,000	1,406	409	1,449	...	1,949	...	5,247	...	...	...	...	...	735	...	...	...	...	786	29,981
Total	853,259	126,099	97,637	77,138	55,910	56,761	18,097	45,216	8,598	7,527	7,391	6,831	5,653	11,775	2,777	2,661	2,272	1,415	64,353	b1,457,370

a Including Etna.

b Not including 87 flasks produced in Utah in 1886.

Production of quicksilver in California by months from 1883 *to* 1886.

Months.	New Almaden.	New Idria.	Redington.	Sulphur Bank.	Guadalupe.	Great Western.	Ætna. (*a*)	Napa. (*a*)	Great Eastern.	Various.	Total.
1883.	*Flasks.*	*Flasks.*	*Flasks.*	*Flasks.*	*Fl'ks.*	*Flasks.*	*Flasks.*	*Flasks.*	*Fl'ks.*	*Fl'ks.*	*Flasks.*
January	2,497	112	367	280	77	390	....	590	262	7	4,582
February	2,150	133	181	310	7	364	....	295	156	4	3,600
March	2,230	142	202	335	......	305	....	485	162	14	3,875
April	1,756	76	243	310	......	294	....	530	142	3	3,354
May	2,344	144	135	350	......	293	....	325	164	13	3,768
June	2,214	137	165	91	......	400	....	360	184	10	3,561
July	2,618	85	141	130	......	446	....	452	150	2	4,024
August	3,000	139	94	112	......	315	....	695	76	......	4,431
September	3,010	164	45	265	......	297	....	750	81	30	4,642
October	2,672	272	109	206	......	215	....	521	134	......	4,129
November	2,212	115	78	160	......	208	....	613	102	......	3,488
December	2,297	87	134	63	......	342	....	274	56	18	3,271
Total	29,000	1,606	1,894	2,612	84	3,869	....	5,890	1,669	101	46,725
1884.											
January	1,440	103	127	263	......	373	329	135	28	7	2,805
February	1,458	59	104	....	......	241	276	174	9	......	2,321
March	1,606	36	123	68	......	223	249	152	2	......	2,459
April	1,785	75	50	76	......	232	422	69	......	......	2,709
May	1,672	125	53	200	......	169	245	6	......	......	2,470
June	1,859	44	118	....	200	258	215	......	......	......	2,694
July	1,543	29	71	52	200	258	374	101	......	......	2,628
August	1,804	63	47	20	306	334	228	110	......	......	2,912
September	1,448	67	52	35	58	354	136	169	58	......	2,377
October	1,625	115	68	25	160	328	153	90	104	......	2,668
November	1,900	157	32	53	150	230	132	240	91	......	2,985
December	1,860	152	36	98	105	292	172	130	40	......	2,885
Total	20,000	1,025	881	890	1,179	3,292	2,931	1,376	332	7	31,913
1885.											
January	1,700	172	40	24	......	190	189	131	37	......	2,483
February	1,506	245	24	85	35	70	96	180	75	......	2,316
March	1,500	314	....	83	......	80	88	145	33	19	2,262
April	2,003	340	....	69	......	80	142	145	37	......	2,816
May	2,000	269	....	194	......	75	62	190	......	3	2,793
June	1,750	330	50	91	......	62	112	250	63	5	2,713
July	1,750	321	43	209	......	75	45	191	50	10	2,694
August	2,104	324	49	150	......	80	118	175	......	47	3,047
September	1,936	347	57	85	......	95	201	180	......	77	2,978
October	1,598	236	42	123	......	85	52	185	65	82	2,468
November	1,576	292	43	61	......	122	54	190	43	87	2,468
December	1,977	279	37	122	......	130	150	235	43	62	3,035
Total	21,400	3,469	385	1,296	35	1,144	1,309	2,197	446	392	32,073
1886.											
January	1,431	70	42	100	......	339	162	147	73	34	2,398
February	1,100	175	24	108	......	274	132	192	53	45	2,103
March	1,522	20	21	91	......	226	209	218	43	75	2,425
April	1,256	90	36	172	......	115	328	172	62	62	2,293
May	1,600	101	18	36	......	99	228	128	76	95	2,381
June	1,806	110	19	113	......	126	276	123	71	78	2,722
July	1,572	95	24	98	......	138	345	138	64	127	2,601
August	1,240	105	35	119	......	156	313	74	76	84	2,202
September	1,210	179	30	100	......	107	303	82	64	33	2,108
October	1,280	106	50	150	......	171	392	124	65	52	2,390
November	1,900	180	76	191	......	109	477	209	55	35	3,232
December	2,083	175	34	171	......	89	313	162	33	66	3,126
Total	18,000	1,406	409	1,449	......	1,949	3,478	1,769	735	786	29,981

a Production of Ætna and Napa mines in 1883 under heading of Napa mine.

Price.—The quicksilver market differed markedly from the condition in 1885. With almost no stocks in this country the price of quicksilver rose from $32 per flask in the early part of the year to nearly $40 towards the close, actual sales having been quoted at $39 per flask.

This price is the highest realized since 1878. Its effect was to stimulate the trade generally, but this was much less apparent than it would have been if the industry had not been severely depressed. The reaction was evidently regarded with distrust, and its effect in increasing the production began too late to bring the total output up to that of the year before. During the advance in price the stock in London was reduced from 74,000 flasks to perhaps 58,000 flasks, owing to continued shipments to China. The course of the market during 1886 is thus reviewed by the San Francisco *Commercial Herald:* "The decline in receipts and production has been due to the low price, obtainable for the past few years, and which has been gradually declining. In this respect the year 1885 was probably the worst year which the United States ever experienced. The year 1886 opened up under better auspices. The prices, which were $30 to $32 per flask in December of 1885, advanced in 1886 till they reached $36.50 to $37 by the middle of the year. From that time the price advanced until September. There were some fluctuations, the market having gone up to $37.75 and dropped back to $37, these being the highest figures. On September 24, owing to a sudden jump in London, it went up to $38 to $40 in this market and remained at that price until November, when the price of New Almaden went down to $39. The market closed at $38 to $39, or about $7 per flask more than the closing price last year. During most of the year the market has been lightly stocked and closed almost bare of stock." There seems to be a reasonable hope that the present prices will continue for some time to come and possibly range higher as the year progresses.

The following table gives the range in price of quicksilver at San Francisco for each month in 1886 and in the three preceding years:

Monthly quotations of quicksilver at San Francisco from 1883 to 1886, per flask.

Months.	1883.		1884.		1885.		1886.	
	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
January	$26.75	$26.00	$26.25	$26.00	$33.00	$32.50	$32.50	$32.00
February	27.25	26.00	29.00	26.00	32.50	32.50	32.50	32.50
March	28.00	26.75	29.00	28.00	32.50	31.00	33.00	32.50
April	27.00	26.75	29.00	28.00	31.00	30.00	33.00	33.00
May	27.00	26.75	29.00	29.00	29.00	28.50	34.00	33.00
June	28.50	26.75	29.00	29.00	30.00	29.00	36.00	34.00
July	28.50	27.50	29.00	28.75	30.00	29.75	37.00	36.00
August	27.50	26.25	30.00	28.75	29.75	29.50	37.00	36.75
September	26.75	26.25	31.00	30.00	30.50	29.50	37.00	36.50
October	26.50	26.50	30.50	29.00	30.50	30.00	39.00	38.75
November	26.50	26.00	34.00	29.00	30.00	29.75	38.75	38.50
December	26.25	26.00	35.00	32.00	32.00	30.00	38.75	38.50
Extreme range	28.50	26.00	35.00	26.00	33.00	28.50	39.00	32.00
Average	$26.83		$29.34		$30.53		$35.35	

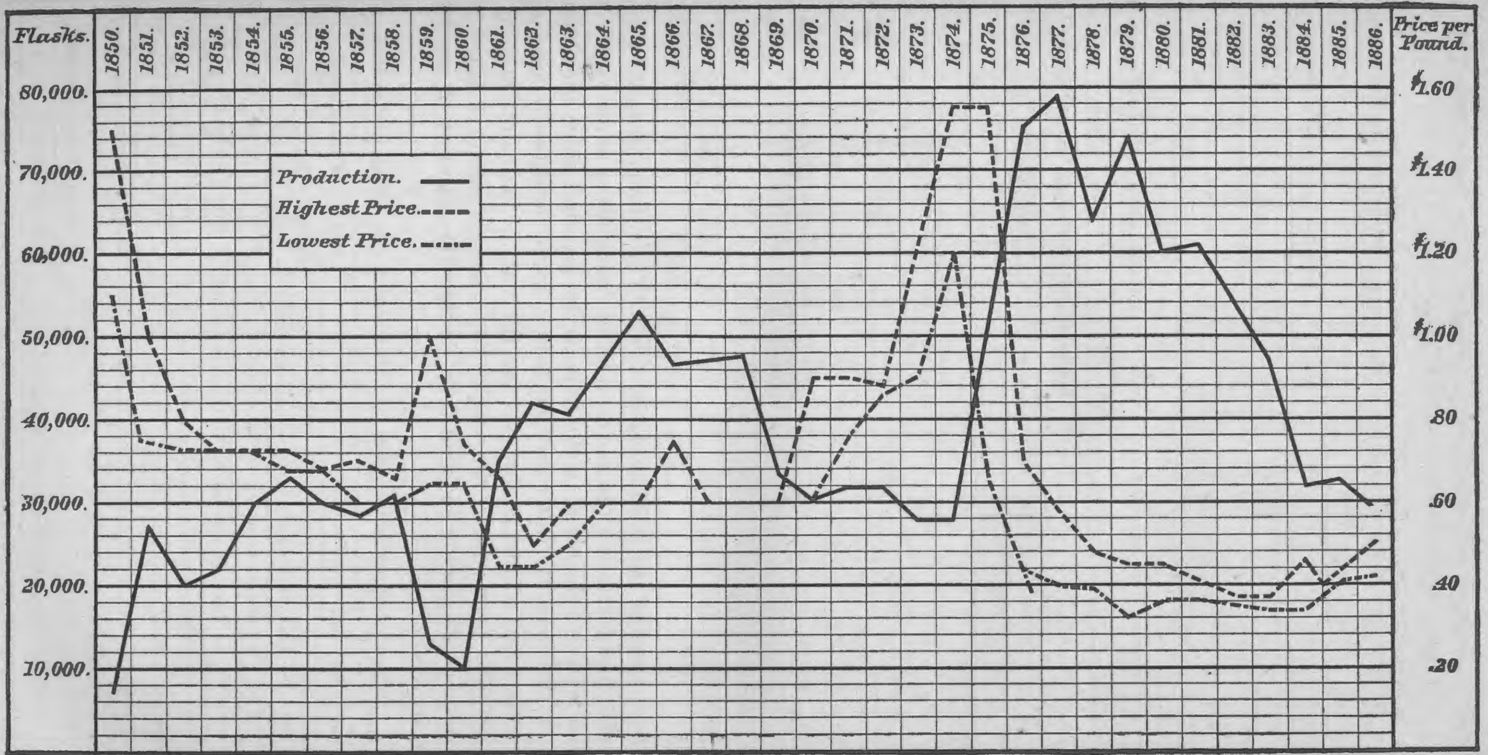
The following table shows the range in price of quicksilver in the San Francisco markets for the past thirty-seven years:

Highest and lowest prices of quicksilver during the past thirty-seven years.

Years.	Price in San Francisco, per flask.		Price in London, per flask.					
	Highest.	Lowest.	Highest.			Lowest.		
			£	s.	d.	£	s.	d.
1850	$114.75	$84.15	15	0	0	13	2	6
1851	76.50	57.35	13	15	0	12	5	0
1852	61.20	55.45	11	10	0	9	7	6
1853	55.45	55.45	8	15	0	8	2	6
1854	55.45	55.45	7	15	0	7	5	0
1855	55.45	51.65	6	17	6	6	10	0
1856	51.65	51.65	6	10	0	6	10	0
1857	53.55	45.90	6	10	0	6	10	0
1858	49.75	45.90	7	10	0	7	5	0
1859	76.50	49.75	7	5	0	7	0	0
1860	57.35	49.75	7	0	0	7	0	0
1861	49.75	34.45	7	0	0	7	0	0
1862	38.25	34.45	7	0	0	7	0	0
1863	45.90	38.25	7	0	0	7	0	0
1864	45.90	45.90	9	0	0	7	10	0
1865	45.90	45.90	8	0	0	7	17	6
1866	57.35	45.90	8	0	0	6	17	6
1867	45.90	45.90	7	0	0	6	16	0
1868	45.90	45.90	6	17	0	6	16	0
1869	45.90	45.90	6	17	0	6	16	0
1870	68.85	45.90	10	0	0	6	16	0
1871	68.85	57.35	12	0	0	9	0	0
1872	66.95	65.00	13	0	0	10	0	0
1873	91.80	68.85	20	0	0	12	10	0
1874	118.55	91.80	26	0	0	19	0	0
1875	118.55	49.75	24	0	0	9	17	6
1876	53.55	34.45	12	0	0	7	17	6
1877	44.00	30.60	9	10	0	7	2	6
1878	35.95	29.85	7	5	0	6	7	6
1879	34.45	25.25	8	15	0	5	17	6
1880	34.45	27.55	7	15	0	6	7	6
1881	31.75	27.90	7	0	0	6	2	6
1882	29.10	27.35	6	5	0	5	15	0
1883	28.50	26.00	5	17	6	5	5	0
1884	35.00	26.00	6	15	0	5	2	6
1885	33.00	28.50	6	15	0	5	10	0
1886	39.00	32.00	7	10	0	5	16	3
Extreme range in thirty-seven years	118.55	25.25	26	0	0	5	2	6

The following chart shows graphically the variation in the price and production of quicksilver since the discovery of gold in California:

FIG. 2.—Production and price of quicksilver in the United States to December 31 1886.



Quicksilver imported and entered for consumption in the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Quantity.	Value.	Fiscal years ending June 30—	Quantity.	Value.
	Pounds.			*Pounds.*	
1867	....	$15, 248	1877	38, 250	$19, 558
1868	152	68	1878	294, 207	135, 178
1869	....	11	1879	519, 125	217, 770
1870	239, 223	107, 646	1880	116, 700	48, 463
1871	304, 965	137, 332	1881	138, 517	57, 733
1872	370, 353	189, 943	1882	597, 898	233, 057
1873	99, 898	74, 146	1883	1, 552, 738	593, 367
1874	51, 202	52, 093	1884	136, 615	44, 035
1875	6, 870	20, 957	1885	257, 659	90, 416
1876	78, 902	50, 164	1886	402, 140	142, 325

Mercurial preparations imported and entered for consumption in the United States, 1867 *to* 1883 *inclusive.* (*a*)

Fiscal years ending June 30—	Blue-mass.		Calomel.		Mercurial preparations not otherwise specified.	Total value.
	Quantity.	Value.	Quantity.	Value.		
	Pounds.		*Pounds.*			
1867	....	....	....	$4, 242	....	$2, 242
1868	....	....	....	4, 440	....	4, 440
1869	....	....	....	4, 516	....	4, 516
1870	....	....	....	6, 306	....	6, 306
1871	....	....	....	3, 147	....	3, 147
1872	1, 009	$667	8, 241	6, 590	$629	7, 886
1873	919	660	5, 520	5, 240	699	6, 599
1874	259	192	6, 138	6, 676	4, 334	11, 202
1875	125	109	2, 424	2, 817	52	2, 978
1876	489	365	5, 433	5, 820	92	6, 277
1877	455	327	4, 649	4, 305	90	4, 722
1878	397	252	4, 133	3, 576	363	4, 191
1879	485	266	5, 875	4, 635	6, 453	11, 354
1880	533	262	4, 780	3, 330	30	3, 622
1881	395	236	8, 177	5, 640	116	5, 992
1882	207	124	5, 215	3, 411	58	3, 593
1883	188	79	8, 732	5, 503	190	5, 772

a Not specified since 1883.

Disposition of the production in 1886.—The following table prepared by Mr. Randol shows the movement of quicksilver since 1883. There was a manifest decrease in the exports by sea, and since the shipments out of the State by rail were constant a large increase in consumption is evident in California, due to the revival in hydraulic mining. As has already been stated the stocks were merely nominal, which shows the use on the Pacific coast of fully double the amount of quicksilver used in 1885.

Movement of quicksilver from San Francisco in detail from 1883 *to* 1886.

To—	1883.	1884.	1885.	1886.
By sea:	*Flasks.*	*Flasks.*	*Flasks.*	*Flasks.*
China	16, 330	200	233	....
Japan	1, 253	588	302	3
Mexico	10, 764	5, 404	5, 884	5, 530
South America	970	155	100	....
Australia	600	110	....	....
New Zealand	160	20	100	91
Central America	59	52	9	23
New York	3, 100	8, 350	9, 055	600
Various	11	22	47	54
Total by sea	33, 247	14, 901	15, 730	6, 301
By rail:				
Central Pacific, Southern Pacific, and Northern Pacific railroads	4, 620	(*a*)7, 000	(*a*)10, 000	10, 000
Grand total	37, 867	21, 901	25, 730	16, 301

a Including about 3,500 flasks to Mexico by Southern Pacific railroad.

Mr. Randol's comparison of the total production and exports in the last three years is also highly valuable in this connection.

Production, exports, and domestic consumption of quicksilver in California during the last three years.

Years.	Total production.	Total exports.	Stock and consumption on Pacific coast.
	Flasks.	*Flasks.*	*Flasks.*
1884	31, 913	21, 901	10, 012
1885	32, 073	25, 730	6, 343
1886	29, 981	16, 301	13, 680

Quicksilver mining.—Mr. J. B. Randol, in continuing his valuable statements concerning the production of quicksilver, has published the following tables relative to the cost of production, which will be interesting without further comment:

Table showing tons of rock and ore extracted from the New Almaden mine during the last ten years.

Years.	Rock from shafts, drifts, and crosscuts.	Rock from vein.	Ore.		Total.
			Granza.	Tierras. (*a*)	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1877	30, 348	27, 282	5, 980	11, 034	74, 644
1878	29, 926	26, 537	6, 322	9, 359	72, 144
1879	30, 223	30, 009	6, 655	8, 549	75, 436
1880	24, 529	35, 340	7, 401	12, 125	79, 395
1881	18, 063	38, 417	8, 021	14, 097	78, 598
1882	40, 909	45, 095	9, 237	14, 706	109, 947
1883	32, 345	44, 147	9, 584	20, 289	106, 365
1884	42, 077	44, 795	7, 625	20, 038	114, 535
1885	56, 096	44, 927	8, 485	25, 334	134, 842
1886	48, 289	34, 124	7, 183	24, 718	114, 314

a Terrero and Tierras from dumps not included.

Earnings for sixteen years at the New Almaden Mine.

Years.	Production, flasks.	Quicksilver, value.	Average value per flask.	Miscellaneous earnings and ore account increased.	Total earnings.	Total profits.	Profits per flask.
1871	18, 568	$575, 608. 00	$31. 00	$63, 931. 57	$639, 539. 57	$238, 742. 07	$12. 86
1872	18, 574	876, 406. 00	47. 18	32, 964. 72	909, 370. 72	451, 759. 17	24. 32
1873	11, 042	746, 457. 05	67. 60	80, 712. 23	827, 169. 28	428, 503. 27	38. 80
1874	9, 084	897, 561. 12	98. 80	95, 121. 93	992, 683. 05	499, 243. 85	54. 95
1875	13, 648	678, 917. 37	49. 74	45, 502. 00	724, 419. 37	218, 704. 81	16. 02
1876	20, 549	782, 120. 16	38. 06	33, 569. 95	815, 690. 11	381, 007. 96	18. 54
1877	23, 996	782, 633. 42	32, 61	30, 914. 78	813, 548. 20	376, 668. 89	15. 69
1878	15, 852	489, 186. 40	30. 86	40, 382. 09	529, 568. 49	132, 969. 32	8. 39
1879	20, 514	563, 436. 10	27, 47	17, 839. 30	581, 275. 40	112, 094, 74	5. 46
1880	23, 465	677, 442. 85	28. 87	16, 982. 30	694, 425. 15	242, 118. 88	10. 32
1881	26, 060	727, 249. 90	27. 91	59, 031. 52	786, 281. 42	415, 103. 88	15. 93
1882	28, 070	765, 695. 77	27. 27	17, 839. 86	783, 535. 63	264, 139. 27	9. 40
1883	29, 000	755, 601. 24	26. 05	20, 050. 04	775, 651. 28	287, 687. 04	9. 92
1884	20, 000	587, 419. 53	29. 37	23, 202. 28	610, 621. 81	103, 578. 99	5. 18
1885	21, 400	624, 116. 79	29. 16	21, 476. 63	645, 593. 42	37, 413. 70	1. 75
1886	18, 000	629, 970. 85	35. 00	30, 206. 45	660, 177. 30	105, 444. 64	5. 86
Totals and averages.	317, 822	11, 159, 822. 55	35. 11	629, 727. 65	11, 789, 550. 20	4, 295, 180. 48	13. 51

Expenses for sixteen years at the New Almaden mine.

Years.	Mine and hacienda pay rolls.	Miscellaneous, taxes and ore account reduced.	Supplies consumed.	Totals.	Total cost per flask.	Net cost per flask. (a)
1871	$321, 565. 51	$26, 538. 13	$52, 693. 86	$400, 797. 50	$21. 58	$18. 14
1872	343, 748. 17	55, 942. 95	57, 920. 43	457, 611. 55	24. 64	22. 86
1873	317, 573. 69	24, 848. 03	56, 244. 29	398, 666. 01	36. 10	28. 79
1874	389, 190. 69	31, 505. 33	72, 743. 18	493, 439. 20	54. 32	43. 85
1875	381, 758. 44	31, 240. 49	92, 715. 63	505, 714. 56	37. 05	33. 72
1876	310, 266. 61	30, 334. 49	94, 081. 05	434, 682. 15	21. 15	19. 52
1877	291, 801. 06	41, 909. 81	103, 168. 64	436, 879. 51	18. 21	16. 92
1878	283, 839. 60	30, 346. 57	82, 413. 00	396, 599. 17	25. 01	22. 47
1879	263, 229. 92	107, 600. 23	98, 350. 49	469, 180. 66	22. 86	22. 00
1880	240, 157. 76	100, 748. 63	111, 399. 88	452, 306. 27	19. 27	18. 55
1881	238, 580. 76	29, 098. 52	103, 498. 26	371, 177. 54	14. 24	11. 98
1882	330, 806. 33	54, 822. 59	133, 767. 44	519, 396. 36	18. 50	17. 87
1883	314, 684. 73	35, 953. 23	137, 326. 28	487, 964. 24	16. 80	16. 13
1884	333, 084. 88	34, 296. 91	139, 661. 03	507, 042. 82	25. 16	24. 19
1885	387, 644. 52	43, 501. 45	177, 033. 75	608, 179. 72	27. 76	27. 42
1886	384, 586. 86	26, 650. 06	143, 495. 74	554, 732. 66	30. 81	29. 14
Total and averages	5, 132, 519. 53	705, 337. 42	1, 656, 512. 95	7, 494, 369. 92	23. 58	21. 60

a Ascertained by deducting amounts to credit of miscellaneous and ore account increased.

Statement of mine and furnace works for sixteen years.

Years.	Total ores produced.		Total ores roasted.		Yield of quicksilver.	Quicksilver produced.
	Short tons.	*Pounds.*	*Short tons.*	*Pounds.*	*Per cent.*	*Flasks.*
1871	11, 134	1, 600	11, 117	700	6. 44	18, 568
1872	10, 716	1, 875	10, 707	1, 800	6. 63	18, 574
1873	13, 602	225	8, 665	850	4. 87	11, 942
1874	18, 560	125	11, 727	....	2. 96	9, 084
1875	17, 407	400	15, 553	200	3. 35	13, 648
1876	16, 883	1, 725	16, 658	950	4. 69	20, 549
1877	18, 539	1, 600	18, 615	1, 300	4. 93	23, 996
1878	18, 328	780	18, 472	1, 808	3. 28	15, [illegible]52
1879	21, 048	380	27, 532	1, 135	2. 85	20, 514
1880	23, 798	964	30, 677	850	2. 92	23, 465
1881	33, 815	1, 900	32, 070	1, 135	3. 11	26, 060
1882	34, 216	480	36, 073	1, 200	2. 98	28, 070
1883	41, 087	1, 520	38, 581	500	2. 87	29, 000
1884	39, 267	440	39, 625	1, 000	1. 93	20, 000
1885	37, 616	1, 280	39, 534	1, 300	2. 07	21, 400
1886	37, 985	1, 980	40, 699	690	1. 69	18, 000
Total	394, 009	1, 274	396, 212	1, 418	(*a*)3. 07	318, 722

a Average.

Quicksilver in Utah.—The production of quicksilver on a small scale was begun at the "Lucky Boy" mine at Marysville, Piute county, Utah, in October, 1886. The mine is owned and operated by the Richmond Quicksilver Mining Company, of California. The ore, which is said to be selenide of mercury, is treated in two small retorts capable of consuming about one ton of ore in twenty-four hours. During the last three months of 1886 the company produced 87 flasks of quicksilver. It is stated that the efforts have been confined principally to prospecting and developing the property. The company expects to erect a small furnace in 1887 to work about one ton of ore per hour.

The monograph upon quicksilver by Mr. George F. Becker, of the United States Geological Survey, is now in the process of printing, and should be consulted for comprehensive statements concerning all topics relating to quicksilver and especially concerning the conditions under which quicksilver is found and produced.

NICKEL.

Production.—The total amount of nickel produced during 1886, including that contained in the matte and ore shipped to England and Germany, was 214,992 pounds, valued at $127,157. This shows a decrease for the entire industry of 62,912 pounds, or $52,818. To this total amount the contributions of metallic nickel, nickel ammonium sulphate, matte, and ore were as follows:

Production of nickel in the United States in 1885 *and* 1886.

	1885.		1886.	
	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*	
Metallic nickel	245, 504	$169, 398	182, 345	$109, 407
Nickel in nickel ammonium sulphate			7, 047	9, 000
Nickel in matte	14, 400	4, 577	20, 000	7, 000
Nickel in ore	18, 000	6, 000	5, 600	1, 750
Total	277, 904	179, 975	214, 992	127, 157

The difference between the figures given for 1885 and those in the previous report is due to substitution of the values probably obtained for the nickel in ore and matte instead of the value of this nickel if reduced to the metallic state. It will be seen from the above table that the decrease was due principally to the lessened product of grain nickel. There was an item of compensation in the production of 46,138 pounds of nickel ammonium sulphate, but after deducting the nickel represented by this substance the decrease still amounted to nearly 28 per cent. of the metallic nickel produced in 1885, and the percentage decrease in value was still greater, due to a reduction of 13 per cent. in the average price. The increase in imports of 54,157 pounds over 1885 practically balances the decreased production and gives evidence of tolerably steady consumption. The amount of ore from which all the nickel in its various forms was obtained may be stated in round numbers at 5,485 tons, showing that the average percentage of nickel in the ore was about 2 per cent.

The following table shows the amount of metallic nickel and nickel alloy produced in the United States since 1876:

Production of metallic nickel in the United States from 1876 *to* 1886 *inclusive.*

Years.	Pure grain nickel.	Nickel contained in copper-nickel alloy.	Total.	Average price per pound.	Value.
	Pounds.	*Pounds.*	*Pounds.*		
1876			201, 367	$2. 60	$523, 554
1877			188, 211	1. 60	301, 138
1878			150, 890	1. 10	165, 979
1879			145, 120	1. 12	162, 534
1880			233, 893	1. 10	257, 282
1881			265, 668	1. 10	292, 235
1882	277, 034	4, 582	281, 616	1. 10	309, 777
1883	6, 500	52, 300	58, 800	. 90	52, 920
1884		64, 550	64, 550	. 75	48, 412
1885			245, 504	. 69	(*a*)169, 398
1886			182, 345	, 60	(*a*)109, 407

a Not including value of nickel in ore and matte.

Occurrence.—The most interesting feature of the nickel industry during the year 1886 has been the effort to develop the ore known to exist in North Carolina. The ore is a silicate of nickel, and has attracted attention from the fact that garnierite occurring in New Caledonia has become a dominating source of nickel for the world. The silicate of nickel referred to occurs near Webster, Jackson county, North Carolina, and is thus described by Mr. Henry J. Biddle, after a careful examination, at the instance of theUnited States Geological Survey, of every locality where it is known to occur: "In the immediate vicinity of Webster, and also at a point six miles northeast of the town, there is an area of olivine rock (dunite or sherzolite). The rock contains grains of chromite scattered through it nearly everywhere, and has occasional streaks rich in that material. Nickel is probably an original constituent of this rock, as has been found to be the case in many other localities; for instance, Mr. George B. Hanna has found 0.15 per cent. of nickel oxide in chrysolite from Waynesville, in Haywood county. Throughout most of the area the olivine rock near Webster has been changed to a light green serpentine, in which are veins and pockets of chromite, and veins of talc, and other minerals usually found in serpentine. There are at many points streaks of deweylite, and a nickeliferous mineral which is genthite, or some allied species (possibly garnierite). This occurs in thin streaks, rarely more than one-eighth inch in thickness. In places it fills all the joints and fissures in the rock, but is usually but a thin film. As yet no workable vein of this material has been found. Many of the talc veins are also stained or colored by nickel. These veins vary from a fraction of an inch to two or three inches in thickness. The percentage of nickel in the genthite varies greatly. The proprietor, Mr. Schreiber, states that some of it contains 30 per cent. of nickel oxide. The same variation is true in the percentage of nickel oxide in the talc. Whether ore will be found in paying quantity is a question which cannot yet be decided. Prospecting has not been carried to a greater depth than 20 feet. In general the streaks widen as they are followed downward, and there seems to be a chance of finding some workable veins." In addition to the above it appears that nickel is also frequently found in North Carolina in the auriferous sulphides, somewhat in the same manner as in the nickeliferous pyrrhotite of Lancaster Gap, Pennsylvania.

In Nevada Mr. George Lovelock reports an additional discovery of nickel and cobalt ore near the Lovelock mines in Churchill county. The new deposit is in a long mountain bordering the southeast side of Humboldt lake, 10 miles southeast of Lovelock station. Indications of nickel and cobalt are said to have been traced as far as Oreana, on the Central Pacific railroad.

Mr. C. G. Yale reports that the heavy deposit of nickel ore discovered a few years ago in Douglas county, southern Oregon, is likely to meet with early development through the Oregon and California railroad, which passes close by it. There is said to be much rich ore here, with good facilities at hand for its reduction.

Imports and exports.—The following tables show the amounts of nickel and nickel alloys imported, and the values of manufactured nickel, nickel coin, and nickel ore exported from the United States:

Nickel imported and entered for consumption in the United States, 1868 *to* 1886, *inclusive.*

Fiscal years ending June 30—	Nickel.		Oxide and alloy of nickel with copper.		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		
1868		$118, 058			$118, 058
1869		134, 327			134, 327
1870		99, 111			99, 111
1871	17, 701	48, 133	4, 438	$3, 911	52, 044
1872	26, 140	27, 144			27, 144
1873	2, 842	4, 717			4, 717
1874	3, 172	5, 883			5, 883
1875	1, 255	3, 157	12	36	3, 193
1876			156	10	10
1877	5, 978	9, 522	716	824	10, 346
1878	7, 486	8, 837	8, 518	7, 847	16, 684
1879	10, 496	7, 829	8, 314	5, 570	13, 399
1880	38, 276	25, 758	61, 869	40, 311	66, 069
1881	17, 933	14, 503	135, 744	107, 627	122, 130
1882	22, 906	17, 924	177, 822	125, 736	143, 660
1883	19, 015	13, 098	161, 159	119, 386	132, 484
1884			(*a*) 194, 711	129, 733	129, 733
1885			105, 603	64, 166	64, 166
1886			159, 760	88, 760	(*b*) 89, 003

a Including metallic nickel. *b* Including $243 worth manufactured nickel.

Value of exports of nickel and nickel ore of domestic production from the United States.

Fiscal years ending June 30—	Manufactured nickel.	Nickel coin.	Nickel ore.
1864	....	....	$25,494
1865	....	....	36,710
1869	....	....	11,350
1872	....	....	43,500
1873	$19,780	....	19,891
1874	16,062	....	75,696
1875	26,000	....	72,020
1876	168,050	....	35,100
1877	8,200	....	....
1878	....	....	2,452
1880	4,120	....	....
1881	6,600	$32,880	....
1882	12,474	7,200	....
1883	9,911	....	(c) 12,182
1884	....	....	(c) 22,249
1885	1,223	....	10,500
1886	35,302	....	11,687

c Classed as "nickel and cobalt ore."

Price.—The average price of nickel in 1886 was 60 cents per pound, a decrease of 9 cents from the price in 1885. This reduction is largely due to forcing the market with the product of the New Caledonia mines by the "Société Anonyme Le Nickel," in Paris. This forcing of the market is reflected in the decreased production of nickel in the United States and increased importation.

The situation of refining works and the methods used in them have remained practically constant, the only changes in the trade having been in regard to foreign competition and its effects upon the price.

The following table shows the coinage in nickel alloy since 1857. In late years the nickel has been purchased principally abroad, although 2,000 pounds of domestic nickel were bought in 1886:

Nickel coinage of the United States.

Calendar years.	One-cent nickel coins.		Three-cent nickel coins.		Five-cent nickel coins.		Pure nickel consumed.
	Pieces.	Value.	Pieces.	Value.	Pieces.	Value.	*Troy ounces.*
1857	17,432,410	$174,324.10	....	....	....	....	313,931.92
1858	24,600,000	246,000.00	....	....	....	....	443,731.22
1859	36,400,000	364,000.00	....	....	....	....	637,687.87
1860	20,566,000	205,660.00	....	....	....	....	391,199.20
1861	10,100,000	101,000.00	....	....	....	....	181,076.48
1862	28,375,000	283,750.00	....	....	....	....	505,320.42
1863	49,840,000	498,400.00	....	....	....	....	895,878.04
1864	13,170,000	131,700.00	....	....	....	....	237,049.00
1865	....	....	11,382,000	$341,460.00	....	....	165,955.08
1866	....	....	4,801,000	144,030.00	14,742,500	$737,125.00	674,553.54
1867	....	....	3,915,000	117,450.00	30,909,500	1,545,475.00	1,307,978.08
1868	....	....	3,252,000	97,560.00	28,817,000	1,440,850.00	1,213,242.65
1869	....	....	1,604,000	48,120.00	16,395,000	819,750.00	688,017.22
1870	....	....	1,335,000	40,050.00	4,806,000	240,300.00	215,171.62
1871	....	....	604,000	18,120.00	561,000	28,050.00	32,591.00
1872	....	....	862,000	25,860.00	6,036,000	301,800.00	215,303.32
1873	....	....	1,173,000	35,190.00	4,550,000	227,500.00	110,057.07
1874	....	....	790,000	23,700.00	3,538,000	176,900.00	76,772.51
1875	....	....	228,000	6,840.00	2,097,000	104,850.00	21,135.36
1876	....	....	162,000	4,860.00	2,530,000	126,500.00	2,688.42
1877	....	....	....	....	....	....	....

Nickel coinage of the United States—Continued.

Calendar years.	One-cent nickel coins.		Three-cent nickel coins.		Five-cent nickel coins.		Pure nickel consumed.
	Pieces.	Value.	Pieces.	Value.	Pieces.	Value.	*Troy ounces.*
1878			2, 350	70. 50	2, 350	117. 50	132. 90
1879			41, 200	1, 236. 00	29, 100	1, 455. 00	1, 821. 78
1880			24, 955	748. 65	19, 955	997. 75	1, 197. 32
1881			1, 080, 575	32, 417. 25	72, 375	3, 618. 75	10, 505. 16
1882			25, 300	759. 00	11, 476, 600	573, 830. 00	344, 553. 71
1883			10, 609	318. 27	22, 969, 421	1, 148, 471. 05	703, 426. 73
1884			5, 642	169. 26	11, 273, 942	563, 697. 10	399, 141. 37
1885			4, 790	143. 70	1, 476, 490	73, 824. 50	58, 615. 82
1886			4, 223	128. 70	3, 330, 290	166, 514. 50	166, 729. 00
Total	200, 483, 410	2, 004, 834 10	31, 307, 644	939. 231. 33	165, 632, 523	8, 281, 626. 15	10, 015, 463. 81

A nickel coinage was executed at the mint at Berlin, Germany, for the Egyptian government during 1886, consisting of pieces of $\frac{1}{2}$, $\frac{2}{10}$ and $\frac{1}{10}$ piasters, amounting to 12,510,210 pieces, valued at 43,723.699 Egyptian pounds (the Egyptian pound equals $4.943, and contains 100 piasters). This coinage is spoken of as nickel coinage, but the percentage of nickel is not given. Messrs. Ralph Heaton & Sons, of Birmingham, England, coined 600,000 nickel half-decimos and 1,000,000 centimos for the republic of Ecuador.

In connection with the uses for nickel the Société Anonyme, of Paris, has been endeavoring to increase the consumption by the manufacture of rolled nickel plate on iron. Considerable of this material has been made and formed into various utensils. There is considerable prospect that this company will ultimately succeed in finding a liberal outlet for the stock of nickel which can very easily be accumulated from New Caledonia. In this country no consumption of nickel has resulted from this process of rolling out plates of nickel welded on iron, although several years ago Mr. Joseph Wharton showed the possibility of making sheets by erecting a mill at a cost of, perhaps, $50,000 for rolling them. But at that time no one was found willing to buy the plates. Mr. Wharton can show specimens of cooking utensils made several years ago in the forms which are now becoming quite popular in Europe. Nickel plating increases slowly, and there is without doubt an increase in the use of nickel alloys, such as white casting metal, nickel bronze, silveroid, and other special alloys, which combine cheapness with hardness, durability, and good color. For tube-drawing nickel is now used more generally, especially for ornamental work, in the place of brass.

COBALT.

The only new occurrences of cobalt ores during 1886 have been discussed in the preceding article on nickel. The industry has remained practically steady during the year. The total production was:

Total production of substances containing cobalt in 1885 and 1886.

	1885.		1886.	
	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*	
Cobalt oxide	8,423	$19,373	8,689	$17,378
Matte	180,000	14,500	243,875	20,000
Ore	201,600	31,500	70,000	3,500
Total	....	65,373	....	40,878

The marked decrease in value is due to the diminished value of the Nevada product. The record of the production of cobalt oxide has been kept for a number of years by Mr. Joseph Wharton, and is given in the following table:

Production of cobalt oxide in the United States.

Years.	Pounds.	Years.	Pounds.
1869	811	1878	4,508
1870	3,854	1879	4,376
1871	5,086	1880	7,251
1872	5,749	1881	8,280
1873	5,128	1882	11,653
1874	4,145	1883	1,096
1875	3,441	1884	2,000
1876	5,162	1885	8,423
1877	7,328	1886	8,689

Price.—During 1886 the price of cobalt oxide continued to decline, reaching $2 per pound, the lowest price in any year. While the effect of this will undoubtedly be to stimulate consumption to some extent in the manufacture of ornamental glassware, this use is only a minor one. It is not thought that the production of 1887 will show any increase over 1886. The price has been lowered by foreign competition, the extent of which is indicated by the following table of imports and exports:

Cobalt oxide imported and entered for consumption in the United States, 1868 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Oxide.	
	Quantity.	Value.
	Pounds.	
1868	....	$7, 208
1869	....	2, 330
1870	....	5, 019
1871	....	2, 766
1872	....	1, 920
1873	1, 480	4, 714
1874	1, 404	5, 500
1875	678	2, 604
1876	4, 440	11, 180
1877	19, 752	11, 056
1878	2, 860	8, 693
1879	7, 531	15, 208
1880	9, 819	18, 457
1881	21, 844	13, 837
1882	17, 758	12, 764
1883	13, 067	22, 323
1884	25, 963	43, 611
1885	16, 162	28, 138
1886	14, 215	22, 757

Consumption.—It is possible to account for a consumption of fully 35,000 pounds of cobalt oxide each year, of which a large part, over 95 per cent., goes to coloring pottery, and the remainder principally for ornamental glass. This is not all accounted for by the domestic production and imports. It is possible that some of the imported product comes in under other classifications. The use of smalt may account for part of the discrepancy. The value of the imports of this substance in the fiscal year 1886 was $6,073. The ordinary price of smalt is 60 cents per pound.

CHROMIUM.

Condition of the industry.—The decline in the production of chrome iron ore in the United States, which was a marked feature in 1885, continued in 1886. The low price which must necessarily be received in California for material which is to compete with foreign importations in the eastern market has discouraged mining to a marked extent. The uncertain character of the mining is also a factor in the decreased production. The majority of the openings made for chrome iron ore in California have yielded comparatively small amounts of rich ore. A change of base, and indeed a new investment, is frequently necessary in order to keep up the supply in almost any district. The low prices are particularly effective in discouraging new explorations when the old deposits become exhausted. There are two deposits in California situated at opposite ends of the large region in various parts of which chrome ore has been found, which are less influenced by the above conditions than the usual deposits. At San Luis Obispo, the most southerly of the productive localities, mining is carried on by the local inhabitants intermittently, and without a plant too expensive to shift to any locality where rich ores may be discovered. The miners while engaged in agriculture have opportunity for surface exploration and seldom carry their mining far below the surface. This irregular industry results in an important yield of rich chrome iron ore every year. In 1886 it amounted to 876 long tons. It is probable that the continued exploration will eventually lead to the location of large and permanent deposits, if not to some vein with definite walls. The great embarrassment in establishing a costly plant to effect cheap mining has been the absolute uncertainty as to the extent of the supply. But a steady supply of ore in the future can only be looked for when the producing regions shall be thus equipped. The ore sometimes ceases abruptly, but more commonly becomes poorer, shading off into rock of another character in which the chrome ore is a very minor constituent. There is no wall to the deposits, nothing like a definite vein except in the most northern locality referred to, which is in Del Norte county, California. Here the ore seems to occur within definite walls, which give aid in planning the work of excavation. The Tyson Mining Company has erected excellent facilities for mining the ore, and it is probable that Del Norte county will continue to be a steady though not large source of supply.

Production.—During 1886 the production of chrome iron ore amounted to 2,000 tons, valued in San Francisco at $30,000. It was all mined in California, principally in San Luis Obispo, Alameda, and Del Norte counties. Shipments were made also from Placer and Shasta counties. The production and value for a number of years is given in the following table:

Production of chrome iron ore from 1882 *to* 1886.

Years.	Quantity, long tons.	Value in California.
1882	2, 500	$50, 000
1883	3, 000	60, 000
1884	2, 000	35, 000
1885	2, 700	40, 000
1886	2, 000	30, 000

The importations from Turkey and Asia Minor more than compensated for the increased domestic production, so that the total amount consumed increased. There was a corresponding increase in the importation of manufactured products.

Potassium bichromate.—The production is given in the following table; it is still limited to Baltimore and Philadelphia.

Production of potassium and sodium bichromate.

Years.	Potassium bichromate.	Sodium bichromate.
	Short tons.	*Short tons.*
1882	1, 000	....
1883	1, 000	....
1884	1, 250	....
1885	2, 000	500
1886	2, 250	1, 000

Chromate and bichromate of potash and chromic acid imported and entered for consumption in the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Chromate and bichromate of potash.		Chromic acid.		Chrome ore.		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		*Long tons.*		
1867	875, 205	$88, 787	....	....	....	....	$88, 787
1868	777, 855	68, 634	....	....	....	....	68, 634
1869	877, 432	78, 288	....	$3	....	....	78, 291
1870	1, 235, 946	127, 333	....	8	....	....	127, 341
1871	2, 170, 473	223, 529	....	5	....	....	223, 534
1872	1, 174, 274	220, 111	514	49	....	....	220, 160
1873	1, 121, 357	178, 472	922	276	....	....	178, 748
1874	1, 387, 051	218, 517	44	13	....	....	218, 530
1875	1, 417, 812	183, 424	45	22	....	....	183, 446
1876	1, 665, 011	175, 795	120	45	....	....	175, 840
1877	2, 471, 669	264, 392	13	10	....	....	264, 402
1878	1, 929, 670	211, 136	32	35	....	....	211, 171
1879	2, 624, 403	221, 151	....	....	....	....	221, 151
1880	3, 505, 740	350, 279	5	3	....	....	350, 282
1881	4, 404, 237	402, 088	124	89	....	....	402, 177
1882	2, 449, 875	261, 006	52	42	....	....	261, 048
1883	1, 990, 140	208, 681	290	338	....	....	209, 019
1884	2, 593, 115	210, 677	....	120	2, 677	73, 586	284, 383
1885	1, 448, 539	92, 556	....	39	12	239	92, 834
1886	1, 985, 809	139, 117	....	101	3, 356	43, 731	182, 949

The average price of potassium bichromate in first hands was $9\frac{3}{4}$ cents per pound for the year. The production and imports indicate a moderate growth in the consumption in this country, and a better feeling in several industries using potassium and sodium bichromates. These are, in their order of importance, calico printing, electric batteries, pigments, and as oxidizing agents for other purposes than electric batteries.

The production of sodium bichromate increased to 1,000 short tons. Objections are urged against the adoption of this salt on account of its property of deliquescing on exposure to moist air, and the fact that its percentage of chromic acid has not been uniform; but it is evidently suitable for many of the ordinary uses for the potassium compound, and lately it has been claimed by manufacturers in Russia that if a sufficient quantity of neutral sodium chromate, Na_2CrO_4, which has been deprived of its water of crystallization, is added to sodium bichromate so as to give always just 72.5 per cent. of chromic acid, CrO_3, in the finished product the deliquescing is not objectionably great.

Chrome steel.—There seem to be sufficient uses for the chrome steel made in Brooklyn, New York, to maintain a steady production of the material. It is stated that 3,000 tons were produced in 1886. Of this about one-fourth was welded in layers with wrought iron for safes and jail bars; one-fourth was tool steel; the remainder was divided among many minor uses, among them shoes and dies for stamp mills and crusher plates for rock breakers are most prominent. Previous to 1886 the annual production was 2,000 tons. The industry was established in 1867 as the results of experiments commenced in 1863 by Mr. Julius Bauer, in the employ of Mr. C. P. Haughian. The percentage of chromium is usually small, but does not seem to be constant. From some published directions for the treatment of chrome steel it seems that the steel may be heated uniformly to almost a white heat without fear of injury; in fact, it is desirable that it be worked at a high temperature. For tempering, the steel should be dipped at a low red heat, as seen in the shade. All tools forged from a large body to a small edge should be allowed to cool off after forging and be reheated for tempering. The reason for this is that the interior of the tool retains the heat at which it was forged for some time after the exterior surface has cooled and is still too hot for tempering; if it is put into water or other cooling substance then it is liable to crack. A simple method of attaining the proper degree of heat for hardening chrome steel is to put the end of a bar into the fire and heat it, take it out, and note the different degrees of heat along the entire heated portion, then plunge it into cold water. Then, after cooling, break off a little at a time with a hammer across the anvil; if the point of the bar was too hot the "grain" will appear at first coarse and granular, but gradually becoming finer until the point is reached where the bar was heated to a dull red; there the grain will be fine and fibrous, and the steel harder, stronger, and tougher than

where the heat was greater. The temperature at the point where the fibrous grain appears is the proper heat when dipped. For welding, heat the steel as would be done with iron, lay the pieces together, and tap quickly and lightly till they adhere, then gradually increase the force of the blows until the weld is complete. When possible it is well to upset a little by tapping lightly on the ends with the hammer. For annealing, heat the steel uniformly in all its parts to a low red heat, and cover well in any of the usual annealing substances. The steel may be spoiled by dipping it in water or hardening mixtures at too high a temperature.

MANGANESE.

BY JOS. D. WEEKS.

In the article on manganese in "Mineral Resources of the United States, 1885," the ores of this metal were divided for the purposes of the report into two general classes, first, manganese ores, and second, manganiferous iron ores. The dividing line between these two grades was 70 per cent. binoxide, equal to 44.252 per cent. of metallic manganese, the standard of shipments to English chemical works. The amount of manganiferous iron ore mined and shipped in the United States in 1886 was so small, however, and the average contents of manganese in such ores so nearly approached the standard of 44¼ per cent. that the distinction has been ignored in this report, and all ores whose production is included are classed as manganese ores.

To this statement there are two exceptions:

First. The manganese ores of Montana, Colorado, etc., which are utilized for their silver content, as well as for the fluxing qualities of the manganese, and

Second. Those ores from the Lake Superior district, which, though utilized for their iron, have an additional value in the quality of the iron produced from them, if not in money, because of the manganese they contain. The long ton of 2,240 pounds, is uniformly used in this chapter.

Localities in the United States.—The discussions of the ores of manganese and the localities in which they are found, given in the last two volumes of "Mineral Resources" have been so thorough as to make any reference to these points in this report unneccessary, except in the case of new localities or where fuller information has been obtained respecting old deposits. The localities in which manganese is mined will be given in detail when discussing its occurrence in the different States. It need only be said here that it has a distribution almost co-extensive with the deposits of the brown hematite ores of the country. In almost all of these ores manganese occurs as a constituent. At times the manganese displaces so much of the iron as to make the ore a manganiferous iron ore, while at other times, in close association with the iron ores, veins or pockets of manganese ores will be found. This statement is especially true of the hematite-ore beds of the great Appalachian chain of mountains from its northern to its southern extremity. This is particularly true of Virginia. It will also be found that the hematite ores of some of the newly-discovered ore fields of what is known in a general way as the Lake Superior region carry considerable manganese, while at other times there are pockets of manganese of greater or less extent, though up to the close of 1886 no deposit of manganese ore (44¼ per cent. or more metallic manganese) had been opened in this section. Notwithstanding a most earnest search in many parts of the country, no deposit of manganese ores that has as yet given promise of developing into any importance has been added to the known localities of 1885. It is still true that Crimora (Virginia), Cartersville (Georgia), and Batesville (Arkansas), furnish practically all the manganese ores mined in the United States. Deposits which it was confidently hoped at the close of 1885 would develop into large producers have added little or nothing to the tonnage of 1886. The history of these mines is only further illustration of the great uncertainty attending manganese mining.

Production of manganese in 1886.—The total production of manganese ores in the United States in 1886 was 30,193 long tons, valued at $277,636, an average of $9.19½ per ton. Of this amount Virginia produced 20,567 tons, or 68 per cent.; Georgia, 6,041 tons, or 20 per cent.; and Tennessee, 3,316 tons, or 11 per cent. All the other States produced but 269 tons, or less than 1 per cent. of the total product.

The distribution of production was as follows:

Amount and value of manganese ores produced in the United States in 1886

States.	Production.	Total value.	Average per long ton delivered on cars.
	Long tons.		
Virginia	20,567	$232,594	$11.31
Georgia	6,041	24,982	4.14
Arkansas	3,316	19,258	5.81
California	100	400	4.00
Alabama	75	113	1.50
Tennessee	50	150	3.00
Nevada	30	90	3.00
North Carolina	14	49	3.50
Total	30,193	277,636	9.19½

Production of argentiferous manganese ores.—It is estimated from the best data obtainable that the production of manganiferous iron ores, containing silver, in the Rocky Mountain region in 1886 was some 60,000 tons, valued at $10 a ton. These ores are not utilized for their manganese directly, but for their silver, the manganese they contain adding to their value because of its fluxing qualities.

Production of manganiferous iron ores in 1886.—As has already been stated, the separation between manganese and manganiferous iron ores which was made in the report for 1885 is not continued in this report, as the content of the manganese in those ores that would be reported as manganiferous iron ores approached so nearly the dividing line as to make the distinction less necessary than in the report for 1885. The ore from one iron mine, however, the Colby mine in Michigan, carried uniform lya small proportion of manganese, and was received with so much favor by iron smelters because of this manganese that it deserves notice here. The production at this mine in 1886 was 100,000 tons of iron ore, with 2 per cent. manganese, and 157,000 tons of 4 per cent. of manganese, the ore being worth, free on board the cars at the mines, some $2.85 per ton.

Total production of all classes of manganese ores in 1886.—Regarding all these three classes of ores as manganese ores, the total production of all manganese ores in the United States in 1886 was as follows:

	Quantity.	Value.
	Long tons.	
Manganese ores	30, 193	$277, 636
Argentiferous manganese ores	60, 000	600, 000
Manganiferous iron ores	257, 000	732, 450
Total	347, 193	1, 610, 086

While these items are grouped together as a matter of interest, it will, of course, be understood that it is only the manganese included in the first item that is to be regarded, in a commercial sense, as manganese ore.

Value of manganese ores.—From the above table it will be seen that the total value of the 30,193 tons of manganese ores produced in the United States in 1886 was $277,636, an average of $9.19½ per ton, the average value of the ores of the several States varying from $1.50 in Alabama to $11.31 in Virginia. Outside of the three States of Virginia, Georgia, and Arkansas, however, the value placed upon the ores is not to be regarded as indicating what their value would be should the production at the deposits from which the ore was taken assume any importance. Most of the ores in these States, certainly the ores reported as mined in Alabama, Tennessee, Nevada, and North Carolina, were mined for developing deposits. Only the values given for the ores of Virginia, Georgia, and Arkansas may be regarded as representing commercial values. The range of values per ton in Virginia was from $4 to $11.62, the average being as given above, $11.31. In Georgia the range was from $3 to $4.50, the average being $4.14, while in Arkansas the range was from $4.25 to $7, the average being $5.81. It should be distinctly understood that these values are free on board carts or cars at the mines. Where ore is sold delivered on cars or at localities distant from the mines, the cost of carting the ore to the cars or to the locality is deducted from the free-on-board price. For example, at Batesville some ore was sold at $7.50 delivered on the cars. The transportation of this ore cost $1.50, which would make the price of this particular ore free on board at the mines $6.

Production of manganese ores, 1880 *to* 1886.—Continuing the table published in the last volume of "Mineral Resources of the United States," we give below the production of manganese in the United States, so far as the same has been ascertained, in the years 1880 to 1886:

Production of manganese ores (over 44½ per cent. of metallic manganese) in the United States, from 1880 *to* 1886 *inclusive.*

States.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Virginia	3, 661	3, 295	2, 982	5, 355	8, 980	18, 745	20, 567
Arkansas		100	175	400	800	1, 483	3, 316
Georgia	1, 800	1, 200	1, 000			2, 580	6, 041
Other States	300	300	375	400	400	450	269
Total	5, 761	4, 895	4, 532	6, 155	10, 180	23, 258	30, 193

As was stated in the last report, prior to 1885 the statement is simply the best approximation to the actual figures that could be secured. The Virginia production is very nearly correct through all the years; Georgia's figures are taken from railroad manifests; the Arkansas figures have been collected from several sources, and checked as far as possible, and are believed to be substantially correct. The statements for 1885 and 1886 are compiled from actual returns.

ALABAMA.

In a number of the iron ore beds that are worked to supply the blast furnaces of Alabama, notably those of the Edwards Iron Company, near Woodstock, Bibb county, considerable amounts of manganese are found. This manganese occurs either as a constituent of the iron ore, making the ore manganiferous; as veins or crusts resting upon the iron ore, or in chimneys or pockets in the ore belt or vein. One of these deposits was described in the last report. At these furnaces no attempt is made to separate the manganese, even when it occurs in small pockets, from the iron ore, but both are charged into the furnace together. If the proportion of manganese in the charge is not too large, the resulting iron is much improved and is much more valuable for certain purposes.

At Stocks' Mills, in Cherokee county, late in 1886, prospecting by Messrs. Kelly & Webb, of Pittsburgh, Pennsylvania, the same parties who operated at Cave Spring, in Georgia, showed the existence of a series of small pockets yielding an ore quite low in phosphorus, analyzing about 45 per cent. manganese, 0.08 per cent. phosphorus, 5 per cent. iron, and 8 per cent. silica. Some 75 tons were mined.

This is the only manganese ore shipped from Alabama for many years. Indeed, it is the first shipment of which any record has been found. The indications are promising, and some considerable amounts of ore may be shipped in 1887.

ARKANSAS.

The promise at the close of 1885 as to the production of manganese in Arkansas in 1886 has not been fulfilled. There has been a considerable percentage increase, nearly 125 per cent., or from 1,483 tons in 1885 to 3,316 tons in 1886, but the expected production has not been reached. This is in part due to the fact that the branch railroad in course of construction from Batesville to the mines was not completed as early as expected. Indeed, some of the mines did not begin shipments until the latter part of December, because of this lack of railroad facilities. The railroad was completed to the Southern mine in November, and the expensive haul is now obviated. Another reason for the failure to reach the volume of shipments anticipated was that certain deposits which gave great promise, either proved of no value or of much less extent and importance as producers of ore than was expected.

But little can be added to the description of the Batesville region given in the last volume of "Mineral Resources." The work at most of the mines during the year has been development and exploration. The prior workings at the mines now owned and operated by the Keystone Manganese and Iron Company generally found ore in large lumps. Those of 1886 developed the ore chiefly as wash ore, requiring washers or jigs. This company has erected two, which did not get into operation until 1887. A large amount of ore had been mined awaiting the completion of the washers, which is not reported in the table of production, as its production was not regarded as complete until it was washed. The difficulty in washing, a hindrance which exists in almost all manganese districts, is a lack of water. The water for one of these washers has to be pumped three miles. The capacity of the washers, with rather lean material, is some 20 tons a day, this amount having been shipped from one washer in March, 1887. This indicates that the production of this mine will be much increased in 1887, and with it the production of the district. The ore from the mines of the Keystone Manganese and Iron Company runs from 50 to 60 per cent. of manganese, 2 to 6 per cent. iron, and 0.12 to 0.20 per cent. phosphorus.

The Ferro-Manganese Company and the Saint Louis Manganese Company were the other large shippers during the year, the latter, however, not making any shipments until December. These ores, as well as those of the American Manganese Company, limited, which was the only other producer of manganese in this district in 1886, are of the same character as those described in the last volume of "Mineral Resources."

Analyses of the ores of the Saint Louis Manganese Company show the following range:

Analyses of Batesville, Arkansas, manganese ores.

	Per cent.
Metallic manganese	44.0 to 60.0
Silica	1.5 5.0
Metallic iron	1.0 6.0
Phosphorus	.12 .21

The following shows the production of manganese ores raised in this district since 1880. The remarks relative to the accuracy of the figures of production for Virginia will apply here also:

Production of manganese ores in Arkansas, 1880 *to* 1886.

Years.	Quantity.
	Long tons.
1880	
1881	100
1882	175
1883	400
1884	800
1885	1,483
1886	3,316

Some estimates place the production of ore in this State prior to 1885 at 5,000 tons. This is probably an overestimate. The figures given above are based on railroad and other shipments.

Explorations are again in progress in southwestern Arkansas. It is known that surface specimens in this section indicate extensive deposits, but the distance from railroads has not only interfered with their development, but even with their careful exploration. Some pits have been put down, but they are shallow and but little is known of their character except what may be gathered from the surface.

Analyses of these ores were given in the last volume of "Mineral Resources."

GEORGIA

Georgia still retains its position as the second State in point of production of manganese, the production of the Batesville district, Arkansas, which gave promise of surpassing it, being in 1886 but little more than one-half the production of Georgia. The production of manganese in this State, as will be seen from the table given below, has more than doubled during the past year, increasing from 2,580 tons in 1885 to 6,041 tons in 1886. This is the largest production in any one year since manganese mining began in the State. Practically all the ore mined in the State is from the Cartersville district, but 60 tons of the 6,041 tons reported coming from other localities. This 60 tons is from Cave Spring. While several of the mines in the Cartersville district have slightly increased their production in 1886 over 1885—others reporting a reduced output—the great increase in production, accounting for most of the increase in the State, was at the Dade mines. The production of these mines in 1886 was 2,654 tons as compared with 100 in 1885, the mines being worked but a short time in the fall of the latter year. The ore carries a varying percentage of metallic manganese. The following gives the range of the analyses, and shows how greatly the ore varies in composition. This is by no means especially characteristic of this ore, however; all the ores of this district present the same variety.

Analyses of manganese ore from the Dade mines, Bartow county, Georgia.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No.10.	No.11.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Silica	6. 370	7. 560	17. 490	7. 520	11. 370	9. 450	12. 300	17. 370	20. 151	14. 100	16. 450
Iron	23. 900	15. 836	3. 286	11. 055	10. 956	25. 250	8. 534	4. 216	6. 292	10. 341	4. 267
Manganese	30. 320	36. 489	40. 354	41. 430	36. 950	27. 711	42. 933	42. 612	41. 655	39. 226	43. 457
Phosphorus	. 100	. 089	. 119	. 215	. 167	. 123	. 109	. 106	. 134	. 179	. 103

NOTE.—All samples dried at 212°. Some ores run as low as 5 per cent. manganese and 46 per cent. iron.

The ore is brought by a short railroad line to Rogers Station, the next station northwest of Cartersville on the Western and Atlantic railroad. Mr. E. P. Silva, who was the largest miner of manganese ores in 1885, is still the largest producer next to the Dade Coal Company, his production in 1886 being 1,241 tons. His mines are on the land of T. H. Milner, four and a half miles northeast of Cartersville, and on the Barren property, about three miles east of Cartersville.

Production of the Cartersville district in 1886.—But little can be added to the general description of this district given in "Mineral Resources, 1885." Two points in that description appear to be open to question. The statement made on the authority of the producers of the district that the ore occurs "imbedded in a drift deposit" seems to be erroneous. The matrix of the ore appears rather to be a residual clay resulting from the decay of the rock *in situ*. The occasional regularity of the deposits is perhaps due to the concentration of the ore along certain strata, all traces of stratification being subsequently obliterated by the decay of the rock. The age of the rocks adjacent to the metamorphic area in this region is still an open question. The ore is frequently accompanied by fragments of sandstone, and is nowhere observed in proximity to any other rock.

The method of mining varies with the locality, and there cannot be said to be any definite system. Sometimes the pockets of ore are worked by open cuts, sometimes by tunneling from the cuts or from a shaft. The method of washing the lump ore now in general use is to rotate it in a horizontal cylinder into which water is admitted. These cylinders are made either with boiler-iron jacket and lined with cast iron, or else of iron slats running longitudinally with one-sixteenth of an inch interval between them. This method saves all but the very smallest particles of ore.

The following are the chief producers of manganese ore in this district:

Mr. E. H. Woodward shipped 726 long tons from Cartersville. Mr. Woodward leases the Dobbins mine, 4½ miles northeast of Cartersville, from which this ore was taken. Mr. J. F. Carroll shipped 338 long tons from Cartersville. Mr. G. W. Satterfield shipped 292 long tons from Cartersville. Other parties shipped smaller amounts.

Most of the ore shipped from this district was sent to Bessemer, Pennsylvania, to Carnegie Bros. & Co., limited. They appear to consume practically all of the product of this region. The ore sent from Cartersville is brought by wagons to the railroad, and that consigned to the Pittsburgh region goes by rail via Chattanooga and Cincinnati. That consigned to New York goes via Atlanta to Savannah and thence by steamer.

An exact estimate of the value of the ores of this region is difficult to obtain. A valuation of $5.50 per long ton on the cars will, however, be near the true average value. Deducting from this the cost of hauling to cars, and we have the average of $4.14 given above as value free on board at the mines. A gentleman engaged in mining in this district estimates the average number of hands employed as 115. The cost of production varies greatly, according to the method of occurrence of the ore, and an estimate would be of no value. There are large quantities of low grade manganese and manganiferous limonite ores in this district which are not at present utilized.

The large tract of land known as the "Etowah" property, including some of the best manganese tracts in the district, has recently been purchased by a company known as the "Etowah Iron and Manganese Company;" and the probabilities are that this property, which has long laid idle, will now add to the manganese production of the region. This would indicate a probable increase of the output during 1887.

The following is the production of the Cartersville region since 1866:

Production of manganese ore in the Cartersville region, Georgia.

Years.	Long tons.	Years.	Long tons.
1866	550	1877	2,400
1867		1878	2,400
1868		1879	2,400
1869		1880	1,800
1870	5,000	1881	1,200
1871		1882	1,000
1872		1883	
1873		1884	
1874	2,400	1885	2,580
1875	2,400	1886	5,981
1876	2,400		

In addition to the Cartersville deposit explorations made late in the year by Messrs. Kelly & Webb, of Pittsburgh, Pennsylvania, developed the existence of a series of small pockets of manganese ore in the vicinity of Cave Spring, Floyd county. The deposit extends across the State line into Alabama, the same parties shipping some ore from Stock's Mills in the latter State. Some 60 tons were mined and shipped from Cave Spring in 1886. An analysis of this ore is as follows:

Analysis of manganese ore from Cave Spring, Floyd county, Georgia.

	Per cent.
Silica	12.220
Iron	7.655
Manganese	44.716
Phosphorus	0.031

The percentage of phosphorus in this ore is remarkably low, one of the lowest recorded in this or the last report. This will make it a valuable ore, though its content of manganese is somewhat below what is regarded as the figure for shipping, as it can be used with ores richer in manganese but containing more phosphorus.

MICHIGAN AND WISCONSIN.

The recent developments of the new iron ore regions of Michigan and Wisconsin have resulted in the discovery of large deposits of low manganiferous iron ore, as well as of associated deposits that approach very nearly the character of manganese ores, the manganese running from a trace to 33 per cent. and even higher. Up to the close of 1886, however, there had been no such developments of these manganese deposits as to justify the statement that manganese ores were found in paying quantities in either of these States, though there are several locations in which surface indications, as well as developments in the mine itself, promise that valuable deposits of manganese may be discovered. The uncertainty, however, which everywhere attends manganese mining, forbids any positive assertion as to the content of manganese or the extent of these deposits. The old locality on Keweenaw point remains undeveloped.

The Gogebic region.—The Gogebic region, in which the manganiferous iron ores reported as mined in this State in 1886 are found, runs nearly parallel with the southern shore of Lake Superior, and about 15 miles distant from it. The Montreal river, the boundary between the State of Wisconsin and the upper peninsula of Michigan, cuts through the range nearly midway. About one-half of the ore deposits lie in Ontonagon county, Michigan, and the other half in Ashland county, Wisconsin. The range may be regarded as the eastern prolongation of the Penokee range of Wisconsin, as well as the western extension of the Marquette series, the whole being Huronian. Though ore has been known for fully twenty years to exist in this region, the lack of transportation facilities has retarded its development. At several of the mines in this district the iron ore carries quite a percentage of manganese, and is also low in phosphorus. In some cases the manganese is as high as 33 per cent., samples from the Colby mine showing as much as this, though the average of the ores that are regarded with any favor because of their content of manganese is from 2 to 5 per cent. The phosphorus rarely, if ever, exceeds .05 per cent., and in many cases is much lower than this, and this in an ore carrying, say, 58 per cent of metallic iron.

The Colby mine, which produced the 257,000 tons of manganiferous iron ore reported in the earlier part of this chapter, is in Ontonagon county, Michigan, near the Montreal river, which, as is stated above, is the dividing line between Wisconsin and Michigan. The ore, which is a red hematite of the very reddest character, as is most of the ore of this district, occurs in large lenses or pockets, some of which have a length of 1,000 feet, and a width, in places, of 150 feet. At the Colby mine there are two ore zones parallel to each other, and about 150 feet apart. These zones are usually known as the "northern" and the "southern" veins, though whether there is more than one vein, strictly speaking, in the Gogebic region is an open question. In both zones of the Colby mine these lenses occur. All of the ore in both zones carries a greater or a less percentage of manganese, the average of the northern vein being some 2 per cent. of manganese, with 61 per cent. of iron and 0.049 per cent. of phosphorus; the southern vein or zone carries 4 per cent. of manganese with 59.30 per cent. of iron, with the same amount of phosphorus as the northern vein. The following are three analyses of ore from the southern vein of the Colby mine, made by Messrs. Carnegie Bros. & Co., limited, Pittsburgh:

Analyses of manganiferous iron ores from the southern vein, Colby mine, Gogebic region.

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Silica	5.110	5.450	4.420
Iron	54.102	54.825	57.936
Manganese	7.301	6.662	4.677
Phosphorus	.063	.065	.056

The following two analyses are furnished by Messrs. Pickands, Mather & Co., of Cleveland, who operate the Colby mine, as fair average analyses of the two veins:

Assumed average analyses of the manganiferous iron ores of the Colby mine, Michigan.

	Northern vein.	Southern vein.
	Per cent.	*Per cent.*
Iron	61.00	59.30
Manganese	2.00	4.00
Alumina	1.75	1.68
Lime	.11	.10
Magnesia	.23	.25
Silica	4.50	2.50
Phosphorus	.049	.049
Sulphur	.07	.06

The advantages in the use of pig iron containing a proportion of manganese, and made from ores similar to those from the Colby mine, are stated elsewhere.

Saint Croix district.—Developments made in the Saint Croix range near the close of 1886 indicated the presence of considerable deposits of manganese ore, and quite a number of companies with large capital have already been formed to develop the properties, the developments being primarily undertaken in the hope of discovering large bodies of manganese ore, and if not, of mining for iron ores. Saint Croix county, in which these developments have been made, is in the extreme western part of the State, where the boundary thrusts itself out into Minnesota, and lies in a southwesterly direction from Ashland county, in which the Wisconsin portion of the Gogebic region is located. In Dunn county, which adjoins Saint Croix county on the east, developments are also in progress. At the mine of the Saint Croix Mining Company, in Wilson, Saint Croix county, manganese seems to exist in three forms; that is, as wad, with from 15 to 35 per cent. of ore, found in pockets from 1 to 5 feet in depth; as a manganiferous iron ore, limonite, carrying from ½ to 15 per cent. of manganese, and as a real manganese ore. But little was learned about this ore. The two following analyses are from Mr. G. W. La Pointe, vice president of the Saint Croix Mining Company, one of them at least having been made by Carnegie Brothers & Co., limited, Pittsburgh:

Analyses of Saint Croix, Wisconsin, manganese ores.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Silica	11.350	5.200
Iron	2.259	1.000
Manganese	47.031	48.879
Combined water	6.314	6.717
Phosphorus	{ .017 .016 }	.022

NORTH CAROLINA.

The only manganese mined in this State in 1886, so far as has been ascertained, was a sample car load from Madison county, near Warm Springs, from what is known as the Warm Springs basin. The conformation and geology of this region, which are somewhat remarkable, are thus described by Prof. Henry E. Colton: "A little distance west of the French Broad river, and just within the limits of the State of North Carolina, is one of nature's most singular freaks. There, entirely surrounded by high mountains of Potsdam sandstone, is an elliptical valley, the rocks of which are Quebec dolomite, and they, as well as the surrounding sandstone, are pitched at a steep angle. At the upper end of this area, immediately on and in the French Broad river, and just before the dolomitic limestone is cut off by the Potsdam sandstone, are the Warm Springs. The water bursts up through the limestone in more than a dozen places at temperatures varying from 90° to 130° F.;

and from these springs I have given the name to the singular basin which lies to the northwest. This basin is about 8 miles long and from 1 to 3 miles wide; on its northern end are large beds of limonite, and on its whole western side is a continuous belt of manganese ore. While the ore may be in a series of large disconnected beds, yet there is no doubt of its continuity from the old Allen place, near the North Carolina line, to near the Warm Springs.

"The geological position of this manganese belt is that of a contact deposit between the dolomitic limestone and the Potsdam sandstone, and it occurs continuously in the lowest valleys as well as on the summits of the highest ridges that cut across its course. In the regular line of the vein the ore appears to be pyrolusite, beautifully crystallized, but to the east of the line are found beds—undoubtedly drift—in which the ore is a very light blue binoxide, only slightly and minutely crystallized. A cut has been made across this ore which is perfectly vertical, and some very handsome ore taken out. This cut, however, only develops it for about 10 feet from the surface. The strike of the clays and slates at that point is near east and west, while the general course of the main line of ore to the west is about southeast and northwest. Assuming a similarity of formation to that of Crimora, Professor Ritchie has gone south of the cut above mentioned and is sinking a shaft at 35 feet. He had not reached any ore; in fact, had not gone through the bowlder drift. As to quality, I made a selection of the average from five different places on this lead of ore, and they were sent to Prof. James A. Burns, of Atlanta, who analyzed them, with the following results:"

Average composition of manganese ore from the Warm Springs basin, North Carolina.

	Metallic manganese.	Pposphorus.
	Per cent.	*Per cent.*
No. 1	41.71	0.103
No. 2	38.27	.064
No. 3	42.80	.187
No. 4	48.01	.157
No. 5	44.09	.254
Average	42.976	.153

Other and more complete analyses of this ore are as follows: No. 1 being from Carnegie Bros. & Co., limited, of Pittsburgh, and No. 2 by Dr. Charles W. Dabney, jr.:

Analyses of manganese ore from Madison county, North Carolina.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Silica	10.120	....
Iron	2.650	12.40
Manganese	48.925	49.86
Phosphorus	.172	....
Gangue	....	.86
Manganese dioxide	....	78.87
Sesquioxide	....	17.72

It is reported that there is a very promising bed or vein of psilomelane in Caldwell county, 5 miles west of Lenoir; it is found in irregular and rounded masses, imbedded in light-colored gneissic slates, some of the masses being 10, 15, and 20 inches thick, and occupying a breadth of 3 or 4 feet of the strata. Another locality in this county is the Perkins mine, 10 miles west of Lenoir, where a bed of oxide of manganese was opened to a depth of 6 feet, and shown to have a thickness of 1 foot. A large bed carrying oxide of manganese is reported by Mr. S. A. Lowe, 10 miles north of Dobson, in Surry county. One-half mile west of Blue Ridge gap, in Mitchell county, is a bed or seam of earthy pyrolusite or psilomelane 2 to 4 inches thick; it occurs in feldspathic and hornblendic slate, extending nearly east and west across the fields for about one-third of a mile. There is also a small seam in the town of Danbury, Stokes county. Laminated masses ½ to 1 inch thick occur in the Buckhorn iron-ore beds. There are specimens in the museum of the University of North Carolina from Nash and other counties. A specimen of manganese ore from Jackson county gives:

Analysis of manganese ore from Jackson county, North Carolina.

	Per cent.
Silica	12.25
Alumina and sesquioxide of iron	14.10
Proto-sesquioxide of manganese	74.45
Total	100.80

It is probably braunite; variety, marceline. A similar specimen was found in Chatham county. Manganese is found (as already stated) associated with the iron ores in various parts of the State. At Buckhorn it is found as a silicate, and probably in the form of knebelite. Beds of manganese garnets are of common occurrence and often of great thickness.

There is a series of beds containing manganese associated with the King's Mountain slates of Gaston, Lincoln, and Catawba counties, which are superficially changed to black oxide. One notable locality is near the old forge on Crowder's creek, formerly operated by Mr. Briggs; it is under the west flank of Crowder's mountain, and quite near the Yellow Ridge ore bank.

Analysis of manganese ore associated with the King's Mountain slates, North Carolina.

	Per cent.
Silica	40.395
Oxide of iron	12.146
Alumina	9.025
Phosphoric acid	.030
Sulphuric acid	.024
Sulphide of iron	.218
Proto-sesquioxide of manganese	29.780
Lime and magnesia .... not determined	
Metallic iron	8.602
Metallic manganese	21.450
Phosphorus	.013
Sulphur	.112

A vein of oxide of manganese crosses the road from Iron to Maj. W. A. Graham's residence, in Lincoln county. The bed is apparently a highly altered silicate, and is fully 6 feet wide. A vein of manganese ore, which is believed to be a northeast extension of the above, is found about one-fourth mile west of Vesuvius furnace, on the road to the Big Ore bank.

Analysis of manganese ore from near Vesuvius furnace, Lincoln county, North Carolina.

	Per cent.
Silica	47.93
Protoxide of manganese	12.86
Binoxide of manganese	5.60
Alumina and sesquioxide of iron	30.44
Total	96.83

This has been used in a neighboring furnace as a mixing ore, and with very good results.

SOUTH CAROLINA.

It is reported that the Manganese Mining Company, which is operating on what are known as the Dorn lands, near McCormick, in South Carolina, produced some ore in 1886, but the author has not been able to ascertain the amount produced, if any. The mines are reported to be quite extensive, the vein or deposit in which the manganese is found averaging from 30 to 80 feet in width. The ore is crushed and washed. It is reported that since operations began in this mine in 1885 some 300 tons have been mined. The following is given as an analysis of the ore:

Analysis of manganese ores from Dorn county, South Carolina.

	Per cent.
Peroxide of manganese	75.28
Protoxide of manganese	3.73
Oxide of iron	14.56
Alumina	2.63
Phosphoric acid	.24
Silica	3.54
Sulphur	.02
Total	100.00

The metallic manganese in the above ore is 50.34 per cent., and phosphorus 0.11 per cent.

TENNESSEE.

But 50 tons of manganese ore are reported as having been mined in Tennessee in 1886. A small amount in addition to this, possibly a few hundred pounds, was mined at the deposit in Hickman county referred to in the last volume of "Mineral Resources of the United States." The 50 tons referred to was mined for use in a charcoal furnace, and is probably better classified as manganiferous iron ore than as manganese ore.

Lumps of manganese oxides are frequently found in the iron-ore regions of Tennessee. They are isolated pieces, however, the ore rarely, if ever, occurring in beds or deposits worthy of any special notice. Hickman county is in the western iron region of Tennessee, in which iron was extensively made before the war, and in which some furnaces are now at work. The ore in this region is limonite, and it is with this and with the cherty gravel scattered over the surface of the county that the isolated lumps of manganese ores are found.

To what was said in the last report relative to Greene county, it may be added that small masses of manganese oxide, more or less pure, are often met with on nearly all the low, cherty regions of the valley of east Tennessee. They also occur as in Greene county, with iron ore at intervals at the foot of the extreme eastern mountains (the Unakas), all the way from Virginia to Georgia.

Manganese ores are also found all down the Chilhowee Mountain range, but in pockets and too far from any railroad to justify their transportation. In a letter received from Professor Colton, it is stated that a mine is being opened near the East Tennessee and Western North Carolina railroad, about six miles from Elizabethtown, Carter county.

VIRGINIA.

The exhaustive discussion in the last volume of "Mineral Resources of the United States," not only of localities in which manganese has been mined in Virginia, but of many at which only surface indications have been observed, leaves but little to be said in addition in this report. The search for manganese in this State has been unremitting, and no small amount of effort and money has been expended in examining and developing localities in which it was believed profitable deposits could be found. With possibly one exception, however, that of the Old Dominion Manganese Company, none of the explorations in progress at the beginning of 1886 resulted, so far as has been learned, in the development of any considerable body of ore; at least none of these, not even the Old Dominion itself, has added any considerable amount to the production of manganese in 1886. At some of the localities in which the work of exploration was in progress at the beginning of the year, some work is still being done, and at some of these it is claimed that the indications justify a belief in the existence of extensive and valuable deposits, which it is proposed to mine in the coming year. At other localities work is temporarily suspended, while at still others it has been definitely abandoned.

The search for manganese in Virginia, however, is by no means at an end, and it is not at all improbable that at some locality, of which there are many in the State giving good surface indications, but which have not yet been carefully and thoroughly examined, a second Crimora may be found. Many deposits, that in the past have produced considerable ore of a good grade, are so situated with reference to transportation as to forbid mining. Some of these properties will be brought by railroad extensions, that are now in progress, much nearer to transportation facilities, and it is more than probable that some of these will develop profitable deposits of ore.

During the past year the explorations of the Old Dominion Manganese Company, to which reference was made in the last report on page 317, on the lands adjoining those of the Crimora mines, have resulted in the development of a body of ore that seems to overthrow the previous belief relative to the Crimora deposit. It has been generally believed that the Crimora mine was a deposit of "wash" in a basin cut out of the Potsdam sandstone, the basin being the work of old-time eroding agencies. It was believed that outside of this basin the sandstone approached so near the surface as to preclude the possibility of any beds of ore in the near vicinity of any magnitude. The shaft sunk by the Old Dominion Company proved that if this idea is not erroneous, at least that there are basins of some depth other than the Crimora containing ore in paying quantities.

The property has been leased by the American Manganese Company, limited, who are also the lessees and workers of the Crimora mine. But little work was done in raising ore in 1886, the operations being confined chiefly to prospecting and drifting. The output of this mine was therefore quite small in 1886, not exceeding 100 tons. At none of the other deposits in Virginia at which explorations were in progress in 1886 was any considerable quantity of ore mined in that year. The developments of the Kennedy tract, referred to on page 318 of the last report, have been practically abandoned. At Doom's station some 80 tons were mined in 1886, and at Guy's run some 15 tons. Work will be resumed at several places in Virginia in the spring of 1887, a large output being confidently expected at some points.

The Crimora mine.—The Crimora mine, operated by the American Manganese Company, limited, at Mushet, on a short branch of the Shenandoah Valley railroad, is still not only the largest manganese-producing mine in Virginia, but the largest in the United States. In 1886, 19,382½ tons, or 94 per cent. of the 20,567 tons produced in Virginia, were from the Crimora mine. This mine also produced 64 per cent. of all mined in the United States.

The production of this mine, brought down to 1886, is as below:

Production of the Crimora mine, Virginia.

	Quantity.
	Long tons.
Prior to 1869	5,684
May, 1869, to February, 1876	280
February, 1876, to December, 1878	2,326
December, 1878, to December, 1879	1,602
1880	2,963
1881	2,495
1882	1,652
1883	5,185
1884	8,804
1885	18,212
1886	19,382

From this it will be seen that the production in 1886 was but 1,170 tons greater than in 1885. It is probable that with the present facilities and the delays from water in the mine, that this about represents the annual capacity of this mine. It has produced as high as 2,000 tons a month, and improvements in progress will enable the proprietor to maintain this capacity for production unless the mine should again be flooded.

The Mount Athos mine.—Next to the Crimora the most important mine in Virginia producing a high grade of manganese, is what is known as the Leet's or Mount Athos mine. This mine is now over 200 feet deep. The deposit seems never to run over 5 feet wide, and averages 3 feet 6 inches. Like the Crimora it requires heavy timbering. The ore, which has always been regarded as of good quality, improves as the mine deepens. The mine has been worked for some years on a royalty of $1.25 a ton. Early in 1887 it was leased to the United States Chemical Company, of Middleport, Ohio, at $2 a ton royalty. Of the 191 tons shipped from this mine in 1886, 106 tons were sent to England for chemical purposes and 85 tons to Middleport, Ohio.

Manganiferous iron ores in Virginia.—In "Mineral Resources" for 1885 a considerable quantity of manganiferous iron ore was reported as mined in this State at two points. From the mines of the Shenandoah Iron Company, near Milnes station, in Page county, 2,155 tons were shipped in that year, and from the Houston mines, worked by Mr. Ed. S. Hutter, 1,082 tons were shipped in 1885. In 1886, however, a total of but 497 tons was shipped from these mines, 480 tons of this being from the Houston mine and 17 tons from the Milnes mine. The average of the shipments by Mr. Hutter from the Houston mine showed 44 per cent. of metallic manganese and 9 per cent. of iron.

ROCKY MOUNTAIN REGION.

The character of the manganese ores in the Rocky Mountain region was set forth in detail in the last two volumes of the "Mineral Resources of the United States," and will be found on page 379 of the volume for 1883-'84, and on pages 348 and 349 of the volume for 1885. The ore is practically a manganiferous ore, containing silver, and is used entirely as a flux to help smelt siliceous ores. The ore carries some lead, and from 5 to 30 ounces of silver per ton; from 3 to 15 per cent. of manganese, and from 35 to 50 per cent. of iron. The amount of these ores used at some of the smelters is quite large, one establishment using as much as 18,000 long tons in 1886.

The amount of these argentiferous manganese ores treated in the country in 1887 is estimated at 60,000 tons, valued at an average of $10 a ton.

PACIFIC STATES.

Though there are many known deposits of manganese ores in California and Nevada, so far as has been learned but little has been mined. A few tons of 65-per cent. ore were raised at the mine of J. R. Jennings, near Golconda station, Humboldt county, Nevada. This deposit is described in "Mineral Resources of the United States, 1885," page 349. Messrs. John Taylor & Co. write that the manganese they have mined in California is in pockets, no well defined vein having been noticed. The output of the State is small, the demand for manganese being chiefly for the manufacture of chlorine gas to be used in working sulphuret in gold ore. They estimate that from 100 to 150 tons are used annually on the Pacific coast, the value at the mine being from $3 to $4 a ton for ore, with 50 to 60 per cent. of manganese. Considerable ore of a lower grade than this, say from 20 to 30 per cent., is found. No mining was done at the deposit at Livermore, Alameda county, California, mentioned in the last volume of "Mineral Resources," though further operations are in contemplation.

Other deposits of manganese in these two States are mentioned in previous volumes of "Mineral Resources of the United States." Some of these are not only reported to be quite extensive and valuable, but are well situated relative to transportation facilities. The demand for these ores on the Pacific coast is very light, however, and in most instances, even where the deposits are near railroads or navigable waters, the cost of transportation to points of consumption is too great to justify mining and shipping the ores. A deposit at Red Rock, in the bay of San Francisco, which has not been worked since 1866; a mine known as the "Old Ladd mine," in Corral Hollow, from which considerable ore has been taken, and the Livermore deposit, appear to be the only ones from which any considerable amounts of ore have been taken in these States.

In Oregon a deposit similar in character to those of the Rocky Mountain region is reported to have been found on Wolf creek, in Columbia county. The mines are known as the White Bear. It is stated that both gold and silver are found with the manganese. Assays of the ore have been made with most satisfactory results. The ore is at presen[t] some 20 miles from the nearest railroad, but the location of Astori[a] and Forest Grove Railroad is within 2½ miles.

OTHER STATES.

So far as has been ascertained no ore has been mined in any other State[s] than those mentioned above, and as the known localities where manganese occur have been so fully described in previous volumes of "Mineral Resources" it is unnecessary to repeat these descriptions in this report.

CANADIAN MANGANESE.

Concerning the distribution of manganese ores in Canada, there is nothing to add to the very full description given in the last volume of "Mineral Resources." No statement of the production of New Brunswick has been received. I am again indebted to Mr. E. Gilpin, jr., chief inspector of mines for the Province of Nova Scotia, for a statement of the production of manganese in that province for 1886, which is added to the table in the last report, giving the production of manganese in Nova Scotia since 1861:

Production of manganese ore in Nova Scotia from 1872 *to* 1886 *inclusive.*

Years.	Mines.	Production.	Value.
		Long tons.	
1861 to 1871		1,500	$10,500
1872		40	1,400
1873		131	
1874			
1875		7	
1876		16	
1877		97	5,335
1878	Tenny Cape No. 1	79	4,345
	Tenny Cape No. 2	48	2,160
		127	6,505
1879	Tenny Cape No. 1	90	4,950
	Tenny Cape No. 2	55	2,220
		145	7,170
1880	Windsor	62	2,831
	Walton	81	3,600
	Cheverie	70	7,000
	Others	70	1,400
		283	14,831
1881	Tenny Cape	125	
	Walton	7	
	Cheverie	17	
	Pembroke	6	
	Windsor	6	
	Loch Lomond, Cape Breton	70	
		231	
1882	Tenny Cape	120	
	Walton	6	
	Cheverie	21	
	Onslow	6	
	Loch Lomond, Cape Breton	56	
		209	

Production of manganese ore in Nova Scotia from 1872 *to* 1886 *inclusive*—Continued.

Years.	Mines.	Production.	Value.
		Long tons.	
1883	Tenny Cape	125	$12,462
	Walton	5	
	Cheverie	4	
	Loch Lomond, Cape Breton	16	....
		150	12,462
1884	Tenny Cape	126	11,970
	Windsor	5	550
	Cheverie	2	180
	Walton	89	8,430
	Onslow	30	2,700
	Loch Lomond, Cape Breton	50	....
		302	23,830
1885	....	354	....
1886	Tenny Cape	171	12,066
	Cheverie	6	358
	Cornwallis	250	750
	Onslow	20	85
	Stewiacke	18	590
		465	13,849

It is believed from its low price that the Cornwallis ore is ocher. The great value of most of these ores, as compared with those of the United States, will be noted. These ores are high grade, mined chiefly for glass making, and command a high price. Some of the Truro ore runs 92 to 95 per cent. manganese dioxide.

GREAT BRITAIN.

As is stated in discussing elsewhere in this report the fall in the prices of manganese, considerable quantities of manganese were mined in Great Britain some forty years ago. Pyrolusite and psilomelane were mined near Tavistock in Devonshire, and Launceston in Cornwall, and wad with 60 per cent. peroxide in both of these counties. These deposits were worked chiefly as surface workings, and as surface deposits are worked out; and, though it seems to be believed that the ore exists in quantities at lower levels, it will require long adits and deep shafts to develop the mines properly, and this, as is well known, is quite expensive, and will bring the cost of the Devonshire and Cornwall ore to a figure which will shut it out of the English markets in competition with ore from newer fields. It is also true that many of the ores imported into England are richer in manganese by at least 10 per cent. than the ores from the two localities named. This view of the probabilities as to the profitable workings of the Cornwall manganese deposits is not universal in England. Some persons hold that active and intelligent explorations would develop deposits that could be worked profitably. The fact remains, however, that with the great demand for manganese of the last few years the deposits have not been reopened and worked; at least to but a small extent.

In a paper read before the British Association, Birmingham, September, 1886, Dr. C. Le Neve Foster stated that manganese ore is now worked in the Cambrian rocks at several places near Barmouth and Harlech. It occurs in the form of a bed, varying from a few inches to 4 feet in thickness; the average thickness is from 18 inches to 2 feet. The undecomposed ore contains the manganese in the form of carbonate, with a small proportion of silicate; but at the outcrop it is changed into a hydrated black oxide. Dr. Foster states that some of the outcrops of the manganese bed are erroneously marked on the geological survey maps of Great Britain as mineral veins, though Sir Andrew Ramsey was of opinion that the deposits were not true lodes. Recent workings show plainly that the deposits are truly stratified beds, or possibly various outcrops of one and the same bed, extending over a considerable area. The ore contains from 20 to 35 per cent. of metallic manganese, and is dispatched to Flintshire for the manufacture of ferro-manganese. The new Merionethshire mines are the first instance of the workings for carbonate of manganese in the British Isles. The output of the mines of the Dyffryn Company approaches 1,400 tons of ore a month.

These deposits consist of carbonate of manganese, that has heretofore played but little part in the manganese market. The pure carbonate contains 28 per cent. carbonic acid, 56 per cent. protoxide of manganese, 5.4 per cent. lime, 4.5 per cent. protoxide of iron, and 0.8 per cent. magnesia. Manganese was also mined in Ireland about the time that the Cornwall deposits were worked. The suspension of operations was from the same cause that closed the English and Welsh mines. The production of manganese has varied greatly in Great Britain in different years. It is estimated that in 1835 to 1839 the production was 5,000 tons a year. In 1873 it was 8,254 tons. In 1875 there were sixteen mines in operation, producing 3,725 tons. In 1882 there were 1,548 tons mined, valued at £3,907; and in 1883, 1,287 tons, worth £2,976.

FRANCE.

While it is known that there are deposits of manganese in France that are used both for chemical purposes and for the manufacture of spiegeleisen and ferro-manganese, nothing has been learned regarding the character of the ore or of the deposits, except an analysis of the ore from the department of the Saône-et-Loire. This analysis is as follows:

Analysis of French manganese ore.

	Per cent.
Silica	6.20
Alumina	?
Lime	?
Oxide of barium	13.00
Manganese	40.00
Iron	1.50

SPAIN.

From the iron ore mines in the neighborhood of Cartagena, Spain, considerable quantities of manganiferous iron ores are produced. These ores occur in pockets associated with brown hematities. They are used largely in this country in the manufacture of spiegeleisen. The ore varies greatly in richness, running from 3 to 4 per cent. of manganese with 50 to 55 per cent. of iron, up to 19 or 20 per cent. of manganese with 28 to 30 per cent. of iron. Phosphorus runs from .013 to .04 per cent., silica from 3 to 10 per cent.

Three analyses of this ore dried at 212° F. are as follows:

Analyses of manganiferous iron ores from Cartagena, Spain.

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Silica	6. 090	8. 170	6. 240
Iron	36. 144	41. 574	40. 560
Manganese	15. 221	11. 843	11. 400
Phosphorus	. 022	. 022	. 031

It is stated that 1,201 tons of manganese ore were exported from Spain in 1886. This must refer to manganese ores proper, that occur in connection with hematite ores of that country, and not to the manganiferous iron ores mentioned, which were probably exported as iron ores.

PORTUGAL.

There are several manganese mines in Portugal, but the information regarding them is exceedingly scanty. It is reported that in 1883 there were 90 mines of this mineral worked in this country, the character of the ore being very high.

The only statement obtained concerning the production of manganese in Portugal is for 1881, when 9,906 long tons were produced.

PRUSSIA.

No statement as to the character of the manganese ores of Prussia or as to their method of occurrence has been secured, though the Prussian mining reports give quite full statistics of production and prices.

The details of the production of manganese in Prussia in 1885 are as follows, the statistics for 1886 not having come to hand as yet:

Production of manganese ore in Prussia in 1885.

Districts.	Province of—	Quantity.		Value.
		Tonnes.	*Kilos.*	*Marks.*
Hildesheim	Hanover	20	500	5, 740
Cassel	Hesse	447	750	13, 549
Wiesbaden	do	11, 825	125	284, 618
Coblenz	Rhine	2, 399	100	34, 212
Treves	do	4	5	641
Total		14, 696	480	338, 760

The statistics of production and value of the manganese ore mined in Prussia from 1881 to 1885 are as follows:

Production and value of manganese ores mined in Prussia, 1881–'85.

Years.	Quantity.		Value.
	Tonnes.	*Kilos.*	*Marks.*
1881	11,085	719	329,599
1882	4,670	525	140,606
1883	4,573	885	118,430
1884	7,750	911	179,657
1885	14,696	480	338,760

ITALY.

The only manganese ores of the kingdom of Italy concerning which we have much information are those of Sardinia, though it is well known that both manganese and manganiferous iron ores are found in other parts of the kingdom and mined to some extent.

The San Pietro district in Sardinia, as described in a paper read before the North of England Institute of Engineers by Professor Lebari, is situated on the little islet of that name. The manganese mines are on the western coast, and consist of two concessions—Cape Rosso and Cape Becco—and of two "permissions of research," the whole covering nearly 2,000 acres. The seam of manganese ore (black to brown) is of an average thickness of 1 foot, lying on a bed of soft whitish clay, containing fragments of trachyte, and forming the floor of the deposit; above it is jasper (some 4½ feet), above which again comes trachyte of various colors and qualities. The percentage of manganese in the best portions of the mine will be from 31 to 35 per cent., and the ore will contain from 7 to 13 per cent. of iron. The second quality will contain about 20 per cent. of manganese and about 14 per cent. of iron. In the more manganiferous portions of the ore there is a considerable quantity of free silica, which renders this portion of the bed to a great extent not adapted to the manufacture of ferro-manganese.

The mode of working is to drive crosscuts from the gallery in the direction of the strike; a rise is then put up from this cross level through the bed; small leads, 4 to 4½ feet high, and kept open by good timber at the sides and top, are next driven toward the rise of the bed. The men first dig into the soft curved floor with a somewhat curved pick, having a hammer head prolonged some inches beyond the handle. The clay, which they constantly throw behind them, forms the *ramblai* or *goaf* with which the old workings are filled up. The manganese is afterwards brought down by sledge hammer and long thick wedges. The mine is cheap to work, or else it would have been useless to go on with any show of success, when so often, too, the bed contains on an average only 30 per cent. of manganese. It can be delivered at about 16*s.* per ton free on board at Carlo Forte, and in the year 1881, 4,895 tons were raised at a value of £6,600; and in round numbers 44,000 tons have been raised in all, realizing £57,700, giving an average value of 26*s.* 2*d.* per ton.

In Tuscany a manganese ore used by Purcel in the manufacture of ferro-manganese and showing the following analysis, is found:

Analysis of Tuscan manganese ores.

	Per cent.
Silica	0.40
Alumina	.80
Lime	20.00
Manganese	29.85
Iron	7.85

The latest statement that has been found as to the production of manga ese in Italy is for the years 1877, 1878, and 1879, and is as follows:

Production of manganese in Italy, 1877–1879.

Years.	Long tons.	Value.
1877	6,812	$40,597
1878	6,655	48,256
1879	5,705	35,065

GREECE.

According to U. S. Consul Moffett, the principal mines of manganiferous iron ore in Greece are at Laurium. The production in 1885 amounted to 25,000 tons. This can readily be doubled. This ore contains, ordinarily, from 18 to 19 per cent. of manganese, and from 34 to 35 per cent. of iron. The cost of mining is about 3½ drachmas (67 cents) per ton. The cost of transportation to shipping port, loading, etc., 3½ drachmas; general expenses, 1 drachma; making total cost, including mining, transportation, etc., about 8 drachmas ($1.54) per ton.

The following two analyses of Grecian manganiferous iron ore are of samples from shipments to this country; the ore is stated to be from Mazarron:

Analyses of Grecian manganiferous iron ores.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Silica	3.600	5.020
Iron	50.000	33.588
Manganese	7.638	15.329
Phosphorus	.022	.048

RUSSIA.

The manganese mines of the Caucasian district of southern Russia have, within the past two years, assumed an importance second to none at present operated, and are probably having more effect upon the price of manganese in the markets of the world than the mines of any one district, not even excepting the celebrated Crimora mine in Virginia. These mines are near the village of Chiatura, or, as it is sometimes spelled, Tchiatoor, some 26 miles from Kwirilla station on the Trans-Caucasian railway, which runs between Baku on the Caspian and Batoum and Poti on the Black sea. The mines are situated on the west side of the Lesser Caucasus. They are found on the top of a high cliff overhanging the Kwirilla river. This river has cut its way deeply through the rock, and the overhanging cliffs on both sides show distinct deposits of manganese. A very steep and difficult road, up which no carts can be taken, leads to the mines.

The method of mining is by driving long galleries into the hillside, and over a space of more than 2 miles along the face of the cliff these galleries enter the hill. From them cross-tunnels have been excavated in every direction, but no scientific system of mining is employed. Pillars of the manganese ore are left at intervals to support the roof, but the galleries are dangerous, and expensive falls of the roof, accompanied by loss of life and limb, are by no means unusual. The ore is carried in baskets by the men down the face of the cliff, from the bottom of which it is carried on the backs of horses, mules, and camels 26 miles to Kwirilla station, whence it is sent by railroad to Poti and Batoum, and thence to Liverpool.

The ore contains about 55 per cent. of metallic manganese, and the quantity appears to be enormous. The chief drawback is the want of a good road from Kwirilla station to the mines. The government proposes to build such a road, and in conjunction with this road improvements in the navigation of the river Riom are also projected, so as to allow of floating the consignments of ore down to Poti instead of sending them by the railroad, the facilities of which are already sufficiently taxed by other freight, chiefly grain and petroleum. It is estimated that should these improvements be completed, at least 100,000 tons a year of manganese can be produced in this district, and should the Kwirilla mine become exhausted there are other deposits between Tiflis and Baku on the east side of the Lesser Caucasus, near Elizabethpol station, which would make good the deficiency. These latter deposits are near the copper mines of Messrs. Siemens Brothers, of the Dashkeson defile. At present only large lumps of ore are sent from the Kwirilla deposit, the means of transportation forbidding the carrying of the smaller ore. As a result, fully two-thirds of the manganese is wasted, though this ore in most cases is quite equal, if not superior, to that which is sent to market.

It has only been since 1880 that this region has assumed any importance as a producer of manganese. Before that the production was wholly under the control of a Greek company which shipped a few tons each year from the Caucasus to Constantinople, where it found its way to England. Now, as stated above, it is sent direct to Poti and Batoum, from whence it is forwarded chiefly to England, but also in some quantities to Austria and France. The following is the most complete statement relative to the production that we have been able to find:

Production of manganese ores in the Caucasus region of southern Russia.

Years.	Long tons.
1879	1,000
1880	9,910
1884	21,000
1885	44,447

No exact figures have been secured from 1881 to 1883. It is stated, however, that the export in 1881 was a little less than in 1880; it doubled in 1882 and doubled again in 1883, rising to 21,000 tons in 1884, as is shown above.

The following table shows the increase in the shipments in the first four months of 1886, as compared with the first four months of 1885. No figures for the later months have been received.

Shipments of manganese ores over the Trans-Caucasian railway for the first four months of 1885 *and* 1886.

Months.	1885.	1886.	Increase of 1886 over 1885.
	Tons.	*Tons.*	*Tons.*
January	500	1,500	1,000
February	1,600	2,400	800
March	1,100	2,300	1,200
April	1,200	2,800	1,600
Total	4,400	9,000	4,600

The exact shipments in poods for the first four months of 1886 were 4,547,433, and for the first four months of 1885, 272,400 poods.

TURKEY.

But little manganese is mined in Turkey, though a number of deposits are known to exist in various parts of this country. At Aptal, in the province of Trebizonde, manganese is found and mined to a small extent, the production being some 700 tons a year. It is also found some 9 miles from Flatza, on the Asiatic coast of the Black sea.

CHILI.

Geological researches undertaken in Chili, by direction of the local government, have shown the existence of immense deposits of manganese ores, especially in the northern provinces of the republic. In most cases, however, these deposits are too far from the coast to be profitably worked and sent to market under present conditions, as, in addition to the cost of transportation to the coast by most expensive methods of carriage, the ore must also bear the cost of transportation to England, where it finds market, there being no local demand. This statement, however, applies with modified force to the beds of manganese in the province of Coquimbo. While this is one of the northerly provinces in the republic, its manganese mines are better situated with reference to transportation to the coast than those still farther north; the cost not only of transportation, but of labor as well, increasing rapidly in Chili as we go northward. The first attempts at mining manganese ores in this country were made some four or five years ago, when a bed in the province of Santiago, the central province of the republic, was opened, the ore being taken to Valparaiso for shipment to England. The cost of conveying the ore to this port, however, proved an insuperable obstacle to the success of the undertaking, and it was abandoned. After the abandonment of the Santiago mines a deposit in the province of Coquimbo was opened, and in 1885, 4,118,015 kilograms, equal to 4,054 long tons, were exported to England, the average content of manganese being 45 to 55 per cent., averaging 52 per cent. The beds of manganese worked in the province of Coquimbo are chiefly surface deposits, requiring no expensive or scientific mining. The cost, therefore, of producing the ore is trifling; the ore runs in ridges, the tops of which are visible, the ore being extracted chiefly by crowbar and sledge. The great expense, however, is the cost of transportation, which, though the beds worked are in close proximity to the railroad and though the ore is conveyed to a port of shipment on very liberal terms, makes it cost $5 to $7.50, American money, per ton, by the time it is placed alongside a vessel at Coquimbo.

While, as above stated, there are immense deposits of manganese ore in this republic, it is still an unsettled question whether the ore can be worked and placed in London at a profit, and some time will be required to settle the question definitely, as well as to ascertain whether it can meet in price the ores from other regions that are being produced in large quantities. The only statement of the production of manganese ores in Chili that has been obtained is the one given above for 1885, when 4,054 long tons were produced. It is stated that during the first half of 1886 the amount shipped to England was 38,802 tons.

SOUTH AUSTRALIA.

The following analysis of manganese ore from South Australia is given by Messrs. Gilchrist & Riley:

Analysis of Australian manganese ore.

	Per cent.
Silica	Trace.
Manganese	39.68
Iron	24.08
Phosphoric acid	.08
Sulphur	Trace.
Moisture	Trace.

A deposit of manganese ore was worked near Gordon, in South Australia, some time since, by a company from Adelaide. The first shipment to England realized a profit, the second paid expenses, while on the third there was a loss, and mining was stopped.

NEW SOUTH WALES.

In 1885 some 200 tons of manganese ores were shipped to England from mines near Rockley, 167 miles from Sydney.

NEW ZEALAND.

Manganese has been known to exist in the colony of New Zealand from the date of its earliest settlements. For many years, however, no attempt was made to mine it; indeed it was not until 1874, when an attempt was made to float the New Zealand Manganese Mines Company, limited, that attention was directed to the deposits.

The chief work in mining manganese has been done near Russell, the first capital of the colony, and at Waiheki, a considerable distance north of Russell. The great difficulty in mining these ores is due to the great irregularity of the surface, which makes it not only difficult to trace the lodes, but requires expensive under-work to make the roof secure. These difficulties, with high wages, interfere with the mining of the ore. The ore has to be picked over by hand, the select portions running about 75 per cent. oxide of manganese.

The production of manganese in New Zealand from 1878 to 1883, and the value, so far as it has been ascertained, are as follows:

The production of manganese ores in New Zealand, from 1878 *to* 1883.

Years.	Long tons.	Value.
1878	2,516	$50,080
1879	2,140	41,690
1880	2,611	52,115
1881	1,257	....
1882	2,181	....
1883	384	....

It is stated that only three properties were being worked in 1885, and that but ten men and boys were employed.

DECLINE IN PRICE OF MANGANESE AND ITS CAUSE.

Until some forty years ago the demand for manganese was, as compared with that of to-day, quite limited, it being chiefly used in glass manufacture, manganese having been used in this industry as a decolorizer for many centuries, and for the manufacture of chloride of lime (bleaching powder). At that time the chief sources of supply for the English glass houses and chemical works, which consumed by far the largest proportion of the ore used, was Tavistock, in Devonshire, and Launceston, Cornwall, some also coming from the Hartz mountains and Piedmont.

The prices at this time I have not been able to ascertain, but have learned that with a heavy cost for mining, added to $5 a ton royalty to the owner of the land, and expensive transportation, the ore has sold at a price that left large profits, because bleaching powder, for the manufacture of which it was chiefly in demand, brought good prices. The discovery of large deposits of manganese in Germany about this time so overstocked the market that prices fell to a point where the English mines could not be worked profitably and they were closed. After the cessation of mining in Great Britain the price rose again to £8 per ton for an ore with 70 per cent. oxide, the standard of the chemical works, but this price was reduced by the discovery of extensive deposits in Spain, until in 1865 it was but 60 shillings for 70 per cent. ore, and all of the mines but three in Great Britain and Germany were closed. The Spanish deposits, though quite extensive and furnishing considerable ore, were like all others, pockets, and were exhausted. With their exhaustion, and the reduced supply from Germany, coupled with the demand for manganese products for steel making, came a demand which the mines in operation were unable to supply, and a search for manganese has been undertaken in all parts of the world where there is a possibility of finding deposits.

While the demand for manganese has increased, not only have new deposits been found, but, as is usually the case, new economies in its use have been discovered. In making bleaching powder, for example, formerly the ore was used but once, but methods have been discovered by which the manganese is recovered from the heretofore waste products with an insignificant loss of the manganese—possibly not to exceed 10 per cent. As the result of this saving of manganese in the chemical industry as well as of the increased production at various points, notwithstanding the much larger demand, there has been a gradual fall in the price of manganese ores. Some four or five years ago the price of 70 per cent. manganese for use in the chemical works was 70*s*., or $16.94 per ton, with 2*s*. 6*d*., or 60 cents per additional unit. The price now is 65*s*., or $15.73 for 70 per cent. manganese, with 2*s*. 3*d*., or 54 cents per additional unit.

The price of manganese ore, delivered at the works of Carnegie Bros. & Co., limited, at Bessemer, near Pittsburgh, Pennsylvania, a price which practically rules the United States market, is as follows:

Price of manganese ore per long ton.

Percentage of manganese.	Iron per unit.	Manganese per unit.
	Cents.	*Cents.*
Below 44	10	22
44 to 47	11	23
47 to 50	11	24
50 to 53	11	25
Above 53	11	26

These rates are based on ore containing between 0.17 and 0.18 per cent. of phosphorus.

For ore containing between 0.14 and 0.17 per cent. phosphorus, the price is advanced one cent per unit of manganese, and below 0.14 per cent. of phosphorus, the price is advanced two cents per unit of manganese. For ore containing between 0.18 and 0.20 per cent. phosphorus, the manganese is one cent per unit lower than the above prices.

Analyses are made on sample dried at 212° F., the moisture in the sample as taken to be deducted from the weights.

MANGANESE IN THE MANUFACTURE OF IRON AND STEEL.

Just what is the influence of manganese on iron and steel is as yet, in many respects, an unsettled question among metallurgists, though it is evident from recently-acquired knowledge that many of the opinions held must be abandoned. That it is an absolute necessity in the manufacture of iron and steel from certain grades of pig iron and other raw material is unquestioned, and that, in the form of ferro-manganese, it is almost essential in the production of Bessemer steel is conceded, but the point at issue appears to be as to its functions, and these are at best imperfectly understood. Is manganese absolutely essential to the production of steel which shall be free from redshortness and capable of welding, or is it "merely a cloak to hide imperfections"?

In the admirable treatise on the "Metallurgy of Steel," by Henry M. Howe, now being published in the *Engineering and Mining Journal*, the latest information as to its effect on steel and, presumably, on iron, is summarized as follows:

"Manganese alloys with iron in all ratios, being reduced from its oxides by carbon at a white heat, and more readily in proportion as more metallic iron is present to combine with it. It is easily removed from iron by oxidation, being oxidized even by silica, and, partly in this way, partly in others, it restrains the oxidation of the iron, while sometimes restraining, sometimes permitting, the oxidation of the other elements combined with it. It is also apparently removed from iron by volatilization. Its presence increases the power of carbon to combine with iron at very high temperatures (say 1,400° C.), and restrains its separation as graphite at lower temperatures. By preventing ebullition during solidification and the formation of blowholes, by reducing or removing oxide and silicate of iron, by bodily removing sulphur from cast iron and probably from steel, by counteracting the effects of the sulphur which remains as well as of iron oxide, phosphorus, copper, silica, and silicates, and perhaps in other ways, it prevents hotshortness, both red and yellow. (It does not, however, counteract the coldshortness caused by phosphorus.) These effects are so valuable that it is to-day nearly indispensable, though admirable steel was made before its use was introduced by Josiah Marshall Heath. It is thought to increase tensile strength slightly, hardness proper, and fluidity, to raise the elastic limit, and, at least when present in considerable quantity, to diminish fusibility. It is generally thought to diminish ductility. Evidence will be offered tending to show that its effects in this respect have been exaggerated. While 1.5 to 2.5 per cent. of manganese is nearly universally admitted to cause brittleness, steel with 8 per cent. of manganese is astonishingly ductile; with further increase of manganese the ductility again diminishes. Steel with 8 to 10 per cent. manganese, though extremely tough, is so hard as to be employed without quenching for cutting tools. It is denied and asserted with equal positiveness that manganese confers the power to become harder when suddenly cooled, but it is generally thought to make steel crack when quenched."

Relative to the effect of small quantities of manganese, such as are given by the use of low manganiferous iron ores in the blast furnace, a gentleman who has had large experience has furnished a statement which is copied, as follows:

(a) *In Bessemer pig iron.*—Manganese present in the proportion of 1 to 1.50 per cent. prevents the oxidation of iron "during the blow"; it prevents the absorption of much oxygen in the bath of steel, and insures more solid steel with fewer blowholes and less oxygen in the final product, which is most important to prevent cracks or flaws in the rolling or hammering of the steel. The best steel made has generally been obtained with manganiferous pig; indeed, in the "basic process" of making steel, it is absolutely necessary to have manganese in the pig to produce steel; without it the product would be worthless—red short and full of sponge.

(b) *In foundry pig.*—The presence of manganese is valuable to insure sound castings. By its fluidity and its power of retaining carbon in the combined state it obliterates the faults of iron too rich in graphite. Pig iron containing from 1 to 2 per cent. of manganese will make strong and clean castings. As manganiferous pigs are high in carbon it will be advantageous to use manganese as a mixture with foundry pigs which are of poor quality and low in carbon.

(*c*) *For mills or puddling purposes.*—The presence of manganese in right proportions is valuable in various ways. During the process of puddling it insures a more complete purification from sulphur. Manganese, during the process of "boiling," protects the carbon from total oxidation, leaving some carbon in the final product of muck bar, making what is termed fine-grained or steely wrought iron. Without manganese in the mill-pig, the fine-grained iron is more difficult to obtain and uncertain. The presence of oxide of manganese in the puddling cinder will make it fluid and thin, preventing by its fluidity an excess of cinder being interposed in the muck bar.

(*d*) *For chilled castings, car-wheels, etc.*—The presence of a small proportion of manganese gives it a hard and deep chill, without impairing its tenacity.

(*e*) Manganese ores have been lately used with good results as an ore for "fix" in the puddling furnaces.

(*f*) *In the blast furnace.*—Manganiferous ores in the blast furnace will, by the peculiar quality of the slag formed, which is most always very fluid and thin, prevent the formation on the bosh walls of furnaces of uneven agglomeration, which is so detrimental to even and regular working. The proportion of oxide of manganese which is taken up by the slag will make it more fusible, which is of the greatest benefit where aluminous ores are used, as well as when rich ores are smelting, which invariably give a slag too high in alumina.

HADFIELD'S MANGANESE STEEL.

Reference has been made in previous volumes of the "Mineral Resources of the United States" to the production of steel containing from 7 to 30 per cent. of manganese. This steel is the invention of Mr. Robert Hadfield, of Hadfield's Steel Foundry Company, Sheffield, England, and has been made in this country in an experimental way, the only establishment producing it in any quantities being Messrs. Miller, Metcalf & Parkin, Pittsburgh.

The general characteristics of this steel were fully set forth in the article on manganese in "Mineral Resources of the United States," 1883–1884. Briefly stated, Mr. Hadfield's discovery is that when manganese is introduced into steel in the proportion of from 7 to 30 per cent., instead of imparting brittleness, as manganese in the proportion of from 1 to nearly 7 per cent. does, the steel becomes remarkably strong and ductile, its ductility and toughness being increased by heating it to a yellow or white heat and plunging in water. Indeed, in many of its properties and in the results of certain manipulations it displayed properties entirely contrary to those of ordinary carbon steel. The steel is practically non-magnetic. It has great toughness combined with great hardness, while in carbon steel a very hard steel is usually brittle. Heating and plunging in water softens and toughens it, instead of hardening and reducing its ductility. Some recent experiments, the details of which have not been ascertained, show in a remarkable manner the effects of heating the steel and plunging it into water. A rolled wire which showed as it came from the rolls without any treatment over 200,000 pounds tensile strength, with but ¾ per cent. elongation, showed when heated to a yellow heat and plunged in water from 140,000 to 170,000 pounds tensile strength, with from 38 to 42 per cent. elongation in 8 inches.

The result of a series of tests made at the Woolwich Arsenal, England, gave results as shown in the following table, the report being signed by J. F. Barnaby, Admiralty overseer:

Test of Hadfield's manganese steel, made at the Woolwich Arsenal, England, August 5, 1886.

Number of sample.	Size of sample.		Breaking strain.	Breaking strain per square inch.	Elongation in 8 inches.
	Diameter.	Area.			
	Inches.	*Sq.in.*	*Tons.*	*Tons.*	*Per cent.*
1	.755	.447	22.232	49.736	25.0
2	.745	.435	21.294	48.951	25.78
3	.75	.441	21.607	48.995	23.42
4	.74	.43	22.008	51.181	26.56
5	.75	.441	22.098	50.108	26.56
6	.745	.435	20.00	45.977	22.0
7	.74	.43	21.651	50.351	24.21
8	.76	.453	22.232	49.077	24.21
9	.74	.43	21.696	50.455	26.56
10	.75	.441	23.437	53.145	28.90
11	.745	.435	21.964	50.491	25.78
12	.755	.447	21.25	47.539	22.2

Temperature of test-house, 68° Fahrenheit.

The test pieces had been heated to a white heat and plunged into cold water prior to being put into the machine.

The analysis of the steel was as follows:

Analysis of Hadfield's manganese steel.

	Per cent.
Carbon	.72
Silicon	.37
Sulphur	.06
Phosphorus	.08
Manganese	9.83

At a meeting of the Royal Dublin Society, on December 15, 1886, Professor Barrett, of the Royal College of Science, read a paper on the physical properties of this steel, the sample experimented with being a No. 19 wire, 0.98 millimeter in diameter.

The electric conductivity was found to be very low. The No. 19 wire had a resistance of an ohm per meter, the specific resistance in C.-G.-S. units being 77,000 for 1 cubic centimeter; ordinary iron wire is only 9,800, and German silver 21,170; so that a use might be made of manganese steel for resistance coils in electric lighting. The magnetic character of this steel was then carefully tested by Professor Barrett. Mr. Bottomley found the intensity of magnetization of this steel, after submitting it to the most powerful magnetizing force, was 2.55 in C.-G.-S. units, or the magnetization per gram was 0.013 in C.-G.-S. Ordinary steel gives a number varying from 40 to 90, and even 100, C.-G.-S. units per gram. So that if ordinary steel of average quality be 100,000, manganese steel is 20. This represents the permanent magnetism. Professor Barrett, by different methods, has determined the susceptibility, that is, the induced magnetization, in a uniform field. Compared with iron as 100,000, manganese steel was found to be 300. In fact, it is very wonderful to find no sensible attraction exerted on this steel by the most powerful magnetic field that could be obtained.

Dr. Hopkinson's experiments on the magnetic susceptibility of manganese steel were referred to by Professor Barrett, who mentioned that he had only seen them after his paper had been written. Though Dr. Hopkinson's method of experiment was wholly different, his result is fairly in accordance with the numbers obtained by Professor Barrett for the ratio of iron to manganese steel.

Professor Barrett determined the tenacity of the manganese steel wire. The hard wire had the extraordinary tenacity of 110 tons per square inch, or 164.5 kilograms per square millimeter, a figure confirmed by independent tests which the chief engineer of the Great Southern and Western Railway Works (Mr. Ivatt) had kindly made for Professor Barrett. Ordinary steel is only 99 kilograms per square millimeter, pianoforte steel wire alone showing a higher tenacity. The soft manganese steel wire had a tenacity of only 48 tons per square inch with an elongation of nearly 20 per cent. The modulus of elasticity was also determined by direct stretching. It was even lower than wrought iron, the mean number for the hard manganese wire being 16,800 kilograms per square millimeter, the soft manganese wire having a still lower modulus. The modulus for ordinary steel wire is 18,810, and for iron wire 18,610; so that though hard manganese steel has an enormous tenacity, it "gives" more than steel under sudden stress, of course recovering itself if the limits of elasticity are not passed, a property most useful for certain purposes.

TIN.

The efforts to produce tin in the United States, particularly from the cassiterite in the Black Hills of Dakota, which have been mentioned in former reports, are being continued. The results accomplished since the last report have been in the direction indicated, viz., exploration of the whole territory within which it is probable that cassiterite may be found, and examination of localities which appear more likely than others to yield paying quantities of ore. Beyond the accumulation of some piles of ore awaiting examination by concentration the region cannot be said to have produced any tin during 1886, except specimen bars.

In the list of useful minerals in Alabama contained in "Mineral Resources of the United States, 1882," cassiterite is stated to occur near Ashland, Clay county. Mr. Henry J. Biddle visited this locality lately and could find no evidence of the occurrence of tin ore. Prof. Eugene A. Smith, State geologist of Alabama, states that specimens of the supposed tin ore analyzed by him proved to be mostly menaccanite and rutile, with no trace of tin. Metallic buttons collected from the slag of the tin furnace erected at the mine were found to be chiefly metallic iron with no tin. The work upon the tin deposits in Virginia is at a standstill owing to litigation. A small piece of metallic tin was received by the United States Geological Survey, said to have been obtained from cassiterite found in the Great American lode located near Rosita, in Custer county, Colorado. The only new locality where tin has been found since the publication of the full list of tin localities in "Mineral Resources of the United States, 1883 and 1884," is in the Dutch East Indian possessions. Early in 1886, some fine specimens of stream tin ore (cassiterite) were collected in the interior of the Lampong districts, Sumatra, near the Palembang frontier. As this is an entirely new occurrence, a government mining engineer has been commissioned to collect full particulars of the deposit.

Production.—The relative production of the important districts of the world is shown in the following table, compiled from figures furnished by Messrs. Vivian, Younger and Bond, London:

Production of leading tin districts from 1880 *to* 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Total exports from Singapore and Penang:							
To Great Britain, Europe, and America	11, 908	11, 216	12, 104	17, 145	17, 547	17, 182	19, 600
To India and China	2, 855	3, 519	3, 870	4, 161	4, 920	3, 887	4, 025
	14, 763	14, 735	15, 974	21, 306	22, 467	21, 069	23, 625
Total exports from Australia to Europe and America	9, 100	10, 200	10, 300	10, 500	8, 800	8, 500	7, 375
Total production in the United Kingdom	8, 918	8, 615	9, 158	9, 307	9, 574	(*a*)9, 000	9, 000
Totals	32, 781	33, 550	35, 432	41, 113	40, 841	38, 569	40, 000
Total visible supply December 31	22, 248	19, 241	17, 924	19, 263	16, 774	16, 116	12, 000

a Estimated.

Imports and exports.—The imports of tin during the fiscal year ending June 30, 1886, showed a marked increase; the total quantity in blocks, bars, and grain tin being 27,960,761 pounds.

The importation of tin plates increased also; the total quantity entered for consumption during the fiscal year being 574,098,405 pounds. The following table gives the imports and exports in past years:

Tin imported and entered for consumption in the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	In blocks, bars, or pigs, and grain tin.		In plates, sheets, etc.		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Cwts.		*Cwts.*		
1867	....	$1, 210, 354. 02	....	$6, 276, 136. 78	$7, 486, 490. 80
1868	....	1, 454, 327. 36	....	6, 893, 072. 07	8, 347, 399. 43
1869	80, 811	1, 709, 385. 00	1, 534, 324	8, 565, 432. 56	10, 274, 817. 56
1870	81, 702	2, 042, 887. 71	1, 333, 150	7, 628, 871. 51	9, 671, 759. 22
1871	106, 595	2, 938, 409. 82	1, 556, 023	9, 490, 778. 64	12, 429, 188. 46
1872	102, 006	3, 033, 837. 45	1, 617, 627	10, 736, 906. 59	13, 770, 744. 04
1873	130, 469	3, 938, 032. 25	1, 854, 956	15, 906, 446. 82	19, 844, 479. 07
1874	116, 442	3, 199, 807. 07	1, 553, 860	13, 322, 976. 14	16, 522, 783. 21
1875	102, 904	2, 329, 487. 96	1, 540, 600	12, 557, 630. 75	14, 887, 118. 71
1876	93, 176	1, 816, 506. 00	1, 767, 210	10, 226, 802. 87	12, 043, 308. 87
1877	98, 209	1, 783, 763. 00	1, 984, 893	9, 818, 069. 69	11, 601, 834. 69
1878	128, 849	2, 167, 350. 00	2, 166, 489	9, 893, 639. 61	12, 060, 989. 61
1879	142, 927	2, 301, 944. 00	2, 487, 007	10, 248, 720. 34	12, 550, 664. 34
1880	290, 007	6, 153, 005. 68	3, 298, 534	16, 524, 590. 19	22, 677, 595. 87
1881	171, 146	3, 971, 756. 67	3, 366, 720	14, 641, 057. 87	18, 612, 814. 54
1882	197, 544	5, 204, 251. 68	3, 926, 311	16, 550, 834. 64	21, 755, 086. 32
1883	237, 348	6, 106, 250. 37	4, 051, 108	16, 688, 276. 67	22, 794, 527. 04
1884	(*a*)26, 031, 992	5, 429, 184. 01	(*a*)527, 881, 321	18, 931, 072. 70	24, 360, 256. 71
1885	23, 947, 523	4, 263, 447. 00	505, 559, 076	16, 610, 104. 56	20, 873, 552. 00
1886	27, 960, 761	5, 873, 773. 00	574, 098, 405	17, 719, 957. 12	23, 593, 730. 12

a Pounds in 1884, 1885, and 1886.

Oxide of tin imported and entered for consumption in the United States, 1869 *to* 1883 *inclusive.* (*a*)

Fiscal years ending June 30—	Value.	Fiscal years ending June 30—	Value.
1869	$1, 524	1877	$1, 886
1870	2, 958	1878	929
1871	3, 061	1879	2, 138
1872	18, 414	1880	2, 849
1873	1, 475	1881	2, 510
1874	4, 962	1882	920
1875	14, 838	1883	4
1876	3, 484		

a Not enumerated in 1884, 1885, and 1886.

Value of tin manufactures exported from the United States. (*a*)

Fiscal years ending September 30, until 1843, and June 30 since.	Value.	Fiscal years ending June 30—	Value.	Fiscal years ending June 30—	Value.
1826	$4, 515	1847	$6, 363	1868	$27, 110
1827	2, 967	1848	12, 353	1869	18, 994
1828	5, 049	1849	13, 143	1870	46, 007
1829	1, 757	1850	13, 590	1871	70, 366
1830	4, 497	1851	27, 823	1872	67, 241
1831	3, 909	1852	23, 420	1873	69, 865
1832	3, 157	1853	22, 988	1874	62, 973
1833	2, 928	1854	30, 698	1875	48, 194
1834	2, 230	1855	14, 279	1876	48, 144
1835	2, 545	1856	13, 610	1877	87, 057
1836	5, 604	1857	5, 622	1878	116, 274
1837	10, 892	1858	24, 186	1879	103, 467
1838	10, 179	1859	39, 289	1880	144, 185
1839	19, 981	1860	39, 064	1881	498, 524
1840	7, 501	1861	30, 229	1882	198, 608
1841	3, 751	1862	62, 286	1883	191, 947
1842	5, 682	1863	41, 558	1884	166, 819
1843 (nine months)	5, 026	1864	46, 968	1885	162, 304
1844	6, 421	1865	106, 244	1886	157, 724
1845	10, 114	1866	79, 461		
1846	8, 902	1867	40, 642		

a Classed as "tin, and manufactures of," from 1851.

Prices.—During 1886 the prices of tin have been higher than in 1885, and subject to smaller fluctuations. The extreme prices for Straits tin in New York were 20.45 to 23.25 cents per pound in 1886, as compared with 16.10 to 23.5 cents per pound in 1885 and 16.10 to 19.75 cents in 1884. The demand for tin was light until spring, and during the first part of the year the price was only sustained by light stocks and firm prices in London. During nearly all of the rest of the year the consumption was above the average and kept prices fully up to the advance abroad. Possibly the low price of copper has had the effect of increasing the demand for tin for making bronze. The following list shows the prices of the ruling quality of tin in New York:

Opening, highest, lowest, and closing prices of Straits tin at New York in each month of the last three years.

Months.	1886.				1885.				1884.			
	Opening.	Highest.	Lowest.	Closing.	Opening.	Highest.	Lowest.	Closing.	Opening.	Highest.	Lowest.	Closing.
	Cts.	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
January	20. 80	20. 80	20. 45	20½	16¼	17¼	16. 10	17⅛	19	19¼	17. 90	18½
February	20½	20⅞	20½	20. 90	17⅜	17⅝	17¼	17⅝	18⅜	18⅜	17¾	17⅞
March	20. 90	20. 85	20. 70	20. 95	17⅝	17. 80	16. 95	17. 70	17¾	18⅝	17⅝	18½
April	20. 95	21	20. 65	21	17⅝	18¼	17⅜	18. 20	18½	19¼	18½	19¼
May	21	21¾	20. 85	21¾	18	19¼	18	19¼	19⅜	19⅜	18. ⅝	18¾
June	21¾	23¼	21¾	22. 90	19¼	21½	19¼	21⅜	18¾	19¾	18. 55	18¾
July	22. 80	22. 80	21¾	21¾	21¼	23½	21¼	22	18¾	18⅞	18. 70	18¾
August	21. 70	21. 80	21. 70	21. 80	22	22	20½	20⅞	18¾	19⅜	18. 15	18. 15
September	21. 80	22. 65	21. 70	22½	20¾	21⅛	20¾	20. 80	18⅛	18. 20	18. 95	18
October	22½	22. 60	21. 90	22⅜	20. 70	20. 70	21¼	20½	17¾	17¾	16¼	16⅝
November	22⅜	22. 65	22. 17½	22¾	20½	21¼	20. 05	21⅛	16⅝	16⅞	16½	16½
December	22¾	22¾	21¾	22	21⅛	21½	20. 55	20. 80	16½	16½	16. 10	16⅜

Average prices realized at the Banca and Billiton sales in the last three years.

[Taken from the annual number of the *American Metal Market.*]

Months.	Banca.			Billiton.		
	1886.	1885.	1884.	1886.	1885.	1884.
	Florins.	*Florins.*	*Florins.*	*Florins.*	*Florins.*	*Florins.*
January	55½	48½	51⅜			
February				64⅛	54.30	55.34
March	56¼	48¼	52⅜			
April				64	54¼	58½
May	58	52½	53⅛			
June				71	60¼	56.22
July	60	55½	51⅛			
August				59½	60.30	55¾
September	61¾	55½	49¾			
October				60¾	61¾	49¾
November	61⅜	56¾	46½			
December				60⅝	63¾	50.13

TUNGSTEN.

This substance is usually imported under the name "wolfram," its German name, and thus no distinction is made between the metal and the mineral wolfram, which is a tungstate of iron and manganese, and is the ordinary substance from which the metal tungsten is derived.

The use of tungsten as an addition to steel is increasing in this country. It is a constituent of some particularly tough and hard varieties of steel made by firms in Philadelphia, New York, and Pittsburg. This use is the result of long and tedious experiments in all these places. While wolfram and other ores of tungsten are known to occur in the United States, the supply is practically all imported.

Dr. G. Heppe, of Lindenau, Germany, has published a number of articles upon the use of tungsten for improving the quality of steel. He is of the opinion that the varying results obtained in the manufacture of steel containing tungsten are due to impurities, such as sulphur, phosphorus, and arsenic in the crude metallic tungsten used. To obviate this there is an establishment in Roswein, Saxony, where nothing but very pure tungsten and preparations from it are made. Metallic tungsten 98 per cent. pure has been made at this place. When definite percentages of this are added to steel or to iron, with precautions to prevent oxidation of the tungsten, it is claimed that much improvement in the quality results. In order to produce cast iron of great hardness ½ to 1½ per cent. of tungsten is added. For bar iron 1 to 2 per cent., but not exceeding 2½ per cent. It is claimed that the resistance to demagnetization in steel magnets is increased by the hardening effect of tungsten. For puddled steel the range is larger, but an addition beyond 3½ per cent. only increases the hardness, so that it is brought up to only 1½ per cent. for special tools, coinage dies, drills, etc. It has been shown repeatedly that good tungsten steel can also be produced in the Bessemer converter; the drawback has been that a part of the tungsten is burned, and its consumption, therefore, is greater than in the case of crucible steel; but it has been successfully tried to carry all of the tungsten added to pig iron in a cupola. Pure tungsten is a powder, and therefore a great part of it would be blown out of a cupola if in that form; the metal is mixed with one part of slaked lime, perfectly dry, and enough hot tar to make small bricks. A layer of coke is put on the bottom of the cupola, followed by a layer of these bricks, covered with some coke, and then a charge of pig iron with lime as a flux; following in regular order are charges of coke, bricks, pig iron, etc., until the furnace is full. After the iron is melted it must be well stirred and kept hot for half an hour.

Tungsten steel must be tempered and annealed like other hard cast steel, but the manufacturers recommend that the metal need only be heated just to the degree required for forging and not to a higher degree than is precisely necessary to give the requisite and fitting form to the cutting edge. In tempering or hardening only the cutting edge is to be heated and dipped into lukewarm water; otherwise fissures, longitudinal veins, or cracks will afterwards be found in the steel. The various degrees of tempering or annealing must be effected at various degrees of heat from very light to deep yellow, according to the hardness of the material to be worked.

In addition to the establishment at Roswein, Saxony, referred to above, Biermann's "Metall-Industrie" in Hanover, Germany, makes metallic tungsten of two qualities, one containing 92 to 94 per cent. pure tungsten, the other 95 to 98 per cent. The firm also makes ferro-tungsten in four grades, containing from 20 to 52 per cent. of tungsten. The source of this tungsten is the wolfram mine in Puy-les-Vignes, Saint Leonard, near Limoges, France.

ALUMINUM.

By R. L. Packard.

The report on the "Mineral Resources of the United States" for 1883 and 1884 contained a summary of the Deville method of extracting aluminum, and a description of a modification of that process patented in this country by Col. William Frishmuth, of Philadelphia. It appeared from the replies of dealers and metal-workers that aluminum of domestic production was used by them that year, and a small quantity was produced in 1885. The replies covering the year 1886 show that little, if any, aluminum of domestic production was in the market that year, the imported article being employed instead. Colonel Frishmuth states that he extracted over 4,000 ounces during the year; but as nearly the whole amount was employed for his own use that figure cannot be taken into account in forming an estimate of production for public sale. It is a reasonable conclusion, therefore, that the production of aluminum has not yet become a commercial success in this country. The newspapers and trade journals have spoken from time to time of proposed new methods of extracting aluminum, but, so far as can be learned, no material improvement in that respect was made public in 1886.

The same general character marks the uses to which aluminum was put in 1886 as in previous years. Advantage was taken of the lightness, strength, and resistance to tarnish of the metal, in the manufacture of leaf, small weights, dental plates, surgical instruments, optical, electrical, and scientific instruments of various kinds, and for like uses. Its use was reported as extending for those purposes, but its price and limited production have prevented its employment in any large way, even supposing its suitability in other respects were assured.

It is said that a new use for aluminum has been discovered, which consists in adding small quantities of it to wrought iron. It is stated that by the addition of one-quarter of 1 per cent. of aluminum the tensile strength of puddled iron is increased one-half and the iron is improved in other respects. No report of tests in confirmation of this statement has been received. This use of aluminum recalls its employment in making "Mitis" castings mentioned in the report for 1885.

The price of aluminum ranged from 90 cents to $1.20 in 1886.

The report for 1885 noticed the manufacture of aluminum bronze and other alloys of aluminum by the "Cowles Electric Smelting and Aluminum Company." This manufacture has increased to such an extent that it may be regarded as an established and growing industry. It is attracting attention in this country and abroad among persons likely to be concerned in its results. In 1886 the Cowles company manufactured 50,000 pounds of aluminum bronze containing 10 per cent. aluminum and 90 per cent. copper, the price of which was 40 cents per pound. The great tensile strength of this alloy was alluded to in the last report. The bronze was used for ordnance supplies, castings, incandescent gas burners, vapor-stove burners, for purposes where non-corrodible metal is required, and for incorporating with other metals to form alloys. Its use was recommended for a great variety of things—cannon, armor-plates, propellers, bells, and other large articles and various parts of machinery, and for all kinds of small articles.

The Cowles company also turned out from 2,000 to 3,000 pounds of the iron-aluminum alloy, containing from 6 to 8 per cent. of aluminum for mixing with steel castings, and wrought and cast iron.

The price of this alloy was at the rate of $5 per pound of the aluminum contained in it.

The statistics of the American manufacture of aluminum since 1883 are as follows:

Production and value of American aluminum, 1883 *to* 1886 *inclusive.*

Years.	Ounces.	Value.
1883	1,000	$750
1884	1,800	1,350
1885	3,400	2,550
1886	(a)	....

a No pure aluminum sold in 1886.

Aluminum imported and entered for consumption in the United States, 1870 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Quantity.	Value.	Fiscal years ending June 30—	Quantity.	Value.
	Pounds.			*Pounds.*	
1870	....	$98	1879	284.44	$3,423
1871	....	341	1880	340.75	4,042
1873	2	2	1881	517.10	6,071
1874	683	2,125	1882	566.50	6,459
1875	434	1,355	1883	426.25	5,079
1876	139	1,412	1884	595.00	8,416
1877	131	1,551	1885	439.00	4,736
1878	251	2,978	1886	464.50	5,297

The amount of aluminum bronze manufactured in 1885 is stated at from 4,000 to 5,000 pounds, which, at 40 cents, would be worth $1,600 to $2,000.

The amount produced in 1886 was 50,000 pounds, value $20,000. The iron-aluminum alloy, containing 6 to 8 per cent. aluminum and amounting, according to the statement of the Cowles company, to 2,000 or 3,000 pounds, would be worth, at the higher estimate, $1,200, reckoning the contained aluminum at $5 per pound.

PLATINUM AND IRIDIUM.

About 50 ounces of platinum were saved from placer gold mines in Oregon and sold for $100. The demand for crude grains of platinum has not been great in past years, owing to the facility with which sheet and ingot platinum and wire and foil can be imported. The source of this imported platinum is Russia, whence the crude grains are shipped to England to be manufactured into sheets, ingots, foil, wire, and various platinum utensils; this manufacture of platinum from crude Russian material sustains a large industry, principally in the hands of the firm of Johnson & Mathey, London. Recently, however, a successful effort was made to introduce the manufacture of wire in this country by Mr. John Entriken, Messrs. Baker & Co., Newark, New Jersey, and by the Wilmington Dental Manufacturing Company. Platinum has been obtained in the crude state from Russia. In this form it is from 70 to 80 per cent. pure. It is then refined and made into wire, of which about 20,000 ounces are annually consumed in this country for the manufacture of artificial teeth. This new attempt to use crude grains for manufacturing platinum wares has aroused considerable inquiry for crude platinum in this country, and it is probable that the production in 1887 will show a marked increase, since the manufacturers are willing to pay $4.50 per ounce for crude platinum containing 70 per cent. of the pure metal or a proportionate amount for poorer material.

About 300 ounces of native iridosmine for pen points, valued at $1,000, were sold during 1886 in addition to the importations.

The imports of platinum during 1886 and previous years are shown in the following table:

Platinum imported and entered for consumption in the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Manufactured.	Unmanufactured.		Vases or retorts, etc.
		Quantity.	Value.	
		Pounds.		
1867	$456			
1868	290		$95,208	$20,274
1869	184		80,014	22,004
1870	648		99,984	16,294
1871	48		108,244	22,470
1872	310		91,472	21,816
1873	43		90,771	9
1874	143		123,293	59,698
1875	173		141,188	18,082
1876	6		141,207	7,421
1877	11		81,925	18,611
1878	241		120,121	50,133
1879	73		166,178	34,209
1880	964		217,144	41,827
1881	290		273,343	21,292
1882	1,731	2,125.60	285,731	48,452
1883	4	3,104.15	298,799	92,967
1884		2,846.00	289,898	83,112
1885	3	2,612.34	285,239	17,473
1886		3,204.28	356,020	83,752

Exports.—There is a demand from England for "scrap" platinum, to which the United States contributes by exporting some worn-out utensils to be repaired and reimported. A portion of these exports also go to France. The following table gives the exports from 1880 to 1886, inclusive:

Value of platinum exports.

Fiscal years ending June 30—	Unmanufactured.	Manufactured.	Old platinum.
1880	....	....	$600
1881	....	....	4,222
1882	....	$19,244	....
1883	$6,250	21,600	....
1884	....	18,587	1,130
1885	....	....	7,000
1886	....	4,048	....

In addition to a small domestic production of iridosmine, the following amounts of iridium were imported, at a value of $20 per troy ounce, for the American Iridium Company, for uses which were described in detail in the last report:

Iridium imported and entered for consumption in the United States, 1873 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Value.
1873	$429
1874	275
1875	500
1876	180
1877	311
1878	(*a*)
1879	425
1881	1,730
1882	7,307
1883	495
1884	(*a*)
1885	5,852
1886	(*a*)

a None reported.

COAL.

By Charles A. Ashburner.

INTRODUCTION.

The statistics of production of coal in the United States for the year 1886 have been collected from various sources in the different States, the returns being made direct, with the exception of those in the State of Colorado and the Territories of Wyoming, New Mexico, and Montana, which were compiled from returns made to Mr. F. F. Chisolm at Denver. In States where the mine inspectors are charged by law with the collection of the production of the coal mines, the reports have been compiled chiefly from inspectors' returns, credit being given in each case. In States and Territories where there are no mine inspectors or where the law does not charge them with the collection of the statistics of the production of the coal mines, the reports have been compiled from statistics and information obtained from detailed reports made directly by individual coal operators and personal correspondents familiar with the coal development.

THE COAL FIELDS OF THE UNITED STATES.

The following table, which differs in some essential features from those previously published, gives a classification of the coal fields in which coal beds have been mined, or where beds are known to exist, which could be profitably mined for local or distant consumption; it also gives an estimate of the approximate area of each field, and the total amount of coal produced during 1886:

Classification of the coal fields of the United States.

	Area.	Production in 1886.
Anthracite.	*Square miles.*	*Short tons.*
New England (Rhode Island and Massachusetts)	500	....
Pennsylvania	470	36,696,475
Colorado	....	....
	970	36,696,475
Bituminous.(a)		
Triassic:		
Virginia	....	....
North Carolina	....	....
Appalachian:		
Pennsylvania	9,000	26,160,735
Ohio	10,000	8,435,211

a Including lignite, brown coal, and scattering lots of anthracite.

Classification of the coal fields of the United States—Continued.

	Area.	Production in 1886.
Bituminous (a)—Continued.		
Appalachian—Continued.	*Square miles.*	*Short tons.*
Maryland	550	2, 517, 577
Virginia	185	684, 951
West Virginia	16, 000	4, 005, 796
Kentucky	9, 000	644, 962
Tennessee	5, 100	1, 714, 290
Georgia	200	223, 000
Alabama	8, 660	1, 800, 000
	58, 695	46, 186, 522
Northern:		
Michigan	6, 700	60, 434
Central:		
Indiana	6, 450	3, 000, 000
Kentucky	4, 000	905, 038
Illinois	36, 800	9, 246, 435
	47, 250	13, 151, 473
Western:		
Iowa	18, 000	4, 312, 921
Missouri	26, 887	1, 800, 000
Nebraska	3, 000	....
Kansas	17, 000	1, 400, 000
Arkansas	9, 043	125, 000
Indian Territory	....	534, 580
Texas	4, 500	100, 000
		8, 272, 501
Rocky mountains, etc.:		
Dakota	....	25, 955
Montana	....	49, 846
Idaho	....	1, 500
Wyoming	....	829, 355
Utah	....	200, 000
Colorado	....	1, 368, 338
New Mexico	....	271, 285
		2, 746, 279
Pacific coast:		
Washington	....	423, 525
Oregon	....	45, 000
California	....	100, 000
		568, 525
Total production sold	....	107, 682, 209
Colliery consumption	....	5, 061, 194
Total production, including colliery consumption	....	112, 743, 403

a Including lignite, brown coal, and scattering lots of anthracite.

The anthracite division, in a commercial sense, may be said to embrace Pennsylvania alone, although a small amount of anthracite coal is mined in Nebraska and Colorado.

The original coal beds in the New England basin have been metamorphosed into graphite and graphitic coal, and some of them have been mined and the product sold as anthracite coal. This area is confined to eastern Rhode Island and the counties of Bristol and Plymouth, in Massachusetts. The coal beds of this area might more properly be called graphite than coal. The graphitic character of the beds has resulted from the metamorphic action which the beds and their associated strata have undergone. This action has expelled all of the volatile matter originally contained in the coal and the bulk of the carbon has been converted into graphite. The product mined from the beds requires a considerable degree of heat for combustion, and it can only be used with other combustible material or under an intense draft or blast. The principal use which is made of the graphite at the present time is in the reduction of high-grade iron ores to a metallic sponge for the direct manufacture of steel. This is being done by the Carbon Iron Company of New York, at their works in Pittsburgh, 30 per cent. of graphite being used with pulverized iron ore. The company's principal mine is about 2½ miles from Narragansett Pier, on the Harrison farm, situated on Sockanossett hill, in Kingston township. The bed varies from 10 to 35 feet in thickness, has a black slate roof, and dips 15° in a southeast direction.

A bed has been found on Prudence island which dips toward the northwest. At Valley Falls a shaft was sunk to a depth of 750 feet, which passed through alternate layers of black slate, true graphite, and graphitic coal.

The outcrop of a bed is reported on Cumberland hill in the northeastern corner of the State. These beds are mined to a considerable extent for use in the manufacture of stove facings. During 1886 there were probably between 3,000 and 4,000 tons mined for the above purposes.

The anthracite coal fields of Pennsylvania are confined to the following counties, in the northeastern part of the State: Carbon, Columbia, Dauphin, Lackawanna, Luzerne, Northumberland, Schuylkill, Sullivan, and Susquehanna. Of these counties, Lackawanna, Luzerne, and Schuylkill produced during 1886 over 86 per cent. of the entire product. The production in Schuylkill and Lackawanna counties was nearly equal, while Luzerne produced 43 per cent. of the total amount of anthracite mined in the State.

The Pennsylvania anthracite region is grouped into five principal divisions, as follows:

(1) Southern or Pottsville field, extending from the Lehigh river, at Mauch Chunk, southwest to within a few miles of the Susquehanna river, directly north of Harrisburg, and embraced by Carbon, Schuylkill, and Dauphin counties. The eastern end of this field, known as the Lower Lehigh or Panther Creek basin, between Tamaqua, on the Little Schuylkill river, and Mauch Chunk, on the Lehigh river, has generally been included by the coal trade in the Lehigh field, from the fact that its coals resemble more closely the coals obtained in the Upper Lehigh region than those in the Pottsville field west of Tamaqua, and since the shipments to market have almost entirely been made through the Lehigh valley. Production in 1886, 3,427,435 long tons.

(2) Western Middle or Mahanoy and Shamokin field, lying between the easternmost headwaters of the Little Schuylkill river and the Susquehanna river and within Schuylkill, Columbia, and Northumberland counties. Production in 1886, 8,122,639 long tons.

These two coal fields (1 and 2) are frequently designated in a general way as the Schuylkill region, although parts of them are better known to the trade by names defining districts from which coals of special characteristics are mined.

(3) Eastern Middle or Upper Lehigh field, lying between the Lehigh river and Catawissa creek and principally in Luzerne county, with limited areas extending into Carbon, Schuylkill, and Columbia counties. Production in 1886, 4,993,361 long tons.

(4) Northern or Wyoming and Lackawanna field lies in the two valleys from which it derives its geographical name, and is embraced almost entirely by Luzerne and Lackawanna counties. A small area in the extreme northeastern end of the field extends into Wayne and Susquehanna counties. Production in 1886, 18,247,875 long tons.

(5) Loyalsock and Mehoopany field lies within the area drained by the headwaters of the Loyalsock and Mehoopany creeks, and is contained in Sullivan and Wyoming counties. This field is from 20 to 25 miles northwest of the western end of the Northern field. Its geological structure resembles more closely that of the bituminous field, in which it has until recently been included, although the composition of many of its coals entitles them to rank with a number from the anthracite region. Production in 1886, 61,767 long tons.

The area of the entire region is about 1,700 square miles. The area underlaid by workable coal beds is only about 470 square miles. The natural geological and topographical boundaries of this area are formed by the mountains and ridges made by the Pocono Sandstone No. X.; no workable coal beds have been found stratigraphically below the Pottsville Conglomerate No. XII.; the Lykens Valley, or lowest anthracite beds being found in the latter formation. The greatest length of the region, from the northeastern end of the Northern field to the southwestern end of the Southern field, is about 115 miles, while the greatest width of the belt, containing the first four fields, is about 40 miles, between Mauch Chunk and Shickshinny, near the western end of the Northern field.

The bituminous areas of the United States, for convenience, are grouped into the (1) Triassic, (2) Appalachian, (3) Northern, (4) Central, (5) Western, (6) Rocky Mountain, and (7) Pacific Coast.

(1) What is known as the eastern Triassic area is composed principally of the Richmond basin and the Deep River and Dan River fields in North Carolina. The first coal systematically mined in the United States was taken from the Richmond basin. In 1822 about 48,214 tons of coal were produced, which was twelve times the total amount of coal shipped during that year from the Pennsylvania anthracite region. The maximum production of the field was in 1833, when 142,587 tons of coal were shipped. This was nearly one-third the total amount of Pennsylvania anthracite shipped during the same year. Mining in this field has gradually declined during the past two or three years, and no extensive mining operations are now carried on. A number of workable beds have been found in North Carolina, which have been worked at different

times, principally to supply local demands. Special reference was made to the latter district in the 1885 report.

(2) The Appalachian field lies immediately west of the eastern frontier of the Appalachian mountains, and extends from the State of New York on the north to the State of Alabama on the south. Its length is a little over 900 miles in a northeast and southwest direction, and its width varies from 30 to 180 miles. It covers western Pennsylvania, southeastern Ohio, the western part of Maryland, nearly all of West Virginia, the eastern part of Kentucky, a portion of eastern Tennessee, the extreme northwestern corner of Georgia, and the northern part of Alabama.

All of the coals in this field are bituminous, and they are of great variety both in chemical composition and physical structure. Although it is difficult to make any general comparisons, the best and most productive coal beds lie probably in the Pittsburgh district and in West Virginia. Some of the best coals in the district are mined in basins detached from the main body of the field, such as the Blossburg and Broad Top basins in Pennsylvania and the Cumberland in Maryland. The thickness of the Coal Measures in the different sections of the productive fields varies from 100 feet to over 3,000 feet. The Appalachian district during 1886 produced 46,186,522 short tons of coal.

(3) The Northern bituminous area is confined exclusively to the State of Michigan, spreading over the central part of that State. Although a number of coal beds are found within the area of this field, which has been computed to be 6,700 square miles, the coal is much inferior to that which can be obtained in the adjoining fields. Mining has been carried on in this district principally for the supply of fuel to the local trade. The numerous transportation routes, both by water and rail, to the more distant fields containing better coal has militated against the development of the Michigan coal basin. The production of this field during 1886 was 60,434 short tons.

(4) The Central field includes the coal areas of Indiana, Illinois, and Kentucky. On account of Illinois containing the most important part of the field it is frequently simply called the Illinois field. That portion of the field in Illinois is over five times as great as that in Indiana and over nine times as great as that in western Kentucky. This field produced during 1886, 13,151,473 short tons.

(5) The Western field embraces those coal fields west of the Mississippi river, south of the forty-third parallel, and east of the Rocky mountains. It is embraced within the States of Iowa, Missouri, Nebraska, Kansas, Arkansas, Texas, and the Indian Territory. The most extensive mining operations in this field are carried on in the States of Iowa and Missouri. The best coal which has so far been mined in the field is that from the Indian Territory.

The area of this field is greater than any other one coal field in the United States. The coals are of great variety, and the region under which they lie is a rich agricultural country. The demand for local fuels must necessarily increase from year to year, so that even poor coal beds within this region will no doubt be extensively developed to supply local demands. The total production of this field during 1886 was 8,272,501 short tons.

(6) In the Rocky Mountain district coal beds are found in a number of geological formations. In the fields above referred to, with the exception of that in West Virginia and North Carolina, the coal beds belong to the Carboniferous age. The Rocky Mountain coal beds have been found in the geological formations from the Carboniferous up to and including the Cretaceous.

No detailed information of the entire coal area of the Rocky Mountain region, similar to that which has been determined by State geological surveys of the coal basins east of the Rocky Mountains, is available, and no reliable estimates have been made of the areas underlaid by workable coal beds. It has been surmised that the total area of the coal fields of this district is between 200,000 and 300,000 square miles, but this estimate is little more than a guess.

(7) In the Pacific Coast region coal has been mined in Washington Territory and in the States of Oregon and California. The area underlaid by workable coal beds has not been definitely determined, although the geological survey of California and the recent work of Prof. Raphael Pumpelly and his associates in Washington Territory have given us very reliable and detailed information in regard to the geology of the coal-bearing rocks.

PRODUCTION.

The total product of all kinds of commercial coal in 1886, exclusive of that consumed at the mines, known as colliery consumption, was 107,682,209 short tons; the spot value, or price at which it was sold at the mines, was $147,112,755. Of this amount 32,764,710 long tons (2,240 pounds), or 36,696,475 short tons, were Pennsylvania anthracite, the spot value of which was $71,558,126. All other coals, including bituminous, brown coal, lignite, and small lots of anthracite produced in Arkansas and Colorado, aggregated a total production of 70,985,734 short tons, the spot value being $75,554,629. The colliery consumption at the individual mines varies from nothing to 8 per cent. of the total product of the individual mines, being greatest at special Pennsylvania anthracite mines and lowest at those bituminous mines where the bed is nearly horizontal and where no steam-power or ventilating furnaces are employed. For the different States it varies from 3 to 6 per cent., the latter being the average in the Pennsylvania anthracite region. The total production, including colliery consumption, was: Pennsylvania anthracite, 34,853,077 long or 39,035,446 short tons; all other coals, 73,707,957 short tons, making the total absolute production of all coals in the

United States 112,743,403 short tons, valued as follows: Anthracite, $76,119,120; bituminous, $78,481,056; total, $154,600,176.

The total production of Pennsylvania anthracite, including colliery consumption, was 699,773 short tons in excess of that produced in 1885, but its value was $552,828 less. The total production of bituminous coal was 1,086,408 short tons greater than in 1885, while its value was $3,866,592 less. The total production of all kinds of coal shows a net gain of 1,785,881 short tons compared with that for 1885, but a loss in spot value of $4,419,420.

The total production, exclusive of colliery consumption, in each State and Territory, and corresponding spot values are shown in the following table:

Production of coal in the United States in 1886.

States and Territories.	Total production, not including colliery consumption.	Value of coal at mines.	States and Territories.	Total production, not including colliery consumption.	Value of coal at mines.
				Short tons.	
Pennsylvania:	*Short tons.*		Virginia	684, 951	$684, 951
Anthracite	36, 696, 475	$71, 558, 126	Indian Territory	534, 580	855, 328
Bituminous	26, 160, 735	21, 016, 235	Washington	423, 525	952, 931
Illinois	9, 246, 435	10, 263, 543	New Mexico	271, 285	813, 855
Ohio	8, 435, 211	8, 013, 450	Georgia	223, 000	334, 500
Iowa	4, 312, 921	5, 391, 151	Utah	200, 000	420, 000
West Virginia	4, 005, 796	3, 805, 506	Arkansas	125, 000	200, 000
Indiana	3, 000, 000	3, 450, 000	California	100, 000	300, 000
Maryland	2, 517, 577	2, 391, 698	Texas	100, 000	185, 000
Missouri	1, 800, 000	2, 340, 000	Michigan	60, 434	90, 651
Alabama	1, 800, 000	2, 574, 000	Montana	49, 846	174, 460
Tennessee	1, 714, 290	1, 971, 434	Oregon	45, 000	112, 500
Kentucky	1, 550, 000	1, 782, 500	Dakota	25, 955	41, 277
Kansas	1, 400, 000	1, 680, 000	Idaho	1, 500	6, 000
Colorado	1, 368, 338	3, 215, 594			
Wyoming	829, 355	2, 488, 065	Total	107, 682, 209	147, 112, 755

IMPORTS AND EXPORTS.

The following tables show the imports and exports of coal for the past twenty years, compiled from official returns of the United States Bureau of Statistics. The values which are given are much higher than the "spot" rates which have been used in computing the total annual value of the coal produced in each State and Territory.

The tariff from 1824 to 1843 was 6 cents per bushel, or $1.68 per long ton; from 1843 to 1846, $1.75 per ton; 1846, 30 per cent. ad valorem; 1847 to 1861, 24 per cent. ad valorem; 1862 to 1864, $1 per ton; 1865, $1.10 per ton; 1866 to 1872, $1.25 per ton; since August, 1872, 75 cents per ton. During the period from June, 1854, to March, 1866, the reciprocity treaty was in force, and coal from the British possessions in North America was admitted into the United States duty free.

The exports consist of both anthracite and bituminous coal, the amount of anthracite being the greater. They are made principally by rail over the international bridges and by lake and sea to the Canadian provinces. Exports are also made by sea to the West Indies, to Central and South America, and elsewhere.

The imports are principally from Australia and British Columbia to San Francisco, from Great Britain to the Atlantic and Pacific coasts, and from Nova Scotia to Atlantic coast points.

Coal of domestic production exported from the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Anthracite.		Bituminous and shale.	
	Quantity.	Value.	Quantity.	Value.
	Long tons.		*Long tons.*	
1867	192, 912	$1, 333, 457	92, 189	$512, 742
1868	192, 291	1, 082, 745	86, 367	433, 475
1869	283, 783	1, 553, 115	....	....
1870	121, 098	803, 135	106, 820	503, 223
1871	134, 571	805, 169	133, 380	564, 067
1872	259, 567	1, 375, 342	141, 311	586, 264
1873	342, 180	1, 827, 822	242, 453	1, 086, 253
1874	401, 912	2, 236, 084	361, 490	1, 587, 666
1875	316, 157	1, 791, 626	203, 189	828, 943
1876	337, 934	1, 869, 434	230, 144	850, 711
1877	418, 791	1, 891, 351	321, 665	1, 024, 711
1878	319, 477	1, 006, 843	340, 661	1, 352, 624
1879	386, 916	1, 427, 886	276, 000	891, 512
1880	392, 626	1, 362, 901	222, 634	695, 179
1881	462, 208	2, 091, 928	191, 038	739, 532
1882	553, 742	2, 589, 887	314, 320	1, 102, 898
1883	557, 813	2, 648, 033	403, 051	1, 593, 214
1884	649, 040	3, 053, 550	646, 265	1, 977, 959
1885	588, 461	2, 586, 421	683, 481	1, 989, 541
1886	682, 975	2, 707, 590	532, 846	1, 480, 940

Coal imported and entered for consumption in the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Anthracite.		Bituminous and shale.	
	Quantity.	Value.	Quantity.	Value.
	Long tons.		*Long tons.*	
1867	....	....	509, 802	$1, 412, 597
1868	....	....	394, 021	1, 250, 513
1869	....	....	437, 228	1, 222, 119
1870	....	....	415, 729	1, 103, 965
1871	973	$4, 177	430, 508	1, 121, 914
1872	390	1, 322	485, 063	1, 279, 686
1873	2, 221	10, 764	460, 028	1, 548, 208
1874	471	3, 224	492, 063	1, 937, 274
1875	138	963	436, 714	1, 791, 601
1876	1, 428	8, 560	400, 632	1, 592, 846
1877	630	2, 220	495, 816	1, 782, 941
1878	158	518	572, 846	1, 929, 660
1879	488	721	486, 501	1, 716, 209
1880	8	40	471, 818	1, 588, 312
1881	1, 207	2, 628	652, 963	1, 988, 199
1882	36	148	795, 722	2, 141, 373
1883	507	1, 172	645, 924	2, 013, 555
1884	1, 448	4, 404	748, 995	2, 494, 228
1885	4, 976	15, 848	768, 477	2, 548, 432
1886	7, 638	20, 140	774, 800	2, 492, 318

The exports of coal exceed in tonnage and value the imports. The fears entertained by many that our coal trade is generally and disastrously affected by the importations from foreign fields do not seem to be well grounded.

COAL TRADE REVIEW.

The coal trade of the United States during 1886 shows a growth in the total amount of coal handled of 1,785,881 tons, but a decrease of $4,419,420 in the total spot value, a large amount of the production of the mines being sold far below the cost of production and delivery.

The greatest increase in the production of any one district was 699,473 tons in the Pennsylvania anthracite field; the increase in the Ohio production was very nearly the same.

A notable increase in the production of individual States occurred in the Virginias, Indiana, Iowa, Tennessee, Kansas, Alabama, Pennsylvania bituminous and several other districts, while in Illinois, Missouri, Kentucky, and one or two other minor localities there has been a marked decline in the production.

Prices lower than in 1885 generally prevailed. The lowest average price per ton of the total production of any one State was that of the Pennsylvania bituminous; detailed returns of the spot value of the production from each mine show an average for the entire product of the State of 80½ cents. Although many of the mines in the State were worked at a loss to the operators, the larger part of the coal mined in western Pennsylvania was unquestionably sold at the mine for more than the actual cost of production. This statement is opposed to many currently made. Even in the face of low values the production of the Pennsylvania bituminous mines was greater in 1886 than in 1885, although the average spot value per ton was between 10 and 15 cents less. This is to be accounted for by greater economy in the mining operations and by continued improvement in the transportation facilities from western Pennsylvania, which has enabled the coal to be carried cheaply to more distant markets.

Although natural gas in western Pennsylvania displaced over 20,000 tons of coal a day during the past year, 15,000 tons being displaced daily at Pittsburgh, many of the mines, particularly those in the Pittsburgh and Westmoreland district, where the best bituminous coal in Pennsylvania is produced, show an increase in production. The falling off in the demand of the local markets has forced this coal to more distant points, to the disadvantage of coal fields in other States, in the vicinity of which consumers have been found willing to give a little better price for the superior Pittsburgh coal than for their local coals.

Great interest has been manifested in the growth of the coal trade from the Virginias. The increase in the product from Virginia over the year 1885 was 49,911 tons, and in that from West Virginia, 636,734 tons, an aggregate for the two States of 686,645 tons. The importance of Virginia coal in the trade is shown by the fact that the bituminous coal producers shipping their product to eastern Atlantic seaports were unable to form a pool controlling this trade until the Virginia companies were granted what they asked for.

In Alabama the increase in the coal product has been caused by the growth of the local demand and the better facilities for shipment to distant markets. It is impossible to state what the actual increase was on account of the unreliable character of the statistics collected and currently reported prior to 1886.

The trade along the Ohio and Mississippi rivers has been greatly affected by the decreased demand at Pittsburgh for local coals and the consequent increased shipments of Pittsburgh coal to Ohio and Mississippi river points. This is doubtless one of the causes for the decrease of the production from Kentucky, Illinois, and Missouri. The natural growth in the population in northwestern Missouri, in Kansas, and in Texas has been one of the potent reasons for the increase in the production of the Kansas and Indian Territory mines.

In the Rocky Mountain region the production of coal is dependent exclusively upon the demand of the local trade. This varies, not only on account of the growth and decline of the local industries, but upon the variable railroad tariffs which have permitted the importation to Rocky Mountain points of more distant and superior coals at prices advantageous to the consumer.

The coal trade of the Pacific coast is dependent upon more varying conditions than that in any other part of the States. The principal market along the coast is San Francisco, and the prices at which English, Welsh, Australian, Scotch, and British Columbia coals can be imported has a direct influence upon the production of the California mines, those of Coos Bay, and those in Washington Territory. The coal from distant foreign countries is frequently imported as ballast, at a nominal price, and the superior quality of the British Columbia coal from the mines at Nanaimo, which can be imported at San Francisco and compete with the Washington Territory coals in the open market even after paying the duty, must always hold the development of the domestic Pacific coast coals in check. The greatest increase in the importation of any foreign coals during three years at San Francisco has been in those from Australia. These imports during 1886 aggregated over 80,000 tons more than those in 1885 and about 100,000 tons more than those in 1884.

The Canadian Pacific railroad and the entire districts through which it passes procure their supply of coals now principally from local interior mines which are rapidly being opened. Australia will continue to supply the eastern countries and the islands of the Pacific with all the coals they may require, and England, having export freights from Chili and Peru, can send coal to these countries cheaper than they can be supplied from British Columbia, so that these circumstances will all combine to keep San Francisco the principal market for British Columbia coals. These facts will always militate against the rapid and independent development of the Pacific coast coals, particularly those in Washington Territory.

The condition of the coal trade during the first quarter of the new year goes to show that the coal trade generally throughout the United States for 1887 will be in a more prosperous condition than that for 1886.

Mr. F. E. Saward, in referring to the anthracite trade for 1886, says: "Anthracite trade conditions last year were most unsettled, and subject to wider fluctuations in price than any year since the time of the auction sales. During January, February, and March there was a larger production than in the three months in any preceding year. Late in the month of March some agreement was come to in respect of the production, and prices rallied from the low ebb to which they had fallen. During the next three months there was a constant effort on the part of the producer to bring the supply somewhat within the demand; at the same time there seemed to be a determined effort to refrain from purchasing. As a natural consequence the coal met with slow sales and a dropping of prices until the figures realized in July were as low as those during January; the lowest rates were reached in March. During the month of July and the first part of August the gradual reduction in tonnage, overcoming the excess produced in the first quarter of the year, seemed to have an effect upon buyers, and the market took a turn for the better. Prices were advanced each month up to the first of October, and since that date they have remained nominally at the figures then made. At the time of the meeting in March it was thought that the probable requirements for the year from April to April would be in round numbers some thirty-three and a half million tons. This seems more than likely to be the amount which will actually be required. The percentages of the several sizes of coal made during the year, if figures could be obtained, would show that there was a steady growth in what are termed the domestic sizes. Egg, stove, and chestnut now form the larger proportion of the entire output. There is a growing trade in anthracite coal in all the interior cities and towns of the central and western States; the amount delivered to tidewater is not nearly so large, in spite of the increased yearly tonnage, as before. As the northwest becomes settled coal is the first requisite; it must be had from the easterly States of the Union, and the increasing trade in that direction is indicated by the growth of the coal trade at Duluth, Chicago, Cincinnati, Milwaukee, Toledo, Detroit, and other centers.

"The shipment tonnage shows a total of 32,136,362 tons, an increase of some 500,000 tons over the preceding year, and of 1,400,000 tons over that of two years preceding. From this bare statement it will be seen that there has been no restriction of the output. Prices have been lower than in four previous years; but 1886 closed with figures which, if continued, would give a very good average. The lowest prices were in March (duplicated in July) and the highest at the close of the year. There was apparently so much coal sold early in the year during the range of low prices that the average for the year is a very low one, the figures of the

Philadelphia and Reading, the Lehigh Navigation, and the Scranton averages all showing a great reduction from preceding years. The East and West each had the benefit of these low figures. One of the important influences which brought about increased steadiness to the coal trade during the last few months of the year was the improved condition of the iron trade. The 'anthracite' furnaces in blast on the first of January, 1887, numbered 131 as against 86 at the same date two years previously."

THE WORLD'S COAL PRODUCTION.

The following table shows the commercial coal produced by the principal countries of the world.

Long tons of 2,240 pounds are used in giving the statistics of Great Britain, Australia, India, Nova Scotia, New Zealand, British Columbia, and Russia.

Short tons of 2,000 pounds are used for the United States, and the metric ton of 2,204 pounds for all continental countries except Russia.

The world's production of coal.

Country.	Quantity.	Country.	Quantity.
	Tons.		*Tons.*
Great Britain (1886)	157, 518, 482	New Zealand (1885)	511, 063
United States (1886)	112, 743, 403	India, Bengal (1884)	1, 200, 957
Germany (1885)	78, 266, 288	Borneo (1884)	5, 866
France (1886)	20, 044, 597	Nova Scotia (1886)	1, 502, 611
Belgium (1886)	17, 253, 144	British Columbia (1886)	326, 635
Austria and Hungary (1885)	17, 191, 000	Japan (1884)	900, 000
Russia (1885)	4, 500, 000	Australia (1885)	2, 878, 863
Sweden (1885)	264, 000	Other countries (1886)	10, 500, 000
Spain (1885)	1, 000, 000		
Italy (1884)	220, 000	Total	426, 826, 909

The increase in the world's production, exclusive of the United States, over that shown in the report for 1885 is 5,275,295 tons. The production of the United States for 1885 (95,832,705) was reported in long tons, and did not include colliery consumption, while that given in the above table is reported in short tons and includes colliery consumption.

ALABAMA. (a)

Total production in 1886, 1,800,000 short tons; spot value, $2,574,000.

The coal fields of the State occupy the extreme southern part of the Appalachian coal field. The area of the fields has been variously

(a) On account of the different classes of information bearing on the coal fields and their statistics in the different States which are available, it has been impossible to follow any fixed system in composing the individual reports. The reports on the coal industry in some States deal in considerable detail with special subjects which are not even mentioned in the reports of other States. This inconsistency in the character of the reports will necessarily grow less from year to year.

stated from 5,400 square miles upwards. The latest estimate is that of Mr. Henry McCalley, assistant State geologist, of 8,660 square miles.

The field has been divided into the Warrior, Cahaba, and Coosa coal fields, respectively, these names being derived from the rivers which drain the fields. The area of the Warrior field is about ten times as great as that of the other two fields combined. It is estimated that there are 108,394,000,000 tons of available coal in the seams over eighteen inches thick in this field.

The greatest thickness in the coal measures exists at Tuscaloosa, being estimated at 3,000 feet, with nearly fifty seams of coal, both workable and unworkable, the aggregate thickness of which is 100 feet.

The coal beds in the Warrior field are more or less horizontal as compared with the coal beds in the Cahaba and Coosa fields to the east, where the beds dip at all angles, at times being even overturned.

The Coosa field extends northeast and southwest from Calera to Eastport, a distance of about 60 miles, the width of the field ranging from 5 to 12 miles. Prof. J. L. Campbell considers the Cahaba field to be along a prolongation of the axis of Lookout mountain. The length of this field is about the same as that of the Coosa field; its width at the northern end is less than the width of the Coosa field, but it broadens toward the southern end.

Very few reliable statistics have been collected since 1880 of the production of coal in the State. According to the census reports there were produced in 1870, 11,000 tons, and in 1880, 323,972 tons. The annual production since 1880 has been variously estimated; in 1885 the production was reported as 2,225,000 tons. Mr. F. E. Saward, editor of the *Coal Trade Journal*, reports the production for 1886 as 2,500,000 tons and adds: "Some conservative reports put the output of coal at less than the above figures, but we have returns of 1,774,621 tons of coal mined and sold, and this, in addition to the coal mined for coke, would give the total nearly as we have made it."

Detailed returns of the production for 1886 from all the known mines in the State were received directly by the Survey; in collecting these returns assistance was rendered by Prof. Eugene A. Smith, State geologist. The total production from these returns is 1,750,136 tons, including all the coal mined, whether used for making coke or whether shipped as coal.

If all the coal which is mined at country banks for local consumption should be included, it it believed that 1,800,000 tons would be a maximum estimate for 1886. A summary of the returns received from the individual mines is given in the following table:

Returns from individual coal mines in Alabama.

Counties.	Name of operator.	Location of mine.	No. of mines.	Total production.
				Short tons.
Jefferson	Tennessee Coal, Iron, and Railroad Company.	Pratt mines	4	622, 940
	Henryellen Coal Company	Henryellen	2	40, 627
	Coalbnrg Coal and Coke Company	Coalburg	4	180, 000
	Watts Coal and Iron Company	Warrior	3	18, 000
	Warrior Coal and Coke Company	do	2	62, 400
	Brake mines	Brake	1	18, 375
	Mabel Mining Company	Warrior	1	30, 000
	Pierce Warrior Coal Company	do	3	60, 000
	Hoene Warrior and Jefferson Coal Company.	do	2	32, 660
	Milnor Coal and Railroad Company	New Castle	1	60, 000
	Woodward Iron Campany	Woodward	1	107, 112
Total				1, 238, 114
Bibb	Brierfield Coal and Iron Company	Brierfield	2	75, 000
	Cahaba Coal and Mining Company	Blocton	1	124, 206
Total				199, 206
Saint Clair	Coosa Coal and Coke Company	Broken Arrow and Trout creek.	2	56, 350
	Saint Clair Coal Company	Trout creek	1	15, 600
Total				71, 950
Walker	W. J. Smith	Corona	1	1, 600
	Penn Mobile Coal Company	do	1	44, 000
	O'Brien Coal Company	do	1	15, 000
	Virginia and Alabama Mining and Manufacturing Company.	Patton	3	100, 000
	T. H. Dunn & Co	York	1	18, 750
Total				179, 350
Tuscaloosa	A. Duril	Tuscaloosa	1	3, 200
	H. C. Fikes	Coaling	1	1, 800
	Alabama Insane Hospital	Tuscaloosa	1	2, 363
Total				7, 363
Shelby	Montevallo Coal and Transportation Company.	Aldrich	1	39, 153
	Unreported	Stonestreet mines		15, 000
Total				54, 153
Grand total				1, 750, 136

The maximum individual production is from the Pratt mines, operated by the Tennessee Coal, Iron and Railroad Company. The thickness of the bed at these mines is reported from 4 feet to 4 feet 6 inches. The greatest average thickness reported is 6 feet on the property of the Henryellen Coal Company. The thickness of the coal beds mined by the different coal companies ranges from 2 feet 6 inches to 4 feet 6 inches.

The price of coal at the mines ranges from $1.00 to $2.75, depending upon local conditions of trade. The average price at the mines for all the coal mined in the State may be stated at $1.43 per ton.

The Alabama coals are consumed mostly in southern markets. The following reference will give a general idea as to the distribution of the coal. The coal from the Pratt mines is consumed principally at Birmingham and New Orleans and intermediate points. That from Saint

Clair county is shipped to Atlanta, Augusta, Macon, and intermediate points. That from the Coalburg mines is consumed principally by the Georgia Central railroad, the Georgia Pacific railroad, and the Danville railroad. The product of the Coosa mines is shipped principally to New Orleans, Texas, Vicksburg, and intermediate points. A large amount of the product of the Jefferson County mines is taken by the Louisville and Nashville railroad. The shipments made to Mobile and New Orleans are increasing annually. At the present time, however, they do not probably exceed 150,000 tons.

Messrs. A. S. McCreath and E. V. d'Invilliers, in referring to the fuel supply of the Birmingham district, say:

"The fuel supply of the Birmingham district is practically derived from one coal bed—the Pratt seam of the Warrior coal field. Although several other seams of this field are known to possess good coking qualities, the proportion of coke made from them is very insignificant. The Pratt mines, recently merged into the Tennessee Coal and Iron Company, furnish fully 90 per cent. of the coal and coke used in this district. The Woodward Coal and Iron Company mines from its own property, a few miles south of Birmingham, but from the same Pratt seam. The reported defined area of this bed in the Warrior field is generally put at about 150 to 175 square miles. The seam varies from 4 feet 6 inches to 5 feet 6 inches in thickness, but rarely averages over 4½ feet. It carries a 2 to 3-inch slate parting at about 7 inches from the top, which is everywhere persistent. Under the active demand for the coal and coke of the Pratt mines, too little attention is frequently paid to eliminating this hurtful ingredient from the product of the mines, and as a consequence the percentage of ash and sulphur is frequently excessive. The yield averages about 4,000 tons an acre of merchantable coal.

"The company operates on the eastern rim of the Warrior coal field a branch road 6 or 7 miles long, leading nearly due west from Birmingham to the mines. The output may be put down as about 2,500 to 3,000 tons a day, although recent developments will increase this considerably. About 33 per cent. of the product is lump, the balance being nut and slack, utilized in the coke ovens. The company furnishes considerable raw coal to the furnaces, which have their own oven plants. Others buy the coke directly."

In January, 1886, mining averaged 54 cents per ton, laying down coal in Birmingham for 65 cents, and receiving for it $1 to $1.50, according to grade of coal and contracts. Many of the furnaces have special arrangements for a period of years, the terms of which are private; but the cost of coke at any of these furnaces approximates $2 a ton or a little over for the district.

Prof. O. H. Landreth, of Vanderbilt University, in the spring of 1885 made a number of comparative tests of the heating value of southern coals. The following table gives the results of his investigation:

Relative heating values of southern coal.

Name of coal.	Name of State.	Water evaporated per pound of coal.	Ash (from combustion under boiler).	Relative heating or steaming values, Cumberland coal being 100.
		Pounds.	*Per cent.*	
Cumberland	Maryland	8.21	11.5	100.0
Pratt	Alabama	8.04	7.4	97.9
Jellico	Tennessee	7.45	6.3	90.7
Pittsburgh	Pennsylvania	7.63	7,4	92.9
Altamont	Kentucky	7.41	3.5	90.3
Saint Bernard	do	6.73	6.9	82.0
Warrior	Alabama	7.73	4.6	94.2
Helena	do	7.58	7.7	92.3
Watt	do	7.11	13.2	86.6
Diamond	Kentucky	6.20	10.2	75.5
Mud River	Illinois	6.89	4.6	83.9
Memphis	Kentucky	6.45	8.5	78.6
Clifton	do	5.74	14.6	69.9
Sewanee	Tennessee	7.37	11.3	89.8
Cahaba	Alabama	7.65	5.0	93.2
Blocton	do	7.37	5.7	89.8
Black Creek	do	7.63	4.0	92.9
Henryellen	do	7.25	5.2	88 3
Daisy	Tennessee	7.16	11.4	87.2

A great many analyses have been made of Alabama coals. The following table includes a number of analyses reported by the State Geological Survey:

Analyses of Alabama coals.

Location.	Specific gravity.	Sulphur.	Moisture.	Volatile matter.	Fixed carbon.	Ash.
Walker county.						
Mrs. Burton's upper bed in S. 20, T. 14, R. 5 W	1.32	3.07	2.05	38.08	55.26	4.61
Phillips & Cordell's bed in S. 28, T. 14, R. 5 W	1.29	.65	3.10	34.55	60.74	1.61
James Cole's spring branch bed in S. 21, T. 14, R. 5 W	1.26	.99	1.70	36.13	60.59	1.48
J. Phillip's bed in S. 22, T. 14, R. 5 W	1.27	.59	4.05	34.19	60.70	1.06
Bed in fork in S. 34, T. 13, R. 5 W	1.26	.55	2.08	31.95	64.34	1.63
Jagger's bed in S. 11, T. 13, R. 10 W	1.44	.36	2.24	29.04	50.64	17.99
Do	1.23	.57	3.09	20.04	56.54	11.33
Lost creek in S. E. ¼ of S. 30, T. 13, R. 9 W	1.31	.59	2.61	34.11	56.63	6.66
Guttery's cave hole in S. 18, T. 14, R. 8 W	1.36	.69	3.33	30.68	52.76	13.22
Baker's upper bed on Lost creek	1.32	.69	6.36	31.09	60.66	1.89
Baker's lower bed on Lost creek	1.28	1.33	2.58	35.16	59.35	2.91
Townly bed in S. 34, T. 13, R. 8 W	1.31	.71	3.01	29.08	63.35	4.56
Do	1.45	1.74	2.96	26.16	44.52	26.36
Frog Ague creek in S. 8, T. 15, R. 6 W	1.45	......	2.71	25.36	53.62	18.31
Mount Carmel bed, upper bench, in S. 8, T. 15, R. 6 W	1.38	.59	2.21	28.99	56.45	12.36
Do	1.35	.46	1.69	28.50	54.63	15.18
Mount Carmel bed, lower bench, in S. 8, T. 15, R. 6 W	1.37	.57	1.78	25.87	57.51	14.84
Big Crane creek in S. 4, T. 15, R. 6 W	1.40	.48	3.70	26.22	57.32	12.67
Hawthorne bed in S. 4, T. 15, R. 5 W	1.33	.52	2.97	29.78	60.60	6.65
Upper coal in S. E. ¼, S. 4, T. 15, R. 6 W	1.34	trace.	1.66	26.26	61.56	10.51
Horse creek in S. 24, T. 15, R. 6 W	1.36	.71	1.85	28.36	58.23	11.58
Robinson bed, Horse creek in S. 26, T. 15, R. 6 W	1.37	.58	2.45	27.01	57.65	12.99
Do	1.36	.60	2.70	26.60	56.37	14.33
Flat creek in S. 23, T. 15, R. 6 W	1.36	1.52	1.67	33.20	54.54	10.29
Beechy hollow in S. 6, T. 16, R. 5 W	1.44	.53	6.95	27.07	55.64	10.34

Analyses of Alabama coals—Continued.

Location.	Specific gravity.	Sulphur.	Moisture.	Volatile matter.	Fixed carbon.	Ash.
Walter county—Continued.						
Corona in S. 27, T. 15, R. 9 W	1.33	......	1.52	31.89	57.24	9.34
Corona in lower bench	1.30	......	1.63	30.94	59 57	7.85
Corona in upper bench	1.36	......	1.78	32.54	55.62	10.07
Corona S. 27, T. 15, R. 9 W	1.32	1.95	1.55	37.74	58.81	1.90
Coal valley in S. 19, T. 15, R. 8 W	1.32	......	1.32	32.67	56.60	9.41
Cane creek in S. 6, T. 16, R. 7 W	1.31	.73	2.26	33.78	57.00	6.96
Bradley bed in S. 26, T. 15, R. 7 W	1.28	.69	2.70	29.56	64.82	2.92
Mrs. Bailey's bed in S. 20, T. 15, R. 7 W	1.34	.60	5.71	28.10	62.61	3.58
Mrs. Bailey's bed, bony part	1.42	1.24	1.53	30.40	51.96	16.10
Brake's Bend S. W. ¼, S. T. 16, R. 7 W	1.34	1.10	4.53	26.41	56.89	12.17
Van Hoose, lower seam, Franklin bend	1.33	1.14	1.90	23.87	56.21	18.02
Van Hoose, upper seam, Franklin bend	1.31	1.22	2.25	28.29	50.79	8.67
Franklin bend in S.W. ¼ S. 16, R. 6 W	1.35	.51	6.00	28.84	59.96	5.19
Richardson's lower bed, S. 24, T. 17, R. 7 W	1.27	1.13	1.47	34.27	59.13	5.13
Thomas' bed, S. E. ¼, S. 23, T. 17, R. 7 W	1.28	1.51	1.44	27.21	66.00	5.35
Robinson's lower bed, S. 26, T. 17, R. 7 W	1.34	.72	3.56	26.57	64.29	5.65
Robinson's upper bed, S. 24, T. 17, R. 7 W	1.31	1.08	1.40	30.67	62.18	5.77
Jefferson county.						
Warrior Coal and Coke Company's mines	......	.56	......	32.24	65.12	1.27
Warrior Coal and Coke Company's coke	......	.61	2.55	......	93.86	2.98
Watt's Coal, Coke and Iron Company's mines	......	1.11	1.61	33.00	61.79	2.49
New Castle seam, New Castle	1.38	.46	.50	28.24	59.69	10 92
Black creek seam, New Castle	1.29	.32	1.36	31.79	64.71	1.82
Pratt seam, Slope No. 1, Pratt mines	1.30	.92	1.50	31.48	61.60	5.42
Pratt seam, Pratt mines	1.29	.47	1.07	32.08	64.30	2.08
Pratt seam, Coalburg Coal and Coke Company's mines	1.32	1.70	.93	30.51	65.54	3.01
Pratt seam, Drinking branch	1.29	1.20	.85	30.75	65.07	3.33
Pratt seam, New-found creek	1.29	.82	.77	36.03	60.33	2.87
Coke, Pratt mines	......	.57	......	......	93.01	6.83
Do	......	.17	......	......	91.16	8.67
Pratt seam, Coalburg Coal and Coke Company's mines	......	1.02	......	32.17	63.34	3.34
Pratt seam, upper bench, No. 1 slope	1.33	1.22	1.47	32.29	59.50	6.74
Pratt seam, lower bench, No. 1 slope	1.28	.61	1.53	30.68	63.68	4.10
Pratt seam, slate parting bench, No. 1 slope	1.99	......	1.62	11.72	23.84	62.82
Col. Williams's lower seam of upper group	1.39	.52	4.17	22.42	62.48	10.93
Col. Williams's main bench of lower group	1.31	.60	1.52	26.17	66.02	6.29
Coal creek in S. 26, T. 16, R. 5 W	1.35	1.52	1.85	27.56	61.70	8.89
Fork shoals in S. 20, T. 17, R. 6 W	1.32	.80	4.98	27.17	62.13	5.72
Coal Cave hollow in S. 30, T. 17, R. 6 W	1.33	1.94	1.26	26.25	59.90	12.59
Near Wetona, P. O, in S. 4, T. 10, R. 6 W	......	......	......	26.55	71.28	2.10
Tuscaloosa county.						
Cannel coal in S. 30, T. 20, R. 8 W	1.35	2.75	.83	36.21	48.32	14.64
Manly coal bed in S. 1, T. 21, R. 9 W	1.28	.75	2.00	33.83	61.87	2.29
University mines in S. 2, T. 21, R. 9 W	1.30	1.04	1.83	36.23	54.53	7.40
Prude's lower mine in S. 22, T. 21, R. 9 W	1.33	.63	5.43	31.95	59.46	3.17
Chamber's mine in S. 10, T. 21, R. 9 W	1.28	2.38	1.84	30.68	64.34	3.14
Double seam in S. 21, T. 20, R. 9 W	1.30	2.13	1.81	34.03	58.24	5.92
Block coal in S. 27, T. 20, R. 9 W	1.41	1.61	2.24	34.61	50.37	12.78
James Beaver's coal in S. 13, T. 20, R. 9 W	1.31	.66	2.51	31.98	60.03	5.48
Prince Christian's coal in S. 14, T. 19, R. 9 W	1.32	.61	2.18	32.85	59.82	5.15
Panther branch in S. 7, T. 19, R. 8 W	1.33	.83	.78	33.27	61.08	4.87
Blue creek in S. 32, T. 18, R. 8 W	1.28	.80	2.39	33.87	59.07	4.67

The following analyses were reported by the respective coal companies:

Name of operator.	Volatile matter.	Sulphur.	Ash.	Moisture.	Fixed carbon.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Virginia and Alabama Mining and Manufacturing Company	41.12	0.42	7.36	0.83	50.69
Watts Coal and Iron Company	33.38	1.20	1.92	1.17	63.03
Watts Coal and Iron Company (coke)	......	2.96	14.51	0.18	85.31
Pierce-Warrior Coal Company	32.24	0.50	1.27	....	65.13

ARKANSAS.

Total production in 1866, 125,000 short tons; spot value, $200,000.

The coal beds of the State are contained in the Carboniferous system and lie in the western part of the State. Coal has been found in twelve counties, and the estimated area of the field is about 9,000 square miles. As far as is known, the beds have been reported to be included within or underneath the Millstone Grit. Much of the coal which is mined is of a semi-bituminous character.

The three principal mining districts at present are the Ouita mines, near Russellville, about 75 miles from Little Rock, the Spadra openings, 25 miles farther up the valley, and the Coal Hill openings, 15 miles still farther up.

On account of the limited coal mining which has been carried on in the State, no reliable statistics of the production could be obtained. The total amount of coal carried from the mines in Arkansas by the Little Rock and Fort Smith Railroad Company during 1886 was 56,072 tons.

The Ouita Coal Company reported a production of 46,092 tons, an increase over 1885 of about 20,000 tons. This coal is shipped as far as Tennessee, Mississippi, Louisiana, and Texas, and is used largely by the local market.

The production for 1885 was variously estimated at from 150,000 to 175,000 tons. This was excessive, since from facts recently gathered the production for 1885 was not over 100,000 tons.

The Kansas and Texas Coal Company is opening two shafts at Hackett City, in Sebastian county, with a capacity of 60 car loads per day. Mr. Stephen Wheeler, of Fort Smith, reports that this is the first regular coal mining which has been planned in the county; that which has previously been engaged upon has been done by individuals without the use of machinery. Two-thirds of the county is underlaid by semi-anthracite coal containing from 80 to 84 per cent. of fixed carbon, the beds varying in thickness from 3 to 6 feet.

A mine was opened by Mr. M. R. Shinn in the fall of 1886, in the vicinity of Russellville, which produced during the month of December 80 tons, and which was marketed at Russellville and Dardanelle, $2 being paid for the coal at the mouth of the mine. The bed which was worked was 3 feet thick. Mr. C. E. Tobey reports that excellent coal has been found three-quarters of a mile from the railroad at the town of Atkins.

The coal bed is thin, having a maximum thickness of 30 inches, is situated in the brow of Crow mountain, and at an elevation of between 400 and 500 feet above the town.

CALIFORNIA.

Total production in 1886, 100,000 short tons; spot value, $300,000.

A number of localities have been reported in this State where coal beds of commercial thickness and purity have been reported for a number of years past. No mining operations have, however, been carried on making shipments to the open market, except at the mines in the counties of Amador, Contra Costa, and Los Angeles. The most important mines are those in Contra Costa county, directly east of San Francisco bay. Coal was first discovered in this county in 1852. No mines were located, however, until 1860, while several of the most productive mines have been opened since 1860. The coal comes into direct competition with that from British Columbia, Australia, and Washington Territory, to all of which it is an inferior fuel, so that the output of the mines has in the main been gradually decreasing, as shown by the following table:

Coal produced in California since 1871.

Years.	Short tons.	Years.	Short tons.
1871	133,485	1879	134,435
1872	177,232	1880	158,723
1873	171,741	1881	103,055
1874	206,455	1882	113,255
1875	142,808	1883	76,162
1876	108,078	1884	77,485
1877	96,172	1885	71,615
1878	122,034	1886	90,664

It is estimated that the total production of the coal mines in California, including a number of banks worked for local consumption, for the past year would not exceed 100,000 tons.

Receipts of coal at San Francisco for the past three years.

	1884.	1885.	1886.
	Short tons.	*Short tons.*	*Short tons.*
British Columbia (Wellington and Nanaimo)	291,546	224,298	253,819
Australia	190,497	206,751	287,293
English and Welsh	108,808	170,656	160,869
Scotch	21,143	20,228	19,795
Eastern (Cumberland and anthracite)	38,124	29,834	19,517
Seattle	125,000	75,112	57,552
Carbon Hill	122,060	157,241	124,527
Mount Diablo	77,485	71,615	90,664
Renton, Oregon, and South Prairie	60,413	67,604	73,654
Total	1,035,076	1,023,339	1,087,690

The low prices at which foreign coals were sold in the California market during 1886 have prevented the extensive development of the mines along the coast for San Francisco shipments. These same prices are shown in the following table, with the fluctuation in the prices from month to month:

Prices of foreign coals in San Francisco in 1886.

	Australian.	English steam.	Scotch splint.	West Hartley.
January	$5.87	$5.75	$6.75	$7.50
February	5.55	5.55	6.75	7.50
March	5.50	5.50	6.75	7.50
April	5.75	5.62	6.75	7.50
May	5.75	5.62	6.75	7.50
June	5.75	5.62	6.75	7.50
July	5.75	5.62	6.62	7.25
August	5.87	5.62	6.50	7.00
September	5.87	5.62	6.50	7.00
October	6.12	5.75	6.50	7.00
November	6.20	5.90	6.50	7.00
December	6.25	6.12½	6.50	7.00

During the past year a discovery of bituminous coal was made in the Tehachipi mountains, along the Southern Pacific railroad, in Kern county. A coal mine is reported to have been opened in Fresno county, 18 miles west of Huron. The bed is 4½ to 5 feet thick, and the coal is of good quality. The outlook of the mine is reported to be promising. Four other beds are reported to occur in the coal measures at this point. It is estimated that the bed which has been opened contains about 1,500,000 tons of coal above the level of the opening.

The coal has been sold by car loads in Fresno at $7 a short ton, notwithstanding the fact that it costs from $3 to $3.50 to haul the coal from Huron, which is the terminus of the railroad. The coal does not coke, but is reported to be an excellent fuel. No return has been made of the amount of coal produced from this mine.

A coal bed is reported to have been discovered in the Temescal mountains, in the southwestern corner of San Bernardino county. The bed as far as developed is thin, measuring only between 12 and 16 inches, and dips at an angle of about 45°. Explorations have been made in this locality with the hope of discovering a thicker bed.

COLORADO. (a)

Total production in 1886, 1,368,338 short tons; spot value, $3,215,594.

The general prosperity of Colorado in 1886 has in no way been better shown than in the great development of the coal fields of the State, although this development was begun too late to show a very great increase in the production for 1886 over 1885. While the mines in the northeastern portion of the State have only held their own, those of southeastern Colorado have materially increased their output to respond to the steadily increasing demand from western Kansas and Nebraska points. The greatest amount of new work has, however, been done west of Pitkin and the continental Divide in what is known as the Glenwood field.

Noteworthy discoveries of coking coal have also been made in Gunnison county, on Ohio creek, and of anthracite of good quality in a re-

(a Reported by F. F. Chisolm.)

gion where its existence has only been suspected; the basalt-covered tract southwest of Hahn's Peak, in Routt county. The more remote coal fields, although known to produce excellent coals of varying qualities, have still been neglected, because of the remote prospect of railway communication being made necessary to bring their product into competition with that from well-opened mines.

The great activity in railway building in the direction of Garfield, Routt, and Pitkin counties has spurred the work of opening the coal beds in these counties, in order to meet the demand which the completion of the three railways now being built in that direction will bring. The superior quality of the coke made from the coal from the mines in Pitkin and Garfield counties, and the accessibility, low altitude, and thickness of the beds in the anthracite district of Routt county, will meet a commercial demand from the smelting and manufacturing centers of Colorado, and also from those in the adjoining States and Territories. The great economic importance of these new fields renders them fully worthy of more extended description than usual, and the following notes on the different deposits are therefore given as the result of careful examinations:

The Elk Head anthracite coal field lies in the northeastern portion of Routt county, on the headwaters of Elk Head creek, and at the base of the Elk Head mountains.

The altitude at which the exposures occur is from 7,000 to 7,750 feet above sea level, in a section which is rather rolling than mountainous in character.

The great coal beds underlying the major part of the county are here capped by beds of varying thickness of basaltic rocks, sometimes lying close to the coal seams, and "baking" the coal into an anthracite, by expelling its more volatile constituents. The extent of this metamorphism varies with the vertical distance and thickness of the overlying eruptive beds, and exploration has not yet been carried far enough to definitely ascertain the area of coal carrying more than 80 per cent. of fixed carbon, but it seems very probable that this area is sufficiently large to insure an ample supply for many years to come. This question will probably be settled by explorations with the diamond drill during 1887.

The coal occurs in rocks probably of the "Fox Hills" group, in which much of the coal in western Colorado is found. The tilting of the strata against the Rabbit Ear, or main range, exposes the edge of the coal seams, and excellent opening points are made by the cutting through of small creeks flowing into the Elk Head creek. While the main coal field shows from eight to thirteen seams of coal, so far in the anthracite district only three beds are found. The uppermost is 4 feet in thickness and separated from the middle bed by about 8 feet of sandstone and sandy shale. The middle bed is 3½ feet thick and occurs about 4 feet above the lowest small bed, which shows 1 foot of coal. These thicknesses do not seem to be constant, for in localities near by exposures of the middle bed are found which are 8 feet in thickness. Where the bed is thickest the percentage of fixed carbon is lowest; here the distance of the coal from the eruptive rocks is greatest.

The coal is jet black, with brilliant luster and conchoidal fracture. It is generally very hard, and burns well. The presence of considerable quantities of "mineral charcoal" in the coal is characteristic.

Samples from various points in this field show the following composition:

Analyses of anthracite from the Elk Head field, Colorado.

Sample.	Width of vein.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Specific gravity.
	Feet.	*Per cent.*	*Per cent.*	*Per cent.*	*P. ct.*	*Per cent.*	
1	4	4.86	13.41	69.45	12.28	0.89	1.45
2	2	1.99	3.46	86.24	8.29	1.18	1.54
3	9	8.68	17.71	63.33	10.28	0.09	1.71
4	4	1.02	9.66	83.50	5.82	0.71	1.39
5	3½	2.10	8.16	83.34	6.40	0.44	1.40
6	4	1.86	4.10	87.34	6.70	0.59	1.41

The high percentage of ash and moisture in the first and third samples is due to the fact that all the openings are of the most superficial character.

The economic value of the discovery of this coal to the State of Colorado and the entire Missouri valley will probably be very great, as coal can be mined cheaper here than at the other anthracite localities in Colorado, and the low altitude and easy railroad grades by which it can be reached will render the marketing of the coal at all seasons a comparatively easy matter. The district will be thoroughly prospected during 1887.

During the summer of 1886 the anthracite field west of Irwin was carefully prospected by the Union Pacific Railroad Company with the object of determining the value of the land. An anthracite seam was found having a very uniform thickness of about 39 inches. The coal is hard and brilliant, and of a very fair composition. The fixed carbon is generally about 90 per cent. and the ash varies from 6 to 9 per cent.

Some parts of the field are very favorably situated for opening, and it is possible that the western end of the Denver, South Park, and Pacific railroad will be pushed to the mines during 1887, bringing their products within reach of the market for hard coal. The workable area of coal here is about 2 square miles.

At the Anthracite Mesa mine, near Crested Butte, the extraction of coal was delayed by many causes, and the production in 1886 was less than in 1885. The output was 19,628 tons.

The coal field extending from the head of Rock creek in Pitkin county to Elk creek in Garfield county, a distance of some 60 miles, has been the scene of the greatest activity during 1886. The Colorado Fuel

Company has occupied the southern portion of the field and has about sixteen sections of land containing anthracite, coking, and non-coking bituminous coals of excellent quality.

No analyses of the above coals have been furnished, so that nothing can be said definitely regarding the mines, except that the location was selected after a careful and exhaustive examination of the entire field, and therefore it is probable that the coal found on this land is the best in the field. Next to these mines the Colorado Coal and Iron Company has taken several sections of land which contain coking and non-coking bituminous beds. This entire district is being actively prospected with the expectation of the early completion of the Denver and Rio Grande and Colorado Midland railways to this section. Below and north of the Colorado Coal and Iron Company's tracts are the mines which have been operated by J. B. Wheeler & Co., and from which the coke taken hitherto for the use of the smelter at Aspen has been mined. The coking bed is 5½ feet thick. There is probably another coking bed, and possibly two more.

Next north and on Four Mile creek are the mines owned by the Colorado Midland railway. There is probably no coking coal on this company's tract. The bed of bituminous coal worked is from 12 to 14 feet in thickness.

At the mouth of Elk creek the land is owned by the Colorado Fuel Company and by J. B. Wheeler & Co. The coal is non-coking. Full analyses of the coals from this bed were published in the report for 1885. These were furnished by Mr. R. C. Hills, of Denver. Later analyses of these coals, made from samples taken personally by Mr. F. F. Chisolm, are tabulated below.

Analyses of samples from the Glenwood coal field, Colorado.

Mine.	Thickness.	Moisture.	Volatile matter.	Fixed carbon.	Ash.
	Inches.	*Per cent.*	*Per cent.*	*Per cent.*	*Pr. ct.*
Elk creek	5	3.24	39.90	53.76	3.10
Elk creek	4	2.49	36.2	54.82	6.43
Four Mile creek	12	6.81	34 1	54.07	4.96
Wheeler's new mine	5½	1.76	36.96	58.95	2.33

Considerable activity has been manifested in the Durango coal field, but no results have been made public.

Production of coal by the Colorado Coal and Iron Company.

Years.	Short tons.	Years.	Short tons.
1873	12,187	1880	221,378
1874	18,092	1881	350,944
1875	15,278	1882	511,239
1876	20,816	1883	602,396
1877	44,410	1884	450,808
1878	82,140	1885	562,660
1879	120,102	1886	605,956

The fuel supply of the Denver and Rio Grande Railway Company is mainly derived from this company. This coal is also shipped to the Burlington and Missouri River railway for fuel and for sale in Nebraska. Coke is made at the Crested Butte and El Moro mines.

The production of the company's different mines in 1886 was:

Statement showing the production of the Colorado Coal and Iron Company's mines in 1886.

Name and location.	Short tons.
Coal Creek mines and Oak Creek mines, Fremont county	126, 822
El Moro mines, Las Animas county	286, 303
Walsen mine and Cameron mine, Huerfano county	89, 913
Crested Butte mine, Gunnison county	• 102, 918
Total	605, 956

The production of the Union Coal Company is considerably less than in 1885. This is due to the decrease in the production of the Como mine. The coal bed at this place was lost in a fault for a time. The Welch mine was leased to other parties.

Production of the Union Coal Company's mines in 1886.

Name and location of mine.	Short tons.
Como mine, Park county	23, 823
Baldwin mine, Gunnison county	37, 405
Total	61, 228

Production of the mines operated for the benefit or in the interests of railway companies in Colorado in 1886.

	Short tons.
Burlington and Missouri River railroad, Anthracite Mesa coal, Gunnison county	19, 628
Atchison, Topeka and Santa Fé railroad, Fremont County mines	205, 212
Atchison, Topeka and Santa Fé railroad, Las Animas County mines	143, 403
Denver, Texas and Gulf railroad, Franceville mine, El Paso county	50, 000
Denver, Utah and Pacific railroad, Mitchell mine, Weld county	18, 840
Denver Railway and Land Company, Scranton mine, Arapahoe county	11, 000

Total product of mines operated in the interest of railways in Colorado for 1886, 1,115,267 tons; increase, 0.7 per cent. over 1885. The increase in railway production is very slight indeed.

Coal production of Colorado from 1864 *to* 1886.

Years.	Localities.	Short tons.	
1864	Jefferson and Boulder counties		500
1865	do		1,200
1866	do		6,400
1867	do		17,000
1868	do		10,500
1869	do		8,000
1870	do		13,500
1871	do		15,860
1872	do	14,200	
	Weld county	54,340	
			68,540
1873	Jefferson and Boulder counties	14,000	
	Weld county	43,790	
	Las Animas and Fremont counties	12,187	
			69,977
1874	Jefferson and Boulder counties	15,000	
	Weld county	44,280	
	Las Animas and Fremont	18,092	
			77 372
1875	Jefferson and Boulder counties	23,700	
	Weld county	59,860	
	Las Animas and Fremont counties	15,278	
			98,838
1876	Jefferson and Boulder counties	28,750	
	Weld county	68,600	
	Las Animas and Fremont counties	20,316	
			117,666
1877			160,000
1878	*Northern division*	87,825	
	Central division	73,137	
	Southern division	39,668	
			200,630
1879	Northern division	182,630	
	Central division	70,647	
	Southern division	69,455	
			322,732
1880	Northern division	123,518	
	Central division	136,020	
	Southern division	126,403	
	Northwestern division	1,064	
	Unreported mines	50,000	
			437,005
1881	Northern division	156,126	
	Central division	174,882	
	Southern division	269,045	
	Northwestern division	6,691	
	Unreported mines	100,000	
			706,744
1882	Northern division	300,000	
	Central division	243,694	
	Southern division	474,285	
	Northwestern division	43,500	
			1,061,479
1883	Northern division:		
	Mines near Erie and Canfield	80,165	
	Louisville	97,138	
	Langford	45,500	
	Golden	21,100	
			243,903
	Central division:		
	Mines near Sedalia	1,500	
	Franceville	54,416	
	Como	60,140	
	Cañon City	280,345	
			396,401
	Southern division:		
	Mines near Trinidad and El Moro	400,929	
	Walsenburg	87,689	
	Durango and Rico	12,689	
			501,307
	Northwestern division:		
	Mines near Crested Butte		87,982
	Total, 1883		1,229,593
1884	Northern division	253,282	
	Central division	296,128	
	Southern division	483,865	
	Northwestern division	96,689	
			1,130,024

Coal production of Colorado from 1864 *to* 1886—Continued.

Years.	Localities.	Short tons.	
1885......	Northern division:		
	Mines near Erie and Canfield	111,089	
	Louisville	33,646	
	Langford	75,392	
	Golden	22,719	
			242,846
	Central division:		
	Mines near Sedalia	1,500	
	Franceville	44,083	
	Como	43,752	
	Cañon City	327,038	
			416,373
	Southern division:		
	Mines near Trinidad and El Moro	463,731	
	Walsenburg	89,441	
	Durango	15,147	
	La Veta	125	
	Rico	3,240	
			571,684
	Northwestern division:		
	Mines near Crested Butte	79,914	
	Baldwin	14,175	
	Keubler	250	
	Wheeler's	4,500	
	Four Mile	300	
	Anthracite coal	26,020	
			125,159
	Total, 1885		1,356,062
1886......	Northern division:		
	Mines near Erie and Canfield	93,645	
	Louisville	55,896	
	Langford	89,586	
	Golden	10,018	
	Denver	11,000	
			260,145
	Central division:		
	Mines near Franceville	53,000	
	Como	23,823	
	Cañon City	332,034	
			408,857
	Southern division:		
	Mines near Trinidad and El Moro	429,706	
	Walsenburg	89,913	
	Durango	18,166	
			537,785
	Northwestern division:		
	Mines near Crested Butte	102,918	
	Baldwin	37,405	
	Glenwood	1,600	
	Anthracite coal	19,628	
			161,551
	Total, 1886		1,368,338

The State inspector of mines estimates the production for 1886 at 1,436,211 tons. The portion in excess of the tabulated estimate is attributed to unreported mines. It seems very improbable that the production of mines from which no returns were made is so great. It is very probable that the returns from certain other mines were greater than the actual output, so no notice has been taken of the unreported mines, this latter amount being estimated to equal the exaggeration from other mines.

The increase in production for 1886 over 1885 is only 12,276 tons, or a little less than 1 per cent.

The average value of the coal is estimated at $2.35 per ton, making the total product of the State worth $3,215,594.

The average number of men employed directly and indirectly in the coal mines of Colorado is estimated at 3,500.

The State inspector estimates that the average thickness of the coal beds worked in Colorado is 5 feet 3¼ inches. He also states that the thickest bed worked is 9 feet and the thinnest is 2 feet.

The average price paid for mining and loading the coal and doing the necessary timbering, is 89 cents per ton of 2,000 pounds of screened coal. The average cost of the coal delivered on the cars is $1.74 per ton.

DAKOTA.

Total production in 1886, 25,955 short tons; spot value, $41,277.

Very little development has been made of the reported coal fields in this Territory and very little information is available as to the extent or value of the coal deposits.

The Mouse River coal field, which lies from 80 to 150 miles or more to the north and northwest from Bismarck, has recently been reported on by Mr. George H. Eldridge. He says:

"The strata carrying the coals of this region may all be referred to the lower part of the Laramie group, upon both lithological and palæontological evidence. They consist, in ascending order, of heavily bedded coarse-grained sandstones, of gray color, and often ferruginous, containing thin, paper-like seams of lignite, the whole weathering easily. These are overlaid by other gray and yellow sandstones intercalated with clays, the former somewhat argillaceous, the latter arenaceous. Above these last come other purer drab clays, with some beds of sandstone, the latter being very variable in texture and in their ability to withstand the weather. Many of the strata have a strong tendency to a concretionary structure. In the uppermost series of strata, just mentioned, the coal seams are larger and the underlying clays thicker, and invariably of a leaden gray color, except where, here and there, they are tinged chocolate from the lignitic matter contained in them. All the clays form bold and steep bluffs, and are a noticeable feature of the landscape where they occur.

"The Lower Laramie of this region contains only comparatively unimportant lignite beds, the more important ones occurring higher up in the series and to the southwest of our area of exploration, on the Missouri river, near Fort Stevenson and elsewhere, there being a dip of very slight amount toward a common center at Fort Union, forming there a great but very shallow synclinal basin.

"The localities of the exposures of lignite are: 8 miles below the Big bend of Mouse river; 25 miles above the Big bend, where the lignite is of comparatively fair quality, taken with the other lignite beds of this locality; another exposure of this seam a mile farther up the river; 1 mile below the mouth of Lake river, a 6-inch seam not figured; on Lake river, 40 miles above its entrance into Mouse river, a 30-inch and a 36-inch seam. the former very dirty. the latter much cleaner, with numerous thin seams of an inch or two scattered all along through the series. While, therefore, we may have seams of lignite, from one-half inch to 8 inches thick, outcropping along the bluffs between the Big bend of Mouse river and the source of Lake river; and also two of a thickness of over 2 feet, but one workable bed of 3 feet was met with. The coal of this bed exhibits the usual characteristics of the poorer classes of lignites, layers of the fibrous structure being intercalated with those of homogeneous appearance, and conchoidal fracture and a jetty luster. The entire seam contains much gypsum in the crystalline and powdered forms. The coal is by far the poorest observed during our exploration, and has no resistance whatever to the influences of weathering. It will, therefore, in all probability, never be used for other than domestic purposes by the future settlers of this river. Owing to the lay of the country, boring is the only means of determining the extent of any of the beds of lignite."

The following table gives a number of approximate analyses of the Dakota lignites:

Analyses of Dakota lignites.

Locality.	Water.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Color of ash.	Water in dry coal.	Water in saturated coal.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*		*Per ct.*	*Per ct.*
Mouse river	13.07	44.31	36.64	5.98	0.91	Yellowish red	5.84	17.21
Do	11.53	44.06	35.74	8.67	0.72	Reddish	7.97	21.88
Lake river	13.70	41.94	31.12	13.24	1.05	Yellowish red	8.72	23.49
Bly mine	13.09	39.81	35.58	11.52	1.07	White	5.66	17.14
Do	12.69	43.06	34.34	9.91	1.04	do	8.09	20.40
Do	14.26	37.72	33.20	14.82	0.95	do	8.14	19.57
Do	14.33	38.98	36.18	10.51	1.04	do	8.36	20.38
Do	14.30	43.26	32.57	9.87	1.10	do	8.04	19.94
Little Missouri	12.19	47.81	35.00	5.00	0.52	Reddish	......	......

It is practically impossible to report the total amount of lignite mined during the year in the Territory, since a large number of openings have been made by farmers, which are worked for fuel for local use and sale. It has been estimated that this unreported product would not exceed 5,000 short tons. The only mining operation carried on in the Territory during the year was that of the Sims mine, owned by the Northern Pacific Railroad Company, the product of which, according to Mr. F. F. Chisolm, amounted to 20,955 tons, and was valued at the mine at $31,277. The total production of the Territory is placed at 25,955 tons, the spot value of which was $41,277.

Practically, no operations have been carried on at the Little Missouri mine near the western boundary on the line of the Northern Pacific railroad. The product from this mine has been replaced by the superior fuel of Montana. As far as developments have been made the Montana lignite beds are generally superior to those in Dakota, and this fact will militate against the rapid development of the Dakota beds.

GEORGIA.

Total production in 1886, 223,000 short tons; spot value, $334,500.

A small portion of the Appalachian coal field crosses the northwestern corner of the State. It is estimated that the area of the coal field in the State is less than 200 square miles. The Dade Coal Company carries on the only operation in the State, with the exception of a few country banks, worked to supply local demands.

The Dade mines in 1886 produced 56,822 short tons of lump coal and 165,361 short tons of slack coal. Out of the latter coal they manufactured 82,680 tons of coke. The total product of the State might therefore be stated as 223,000 tons. The coal produced at these mines was shipped principally to the Western and Atlantic railroad, the coal selling for $1.50 per ton at the mouth of the mine.

The Dade coal bed, according to Mr. A. P. Buck, general manager of the company, lies beneath the millstone grit, and is very uneven in thickness, varying from 1 foot 6 inches to 14 feet. The coal is semi-bituminous. About 600 men are employed at the mines, the cost for digging coal being about 2 cents per bushel, dead work being additional. On account of the coal being soft a large amount of slack is produced in mining, the slack containing a good deal of slate. All the coke manufactured by this company is made out of slack coal.

IDAHO.

Total production in 1886, 1,500 short tons; spot value, $6,000.

Large areas exist in the Territory underlaid by bituminous coal and lignites. Mines have been opened at Smith's fork and on Twin creek, and what is known as the Mammoth bed shows local thickness of 70 feet. This bed is separated by slates and shales from adjoining beds, where the aggregate thickness would be in special localities from 150 to 200 feet. These coal beds are near the east line of the Territory.

A good quality of lignite has been found near Boisè, and bituminous coal at Horseshoe bend, 20 miles from Boisè; also on the Snake river, between Payette and Weiser City. A good blacksmithing coal is also reported on Sucker river, 22 miles north of Silver City; also several deposits near Lewiston, in the north of Idaho.

According to Hon. E. J. Curtis, Secretary of State, the production of coal in the Territory for 1886 did not exceed 1,500 tons. Mr. F. E. Saward reports the production in Idaho for 1884 as 20,000 tons, and in 1885 as 40,000 tons. In regard to these reports Mr. Curtis says: "I am at a loss to account for reports and statements made for the output for 1884 and 1885. I have made inquiries of persons who know something about the facts, and they stated to me without the least hesitation that they believed the lower estimates nearer the truth than the other reports."

ILLINOIS.

Total production in 1886, 9,246,435 short tons; spot value, $10,263,543.

The greater portion of what has been classified under the name of the Central field lies in the State of Illinois. The State contains one hundred and two counties, and out of these fifty produce coal. Macoupin, Saint Clair, and La Salle are reported among those which produce the largest amount of coal, and Brown and Coles among those which produce the smallest amount.

According to Prof. A. H. Worthen, State Geologist, the productive coal area of the State is about 37,000 square miles.

A conservative estimate of the amount of commercial coal contained in the Illinois field would place it at about 30,000,000,000 tons. In an early estimate made by Professor Rogers of the amount of coal contained in the Illinois field he placed it at over 1,000,000,000,000 tons. This latter estimate was based upon very general data, and does not make allowance for the coal washed out by the smaller streams in the coal field, or the coal which must be left in the mine, and that which is too poor to be shipped to market.

The coal beds are all found in the Carboniferous system, which in southern Illinois has an aggregate thickness of between 1,200 and 1,400 feet, while in the northern portion of the State the entire thickness of the system does not exceed 600 to 800 feet.

In this system of strata are contained sixteen distinct and well recognized coal beds, which are numbered from No. I., at the base of the system, to No. XV., at the top. The strata containing the coal seams below No. IX. are designated as the Lower Coal Measures, and those containing the upper seams as the Upper Coal Measures. The most persistent and valuable coal beds are those contained in the Lower Coal Measures, and among them Nos. I., II., V., VI., and VII. are the most productive.

Bed No. I. is a characteristic coal of Rock Island and the adjoining counties. Bed No. II. has its greatest development in the Big Muddy region, where the earliest coal mines in the State were developed. Bed No. V. is the bed from which most of the coal in Sangamon and Macoupin counties is mined. Although not confined entirely within the limits of these two counties, bed No. VI. has been most extensively worked in the Belleville district, east of Saint Louis. Bed No. VII. has its maximum development in Williams county, in the southern part of the State.

Beds No. IX. to XVI., inclusive, contained in the Upper Coal Measures, are rarely of sufficient importance to be worked. In the La Salle shafts, beds Nos. IX., XII., and XIII. are present, but they only range in thickness from 6 to 12 inches. The workable beds in these shafts are beds Nos. II., V., and VII.

According to the reports of the State mine inspectors, the most prolific, accessible, and easily worked seam of coal in the State is found in the Belleville district, in the four or five counties east of the Mississippi river at Saint Louis. The seam is from 6 to 8 feet in thickness, and lies usually 100 feet under cover; seldom less than 50 and rarely more than 250 feet.

The statistics of the Illinois coal field are compiled from the returns of the mine inspectors and from the summary report on the coal of the State by Col. John S. Lord, secretary of the Bureau of Labor Statistics:

Statistics of the Illinois coal field.

	1885.	1886.
Counties producing coal	50	50
Mines and openings of all kinds	778	789
Employés of all kinds	25,446	25,846
Mining machines employed	....	235
Tons of coal mined	9,791,874	9,246,435
Aggregate value of the same at the mines	$11,456,493	$10,263,543
Average value per ton at the mines	$1.17	$1.11
Average number of days of active operation	225	206
Average price paid per ton for mining	$0.725	$0.616
Kegs of powder used	140,382	127,099
Mules employed underground	....	1,344
Men killed	39	52
Men injured so as to lose time	176	169
Tons mined for each life lost	251,073	177,816
Employés for each life lost	652	497

The summaries for 1885 are placed beside those for 1886 for convenience of reference. The differences, it will be observed, are in some respects quite marked. There is a slight increase in the number of openings of all kinds, which is of little significance considering that this total embraces every place where coal is taken out, without regard to the quantity. In regions where the coal is found in outcrops or near the surface, openings are readily made with little expense, for supplying rural neighborhoods, which are as readily abandoned whenever the demand ceases, or other occupation is afforded the miners. Thus the number of openings as enumerated may fluctuate ten or twenty either way from year to year without materially affecting the total output of the State.

A grouping of the mines of the State upon the basis of their relative magnitude will indicate more fully the character of the mining establishments which enter into the total given. The following tabulation presents such a classification for four years:

Classification of the coal mines of Illinois.

Years.	Mines producing—				Total.
	Less than 1,000 tons.	1,000 to 10,000 tons.	10,000 to 50,000 tons.	Over 50,000 tons.	
1883	209	233	135	62	639
1884	262	273	146	60	741
1885	286	290	139	63	778
1886	316	280	136	57	789

From this it is seen that the mines of the first, second, and third classes are somewhat fewer than last year, while those of the smallest capacity, having produced less than 1,000 tons each during the year, is largely increased.

The total number of employés of all kinds, that is, the miners proper and those employed in various capacities about the mines, is seen to be somewhat larger in 1886 than in the preceding year. This number is not obtained by an enumeration but from employers who give the number of men constituting their working force, both in summer and in winter. The number here given is the maximum, and not the average force, and consequently represents a truer approximation to the whole number of mine employés in the State.

The average number employed may be arrived at by an examination of the reported numbers for summer and winter for three years.

Total number of employés in the Illinois coal mines.

Years.	Miners.		Other employés.
	Summer.	Winter.	
1884	13, 961	20, 610	4, 965
1885	14, 194	20, 273	5, 174
1886	14, 129	20, 973	4, 873
Total	42, 284	61, 856	15, 012

The average deducible from these figures is 22,353 for both miners and other employés.

The aggregate product of the year is more than half a million tons less than for the year preceding. The coal industry has not flourished during the last year or two. Every district except the Fourth, in which Macoupin county, the seat of operations of the Ellsworth Coal Company, is situated, shows a decline this year in coal production. In the First district, embracing the field nearest Chicago, the falling off is 192,655 tons; in the Second district it is 18,354 tons; in the Third district, including the Peoria and Danville regions, it is 292,960 tons; and in the Fifth, or Belleville district, it is 175,291 tons. The gain in the Fourth district is 133,821 tons.

The relative output of the several districts and the aggregate for the State for a term of years is shown in the following table:

Coal production by districts in Illinois.

Years.	First district.	Second district.	Third district.	Fourth district.	Fifth district.	Total.
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1870						2, 624, 163
1880	1, 631, 440	696, 046	1, 185, 189	1, 022, 718	1, 579, 984	6, 115, 377
1882	2, 540, 532	710, 526	1, 350, 020	2, 075, 244	2, 412, 321	9, 088, 643
1883	2, 495, 072	831, 522	1, 585, 108	3, 128, 368	1, 990, 921	10, 030, 991
1884	2, 507, 370	728, 341	1, 932, 881	2, 804, 183	2, 128, 230	10, 101, 005
1885	2,519, 397	723, 077	1, 811, 405	2, 615, 992	2, 122, 003	9, 791, 874
1886	2, 326, 742	704, 723	1, 518, 445	2, 749, 813	1, 946, 712	9, 246, 435

The figures in this table for 1870 and 1880 are derived from the United States Census reports for those years, while those for subsequent years have been procured annually by the State Bureau of Labor Statistics. Some fluctuations are noticeable in the product of the districts during this period, as well as in the total for the State. The falling off in the total output since 1883 is 784,556 tons. The aggregate product of all the mines of the State for a period of six years is 54,374,325 tons.

The average valuation at the mines of last year's product was $1.11 per ton, that of the preceding year was $1.17. The valuations upon which these annual averages are based are such as the proprietors choose to give for the product on the track at their respective mines.

The following table will show how continuously the current prices have declined in the given period for each inspection district and for the State:

Average value of coal per short ton at the mines in Illinois since 1882.

Districts.	1882.	1883.	1884.	1885.	1886.	Percentage decline since 1882.
						Per cent.
First	$1.75	$1.59	$1.49	$1.41	$1.321	25
Second	1.87	1.97	1.79	1.71	1.57	16
Third	1.43	1.45	1.31	1.25	1.161	19
Fourth	1.33	1.32	1.09	.985	.969	27
Fifth	1.31	1.26	.961	.894	.862	34
The State	1.51	1.48	1.26	1.17	1.11	26.6

This shows as the highest and lowest average values of coal during the given period: $1.97 per ton in 1883 in the second district, and 86.2 cents per ton in 1886 in the fifth district, the former being in the northern and the latter in the southern portion of the State. Both these sums being averages for the respective districts, they are neither the highest nor the lowest prices of either district. The lowest reported value of coal on track at the mines given this year is 56¼ cents per ton. This is in Randolph county, and the price paid for mining is given as 37½ cents per ton.

The average valuation for the State at large in 1882 was $1.51, and for 1886, $1.11 per ton, the total decline during that interval being 26.6 per cent. Computing the aggregate value of the coal products of the State for six years, upon the basis of these annual valuations, it is found that the 54,374,325 tons of coal mined during that period represented the sum of $71,986,251 in money.

Prices of mining.—This fitly introduces the consideration of miners' wages for a similar period. Upon this subject we have the data for only four years, but in these a decline is shown closely corresponding with the decline in values. The average price is deduced by computing the quantity mined at each given rate both in summer and winter, and from every mine in the State. By this process a rate is reached, which, multiplied by the total number of tons mined, would give the gross sum paid for reducing the whole amount of mineral to merchantable shape

The following is the record of average prices paid for hand-mining in this State for a peried of four years:

Average prices paid for mining in each district and in Illinois for the years 1883 *to* 1886 *inclusive.*

Districts.	1883.		1884.		1885.		1886.		Percentage of decline in four years.
	Summer.	Winter.	Summer.	Winter.	Summer.	Winter.	Summer.	Winter.	
	Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	
First	88.4	93.4	85.4	93.2	84.5	87.8	80.3	88.8	6.3
Second	95.4	99.8	95.0	103.0	90.7	95.8	89.3	94.4	5.7
Third	80.3	91.1	81.4	90.3	78.5	82.9	69.9	74.5	16.7
Fourth	65.8	73.6	63.5	72.4	59.8	63.1	55.6	58.2	19.3
Fifth	58.6	63.5	54.0	63.0	47.9	52.8	43.8	53.3	19.1
The State	75.9	82.4	72.6	81.2	68.1	74.3	59.5	71.7	....
The year	80.2		78.3		72.5		67.6		16
Five years	....		....		....		....		20

By this it is seen that the price this year has reached a lower figure than in either of the three preceding years, and as a matter of fact it is lower than it has ever been be fore in this State. These wages, it must be borne in mind, are averages, and neither the highest nor the lowest in any district. They range, in fact, from 37½ cents to $1.50 per ton, though the latter sum is only paid in small mines and to a small number of men. The whole decline in wages is seen to have been from 80.2 cents to 67.6 cents, or 16 per cent., during the last four years. Assuming that the ratio has been the same for five years, the decline for that period would be 20 per cent., while the decline in values has been 26.6 per cent. It will also be observed that the decline has been much greater in the central and southern districts than in the first and second districts, which lie on the northern limits of the coal field, where the coal is thinner and much more difficult to work.

Working time.—For 1885, 287 mines, which produced 93 per cent. of all the coal mined in the State, were reported as having been in active operation an aggregate of 64,610 days, or an average of 225 days each during the year. A similar calculation, made upon the returns for 1886, shows that the average number of working days in this industry has been only 206 for the year. The mines which afford the data here taken are representative of that industry.

The size of the screens used in preparing the coal for market and the tonnage of lump and nut coal produced at the different mines is shown in the following table:

Sizes of screens and coal produced in Illinois in 1886.

Number of mines.	Lump coal screened.	Space between bars of screens.	Nut estimated.	Total product.	Percentage of nut.
	Tons.	*Inches.*	*Tons.*	*Tons.*	*Per cent.*
12	175,425	$\frac{1}{2}$ to $\frac{3}{4}$	20,579	196,004	10.
98	4,352,252	$\frac{7}{8}$	516,631	4,868,883	10.6
23	437,074	1	62,972	500,046	12.6
10	354,305	$1\frac{1}{8}$	60,356	414,661	14.6
44	1,198,739	$1\frac{1}{4}$	224,417	1,423,156	15.6
25	665,533	$1\frac{1}{2}$ to $1\frac{7}{8}$	167,220	832,753	20.1
6	175,409	2 to $2\frac{1}{2}$	49,705	225,114	22.1
218	7,358,737	....	1,101,880	8,460,617	13

The mines of the State are divided into five inspection districts, as follows:

First district, inspector, Alexander Ronald, comprises the counties of Grundy, Kankakee, La Salle, Livingston, and Will.

Second district, inspector, Thomas Hudson, comprises the counties of Bureau, Hancock, Henry, Knox, McDonough, Mercer, Marshall, Rock Island, Stark, Schuyler, and Warren.

Third district, inspector, James Freet, comprises the counties of Cass, Fulton, Logan, McLean, Menard, Peoria, Tazewell, Vermilion, and Woodford.

Fourth district, inspector, Walton Rutledge, comprises the counties of Bond, Calhoun, Christian, Coles, Edgar, Greene, Jasper, Jersey, Macon, Macoupin, Madison, Morgan, Montgomery, Sangamon, Scott, and Shelby.

Fifth district, inspector, Robert Winning, comprises the counties of Clinton, Gallatin, Jackson, Marion, Perry, Randolph, Saline, Saint Clair, Washington, and Williamson.

Special statistics of interest connected with the inspectors' districts and the individual counties contained in them are given in the following tables:

Statistics of Illinois coal inspectors' districts for 1886.

Counties.	No. of mines.	No. of miners (summer).	No. of miners (winter).	Other employés.	Price per ton for mining.		Tons produced.	Average value per ton at mine.
					Summer.	Winter.		
FIRST DISTRICT.								
Grundy	22	1,595	2,232	509	$0.858	$0.954	776,625	$1.328
Kankakee	2	160	282	79	.850	.950	73,678	1.400
La Salle	29	1,549	2,084	773	.703	.733	980,382	1.291
Livingston	12	280	684	115	.750	.851	208,545	1.244
Will	4	511	796	109	.853	.950	287,512	1.341
Total	69	4,095	6,028	1,585	0.803	0.888	2,326,742	1.321

Statistics of Illinois coal inspectors' districts for 1886—Continued.

Counties.	No. of mines.	No. of miners (summer).	No. of miners (winter).	Other employés.	Price per ton for mining. Summer.	Price per ton for mining. Winter.	Tons produced.	Average value per ton at mine.
SECOND DISTRICT.								
Bureau	19	523	683	129	$0.871	$0.871	140,562	$1.356
Hancock	6	16	50	9	1.000	1.080	8,550	1.633
Henry	23	203	485	80	.784	.847	137,817	1.495
Knox	44	62	238	21	.882	.893	38,154	1.493
Marshall	15	109	160	28	.900	.900	56,174	1.430
McDonough	60	365	519	38	1.095	1.330	91,467	1.632
Mercer	19	361	337	192	.937	.937	103,329	1.850
Rock Island	25	231	329	54	.809	.849	87,713	1.749
Schuyler	5	28	46	6	.721	.813	10,123	1.303
Stark	23	27	93	11	.837	.830	17,198	1.498
Warren	23	28	86	5	1.209	1.217	13,636	1.917
Total	262	1,953	3,026	573	0.893	0.944	704,723	1.571
THIRD DISTRICT.								
Logan	3	145	270	67	$0.711	$0.723	180,000	$1.28
McLean	2	250	312	76	.725	.833	120,600	1.10
Woodford	2	250	310	115	.800	.864	121,200	1.25
Cass	5	6	21	6	.924	1.060	3,227	1.99
Tazewell	10	39	128	21	,732	.832	34,881	1.114
Fulton	56	362	751	126	.686	.715	238,542	1.17
Menard	8	115	256	51	.648	.648	127,464	1.058
Peoria	89	584	1,103	165	.720	.784	386,852	1.125
Vermilion	48	628	869	223	.644	.686	305,679	1.16
Total	223	2,379	4,020	850	0.699	0.745	1,518,445	1.161
FOURTH DISTRICT.								
Bond	2	27	50	11	$0.50	$0.562	18,560	$1.15
Christian	1	70	130	40	.55	.50	102,565	.87
Coles	1	40	95	20	.70	.70	89,110	1.50
Edgar	1	30	50	5	.70	.70	18,022	1.25
Greene	9	37	50	9	.75	.75	12,172	1.50
Jasper	1	....	4	1	....	1.00	826	2.00
Jersey	6	12	10	4	1.00	1.00	2,160	1.75
Macon	3	133	180	60	.68	.696	115,272	1.33
Macoupin	22	1,256	1,602	293	.506	.545	1,085,539	.912
Madison	29	715	999	128	.505	.548	604,214	.882
Montgomery	1	15	20	8	.75	.75	8,666	1.35
Morgan	3	19	16	6	.782	.782	6,253	1.28
Sangamon	17	688	1,024	288	.623	.624	720,153	1.00
Scott	5	36	42	6	1.125	1.125	8,349	1.60
Shelby	7	22	40	6	1.73	1.72	7,952	2.46
Calhoun	1	....	....	....	....	....	....	....
Total	109	3,100	4,312	885	0.556	0.582	2,749,813	0.969
FIFTH DISTRICT.								
Clinton	3	90	122	43	$0.50	$0.571	61,537	$1.105
Jackson	11	458	533	155	.585	.665	251,644	.959
Marion	2	150	250	92	.563	.563	109,434	.955
Perry	15	352	528	185	.492	.575	213,112	.934
Randolph	11	93	133	41	.439	.480	62,220	.840
Saline	7	67	234	52	.643	.643	69,921	.951
Saint Clair	68	1,163	1,532	347	.371	.484	1,003,723	.777
Washington	4	60	75	24	.646	.646	59,072	.913
Williamson	5	169	180	41	.406	.406	116,049	1.000
Total	126	2,602	3,587	980	0.438	0.533	1,946,712	0.860

Sharp competition in the mining, transportation, and selling of coal in the Saint Louis and surrounding markets resulted during the year in the combination of the varied coal interests and the organization of what is known as the Saint Louis Consolidated Coal Company. According to Colonel Lord. within a radius of 100 miles of Saint Louis there are one hundred and eighteen coal mines, which are located on nine different railways centering in Saint Louis, which produced about 3,400,000 tons of coal during 1886. All this coal, however, was not transported to or through Saint Louis.

The Consolidated Coal Company has acquired by lease or purchase the control of seventy-one of the most important mines in the district and chiefly within a radius of 50 miles of Saint Louis. The product of these mines during 1886 was 2,350,000 tons, and the capacity of the same about 4,000,000 tons. It is believed that this combination, which is the most notable enterprise which has been organized in the coal business of the State, will protect the interests of all parties in the coal industry of the field where it appears.

Another important enterprise, organized during the year, was a syndicate to purchase 15,000 acres of coal lands in Bureau county, contiguous to those in La Salle county. In addition, the object of the syndicate was to construct an important line of railroad as an outlet for the mines, and to develop a mining town, which has now a population of 3,000; also, to sink two of eight contemplated shafts to a depth of between 300 and 400 feet.

The following statistics connected with the Chicago coal market are reproduced from the *Black Diamond*, and are significant as showing the movement of coal as affecting the production of Illinois coal mines:

Yearly receipts of coal at Chicago since 1882.

Kinds of coal.	1882.	1883.	1884.	1885.	1886.
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
Anthracite by lake	663, 785	738, 723	820, 002	741, 866	768, 164
Anthracite by rail	447, 636	506, 688	627, 806	613, 054	616, 997
Eastern bituminous coal by lake	287, 794	214, 488	243, 188	206, 817	166, 762
Eastern bituminous coal by rail	390, 212	630, 914	612, 462	790, 169	888, 771
Illinois coal	1, 167, 844	1, 490, 515	1, 467, 989	1, 287, 995	1, 175, 001
Indiana coal	542, 760	500, 925	469, 079	659, 634	732, 191
Coke	467, 633	464, 529	553, 860	558, 963	540, 204
Total	3, 967, 664	4, 546, 782	4, 794, 386	4, 858, 498	4, 888, 090

The following table shows the relative percentage which each kind or division bears of the aggregate receipts for each year:

Kind of coal.	1882.	1883.	1884.	1885.	1886.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Anthracite	27. 46	27. 39	30. 20	27. 89	28. 35
Eastern bituminous	17. 22	18. 59	17. 85	20. 52	21. 59
Illinois coal	29. 67	32. 78	30. 62	26. 51	24. 03
Indiana coal	13. 78	11. 02	9. 78	13. 58	14. 98
Coke	11. 87	10. 22	11. 55	11. 50	11. 05
Total	100. 00	100. 00	100. 00	100. 00	100. 00

The following tables give the receipts of bituminous coal at Chicago during the years 1884, 1885, and 1886:

Yearly receipts of bituminous coal at Chicago since 1883.

Eastern bituminous coal.	1884.	1885.	1886.
	Tons.	*Tons.*	*Tons.*
Hocking	81,224	165,463	211,984
Ohio Central	165,022	115,951	193,732
Shawnee	40,940	54,717	75,558
Jackson Hill	11,999	9,520	10,023
Pittsburgh	190,764	249,684	133,260
Youghiogheny	133,353	173,944	256,515
Erie and Brier Hill	137,899	145,096	71,245
Cumberland	19,515	50,289	25,161
Total	780,716	964,664	977,478
Western bituminous coal.			
Wilmington	931,945	909,854	791,337
Indiana Block	300,035	500,458	575,301
Mount Olive	99,519	88,447	112,497
Streator	107,898	80,878	92,758
Norton Creek and Clinton	32,661	53,185	66,325
Grape Creek	229,994	155,863	89,654
Fountain County	96,597	89,411	90,565
Total	1,798,649	1,878,096	1,818,437

INDIANA.

Total production in 1886, 3,000,000 short tons; spot value, $3,450,000.

The coal field of this State is confined to the southwestern part, being part of the Illinois coal field. The eastern boundary crosses the Indiana-Illinois State line in Warren county, 4 miles west of Williamsport, then passes near Greencastle, in Putnam county, and Freedom, in Owen county. It touches the western boundary and passes between the Huron and Shoales, and the Ohio and Mississippi rivers in Lawrence and Martin counties, and passing through Orange county to the mouth of Deer creek in Perry county, where it crosses the Ohio river into Kentucky.

There are nineteen counties which produce coal, and the area of the State underlaid by coal measures approximates 6,500 square miles. According to Professor Cox, late State Geologist, the coal measures in the State are not greater than 650 feet in thickness.

Although the coal measures exist only in the western part of the State, they dip rapidly toward the west and bring in a number of coal beds in Putnam county; the westward dip being at the rate of 30 feet to the mile.

The coal beds are designated by the letters A to N, inclusive. No beds have, however, been discovered to represent the letters C, D, and E. The vertical thickness of the strata is about 260 feet, and the aggregate thickness of the remaining eleven beds in the general section of the State would be between 25 and 30 feet, the bed having the minimum thickness being bed G, about 6 inches thick, and the bed having the maximum thickness being bed L, or the Staunton bed, having a thickness of about 7 feet.

The mines of the State are divided into four classes, according to the character of the coal which they produce, as shown in the following table:

Classification of the Indiana coal mines.

Counties.	Mines producing—			
	Block coal.	Semi-block coal.	Bituminous coal.	Bituminous and cannel coal.
Clay	22	....	4	....
Daviess	....	....	5	2
Dubois	....	....	2	....
Fountain	....	....	3	....
Greene	....	....	2	....
Gibson	....	....	....	....
Knox	....	....	2	....
Martin	....	....	....	....
Owen	....	1	....	....
Perry	....	2	1	....
Parke	4	2	1	....
Pike	....	....	4	....
Sullivan	....	....	5	....
Spencer	....	....	....	....
Vigo	....	....	7	....
Vermillion	....	....	2	....
Vanderburgh	....	....	5	....
Warrick	....	....	6	....
Warren	....	....	....	....

The number of producing mines and the number of individual operators in each county during 1886 is shown in the following table:

Number of mines and operators in Indiana in 1886.

Counties.	Mines.	Operators.
Clay	26	15
Daviess	14	4
Dubois	11	2
Fountain	13	3
Greene	8	2
Gibson	3	....
Knox	3	2
Martin	3	....
Owen	6	1
Perry	16	2
Parke	15	3
Pike	17	4
Sullivan	12	5
Spencer	8	....
Vigo	14	5
Vermillion	4	2
Vanderburgh	5	5
Warrick	15	6
Warren	5	....
Total	198	61

A list of collieries in the State, with the character of the coal produced, the thickness of the bed worked, together with its name, the depth from the surface, and the average number of men employed in the mines during the year, are shown in the following table:

Number and names of the coal mines in Indiana by counties, with the kind of coal, the name of seam worked, the thickness of the vein, with its depth from the surface, together with the number of men employed in 1886.

Name and location of mine.	Operator.	Kind of coal.	Seam worked.	Coal thickness.		Depth from surface.	Average number of men employed.
Clay county.				*Ft.*	*In.*	*Feet.*	
No. 5	Brazil Block Coal Company	Block	J	3	3	75	90
Abbey	......do	....do	I and J	3	6	20	100
Chicago	......do	....do	J	3	4	80	135
Campbell	......do	....do	I	3	7	106	300
Gart. No. 1	......do	....do	J	3	5	109	125
Gart. No. 2	......do	....do	I and J	3	9	120	275
Hancock	......do	....do	J	3	3	40	35
Crawford	Crawford Coal Company	....do	J	3	9	107	265
Star	Zeller & Sigler	....do	J	3	6	100	20
Peanut	Knightsville Coal Company	....do	I and J	3	8	100	90
Nickel Plate	Jackson Coal Company	....do	I and J	3	4	102	400
Centennial	C. B. Reddie	....do	I	3	5	70	22
Phœnix	P. Ehrlick & Co	....do	I	3	8	40	75
South Slope	......do	....do	I	3	6	30	25
Newburg	......do	Bituminous	L	7	0	75	70
Wheeler	Gaunter & Croasdale	....do	L	6	6	62	22
Staunton	John Summers	....do	L	6	6	38	40
Burgherville	Gart. Coal and Mining Company	....do	L	6	6	60	45
North	William Simpson	Block	I and J	3	7	60	17
Paw-Paw	Morgan & Powell	....do	J	3	6	20	32
Litchfield	Coal Bluff Mining Company	....do	I and J	3	4	90	150
Vandalia	Zeller & Sigler	....do	I and J	3	3	37	110
Watson's No. 1	Gart. Coal Company	....do	I	3	3	52	55
Chicago	Jackson Coal Company	....do	J	3	3	37	50
Diamond	Zeller & Sigler	....do	J	......		69	10
Clay City	Clay City Coal Company	....do	I	......		72	10
Daviess county.							
Sulphur	Cable & Kaufman	Bituminous	L	4	0	60	90
Eureka	......do	....do	L	3	0	48	22
Maple Valley	......do	....do	L	4	6	74	125
No. 4	......do	....do	L	4	0	70	65
Buckeye	Cannel Coal Company	Bituminous and cannel.	I	4	0	100	120
Union No. 2	Mutual Mining Company	....do	J	5	0	96	15
Wilson's	Wilson Coal Company	Bituminous	....	3	6	96	65
Dubois county.							
Rosebank	J. C. Futes	....do	L	4	6	50	125
Banoman	A. Banoman	....do	....	4	0	......	17
Fountain county.							
No. 2	Woodruff & Turnkey	....do	L	6	0	106	125
McVey's	James McVey	....do	L	4	6	50	25
Bunker No. 2	Thomas Tyley	....do	L	4	6	80	30
Greene county.							
Island City	Island City Coal Company	....do	L	5	6	60	150
Price's	Dugger & Neil	....do	L	5	6	76	25
Knox county.							
Indian Creek	Indian Creek Coal Company	....do	K	4	4	95	65
White River	Wright & Curry	....do	L	5	0	60	25
Owen county.							
Lancaster No. 2	Lancaster Coal Company	Semi-block	I	4	6	60	120

Number and names of the coal mines in Indiana by counties, etc.—Continued.

Name and location of mine.	Operator.	Kind of coal.	Seam worked.	Coal thickness. Ft.	Coal thickness. In.	Depth from surface. Feet.	Average number of men employed.
Perry county.							
Sioux Nos. 1 and 2	A. C. C. Company	Semi-block	F	2	9	150	83
Windy Creek	Burgenroth Brothers	Bituminous	G	3	3	140	12
Parke county.							
No. 3	Parke County Coal Company	Semi-block	I	4	0	65	125
No. 4	do	do	I	4	0	80	130
No. 5	do	Bituminous	L	5	6	80	100
Black Diamond	Stephens Coal Company	Block	I	1	10	38	85
Blaine	Brazil Block Coal Company	do	J	3	6	40	125
Blaine No. 2	do	do	I	4	0	30	35
Blaine No. 3	do	do	I	4	0	30	22
Pike county.							
Ayrshire	D. E. Ingle	Bituminous	L	4	8	65	150
Whitman's	C. Townsend	do	L	4	0	50	50
Hazeldell	S. Bettanan & Co	do	L	6	0	40	35
Roger Brothers	Roger Brothers	do	L	7	0	80	75
Sullivan county.							
Pioneer	Curriesville Coal Company	do	L	5	6	248	45
Shelburn No. 2	Shelburn Coal Company	do	L	5	0	248	45
Lyonton	Lyonton Coal Company	do	L	6	0	70	38
Dugger	Dugger & Neil	do	L	5	4	70	115
New Pittsburg	Pittsburg Coal and Coke Co	do	L	6	6	60	60
Vigo county.							
Fountain No. 1	Coal Bluff Mining Company	do	L	6	0	62	32
Fountain No. 2	do	do	L	6	0	60	100
South Mine	Edgar Coal Company	do	L	5	6	60	120
Seeleyville	P. Ehrlick & Co	do	L	7	0	96	60
Kay's	Coal Bluff Mining Company	do	L	6	0	45	55
Eppart	do	do	L	6	0	40	45
Union	Co-operative Coal Company	do	L	5	0	60	40
Vermillion county.							
Hazell Bluff	Sherley Coal Company	do	L	4	4	90	30
Norton Creek	Norton Creek Coal Company	do	L	6	0	40	250
Vanderburgh county.							
Ingleside	J. Ingle & Co	do	K	4	0	263	100
Sunnyside	Sun Coal and Coke Company	do	K	4	0	266	35
Unity	Unity Coal Company	do	K	4	0	257	50
First Avenue	First Avenue Coal Company	do	K	4	0	260	35
Echo	Diamond Coal Company	do	K	4	0	257	20
Warrick county.							
Star No. 2	Lore & Angle	do	K	4	0	104	17
Chandler	Menden & Hall	do	K	4	0	85	25
No. 3	R. Lowden	do	K	5	6	85	20
De Forest	Bettram Menden	do	K	6	6	95	20
Boonville	Robert Goff	do	K	6	6	45	18
Fuller	R. Lowden	do	K	6	6	45	19

The total production of the Indiana coal fields for the past fourteen years is shown in the following table:

Annual production of coal in Indiana for 14 years.

Years.	Short tons.	Years.	Short tons.
1873	1,000,000	1880	1,500,000
1874	812,000	1881	1,771,536
1875	800,000	1882	1,976,470
1876	950,000	1883	2,560,000
1877	1,000,000	1884	2,260,000
1878	1,000,000	1885	2,375,000
1879	1,196,490	1886	3,000,000

Mr. Thomas McQuade, inspector of mines, in referring to the condition of trade during the year, says:

The coal trade has been remarkably good in Indiana during the past year, with the exception of a few months during the summer season. The demand for coal has never been better than now. So great has it been that many companies were unable to meet the demands made upon them by their customers.

New railroads completed into Indiana had much to do with this increased demand for coal. The extension of the Chicago and Indiana Coal Railway from Yeddo to Brazil has enabled the coal companies to secure cheaper transportation for their coal into the Chicago markets, and aided them in getting a better supply of flat cars than formerly. The Evansville and Terre Haute railroad built a switch from Farmersburg to New Pittsburgh, a distance of 10 miles. This switch has opened a new field of coal, hitherto undeveloped, which promises to be very extensive. The extension of the Indianapolis and Evansville railroad from Washington to Worthington, where it was connected with the Terre Haute and Southeastern, has given the coals of southern Indiana an opportunity to get into the northern market, such as they never had before. In addition to those mentioned, there are a number of other railroad improvements made in the State, of less importance, that have aided in making the increased demand for coal.

INDIAN TERRITORY.

Total production in 1886, 534,580 short tons; spot value, $855,328.

No detailed geological survey has been made of the Indian Territory, so that there is very little information in regard to the extent of the coal fields. The only coal mines which are opened, the product of which is shipped to market, are situated along the line of the Missouri Pacific railroad, in the Choctaw Nation, in the southeastern part of the Territory.

The total production of commercial coal in the Territory for the past year was 534,580 tons.

One mine is located at Lehigh, a few miles west of Atoka, two at Savannah, and three at McAlister.

The coal beds worked at these mines range from 4 to 5 feet in thickness. The mines at Lehigh and Savannah are operated by the Atoka

Coal and Mining Company, and produced during the year 307,416 tons. The mines at McAlister are operated by the Osage Coal and Mining Company, and produced during the year 227,134 tons of coal. About 10,000 tons of this latter coal were manufactured into coke. This company has in operation 40 coke ovens. The McAlister coal is currently reported to be one of the best gas and coking coals west of Pittsburg. It is remarkably free from sulphur and other impurities. The following is an analysis of the coal and coke:

Analysis of coking coal from McAlister, Indian Territory.

	Coal.	Coke.
	Per cent.	*Per cent.*
Water	2.10	0.325
Volatile matter	29.71	1.560
Fixed carbon	62.67	87.140
Ash	5.52	10.975
	100.00	100.000

The Savannah coal resembles very much in quality and character the McAlister coal. The Lehigh coal is non-coking and is an excellent steam coal.

Most of the coal from the Indian Territory mines is consumed by the railroads, and the average price of the coal delivered on cars at the mouth of the Lehigh mine during the year was $1.70. The miners are paid by the bushel of 85 pounds.

Two mines have been in operation at Lehigh, one of which was worked out, however, August 31, 1886. Work has been commenced in opening a new mine known as No. 5, but no coal had been shipped up to the close of 1886.

The coal in the Territory is mined under lease from Indian tribes. In January, 1887, the Attorney-General of the United States gave the opinion that the leases for coal mining in the Territory are illegal. Referring to an act of February 19, 1875, the Attorney-General says: This act is significant as showing that in the view of Congress the Indian tribes cannot lease their reservations without the authority of some law of the United States. No laws have been enacted by Congress upon the subject of coal leases in the Territory.

IOWA.

Production in 1886, 4,312,921 short tons; spot value, $5,391,151.

The geology of the coal fields of the State has been carefully portrayed in more or less detail at different times by Professors Owen, Hall, Whitney, Worthen, and White. The coal field of the State forms the northern part of what is frequently called the Fourth Coal Field of the United States, extending over parts of Iowa, Nebraska, Missouri, and Kansas.

The Coal Measures have been divided into three divisions, the Upper, Middle, and Lower. The lower division is the most important and contains most of the productive coals. The strata of this division occupy the surface of the State along the Des Moines river from a little above

Fort Dodge to near Keokuk, the average width being about 50 miles and the length about 175 miles.

South and west of this district coal will be found by sinking shafts to a greater or less depth. The boundaries of the coal may be stated as follows: It corresponds nearly with the eastern line of Van Buren and Jefferson counties, moving a little eastward into Lincoln county, in the southeast corner of the State. From the northeast corner of Jefferson county the boundary follows a northwestern course, passing through the northwestern corner of Keokuk and the northeastern corner of Mahaska county to the middle of the south line of Marshall county. It then runs to within 3 or 4 miles of El Dora, in Hardin county; thence west to a point a little north of Webster City, in Hamilton county; and finally to a point north cf Fort Dodge, in Webster county. Further west the boundaries are uncertain.

The dividing line between the Lower and Middle Coal Measures has a nearly southeasterly course, including in the Lower Coal Measures a part of the counties of Guthrie, Dallas, Warren, Lucas, and Appanoose. The area between these two boundary lines includes the most important and productive part of the Iowa coal field.

The dividing line between the Middle and Upper Coal Measures extends from the northwestern corner of Harrison county to the middle of the northern boundary of Madison county, thence to the northern boundary of Wayne county and then to Centerville and the southern boundary of the State, along the west side of the valley of the Chariton river.

The following table gives the production of the State by counties for the past four years:

Production of coal in Iowa, by counties, for the past four years.

Counties.	1883.	1884.	1885.	1886.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*
Mahaska	927, 387	932, 714	762, 785	851, 362
Keokuk	500, 040	430, 940	372, 816	545, 304
Lucas	487, 821	410, 729	439, 956	530, 759
Polk	558, 821	619, 921	462, 895	337, 964
Boone	466, 981	473, 073	458, 191	294, 970
Webster	248, 560	214, 014	145, 296	107, 777
Wapello	237, 821	240, 720	187, 911	237, 111
Appanoose	128, 896	158, 986	245, 896	150, 000
Monroe	93, 435	98, 427	101, 517	117, 700
Marion	90, 985	97, 085	100, 011	141, 694
Greene	88, 851	96, 327	89, 587	117, 538
Jasper	45, 883	46, 321	90, 425	286, 034
Dallas	38, 008	37, 185	32, 986	21, 986
Jefferson	38, 887	8, 172	1, 116	1, 083
Warren	12, 828	13, 727	12, 825	23, 330
Scott	3, 714	3, 821	5, 937	3, 000
Hardin	1, 203	1, 075	885	....
Adams	3, 891	3, 981	3, 896	9, 581
Hamilton	1, 998	1, 878	918	3, 312
Wayne	1, 892	4, 947	25, 812	34, 000
Van Buren	1, 678	1, 778	1, 193	8, 038
Davis	527	1, 207	33, 655	1, 000
Page	748	1, 009	1, 819	1, 500
Taylor	94	127	617	8, 585
Henry	65	87	196	....
Cass	43	5, 187	....	....
Guthrie	....	....	4, 596	17, 194
Total	3, 981, 057	3, 903, 438	3, 583, 737	3, 850, 822

The greatest developments during 1886 were in Jasper county. The total production of the State has varied very little during the past four years, yet the condition of the Iowa coal trade is healthy and a proper regulation of the railroad freights would greatly aid it. Mr. Parke C. Wilson, late mine inspector, in referring to this, says: There are certain localities that geographically belong to Iowa, but by the State discrimination not being allowed to receive a rebate in freights, other States have been enabled to come into successful competition with the coal from Iowa mines and in some instances have been enabled to undersell our Iowa coal in the markets.

KANSAS.

Total production in 1886, 1,400,000 short tons; spot value, $1,680,000.

The coal fields lie in the eastern part of the State. They extend from the northern to the southern boundaries and from the eastern boundary west to a central line extending through Emporia. This area was estimated by Professor Swallow to contain 17,000 square miles. The coal statistics of the State are collected by the inspector biennially; no complete detailed returns for 1886 have been obtained. The following table gives the list of the producing counties for 1885, with the amount of coal mined in each county. The counties producing coal during 1886 and the percentage of the total product from each county were practically the same as in 1885:

Coal production in Kansas by counties in 1885.

Counties.	Mined.	Stripped.	Total production.
	Bushels.	*Bushels.*	*Bushels.*
Crawford	3,832,717	1,760,816	5,593,533
Cherokee	9,260,681	37,574	9,298,255
Osage	8,460,711	803,086	9,263,797
Shawnee	95,600	....	95,600
Coffey	11,582	215,100	226,682
Franklin	344,952	18,000	362,952
Douglas	20,000	....	20,000
Cloud	102,948	....	102,948
Republic	60,785	....	60,785
Ellsworth	82,708	....	82,708
Lincoln	69,365	....	69,365
Russell	3,500	....	3,500
Neosho	191,500	....	191,500
Linn	113,911	25,000	138,911
Leavenworth	3,014,024	....	3,014,024
Bourbon	66,867	311,000	377,867
Labette	200,000	200,000	400,000
All other coals mined in the State in 1885, estimated	....	1,000,000	1,000,000
Total	25,931,851	4,370,576	30,302,427

While the total production of coal in the State in 1886 was greater than that for 1885, yet the percentage of coal produced by each county for each year would not vary considerably.

Detailed returns of a little over one-half of the total amount of coal produced by the State have been received by the Survey, and are given in the following table:

Partial coal production in Kansas by counties, 1886.

Counties.	Name of operator.	Location.	Total production.
			Short tons.
Osage	Osage Carbon Company	Osage City	200,111
	Industrial Coal and Mining Company	Scranton	6,033
	Underwood and Young	Burlingame	2,883
	J. H. Burke	do	2,201
	Henry Isaac	Scranton	14,776
	Scandinavian Coal and Mining Company	Osage City	12,975
	Western Coal and Mining Company	Fleming	28,186
Douglas	Kansas Carbon Company	Lawrence	7,105
Crawford	Kansas and Texas Coal Company	Pittsburgh and Litchfield.	303,900
Leavenworth	Kansas State Penitentiary	Lansing	53,414
Cherokee	Keith and Perry Coal Company	Scammonville	127,500
	Total		759,084

According to an estimate made by Mr. J. R. Braidwood, late mine inspector, the total production for 1886 was 35,000,000 bushels or 1,400,000 tons.

The Osage Carbon Company produced the greatest amount of coal during the year. This coal commanded a price of $2.10 at the mouth of the mine, and was consumed principally at points between Topeka and Newton. The average thickness of the bed mined by this company ranges from 15 to 22 inches. The company employs from 1,000 to 1,200 miners. Although the bed is thin, industrious miners can earn from $2.25 to $2.75 per day. Most of the coal mined at the Kansas mines is consumed at points within the State.

The following table gives a statement of coal produced by the various coal companies and the shipments of coal made over the line of the Atchison, Topeka and Santa Fé railroad during 1886:

Statement of coal produced by various companies and shipments over line of Atchison, Topeka and Santa Fé railroad during the year 1886.

Names of companies producing and shipping coal.	Mined.	Shipped.
	Short tons.	*Tons.*
The Osage Carbon Company, Osage City, Kansas	199,231	199,231
The Cañon City Coal Company, Rockvale, Colorado	211,406	206,073
The Trinidad Coal and Coking Company, Starkville, Colorado	146,015	102,277
Raton Coal and Coke Company, Raton, New Mexico	87,706	87,706
The San Pedro Coal and Coke Company, Carthage, New Mexico	68,038	68,038
Sundry other shippers		151,951
Total		815,276

The coal companies named above and operated along the line of the railroad shipped their product over the road. In addition to these coal companies there are several other smaller shippers who have furnished coal for transportation over the same road, the aggregate quantity so furnished amounted to 151,951 tons.

The coal furnished by these companies and individual operators to the Atchison, Topeka and Santa Fé Railroad was for shipment to consumers or for consumption by the railroad.

The shipment of coal from individual mines for the year over the lines of the Kansas City, Fort Scott and Gulf Railroad, the Kansas City, Clinton and Springfield Railway, and the Kansas City, Memphis and Birmingham Railroad was as follows:

Name of mine.	Car loads.
Fort Scott	3
Cherokee	440
Scammonville	6,714
Stilson	80
Syepps Switch	703
Clarksburg	16
Arcadia	249
Coalvale	178
Mulberry	698
Midway	1,197
Pittsburgh	23
Weir City	10,552
Total	20,853

The average number of tons carried per car was about 18, making the total amount of coal carried by these companies 375,354 short tons.

KENTUCKY.

Total production in 1886, 1,550,000 short tons; spot value, $1,782,500.

This State is the only one which includes within its boundaries portions of both the Appalachian and Illinois or central coal fields. The former areas lie in the eastern part of the State and east of a line drawn from Portsmouth on the Ohio river, southwest through Irvine on the Kentucky river, and Albany in Clinton county, south of the Cumberland river.

The western coal field covers 10 counties and parts of 15 counties lying in the northwestern part of the State, immediately south of the Mississippi river between the Rolling Fork and Cumberland rivers.

The eastern area, according to surveys made by Mr. Joseph Lesley, late Secretary of the Pennsylvania Railroad, contains about 9,000 square miles. No reliable measurements have been made of the area of the western field. In the eastern area the coal beds lie stratigraphically in two subdivisons, the upper of which represents the Lower Coal Measures of Ohio, West Virginia, and Pennsylvania, and the lower, the conglomerate and sub-conglomerate coals.

The thickness of the Coal Measures ranges from 2,500 to 3,000 feet in the eastern field. In the western field the Coal Measures are about 600 feet thick and are generally divisible into two natural groups, as in the eastern field. No substantial geological connection has been made between the coal beds in the two Kentucky coal fields.

A summary of the coal statistics for 1886 has been furnished by Mr. C. J. Norwood, State mine inspector.

The total production of the State for the year was 1,550,000 short tons, which is about 50,000 tons less than the production for 1885, or about the same as in 1884.

The decrease in the production for the past year has been attributed to local causes, chiefly strikes and disagreements between the operators and miners. An estimate of the production of the three districts of the State for the past three years is given in the following table. In these figures are included the shipments from the mines, being 30,000 tons less than the estimated total product of the State.

Production of coal in Kentucky from 1884 *to* 1886.

	1884.	1885.	1886.
	Short tons.	*Short tons.*	*Short tons.*
Western coal field	875, 593	860, 000	855, 000
Southeastern coal field	384, 031	400, 000	390, 000
Northeastern coal field	278, 630	280, 000	275, 000
Total	1, 538, 254	1, 540, 000	1, 520, 000

No complete statistics are available of the shipment of coal from all the local districts. The following table, however, giving shipments from special districts for the past five years, is of interest:

Shipments of coal from special districts in Kentucky, 1882 *to* 1886.

	1882.	1883.	1884.	1885.	1886.
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
Henderson division of Louisville and Nashville railroad	269, 600	364, 360	340, 887	357, 745	423, 375
Chesapeake and Ohio and Southwestern railroad	274, 700	324, 552	292, 071	282, 660	299, 868
Green river	96, 000	108, 000	118, 000	78, 000	80, 000
Ohio river below Green river	60, 000	72, 500	62, 000	75, 000	70, 000
Ohio river above Green river	60, 000	76, 000	66, 000	70, 000	70, 000
Total	760, 300	945, 412	878, 958	863, 405	943, 243

The following is a list of the principal mines in operation at the present time:

Mines in the western district.—Clifton, Co-operative (new mine), Hecla, Erlington (2 mines), Empire, Henderson, Shotwell (2 mines), Green river (Spottsville), Emporia, Owensboro' (group of 8 mines), Dovey's, Caseyville (group of 5 mines), Mud river, McHenry, Echols, Taylor, Diamond, Saint Charles, Crabtree, People's, Corydon, Uniontown, Robinson, Central (2 mines), Render, Memphis, McDougall, Zion, Bluff City, Breckinridge; total number of mines, 44.

Mines in the northeastern district.—Mary, Music, Coalton, Star, Strait, Peach Orchard (3 mines); total number of mines, 8.

Mines in the southeastern district.—Holloway, Pryse's Tunnel, Ætna, Laurel, Pitman (new mine), Queen City, Peacock, Wood's Creek, Vulcan, Black Diamond, Buckeye (new mine), Altamont, Livingston, Main Jellico Mountain, East Tennessee, Star (formerly Webb, Frost & Co.), Litton, Victoria, Garrard's, Happy Hollow, Beaver Creek Company, Cumberland River companies (2 mines), Barren Fork; total number of mines, 24.

There is a number of small banks in Ohio, Hancock, Webster, and Carter counties, whose individual production may be sufficient during the coming winter to come under the restrictions of the State law providing for mine inspection.

During the year considerable outlays have been made towards increasing or bettering the facilities of the mines for placing their output upon the market, and large improvements are projected for 1887. Eleven mines report a total expenditure of $65,800 for improvements while the cost of projected improvements at eight of them is reckoned at $111,500. The Ohio Valley railroad has been completed from Henderson to the Shotwell mines and beyond; and the Mud River mines have been connected by rail with the Owensboro' and Russellville branch of the Louisville and Nashville system.

Of the projected railroads to reach the untouched fields of coal and iron in southeastern Kentucky, the preliminary work on a branch from Corbin, on the Knoxville extension of the Louisville and Nashville, to Pineville, in Bell county, has been commenced. The building of this road will increase the coal production of the State.

The Altamont Coal Company is extending its field of operations by building a line of railroad about two miles long. It is also erecting additional buildings.

The following table shows the annual production of coal for the past fourteen years:

Production of coal in Kentucky.

Years.	Short tons.	Years.	Short tons.
1873	300,000	1881	1,100,000
1874	360,000	1882	1,300,000
1875	500,000	1883	1,650,000
1876	650,000	1884	1,550,000
1877	850,000	1885	1,600,000
1878	900,000	1886	1,550,000
1879	1,000,000		
1880	1,000,000	Total for 14 years	14,310,000

MARYLAND.

Total production in 1886, 2,517,577 short tons; spot value, $2,391,698.

One of the most important coal districts in the Appalachian coal field is the Cumberland, Frostburg, or George's Creek coal district, situated in Alleghany county, in the western part of Maryland, and between Great Savage mountain on the west and Dan and Piney mountains on the east.

This coal basin extends over the State line into Southampton township, Somerset county, Pennsylvania; here it is included between the Great Savage and Little Savage mountains, and is known as the Wellersburg basin, which is 13 miles long; at the State line it is 3 miles wide.

The great coal bed of the Cumberland basin, which is the representative of the Pittsburgh coal bed of western Pennsylvania, "spoons out" almost entirely before it reaches the State line, and does not extend unbroken over into Pennsylvania; a few hundred acres of the bed are caught, however, in the highest of the Wellersburg hills. The length of that portion of the Cumberland basin which contains the Pittsburgh bed is 20 miles in a northeast and southwest direction, and its average width about 4½ miles. The whole of this area, however, is not underlaid by the bed. According to the surveys made by Dr. James T. Hodge in 1869, the area of the basin, which was originally underlaid by the Pittsburgh coal bed, in workable condition is only about 27 square miles.

The coal bed does not lie horizontal, as in the Pennsylvania bituminous coal region, but has steeply inclined dips, the structure of the basin resembling in many of its essential features some of the anthracite basins. The bed itself varies in thickness, but one of the popular names of the bed, "fourteen-foot bed," gives a fair idea of its average thickness; few of the mines, however, work all the benches of the bed which are included between the bottom clay and roof slate. It has been estimated that the bed rarely produces more than 6,000 tons of commercial coal to the acre. A thickness of 10 feet of clean coal of the Cumberland bed would contain over 16,000 tons to the acre.

From measurements made by Prof. T. C. Tyson, the thickness of the Coal Measures from the base of the Pottsville Conglomerate No. XII. is 1,155 feet; there are 277 feet of coal measures overlying the main coal or Pittsburgh bed, and 878 feet of coal measures underlying the same bed to the base of the Conglomerate No. XII.

This coal field has connections with tide water as follows:

Via Baltimore and Ohio railroad to Baltimore, 178 miles from Cumberland, and 206 miles from Piedmont.

Via Chesapeake and Ohio canal to Georgetown 184 miles, and to Alexandria 191 miles.

Via Pennsylvania State Line branch, which connects with Cumberland and the Pennsylvania railroad near Mount Savage.

Via George's Creek and Cumberland railroad from Lacount to Cumberland, where connections can be made with railroad or canal.

The shipments made by these routes for 1886, compiled from official sources, are shown in the following table:

Shipments from the Cumberland coal field, Maryland, in 1886.

Name of company or mine.	1886.					Compared with 1885.	
	To Baltimore and Ohio Railroad.	To Chesapeake and Ohio Canal.	To Pennsylvania Railroad.	Surplus and local.	Total.	Increase.	Decrease.
	Long tons	*Long tons*	*Long tons*	*Long tons*	*Long tons*	*Long tons*	*Long tons*
Consolidation Coal Company	532, 036	114, 185	258	29, 173	675, 652	....	34, 413
Maryland Coal Company	188, 162	47, 131	47, 837	5, 672	288, 742	....	76, 577
George's Creek Coal and Iron Company	192, 144	69, 129	1, 165	3, 504	265, 942	8, 599	....
American Coal Company	144, 727	6, 349	50, 534	9, 695	211, 305	....	9, 034
Potomac Coal Company	154, 393	....	92	2, 272	156, 757	....	39, 523
New Central Coal Company	110, 700	....	36, 408	2, 453	149, 561	....	54, 253
Borden Mining Company	296	45, 107	83, 525	8, 819	137, 747	....	41, 790
Maryland Union Coal Company	116, 118	....	....	653	116, 771	18, 676	....
Blaen Avon Coal Company	63, 375	901	22	1, 532	65, 830	....	3, 362
National Coal Company	31, 986	....	19, 916	10, 735	62, 637	14, 330	....
Davis & Elkins' mine	56, 405	....	....	1, 977	58, 382	10, 639	....
Swanton Mining Company	36, 718	....	134	5, 836	42, 688	....	10, 174
Atlantic and George's Creek Consolidated Coal Company (Pekin mine)	3, 054	....	....	4, 267	7, 321	....	628
Union Mining Company	....	....	....	6, 824	6, 824	1, 183	....
Piedmont Coal and Iron Company (Empire mine)	....	....	....	1, 678	1, 678	1, 646	....
North Potomac basin.							
Elk Garden mines	209, 236	....	....	2, 143	211, 379	....	58, 504
Atlantic and George's Creek Consolidated Coal Company	61, 574	....	....	....	61, 574	4, 585	....
Big Vein Coal Company	50, 850	....	....	150	51, 000	....	15, 326
Davis' mine	18, 490	....	....	2, 187	20, 677	10, 418	....
	1, 970, 204	282, 802	239, 891	99, 570	2, 592, 467	70, 076	343, 584
	....	....	....	....	....	....	70, 076
Decrease	....	....	....	....	....	....	273, 508

Recapitulation.

From—	To Baltimore and Ohio Railroad.	To Chesapeake and Ohio Canal.	To Pennsylvania Railroad.	Local.	Total.
	Long tons	*Long tons*	*Long tons*	*Long tons*	*Long tons*
Cumberland and Pennsylvania Railroad	1, 064, 670	115, 531	141, 520	67, 279	1, 389, 000
Cumberland Branch	232, 521	113, 791	....	10, 800	357, 112
George's Creek and Cumberland Railroad	332, 829	53, 480	98, 371	15, 367	500, 047
West Virginia Central and Pittsburgh Railway	340, 150	....	....	4, 480	344, 630
Empire mine, Maryland	....	....	....	1, 678	1, 678
	1, 970, 170	282, 802	239, 891	99, 604	2, 592, 467

In this table is included the shipment from the Elk Garden, Atlantic, George's Creek, Big Vein, and Davis mines, all of which are included in the North Potomac basin situated in West Virginia. In the above table the small shipment of 99,570 tons is credited to surplus and local consumption, and in the following table, showing the coal shipment at the different mines and the transportation for forty-five years, from 1842 to 1886, inclusive, the surplus and local consumption is included in the shipments of the Baltimore and Ohio Railroad:

Total shipments from the Cumberland coal field

Years.	Frostburg region. Cumberland and Pennsylvania Railroad. By Baltimore and Ohio Railroad.	By Chesapeake and Ohio Canal.	By Pennsylvania Railroad.	Total.	Cumberland Coal and Iron Company's Railroad. By Baltimore and Ohio Railroad.	By Chesapeake and Ohio Canal.	Total.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
1842	757	....	....	757	951	....	951
1843	3, 661	....	....	3, 661	6, 421	....	6, 421
1844	5, 156	....	....	5, 156	9, 734	....	9, 734
1845	13, 738	....	....	13, 738	10, 915	....	10, 915
1846	11, 240	....	....	11, 240	18, 555	....	18, 555
1847	20, 615	....	....	20, 615	32, 325	....	32, 325
1848	36, 571	....	....	36, 571	43, 000	....	43, 000
1849	63, 676	....	....	63, 676	78, 773	....	78, 773
1850	73, 783	3, 167	....	76, 950	119, 023	875	119, 898
1851	70, 893	51, 438	....	122, 331	103, 808	31, 540	135, 348
1852	128, 534	46, 357	....	174, 891	139, 925	19, 362	159, 287
1853	150, 381	84, 060	....	234, 441	155, 278	70, 535	225, 813
1854	148, 953	63, 731	....	212, 684	173, 580	92, 114	265, 694
1855	93, 691	77, 095	....	171, 056	97, 710	100, 691	198, 401
1856	86, 994	80, 387	....	167, 381	121, 945	105, 149	227, 094
1857	80, 743	55, 174	....	135, 917	88, 573	54, 000	142, 573
1858	48, 018	166, 712	....	214, 730	66, 009	87, 539	153, 548
1859	48, 415	211, 639	....	260, 054	72, 423	86, 203	158, 626
1860	70, 669	232, 278	....	302, 947	80, 500	63, 600	144, 100
1861	23, 878	68, 303	....	92, 181	25, 983	29, 296	55, 279
1862	71, 745	75, 206	....	146, 951	41, 096	23, 478	64, 574
1863	117, 796	173, 269	....	291, 065	111, 087	43, 523	154, 610
1864	287, 126	194, 120	....	481, 246	67, 676	64, 522	132, 198
1865	384, 297	285, 295	....	669, 592	104, 651	57, 907	162, 558
1866	592, 938	291, 019	....	883, 957	52, 251	52, 159	104, 410
1867	623, 031	385, 249	....	1, 008, 280	40, 106	72, 904	113, 010
1868	659, 115	424, 406	....	1, 083, 521	100, 345	57, 919	158, 264
1869	1, 016, 777	573, 243	....	1, 590, 020	130, 017	78, 908	208, 925
					2, 092, 657	1, 192, 224	3, 284, 881
					Cumberland Branch.		
1870	909, 511	520, 196	....	1, 429, 707	114, 404	83, 941	198, 345
1871	1, 247, 279	656, 085	....	1, 903, 364	69, 864	194, 254	264, 118
1872	1, 283, 956	612, 537	22, 021	1, 918, 514	26, 586	203, 666	230, 152
1873	1, 509, 570	641, 220	114, 589	2, 265, 379	89, 765	137, 582	227, 347
1874	1, 295, 804	631, 882	67, 671	1, 994, 902	113, 670	135, 182	248, 852
1875	1, 095, 880	715, 673	160, 213	1, 971, 766	52, 505	164, 165	216, 670
1876	939, 262	443, 435	131, 866	1, 514, 563	15, 285	189, 005	204, 290
1877	755, 278	473, 646	170, 884	1, 399, 808	63, 181	111, 350	174, 531
1878	823, 801	486, 038	145, 864	1, 455, 703	99, 455	123, 166	222, 621
1879	933, 240	397, 009	154, 264	1, 484, 513	141, 907	104, 238	246, 145
1880	1, 055, 491	471, 800	213, 446	1, 740, 737	197, 525	131, 325	328, 850
1881	1, 113, 263	270, 156	153, 501	1, 536, 910	271, 570	151, 526	423, 096
1882	576, 701	115, 344	91, 574	783, 619	199, 183	76, 140	275, 323
1883	851, 985	302, 678	217, 065	1, 371, 728	197, 235	141, 390	338, 625
1884	1, 193, 780	150, 471	199, 138	1, 543, 389	289, 884	124, 718	414, 602
1885	1, 091, 904	171, 460	206, 227	1, 469, 591	289, 407	117, 829	407, 236
1886	1, 131, 949	115, 531	141, 520	1, 389, 000	243, 321	113, 791	357, 112
	22, 740, 115	10, 717, 309	2, 189, 833	35, 647, 257	2, 474, 747	2, 303, 168	4, 777, 915

a Of this amount 35,149 long tons were shipped to the Chesapeake and Ohio canal via Piedmont,
b Includes 78, 045 long tons used on line of Cumberland and Pennsylvania Railroad and its branches, pany in locomotives, rolling mills, etc.

for 45 years, including the Elk Garden region.

Frostburg region.				Piedmont region.		Total.			
George's Creek and Cumberland Railroad.									
By Chesapeake and Ohio Canal.	By Pennsylvania Railroad.	Local and Baltimore and Ohio.	Total.	George's Creek Railroad.	Hampshire Railroad by Baltimore and Ohio Railroad.	Baltimore and Ohio Railroad and local.	Chesapeake and Ohio Canal.	Pennsylvania Railroad.	Aggregate.
Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
...	...	...	...	...	...	1,708	...	...	1,708
...	...	...	...	...	...	10,802	...	...	10,082
...	...	...	...	...	...	14,890	...	...	14,890
...	...	...	...	...	...	24,653	...	...	24,653
...	...	...	...	...	...	29,795	...	...	29,795
...	...	...	...	...	...	52,940	...	...	52,940
...	...	...	...	...	...	79,571	...	...	79,571
...	...	...	...	...	...	142,449	...	...	142,449
...	...	...	...	...	...	192,806	4,042	...	196,848
...	...	...	...	...	...	174,701	82,978	...	257,679
...	...	...	...	...	...	268,459	65,719	...	334,178
...	...	...	...	73,725	...	376,219	157,760	...	533,979
...	...	...	...	181,303	...	503,836	155,845	...	659,681
...	...	...	...	227,245	65,570	478,486	183,786	...	662,272
...	...	...	...	269,210	42,765	502,330	204,120	...	706,450
...	...	...	...	252,368	51,628	465,912	116,574	...	582,486
...	...	...	...	218,318	63,060	395,405	254,251	...	649,656
...	...	...	...	257,740	47,934	426,512	297,842	...	724,354
...	...	...	...	289,298	52,564	493,031	295,878	...	788,909
...	...	...	...	85,554	36,660	172,075	97,599	...	269,674
...	...	...	...	69,482	36,627	218,950	98,684	...	317,634
...	...	...	...	266,430	36,240	531,553	216,792	...	748,345
...	...	...	...	...	44,552	399,354	258,642	...	657,996
...	...	...	...	...	71,345	560,293	343,202	...	903,495
...	...	...	...	...	90,964	736,153	343,178	...	1,079,331
...	...	...	...	...	72,532	735,669	458,153	...	1,193,822
...	...	...	...	...	88,658	848,118	482,325	...	1,330,443
...	...	...	...	...	83,724	1,230,518	652,151	...	1,882,669
				(a)2,190,673					
				Empire and West Virginia mines.					
...	...	...	...	28,035	60,988	1,112,938	604,137	...	1,717,075
...	...	...	...	81,218	96,453	1,494,814	850,339	...	2,345,153
...	...	...	...	85,441	121,364	1,517,347	816,103	22,021	2,355,471
...	...	...	...	77,582	103,793	1,780,710	778,802	114,589	2,674,101
...	...	...	...	57,492	109,194	1,576,160	767,064	67,671	2,410,895
...	...	...	...	63,537	90,800	1,302,237	879,838	160,698	2,342,773
...	...	...	...	108,723	7,505	1,070,775	632,440	131,866	1,835,081
...	...	...	...	...	...	818,459	584,996	170,884	1,574,339
...	...	...	...	...	998	924,254	609,204	145,864	1,679,322
...	...	...	...	...	51	1,075,198	501,247	154,264	1,730,709
...	...	...	...	66,573	...	1,319,589	603,125	213,446	2,136,160
83,136	125,097	4,947	213,180	88,722	...	1,478,502	504,818	278,598	2,261,918
78,298	93,861	31,436	203,595	277,929	...	1,085,249	269,782	185,435	1,540,466
215,767	202,223	77,829	495,819	338,001	...	1,444,766	680,119	419,288	2,544,173
69,765	156,959	283,336	510,060	466,928	...	2,233,928	344,954	356,097	2,934,979
79,455	214,518	291,685	585,658	403,489	...	2,076,485	368,744	420,745	2,865,974
53,480	98,371	348,196	500,047	346,308	...	(b)2,069,774	282,802	239,891	2,592,467
579,901	891,029	1,037,429	2,508,359	2,489,980	1,475,969	34,447,653	14,848,035	3,081,357	52,377,045

Baltimore and Ohio Railroad, to Cumberland.
by Cumberland and Piedmont; also 280,850 long tons used by the Baltimore and Ohio Railroad Com-

In deducing the total production of the Maryland mines for any one year referred to above, care must be taken to exclude the production of the West Virginia mines. This has not been done in the coal shipment tables, since, for all practical uses, the West Virginia mines are as essential a part of the Cumberland district as those within the State of Maryland.

The total production of the Maryland mines for the years from 1883 to 1886 inclusive, is shown in the following table:

Production of coal in Maryland.

Companies.	1883.	1884.	1885.	1886.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*
Consolidation Coal Company	456, 238	689, 212	710, 064	675, 652
New Central Coal Company	210, 850	210, 140	203, 814	149, 561
George's Creek Coal and Iron Company	257, 490	266, 042	257, 343	265, 942
Maryland Union Coal Company	137, 105	117, 180	98, 095	116, 771
Borden Mining Company	151, 665	162, 057	179, 537	137, 747
Maryland Coal Company	235, 854	295, 736	365, 319	288, 742
American Coal Company	190, 055	194, 330	220, 339	211, 305
Potomac Coal Company	139, 723	169, 463	196, 280	156, 757
Hampshire and Baltimore Coal Company	194, 534	36, 416	....	....
Atlantic and George's Creek Coal Company (Pekin mine)	69, 000	75, 467	64, 938	7, 321
Swanton Mining Company	34, 905	28, 620	52, 862	42, 688
Blæn Avon Coal Company	84, 721	100, 961	69, 192	65, 830
Piedmont Coal and Iron Company	4, 619	1, 250	32	1, 678
Union Mining Company	5, 024	5, 310	5, 641	6, 824
National Coal Company	38, 998	42, 680	48, 307	62, 637
Davis & Elkins mine	....	74, 437	58, 002	58, 382
Totals	2, 210, 781	2, 469, 301	2, 529, 765	2, 247, 837

The following are the average prices for Cumberland coal at Baltimore for the past fifteen years:

Prices of Cumberland coal.

Years.	Prices.	Years.	Prices.
1872	$4.52	1880	$3.75
1873	4.83	1881	3.75
1874	4.70	1882	3.50
1875	4.35	1883	2.90
1876	3.87	1884	2.40
1877	3.15	1885	2.25
1878	2.86	1886	2.10
1879	2.75		

The output of the mines of each company, with the number of miners employed, the amount paid by each company for mining, and the average earnings of each miner for 1886, are shown in the following table, compiled from the report of Mr. C. H. Hamill, State mine inspector:

Output of the Cumberland coal companies in 1886.

Names of companies.	Output of each company.	Number of miners.	Amount paid by each company for mining.	Average earnings of each miner.
	Long tons.			
Consolidation Coal Company	675,652	746	$277,982.53	$372.63
Maryland Coal Company	288,742	267	118,796.93	444.93
George's Creek Coal and Iron Company	265,942	258	109,416.14	424.09
American Coal Company	211,305	180	86,936.91	482.98
Potomac Coal Company	156,757	160	64,494.31	403.09
New Central Coal Company	149,561	177	61,533.67	347.65
Borden Mining Company	137,747	142	56,673.05	399.10
Maryland Union Coal Company	116,771	176	48,042.93	272.97
Blæn Avon Coal Company	65,830	73	27,084.34	371.02
National Coal Company	62,637	110	25,770.65	234.28
Davis & Elkins	58,382	61	24,019.80	393.77
Swanton Coal Company	42,688	54	17,563.06	325.24
Atlantic and George's Creek Coal Company	7,321	10	3,012.07	301.21
Union Mining Company	6,824	10	2,807.59	280.76
Piedmont Coal and Iron Company (Empire mine)	1,678			
Totals	2,247,837	2,424	924,134.06	381.25

In obtaining the figures of the earnings—amounts and averages—in the above table it has been assumed that one-seventh of the coal mined was taken from headings and air-courses.

It will be seen that the average amount paid per miner for the year was $381.25. A stoppage of nearly two and a half months in the early part of the season contributed very materially to lowering this average below usual figures, but for the cause named it would doubtless have reached $500.

MICHIGAN.

Total production in 1886, 60,434 short tons; spot value, $90,651.

The coal field of Michigan is detached from those of any other State. Its area is about 6,700 square miles, and is embraced by the counties of Saginaw, Shiawassee, Clinton, Ionia, Montcalm, Gratiot, Isabella, and Midland. Large areas also of Tuscola, Genesee, Ingham, Eaton, and Bay counties are underlaid by the coal formation, making, in all, thirteen counties in addition to those portions of Livingston and Jackson counties, and probably several counties to the north, which are also underlaid by the coal formation.

The southern boundary of the coal area is in Jackson county, but south of this area there are several detached patches of productive Coal Measures, resting immediately on top of the Parma Sandstone, which occupies the same geological position as the Pottsville Conglomerate in the Ohio and Pennsylvania sections. What is locally known as the Woodville Sandstone caps the Coal Measures.

The greatest thickness of coal measures apparently exists along a line extending from Ionia county to Saginaw bay. The greatest thickness of coal beds is reported along Six Mile creek. One seam measures 5 feet in thickness, and three others 2 feet in thickness each. The largest operation in the State is that of the Jackson Coal Company in Jackson county. This company produced during the year 21,368 short tons.

An analysis of the Jackson coal, given in the State report, shows:

Analysis of coal in Jackson county, Michigan.

	Per cent.
Fixed carbon	45
Volatile matter	49
Ash	2
Water	2
Sulphur	2
	100

The Michigan coals are of an inferior quality compared to the coals shipped by the Lake into the State, so that there is very little encouragement for the active development of the Michigan coal field.

The following table gives the production of coal in the State to date:

Production of coal in Michigan.

	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
Williamston mine	......	......	......	......	......	10, 454	884	......	......	500
Jackson mine	67, 697	61, 785	65, 000	......	......	......	......	......	......	......
Corunna Coal Company	......	22, 537	16, 215	12, 252	7, 000	8, 624	9, 000	8, 000	10, 000	15, 976
Other mines	1, 500	1, 000	800	......	......	......	......	......	......	1, 500
Jackson Coal Company	......	......	......	66, 780	61, 666	60, 103	40, 412	13, 712	15, 55[illegible]	21, 368
Eureka Coal Company	......	......	......	30, 000	37, 477	25, 000	......	......	......	......
Michigan Coal Company	......	......	......	20, 021	23, 987	25, 000	......	......	......	......
Porter Coal Company	......	......	......	......	......	6, 158	21, 000	15, 000	13, 000	......
Star Coal Company	......	......	......	......	......	......	......	......	5, 125	5, 820
Standard Coal Company	......	......	......	......	......	......	......	......	1, 500	15, 270
Total *a*	69, 197	85, 322	82, 015	129, 053	130, 130	135, 339	71, 296	36, 712	45, 178	60, 434

a Years previous to 1877, 350,000 short tons.

MISSOURI.

Total production in 1886, 1,800,000 short tons; spot value, $2,340,000.

The most productive coal areas in this State lie principally in the northern and western part, north of the Missouri river and west of the Lamine and Osage rivers. A small area of coal measures, however, underlies a large part of Saint Louis county, south of the Missouri river.

Thirty-five counties, in all, produce coal, and the total area underlaid by the coal beds, according to an estimate by Professor Swallow, late State geologist, is about 27,000 square miles. The coal measures are divided by Professor Swallow into the Upper coal series, 300 feet thick; the Middle coal series, 200 feet thick, and the Lower series, 150 feet thick, making a total thickness of 650 feet; the entire series underlies the country along the Hannibal and Saint Joseph railroad.

The Lower coal series is considered to contain the most important and most productive coal beds. Very unsatisfactory returns are made of the production of the Missouri coal mines. At present there are mine inspectors in seven different counties, who make their reports to Hon. Oscar Kochtitzky, Commissioner of Labor Statistics. The amount of coal mined in these counties, together with the number of mines, is given in the following table. In addition, there is also included the production of one mine in Johnson county, reported by R. M. McDowell, general manager and mining engineer of the company:

Production of counties in Missouri having mine inspectors.

Counties.	Number of mines.	Production.
		Short tons.
Lafayette	25	216,000
Barton	9	46,480
Vernon	18	74,800
Ray	25	144,514
Macon	8	214,149
Bates	7	537,300
Randolph	34	151,962
Johnson	1	26,530
Total	127	1,411,735

Some of the mines included in the above table do not report their total annual production, but the daily output, from which the total production has been obtained by multiplying the same by the number of days worked.

In addition to these counties, there are twenty-seven others from which no returns have been obtained. The eight counties enumerated have trebled their annual production of coal since the census year 1880, and allowing for the same increase in the production of the twenty-seven other counties, the total production of the State during 1886 would be about 1,760,000 tons.

In addition to these mines, there are many country banks, from which coal is taken for local consumption. This would not exceed in the aggregate more than 40,000 tons, so that it is safe to estimate that the grand total production of all coal in the State for 1886 did not exceed 1,800,000 tons.

It is currently reported by Mr. F. E. Saward and the coal trade generally that the Missouri mines produced during 1886, 3,000,000 tons. There is no question that this estimate is excessive; it was probably arrived at by including the production of the Indian Territory and some of the Kansas mines, which was shipped over the Missouri railroads.

Mr. R. M. McDowell reports the annual production of his companies' mines in Missouri for 1886 as follows:

Production of the different coal companies from which the Survey has received returns.

Name of companies.	Production.
	Short tons.
Lexington Coal Mining Company	95,202
Johnson County mines	26,530
Rock Hill Mining Company	323,002
Osage Coal and Mining Company	41,648
Total	486,382

The total production of these mines is included in the estimate already given.

A recent law has been passed in Missouri which provides for a State mine inspector, who will make a report of all the Missouri mines to the Commissioner of Labor Statistics on the 15th day of each October, so that more reliable statistics can be expected in the future.

The shipments of the Missouri Pacific Railroad Company are shown in the following table. This company controls the Osage Coal and Mining Company in the Indian Territory, and owns the Montana mines in Crawford and Cherokee counties, Kansas, and mines in Baxter county, Missouri, and possesses the controlling interest in the Lexington and Rich Hill Coal Company.

Coal shipments of the Missouri Pacific Railroad Company in 1884, 1885, *and* 1886.

Years.	Coal mined on line.	Received from connection.	Total.	Commercial coal carried.	For company use.	Cost per ton.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	
1884	1,002,972	514,287	1,517,259	601,820	915,439	$2.24
1885	1,031,180	468,817	1,499,997	629,551	870,446	1.80
1886	1,172,052	544,796	1,716,848	877,510	839,338	1.74

The shipment of coal from individual mines for the year over the lines of the Kansas City, Fort Scott and Gulf railroad, the Kansas City, Springfield and Memphis railroad, the Kansas City, Clinton and Springfield railway, and the Kansas City, Memphis and Birmingham railroad was as follows:

Railroad shipments from certain mines in Missouri.

Name of mine.	Carloads.
Rich Hill	9,775
Carbon Center	1,396
Morerod	288
Minden	260
Liberal	708
Urich	8
Hartwell	53
Clinton	14
Deepwater	2,065
Total	14,567

The average number of tons carried per car was about 18, making the total amount of coal carried by these companies 262,206 short tons.

MONTANA.

Total production in 1886, 49,846 short tons; spot value, $174,460.

Much interest has of late years been taken in the extent of the coal fields of Montana, and the development of the coal and lignite beds. The occurrence of good fuel in Montana is a matter of the greatest importance to the development of that Territory.

Mr. George H. Eldridge has recently made a very complete report on a number of the coal fields of the Territory, from which the following description is taken:

The Bozeman coal field lies in the midst of the Belt range, 12 miles east of Bozeman, the leading town of the extensive and fertile Gallatin valley. The coal deposits occupy a large synclinal basin, often covered with from 3,000 to 4,000 feet and more of superimposed Cretaceous strata.

There is nothing intricate in the general geology of the Bozeman coal field. In the southern part we have three anticlinal folds. Their axes lie normally a little west of north, with a downward curve at their northwest extremities, but in the easternmost anticlinal another influence has been brought to bear, causing its axis, 2 miles south of its northern end, to be deflected to the eastward, which strike then continues with minor unimportant cuives across the Yellowstone river for at least 30 miles. The westernmost anticlinal is also connected with the other folds to the southwest, which join it to the high ranges forming the southern wall of the Gallatin valley.

Northeast of Bozeman there is another pre-Cretaceous area, that of the Bridger mountains, which were formed by an enormous overthrow with a reverse dip to the westward, the older measures lying on top of the younger.

The other important development of coal lies along the southern edge of this synclinal basin, becoming quickly covered by its high dip, of 45° and over, by an enormous thickness of strata, rendering it unavailable for mining beyond a certain depth, however valuable it may be.

In the Bozeman fields there are three distinct beds of coal of notable size; the upper two, styled the "A" and "B" seams, will best be considered first; they are separated from each other by only a few feet (from 10 to 15 feet) of interposed rock. The outcrop of the seam pursues a very irregular line from the Yellowstone to the East Gallatin, bending around the depressed northern ends of the three anticlinal axes and extending well into the intervening and elevated ends of the two corresponding synclinal basins. Just south of the westernmost main synclinal basin, and on the road to the Yellowstone river, via Trail creek, the field is continued in a small synclinal. This second area, which may be called the Trail Creek field, is of too small extent for large enterprises, is much pressed into subordinate folds, and is in a position accessible to a railroad only at the considerable expense always accompanying the overcoming of steep grades. The nature of the coal is precisely that of the Bozeman field. The dip of the bed varies throughout the field in a general way; east of the range it is from 37° to 45°, and west of the range it varies from 57° to 80°; the folds being more abrupt and frequent. This field has been prospected by pits and tunnels quite extensively.

The physical characteristics of the coal in the Bozeman field divides it into two distinct varieties, a solid block or dicey coal which can be mined in pieces as large as the width of the seam, and which withstands weather and transportation excellently; and a friable chippy variety coming out in lenticular masses, which, upon being allowed to remain on the dump or upon being transported, crumble into minute fragments an inch or so long by half an inch wide, and of a thickness of about one-eighth of an inch. Both varieties are bituminous and make a fair coke, though perhaps the friable coal gives more uniformly excellent results.

The northern coal field may be considered as composed of two distinct areas, but of identically the same bed of coal throughout, though it has not been proved continuous, nor is it indeed probable that it is between that portion known as the Judith coal field in the southwestern part of Judith basin and that lying to the west, between the Missouri river and the Highwood and Little Belt mountains, and comprising the coals of Belt creek, Sand Coulée, and Deep creek.

Besides the coal field in the southwest corner of the Judith basin, there are found several unimportant beds of coal in the eastern part near the Judith and Snowy mountains, and in the high and much disturbed country connecting the two ranges; also on the eastern flanks of the Judith mountains.

As in the Judith field, the coal in the region of Belt creek, Sand Coulée, and Deep creek lies under the prairie.

The outcrop of the coal beds has a general east-and-west course, with northerly dips, and skirts the edge of the prairies to the Missouri river, though at a point not determined, between Deep creek and the river, the beds probably run nearer the mountains, until finally, south of Ulidia at the Chestnut ferry, they lose much of their economic value. The entire length of outcrop cannot be far from 25 miles.

One bed has been much more extensively opened in the Belt Creek area, one or two mines here having supplied Fort Benton on the Missouri, with coal for domestic and blacksmithing purposes for several years. The universal opinion in Fort Benton is that this coal excels the Fort McLeod coal in British America, some of which finds its way into the Benton market by the return freight teams from that northern coast.

There exist in the Bull mountains many lignite seams, but in view of the great thickness and uniform persistency of the Mammoth seam, the smaller beds of lignite, even where locally developed and found of workable size, will not be touched for many years to come.

The Rock Creek coal field lies at the base of the Snow mountains, the high range that extends 100 miles southeasterly from the Yellowstone cañon, near Livingston, and is about 30 or 35 miles due south from Stillwater, the nearest station on the Northern Pacific Railroad. Its elevation above sea-level is about 5,700 feet, and above the Yellowstone river, at Stillwater, about 2,300 feet. There are found in all seven seams containing workable coal, in addition to several other smaller ones containing a foot or so of coal. All the coal is hard, bright, square-jointed, in appearance similar to the best coal of the Bozeman field, while none is of the soft, "chippy" variety there observed. The total thickness of coal in these seams is 46 feet 6½ inches, of which about 46 feet may be said to be available for mining. The dip is low, from 15° to 20°, and within a few hundred yards from the outcrop toward the mountains becomes flat. Anywhere between this point and the mountains the coal would be found within a distance of perhaps 300 feet from the surface. The seven seams are contained in about 500 feet of measures.

The Gardiner River coal field, the last field of importance in Montana, lies on the Upper Yellowstone, near the Yellowstone National Park, about 60 miles above Livingston and the Bozeman coal field, and extends from the mouth of Gardiner river, down the Yellowstone on both sides to within 2 miles of Cinnabar mountain. The only valuable portion of this field (as far as present developments show) extends from a little below Gourley and Gillis' pit to the Park line, a distance of from 2 to 2½ miles. Above and below Gourley's pit the outcrop is covered by "trap" flows and travertine, and from Eagle pit to the Park line it is continuous. The Coal Measures, however, form only a narrow strip extending from the river back a short distance, probably not over three-quarters of a mile in greatest width, and generally much less. Nearly all the seams furnish coal of excellent quality, black, hard, and square-jointed, giving evidences of coking qualities, and the pits on the portion east of the river show a thickness, which, though not large, could probably be profitably worked. This coal all occurs above the Colorado.

Mr. F. A. Gooch, assisted by Messrs. Edward Whitfield and W. T. Richmond, has recently analyzed 229 specimens of coal and lignite collected in different parts of the fields by Mr. George H. Eldridge, Mr. Wolff, and Prof. Raphael Pumpelly. From these analyses the following table has been compiled:

Analyses of coal and lignite from the Montana coal fields.

Field.	Locality.	Water.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Color of ash.	Water in dry coal.	Water in saturated coal.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*
Bozeman	Chestnut mine (1881)	3. 78	23. 08	59. 27	13. 87	0. 66	Red	0. 77	4. 26
Do	do	3. 91	33. 48	52. 04	10. 57	0. 46	Pale red	0. 83	4. 50
Do	Chestnut mine, new tunnel (1882).	1. 03	39. 48	41. 37	18. 12	0. 64	Dirty white	1. 02	3. 38
Do	Chestnut mine, old tunnel (1882).	0. 75	29. 00	61. 74	8. 51	0. 66	Reddish	0. 75	3. 04
Do	do	0. 80	14. 68	71. 56	12. 96	0. 58	Dirty white	0. 19	2. 27
Do	Chestnut mine, opening southeast of house (1882).	16. 48	34. 30	40. 22	9. 00	0. 36	White	3. 61	15. 98
Do	do	14. 01	30. 11	32. 35	23. 53	0. 27	do	4. 94	14. 11
Do	Chestnut mine, Thompson's pit No. 2 (1882).	10. 64	34. 64	42. 86	11. 86	0. 32	do	3. 94	12. 40
Do	do	9. 79	31. 43	38. 25	20. 53	0. 40	do	3. 16	10. 87

Analyses of coal and lignite from the Montana coal fields—Continued.

Field.	Locality.	Water.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Color of ash.	Water in dry coal.	Water in saturated coal.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*
Bozeman	Incline, Northern Pacific Coal Company, Sec. 24, T. 2, R. 8 (148 feet down incline).	1. 22	36. 86	41. 54	20. 38	0. 68	White	0. 75	3. 10
Do	Incline, Northern Pacific Coal Company, Sec. 24, T. 2, R. 8 (280 feet down incline).	1. 31	34. 66	42. 01	22. 02	0. 57	Pink	0. 66	2. 74
Bull Mountain.	Four miles east of Northern Pacific Coal Company's mine south side of mountain.	7. 76	43. 65	41. 99	6. 60	.....	....do	7. 76	18. 87
Do	......do	5. 39	38. 44	51. 99	4. 18	.....	....do	5. 39	16. 29
Do	East of Northern Pacific Coal Company's mine, south side of mountain, 3 miles.	4. 08	39. 03	50. 50	6. 39	.....	White	4. 08	13. 49
Do	......do	6. 53	42. 38	46. 48	4. 61	.....	Pink	6. 53	17. 24
Do	One-half mile east of Northern Pacific Coal Company's mine, south side of mountain.	3. 80	39. 79	51. 22	5. 19	.....	White	3. 80	14. [illegible]
Do	......do	3. 84	39. 76	51. 09	5. 31	.....	....do	3. 84	14. 20
Judith Basin.	McGiffin's, Sand Coulée	2. 92	28. 86	47. 27	20. 95	5. 23	Pink	0. 56	7. 83
Do	......do	2. 20	26. 48	45. 07	26. 25	3. 67	....do	0. 47	7. 77
Rock Creek	Yankee Jim claim, B seam	2. 18	40. 93	48. 12	8. 77	2. 01	....do	2. 18	9. 40
Do	......do	2. 98	43. 70	47. 89	6. 33	.....	....do	2. 08	8. 39
Do	......do	4. 52	38. 06	41. 76	15. 66	.....	....do	4. 52	12. 37
Do	......do	5. 37	44. 76	38. 54	11. 33	.....	Yellowish white	5. 37	14. 97
Gallatin Valley.	Star mine, Mullen pass	2. 82	23. 20	63. 30	10. 53	0. 84	White	0. 54	3. 12
Do	Star mine, Mullen pass (1881).	2. 97	20. 85	51. 28	25. 03	0. 97	....do	0. 42	3. 00
Do	Star mine, Mullen pass	2. 84	19. 19	42. 23	34. 45	1. 28	Reddish	0. 47	3. 69
Do	......do	4. 13	42. 45	35. 01	12. 79	2. 55	Pink	1. 10	5. 37
Do	......do	9. 75	33. 66	28. 10	16. 92	1. 67	Pale red	7. 04	17. 51
Judith Basin.	Deep creek	2. 58	31. 46	48. 22	17. 74	2. 89	White	0. 60	5. 56
Do	......do	1. 80	28. 63	38. 70	30. 87	0. 98	....do	0. 32	3. 55
Gardiner	Hoar's mine	2. 81	36. 89	53. 63	6. 67	.....	Red	0. 78	3. 68
Do	Gourley & Gillis's mine	12. 60	37. 37	39. 81	10. 22	.....	Pink	5. 19	14. 35
Do	Trout & Co.'s mine	7. 70	35. 71	47. 76	8. 83	.....	Dark red	2. 91	7. 12

The following is Mr. F. F. Chisolm's report on the mining operations and production of coal in Montana during 1886:

There has been no great activity displayed in coal mining in Montana during 1886. The point where there has been the greatest production is at the Timberline mines between Bozeman and Livingston. The production there was seriously interfered with by labor troubles, as a result of which the mines were closed down in July, and no coal was produced during the last six months of the year. The mines were fully described in the report for 1885. Analyses made in 1886 show the coal to be slightly better than it was in 1885. The Northern Pacific Coal Company furnishes the following analysis of this coal:

Analysis of coal from the Timberline mine, Montana.

	Per cent.
Water	2. 16
Volatile matter	20. 98
Fixed carbon	70. 16
Ash	6. 70
Total	100. 00
Sulphur	. 35

As a result of the strike it is likely that these mines will not again be worked as largely as the new mines of the company at Roslyn. Washington Territory will probably hereafter produce the greater amount of coal used by the Northern Pacific railway for fuel, and the demand for smelting, steaming, and domestic purposes in Butte, Helena, and other Montana points will be met by coal from the same field.

The production of the Timberline mines to the end of 1886 has been:

Production of the Timberline coal mines, Montana.

Years.	Short tons.
1883	10,489
1884	55,664
1885	83,156
1886	45,446
Total	194,755

The adjoining Maxey, Bozeman, and Trail Creek mines were closed during the entire year.

The production in the Great Falls region in 1886 was:

	Short tons.
Sand Coulée	800
Belt Creek	600
Smith River	Closed.

The main part of the product of these fields is shipped to Great Falls for local consumption. The months of November and December were characterized by heavy snow falls which made hauling to Great Falls impracticable; hence the small output. During the year very satisfactory explorations were made in the Sand Coulée district. These explorations will be continued during 1887, with the diamond drill on the bench lands. If these borings sustain the good showing hitherto made, it is expected that development on a large scale will be begun in anticipation of the completion of a 12-mile branch of the Montana Central railway from Great Falls to the mines. This branch has already been located.

The production from the Belt Creek mines has been restricted by the same causes as those at Sand Coulée.

The Smith River mines have not been worked for some time.

Coal was also produced for a time in 1886 at a mine near the Mullan tunnel, which was afterwards abandoned, and also from a mine near Livingston in which the bed is reported to have played out. The figures of production at these two localities were not obtainable.

Recapitulation.—Coal production of Montana.

Year.	Timber-line.	Boseman and Maxey.	Sand Coulée.	Belt Creek.	Lignite.	Other mines.	Total.
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1883	10,489	9,306					19,795
1884	55,664	8,006			16,221	485	80,376
1885	83,156	100	700	1,200		1,284	86,440
1886	45,446		800	600		3,000	49,846
Total	194,755	17,412	1,500	1,800	16,221	4,769	236,457

The value of the Territory's output in 1886, at $3.50 per ton, was $174,460. The number of men employed cannot well be estimated.

NEW MEXICO.

Total production in 1886, 271,285 short tons; spot value, $813,855.

The following is reported by Mr. F. F. Chisolm:

There were no special developments in the coal-mining industry of New Mexico in 1886. The field of the largest operations has shifted from Raton to Gallup and other points near by on the line of the Atlantic and Pacific railroad in Bernalillo county and near the Arizona border.

No new mines have been opened. The production of the Raton district fell from 135,833 tons in 1885 to 87,706 tons in 1886. This fall in production was due mainly to the increased production of better coal at the Starkville and Rockvale mines in Colorado, which furnished the Atchison, Topeka and Santa Fé railroad with coal for shipment and for railway uses. The coal from Raton is used almost exclusively for fuel by the Santa Fé railroad. The mines are located within the Maxwell land grant, and it is understood that a royalty is paid.

A large amount of the San Pedro coal is coked, the coke being used by smelting works in New Mexico and Arizona. The production here is slowly but steadily increasing. There was no great activity during the year in the Cerillos field, which produces both anthracite and bituminous coals. The production, which was all used locally, is estimated at 1,000 tons.

The production at the Monero mines shows a falling off of 50 per cent. in 1886. This was due mainly to the greater use of the coal from La Plata county, Colorado. The control of the mine changed during 1886, and it was closed for some time.

The production at the Gallup mines steadily increases. The coal is used by the Atlantic and Pacific railroad for fuel and is also being quite extensively shipped to southern California for domestic uses. There are inexhaustible quantities of coal in this section, and almost any demand can be supplied. Full returns were not obtained of the production in 1886, but reliable estimates are furnished.

Coal production of New Mexico from 1881 *to* 1886.

Localities.	1882.	1883.	1884.	1885.	1886.
	Short tons	*Short tons*	*Short tons*	*Short tons*	*Short tons*
Raton district........	91,798	112,089	102,513	135,833	87,708
Gallup district.......	33,373	42,000	62,802	97,755	106,530
Monero..............	12,000	17,240	11,203	14,958	7,000
Los Cerillos..........	3,600	3,000	3,000	1,000	1,000
San Pedro............	16,321	37,018	41,039	56,656	69,047
Total...........	157,092	211,347	220,557	306,202	271,285

The value of the Territory's product in 1886 was about $813,855. The total number of men employed varies greatly, but will average about 750.

OHIO.

Total production in 1886, 8,435,211 short tons; spot value, $8,013,450.

The Ohio coal field is situated in the northwestern part of the Appalachian coal field and embraces within the State between 10,000 and 12,000 square miles.

Mr. Andrew Roy, late State mine inspector, in describing the coal fields, says:

"More than one-fourth of the State is underlaid with coal-bearing strata. The western margin of the Ohio portion of the great coal field runs through the counties of Trumbull, Geauga, Portage, Summit, Medina, Wayne, Holmes, Knox, Licking, Perry, Hocking, Vinton, Jackson, Pike, and Scioto, and the Coal Measures are spread over all the territory lying east of this line of outcrop to the State line at the Ohio river.

"On the margin of the Coal Measures of Ohio in the above-named counties there is only one workable bed of coal known as the lower seam, or Coal No. 1. The coal strata dip at the rate of about 30 feet to the mile, in an easterly direction (the line of dip being south 65° east), and the lower coal, which crops out on the western flank of the Coal Measures of the State, is carried 1,500 to 1,600 feet below the highlands in the counties of Belmont, Monroe, Washington, and Meigs, on the Ohio river. The dip of the strata is irregular, being at some points as high as 80 or 100 feet to the mile, while at other points it is not more than 10 or 20 feet to the mile. Frequently reverse dips are met, causing the strata to form a series of synclinal and anticlinal waves.

"The Coal Measures of the State are divided into three series, namely: The Lower Measures, the Barren Measures, and the Upper Measures. The first are about 500 feet in thickness, the next measures 400 to 500 feet, and the Upper Measures 600 feet thick. All the beds of coal in present course of development are drawn from the Upper and Lower Coal Measures, the Barren Measures, as the name indicates, containing little coal of sufficient thickness for the immediate purposes of the miner.

"The coals now being worked are mainly drawn from four to five different seams, Nos. 1, 2, 6, 7, and 8 of the geological nomenclature. In mining districts, however, the coals are known by other names than numerals, as, for example, the Brier Hill coal, the Massillon coal, the Nelsonville coal, and the Ohio River coal, and so on, and so they will ever be known; these names indicating the districts from which the coals are mined, and which give them a commercial value which dealers easily comprehend."

Mr. Bancroft, in referring in his report of the Ohio coal trade during 1886, says:

"The coal trade during the past year has been more constant and regular than the average, and the miners and laborers engaged in the industry have made fuller time generally than has been the case for several years. Notwithstanding the inroads made by the discovery of natural gas, and the consequent influx upon the markets, hitherto claimed by our own operators, of large amounts of coal from Pittsburgh and its vicinity, the total output of the State exceeded that of 1885 by 619,000 short tons. The operations in the State for the past year have been further characterized by an almost total absence of strikes or labor difficulties of any magnitude. But two cases of this kind have occurred, one in Coshocton county, extending over a period of six months, and the other resulting from the machine mining question in the Hocking valley. The absence of labor troubles is the natural result of the interstate convention of miners and operators, held at Columbus, February 24 last, when a scale of prices was agreed upon, to last until May 1, 1887. The increased output was mainly caused by an increased demand, consequent upon a general business revival throughout the country, and an extension of markets, made necessary by the use of natural gas in some of the old markets.

"This increase in coal output, however, has not been accompanied during the past year, with a corresponding increase in the price of coal, and the operators complain of an exceedingly unprofitable year. It is claimed that after deducting cost of transportation, and actual cost of mining, there is but little left for interest on their investments and to pay for depreciation in value of coal lands and plant. The cause of this anomalous condition of affairs is no doubt mainly the increased competition in our markets, with the Pittsburgh coal displaced by the use of natural gas in that city. The result of this competition is a reaching out for new markets in the northwest, and coal is fast being introduced as a fuel at points where its use was hitherto unknown."

A new coal field is being developed by the extension of the Columbus and Eastern railroad into Muskingum county. What is known as the Brush Creek basin is being opened up, with large deposits of cannel coal. The Columbus and Eastern Railroad Company owns a considerable tract of coal land in this locality, on which the cannel coal is 10 feet thick, and lying upon 2 feet of good bituminous coal. The mines are nearly ready to commence shipping. The Chicago and Columbus Coal Company has also purchased a body of land in the same basin, and is opening up extensive mines. The cannel coal on this extension is of superior quality, and shows the above thickness by actual measurement.

The Sunday Creek field has been extended during the year by the sinking of two shafts at Sedalia, below Corning. One shaft, sunk by the Sunday Creek Coal Company, on Strait run, 2 miles west of Sedalia, is 110 feet deep, and develops a bed of strong coal from 5 to 7 feet thick. The other shaft, owned by the Republic Coal Company, is 76 feet deep, and located about half a mile from Sedalia. Here the usual formation is found, viz., 6 feet 9 inches of good coal, with about 10 inches of cannel coal above it; the roof coal, 4 feet 3 inches thick, being above that again. The Sedalia Coal Company has also opened up a mine at Sedalia, upon the Bayley's Run coal. The seam here is 4 feet 9 inches thick, and very free from sulphur and slate. The roof is a black band ore of considerable thickness.

About two miles above Buchtel, in Athens county, two mines have been opened on Brush Fork. These are owned by the Consolidated Coal Company and the Babcock and Morris Coal Company, and are opened by drifts on No. 6 seam. The coal is 7 feet thick and of excellent quality, being rather thicker in the former mine than in the latter. These mines, in their method of mining and in their general equipment, are not surpassed by any in the State.

Near Vinton Station, in Vinton county, a shaft has been sunk 135 feet deep by the Elk Coal Company upon what is supposed to be the Wellston coal. The seam has a very good slate roof, and will average 2 feet 9 inches in thickness, and is entirely free from slate.

During the past year seventeen old mines have been abandoned or worked out, while twenty-eight new mines have been opened in the State. This only refers to mines employing at least ten men. Of these mines there are 353 in Ohio, and of smaller mines the records of this office show 352. The list of small mines in the State increases yearly as new ones are opened and old ones, hitherto unknown or overlooked, are discovered.

The statistics of the coal production in Ohio for 1886, and comparisons with figures for previous years, have been furnished by Mr. Thomas B. Bancroft, inspector of mines for the State. His report is as follows:

The coal product for the past year is largely in excess of that of 1885, and in fact is larger than any other recorded year except that of 1882, as will be seen by reference to the following table.

Even the product of 1882 may not have been in excess of 1886, as up to 1884 there was no statutory provision for the collection of these statistics, and the product was estimated (from the best data procurable, no doubt), and was liable to inaccuracies that it was not possible to detect.

Annual coal production of Ohio from 1872 *to* 1886

Years.	Short tons.	Years.	Short tons.
1872	5, 315, 294	1880	7, 000, 000
1873	4, 550, 028	1881	8, 225, 000
1874	3, 267, 585	1882	9, 450, 000
1875	4, 864, 259	1883	8, 229, 429
1876	3, 500, 000	1884	7, 640, 062
1877	5, 250, 000	1885	7, 816, 179
1878	5, 500, 000	1886	8, 435, 211
1879	6, 000, 000		

"The product of the State by counties is given in the following table showing the output of each county as compared with that of 1885. Many and considerable differences will be noticed in the tonnage of the different counties. As heretofore in all coal tables given, the estimates are for the calendar year and calculated at 2,000 pounds to the ton.

Coal production in Ohio by counties in 1885 *and* 1886.

Counties.	1885.			1886.		
	Lump.	Nut.	Total.	Lump.	Nut.	Total.
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
Athens	677, 487	145, 652	823, 139	766, 411	132, 635	899, 046
Belmont	650, 640	93, 806	744, 446	462, 252	111, 527	573, 779
Columbiana	398, 703	64, 030	462, 733	268, 465	67, 598	336, 063
Coshocton	78, 351	21, 258	99, 609	43, 361	9, 573	52, 934
Carroll	121, 125	29, 570	150, 695	184, 095	32, 535	216, 630
Guernsey	236. 366	60, 901	297, 267	349, 503	84, 297	433, 800
Gallia	13, 477	2, 906	16, 383	14, 862	2, 562	17, 424
Holmes	9, 716	1, 743	11, 459	10, 491	2, 179	12, 670
Hocking	574, 086	82, 355	656, 441	637, 224	104, 347	741, 571
Harrison	....	....	....	5, 132	377	5, 509
Jackson	641, 419	150, 189	791, 608	717, 516	139, 224	856, 740
Jefferson	245, 492	25, 837	271, 329	442, 051	33, 615	275, 666
Lawrence	111, 453	34, 463	145, 916	139, 173	27, 760	166, 933
Medina	136, 121	16, 600	152, 721	223, 747	28, 664	252, 411
Meigs	199, 584	35, 172	234, 756	165, 627	26, 636	192, 263
Muskingum	75, 511	11, 335	86, 846	85, 011	11, 590	96, 601
Mahoning	257, 561	18, 383	275, 944	251, 515	61, 525	313, 040
Morgan	5, 536	....	5, 536	4, 370	....	4, 370
Noble	....	....	....	3, 342	....	3, 342
Perry	1, 055, 500	204, 092	1, 259, 592	1, 346, 131	261, 535	1, 607, 666
Portage	67, 683	9, 388	77, 071	61, 273	9, 066	70, 339
Scioto	2, 440	....	2, 440	....	....	....
Stark	341, 859	49, 559	391, 418	519, 992	73, 430	593, 422
Summit	129, 069	16, 065	145, 134	70, 221	12, 004	82, 225
Tuscarawas	225, 530	60, 015	285, 545	212, 362	55, 304	267, 666
Trumbull	234, 654	29, 863	264, 517	162, 331	26, 200	188, 531
Vinton	67, 604	9, 523	77, 127	49, 392	10, 621	60, 013
Wayne	74, 062	7, 445	81, 507	99, 174	9, 883	109, 057
Washington	4, 000	1, 000	5, 000	4, 000	1, 500	5, 500
Total	6, 635, 029	1, 181, 150	7, 816, 179	7, 099, 024	1, 336, 187	8, 435, 211

"The time made by the mines of the State during the past year was 206 days, or five days more than in 1885. This is the average of the time worked by the larger or commercial mines working more than ten men each.

"The output of the State exceeded that of 1885 by 619,032 tons; yet of the larger producing counties nine show a loss of 567,125 tons, while to offset this and make up the aggregate increase thirteen other counties show a gain of 1,178,160 tons. More than half of this gain comes from the Hocking and Tuscarawas valleys, while the Mahoning valley shows a slight loss in product. The counties of Athens, Hocking, and Perry (comprising the Hocking valley) show a gain of 509,111 tons, 348,074 tons of which were from Perry alone. The large gains in Stark and Medina more than offset the losses in Summit and Tuscarawas, and bring the increase in the Tuscarawas valley up to 248,485 tons. The loss in the Mahoning valley is 45,622 tons. This loss is mainly in Trumbull county (175,986 tons), and is lessened somewhat by gains in Mahoning. Apart from the districts named above, the counties mainly furnishing the increased product are Guernsey, Jackson, Carroll, and Lawrence, while the main loss is to be found in Belmont, Columbiana, Coshocton, Meigs, and Vinton. Four of the losing counties show an increased average in the time made, while five show a decrease. With two exceptions (Belmont and Meigs) these counties show a decrease in the average number of miners employed. The falling off in Meigs, notwithstanding the increase in the number of miners, is attributable to the large decrease in time worked (ten weeks). The anomalous condition of affairs in Belmont (an increased time and force, accompanied by a large falling off in product) can only be explained upon the hypothesis that the returns made as to time and men were carelessly gotten up, and were not correct. Every county showing an increase in output shows also an increase in time worked, or miners employed, or both. The number of miners employed and their distribution show many changes from last year, and demonstrate the facility with which our mining population floats from place to place, as employment offers."

Increase and decrease in product, time made, and miners employed in 1886, *as compared with* 1885.

Countries.	Tonnage.		Weeks worked.		Miners employed.	
	Increase.	Decrease.	Increase.	Decrease.	Increase.	Decrease.
Athens	75,907		3		86	
Belmont		170,667	5		280	
Columbiana		126,670		1		273
Coshocton		46,675		19		93
Carroll	65,935			2	189	
Guernsey	136,533		8		132	
Hocking	85,130		3		293	
Jackson (*a*)	65,132				283	
Jefferson	4,337		11			9
Lawrence	21,017		2		93	
Medina	99,690		7		376	
Meigs		42,493		10	144	
Muskingum	9,755		17		16	
Mahoning (*a*)	37,096				44	
Perry	348,074		5		596	
Portage		6,732	1			35
Summit		62,909		9		103
Stark	202,004		6		139	
Tuscarawas		17,879	1			3
Trumbull		75,986	2			499
Vinton		17,114		6	8	
Wayne	27,550		7		241	
Total	1,178,160	567,125	78	47	2,920	1,015

a The time made in Jackson and Mahoning counties was the same in 1886 as in 1885.

In looking over the above table it will be noticed that the increased tonnage of the State was mainly derived from the larger producing counties, and was caused by increased time and force in those counties. The records of Belmont and Tuscarawas counties show on their face that sufficient attention to exactitude has not been given to the details of the returns. The falling off in Columbiana and Summit is accounted for by the large decrease of their miners. Coshocton shows the effect of the strike in a decreased product, and a consequent loss of one-third of her miners. The loss in Trumbull county, both in tonnage and miners, is largely attributable to some of her largest producing mines having been worked out and abandoned during the year. The following table shows the tonnage, number of mines, time worked, etc., in the different counties. In the column giving the number of mines much variation will be observed from last year's list. This difference is caused by increase or decrease in the number of small mines, as there are to-day but eleven more mines in the State employing more than ten men than there were when the last report was written.

Table of tonnage, time worked, number of men, etc., in each county.

Counties.	Tonnage.	No. of mines.	Average weeks worked.	No. of miners.	Outside employés.	Accidents.	Fatalities.
Athens	899, 046	41	35	1, 804	206	4	8
Belmont	573, 779	47	35	949	158	7	3
Columbiana	336, 063	55	36	517	121	2	1
Coshocton	52, 934	19	20	146	25	......	......
Carroll	216, 630	27	37	415	62	4	2
Guernsey	433, 800	15	37	785	113	4	1
Gallia	17, 424	6	36	35	3	......	......
Holmes	12, 670	12	34	56	7	......	......
Hocking	741, 571	18	36	1, 165	194	2	1
Harrison	5, 509	10	......	36	4	......	1
Jackson	856, 740	50	34	1, 995	216	4	3
Jefferson	275, 666	24	40	453	106	......	......
Lawrence	166, 933	24	45	446	56	......	......
Medina	252, 411	8	37	730	55	......	......
Meigs	192, 263	16	28	603	87	3	2
Muskingum	96, 601	63	40	287	57	1	......
Mahoning	313, 040	35	38	981	123	4	5
Morgan	4, 370	6	......	14	1	......	......
Noble	3, 342	3	......	12	3	......	......
Perry	1, 607, 666	60	35	2, 603	356	8	3
Portage	70, 339	3	31	165	24	1	1
Stark	593, 422	52	33	1, 410	298	13	5
Summit	82, 225	11	21	311	54	1	2
Tuscarawas	267, 666	54	31	615	100	3	......
Trumbull	188, 531	24	31	586	111	......	3
Vinton	60, 013	15	35	220	35	......	......
Wayne	109, 057	6	35	380	124	1	2
Washington	5, 500	1	26	16	3	......	......
Totals	8, 435, 211	705	846	17, 735	2, 702	62	43

OREGON.

Total production in 1886, 45,000 short tons; spot value, $112,500.

The only coal basin developed in this Territory has been that in Coos county. This basin covers several hundred square miles, and extends from the Umpqua river, north into Douglas county, south to the Coquille river, and extending back from the Pacific coast line 15 or 20 miles.

The coal bed which is mined contains about 4½ feet of workable coal, and dips towards the southwest at an average rate of about 15°. This coal bed, as far as has been determined, is included in Tertiary strata. The coal is black and handsome when first mined, and resembles very much some of the bituminous coals of the Mississippi valley. During 1886 there were 42,168 short tons of Oregon coal received at San Francisco, which is the principal market for Oregon coal.

No very reliable statistics have been obtained of coal mining in Oregon. It is probable, however, that the entire production of the Territory would not exceed 45,000 tons.

Analyses of four different Oregon coals.

	Coos bay.	Astoria.	Blue mountain.	Camas mountain.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Water	20.00	2.56	1.08	1.53
Volatile matter	32.59	46.29	24.40	42.82
Fixed carbon	41.98	48.49	34.71	44.94
Ash	5.34	2.74	39.81	10.71
	99.91	100.08	100.00	100.00
Sulphur			.91	4.49

The coal from Blue mountain makes very good coke. That from Camas mountain is non-coking. The coal from Blue mountain, when thoroughly dried, contains .02 per cent. of water and the saturated coal contains 1.7 per cent. The Camas coal contains when dried 1.53 per cent. and when saturated contains 6.28 per cent.

PENNSYLVANIA.

Anthracite—total production in 1886 (*a*), 32,764,710 long tons, or 36,696,475 short tons; spot value, $71,558,126.

Bituminous—total production, 26,160,735 short tons; spot value, $21,016,235.

ANTHRACITE.

The anthracite region of Pennsylvania is the most important in the United States, on account of the special character of the coal which it produces, its situation in the most thickly populated portion of the United States, and the amount of coal which it is yearly producing. The coal is the most desirable domestic fuel, natural gas only excepted, which is found anywhere, and it is distributed to more widely separated markets than any other one coal; 34.62 per cent. of all the coal produced

a This does not include colliery consumption.

in the United States during 1886 came from the anthracite mines. The center of the region is distant from New York about 200 miles, and from Philadelphia about 125 miles, with which cities it is connected by seven distinct and independent systems of railroads and by three distinct and separate systems of waterways.

Unlike most of the other coal regions of the United States, particularly those east of the Rocky mountains, its coal beds are highly plicated, occurring under all degrees of dips; in some cases the beds are inverted beyond the perpendicular.

The area of maximum folding and contortion of the coal-bearing measures is in the Southern field, where the occurrence of isoclinals and sharp narrow anticlinals and synclinals is more frequent. In other fields the flexures gradually become flatter, broader, and farther apart toward the northwest. The structure in the Eastern Middle field is an apparent exception; when it is remembered, however, that in this district the flexures in the Coal Measures are found at a much greater height above ocean level, and the coal basins are much shallower than in the Southern field, the general conclusion holds true, for the most complicated structure is invariably found in the bottoms of the coal basins, where the squeezing of the strata was the greatest during the original plication. (*a*)

The Northern field, which is further removed from the area of maximum disturbance, is composed of a broad canoe-shaped basin with moderate dips, the surface of any one of the Coal Measure strata in general being but slightly undulated by broad low anticlinals and shallow synclinals, while the structure of the Loyalsock and Mehoopany field, (*b*) which it still further removed, is identical with that of the Pennsylvania bituminous field, the average maximum dips of the coal bed ranging from between 3 and 5 feet to 100 feet.

Some idea may be had from the following table of the depths of some of the anthracite basins, in which information has been obtained of a sufficiently definite character to permit of estimates being made. The elevations are given in feet above ocean level:

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a The difficulties which have been encountered in mining near and in the bottoms of the Lehigh basins foreshadow the greater irregularities of structure, which will probably be met with in mining in the bottoms of the Southern field basins. Although the details of structure are rarely duplicated in different districts, yet I believe a careful mapping and study of the structural geology of the Lehigh basins will aid materially in the most economical development of the deeper portions of the Southern field basins.

b This field has been provisionally named the Western Northern.

Topographical characteristics of the anthracite basins, Pennsylvania.

	Feet.
Northern field, Wilkes-Barre basin.	
Wilkes-Barre (Lehigh Valley Railroad depot)	+549
Mammoth bed outcrop on north side of basin, at Kingston Coal Company's slope No. 2	+778
Mammoth bed outcrop on south side of basin, at Hollenback slope No. 2	+774
Bottom of Mammoth bed basin under flat, north of Wilkes-Barre (estimated)	(*a*)—800
Width of basin (4.4 miles)	23, 200
Eastern Middle field.	
Drifton basin:	
Drifton (Lehigh and Susquehanna Railroad depot)	+1, 633
Buck Mountain bed outcrop on north side of basin, at Drifton slope No. 2	+1, 692
Buck Mountain bed outcrop on south side of basin	+1, 645
Bottom of Buck Mountain bed basin	+1, 150
Width of basin (.4 mile)	2, 250
Hazleton basin:	
Hazleton (Lehigh Valley Railroad depot)	+1, 612
Mammoth bed outcrop on north side of basin	+1, 660
Mammoth bed outcrop on south side of basin, at Hazleton slope No. 6	+1, 672
Bottom of Mammoth bed basin	+ 850
Width of basin along line through slope No. 6 (.7 mile)	3, 800
Western Middle field, Mahanoy basin:	
Gilberton (Philadelphia and Reading Railroad depot)	+1, 133
Mammoth bed outcrop on north side of basin, at Gilberton slope	+1, 223
Mammoth bed outcrop on south side of basin, at Draper slope	+1, 275
Width of basin along line through Gilberton slope (.6 mile)	3, 050
Southern field, Panther Creek basin (near Tamaqua).	
Tamaqua (Philadelphia and Reading Railroad depot)	+ 803
Mammoth bed outcrop on north side of basin	+1, 250
Mammoth bed outcrop on south side of basin	+1, 300
Bottom of Mammoth bed basin (estimated)	—1, 000

a Depth attained by workings in Prospect colliery is now over 300 feet below ocean level.

The region is exceptionally free from rock faults. No downthrow or upthrow faults have been defined, such as are so frequently met with in the English coal fields, where the hade of the fault makes an angle of more than 90° with any one stratum on either side of the fault plane. The only breaks in the strata which are worthy of mention in this brief description are fractures which occur along the reversed flexures, and which are properly called reversed faults.

No exact determination has been made of the area of the different anthracite coal basins. The general estimates contained in the following table will serve to give an idea as to their relative size:

Area and total production of individual Pennsylvania coal fields.

Field.	Square miles (approximated).	1884.		1885.		1886.	
		Long tons.	*Per ct.*	*Long tons.*	*Per ct.*	*Long tons.*	*Per ct.*
Northern	200	16, 411, 277	50. 28	17, 215, 066	50. 29	18, 247, 875	52. 36
Eastern Middle	40	5, 098, 684	15. 62	5, 329, 607	15. 57	4, 993, 361	14. 33
Western Middle	90	7, 896, 049	24. 19	8, 152, 937	23. 82	8, 122, 639	23. 30
Southern	140	3, 149, 471	9. 65	3, 455, 927	10. 10	3, 427, 435	9. 83
Loyalsock	Unknown.	86, 018	0. 26	75, 011	0. 22	61, 767	0. 18
Total	470+	32, 641, 499	100. 00	34, 228, 548	100. 00	34, 853, 077	100. 00

The region is divided into seven inspection districts, as follows:

First. That portion of the Wyoming coal field included in the counties of Lackawanna, Wayne, and Susquehanna.

Second. The county of Sullivan and that portion of the Wyoming coal field situated in Luzerne county east of and including Plains and Kingston townships.

Third. The remaining portion of the Wyoming coal field west of Plains and Kingston townships, including the city of Wilkes-Barre and the boroughs of Kingston and Edwardsville.

Fourth. That part of Luzerne county lying south of the Wyoming coal field, together with Carbon county.

Fifth. That part of the Schuylkill coal field in Schuylkill county lying north of the Broad mountain and east of a meridian line through the center of the borough of Girardville.

Sixth. That part of the Schuylkill coal field in Schuylkill county lying north of the Broad mountain and west of a meridian line through the center of the borough of Girardville, together with Columbia, Northumberland, and Dauphin counties.

Seventh. All that part of the Schuylkill coal field in Schuylkill county lying south of the Mahanoy valley and the county of Lebanon.

Total production and shipment from the inspectors' districts for the years 1885 *and* 1886, *with the colliery and local consumption.*

District (under law of June 30, 1885).	Inspectors.	1885.			1886.		
		Shipment.	Colliery and local consumption.	Total production.	Shipment.	Colliery and local consumption.	Total production.
		Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
First	Patrick Blewett	6, 829, 977	428, 776	7, 258, 753	6, 631, 226	481, 033	7, 112, 259
Second	Hugh McDonald	3, 686, 695	161, 854	3, 848, 549	4, 143, 575	116, 498	4, 260, 073
Third	G. M. Williams	6, 036, 884	145, 891	6, 182, 775	6, 692, 552	244, 758	6, 937, 310
Fourth	James E. Roderick	5, 055, 407	528, 209	5, 583, 616	4, 916, 310	441, 060	5, 357, 370
Fifth	William Stein	4, 493, 075	276, 005	4, 769, 080	4, 570, 145	402, 356	4, 972, 501
Sixth	James Ryan	3, 965, 959	238, 663	4, 204, 622	3, 463, 265	261, 252	3, 724, 517
Seventh	Samuel Gay	2, 197, 424	183, 729	2, 381, 153	2, 347, 637	141, 410	2, 489, 047
Total production of all anthracites		32, 265, 421	1, 963, 127	34, 228, 548	32, 764, 710	2, 088, 367	34, 853, 077

The shipment of coal from the three prominent districts into which the region has been divided by the transportation companies, from the commencement of mining in 1820, has been carefully recorded by Mr. P. W. Sheafer, and subsequently by Mr. John H. Jones. From these records the following table has been compiled, and is interesting in showing the history of the development of the region:

Annual shipments of anthracite coal in Pennsylvania since 1820, *with the number of tons and percentage shipped from each region.*

Years.	Schuylkill region.		Lehigh region.		Wyoming region.		Total.
	Long tons.	*Per cent.*	*Long tons.*	*Per cent.*	*Long tons.*	*Per cent.*	*Long tons.*
1820			365				365
1821			1, 073				1, 073
1822	1, 480	39. 79	2, 240	60. 21			3, 720
1823	1, 128	16. 23	5, 823	83. 77			6, 951
1824	1, 567	14. 10	9, 541	85. 90			11, 108
1825	6, 500	18. 60	28, 393	81. 40			34, 893
1826	16, 767	34. 90	31, 280	65. 10			48, 047
1827	31, 360	49. 44	32, 074	50. 56			63, 434
1828	47, 284	61. 00	30, 232	39. 00			77, 516
1829	79, 973	71. 35	25, 110	22. 40	7, 000	6. 25	112, 083
1830	89, 984	51. 50	41, 750	23. 90	43, 000	24. 60	174, 734
1831	81, 854	46. 29	40, 966	23. 17	54, 000	30. 54	176, 820
1832	209, 271	57. 61	70, 000	19. 27	84, 000	23. 12	363, 271
1833	252, 971	51. 87	123, 001	25. 22	111, 777	22. 91	487, 749
1834	226, 692	60. 19	106, 244	28. 21	43, 700	11. 60	376, 636
1835	339, 508	60. 54	131, 250	23. 41	90, 000	16. 05	560, 758
1836	432, 045	63. 16	148, 211	21. 66	103, 861	15. 18	684, 117
1837	530, 152	60. 98	223, 902	25. 75	115, 387	13. 27	869, 441
1838	446, 875	60. 49	213, 615	28. 92	78, 207	10. 59	738, 697
1839	475, 077	58. 05	221, 025	27. 01	122, 300	14. 94	818, 402
1840	490, 596	56. 75	225, 313	26. 07	148, 470	17. 18	864, 379
1841	624, 466	65. 07	143, 037	14. 90	192, 270	20. 03	959, 773
1842	583, 273	52. 62	272, 540	24. 59	252, 599	22. 79	1, 108, 412
1843	710, 200	56. 21	267, 793	21. 19	285, 605	22. 60	1, 263, 598
1844	887, 937	54. 45	377, 002	23. 12	365, 911	22. 43	1, 630, 850
1845	1, 131, 724	56. 22	429, 453	21. 33	451, 836	22. 45	2, 013, 013
1846	1, 308, 500	55. 82	517, 116	22. 07	518, 389	22. 11	2, 344, 005
1847	1, 665, 735	57. 79	633, 507	21. 98	583, 067	20. 23	2, 882, 309
1848	1, 733, 721	56. 12	670, 321	21. 70	685, 196	22. 18	3, 089, 238
1849	1, 728, 500	53. 30	781, 556	24. 10	732, 910	22. 60	3, 242, 966
1850	1, 840, 620	54. 80	690, 456	20. 56	827, 823	24. 64	3, 358, 899
1851	2, 328, 525	52. 34	964, 224	21. 68	1, 156, 167	25. 98	4, 448, 916
1852	2, 636, 835	52. 81	1, 072, 136	21. 47	1, 284, 500	25. 72	4, 993, 471
1853	2, 665, 110	51. 30	1, 054, 309	20. 29	1, 475, 732	28. 41	5, 195, 151
1854	3, 191, 670	53. 14	1, 207, 186	20. 13	1, 603, 478	26. 73	6, 002, 334
1855	3, 552, 943	53. 77	1, 284, 113	19. 43	1, 771, 511	26. 80	6, 608, 567
1856	3, 603, 029	52. 91	1, 351, 970	19. 52	1, 972, 581	28. 47	6, 927, 580
1857	3, 373, 797	50. 77	1, 318, 541	19. 84	1, 952, 603	29. 39	6, 644, 941
1858	3, 273, 245	47. 86	1, 380, 030	20. 18	2, 186, 094	31. 96	6, 839, 369
1859	3, 448, 708	44. 16	1, 628, 311	20. 86	2, 731, 236	34. 98	7, 808, 255
1860	3, 749, 632	44. 04	1, 821, 674	21. 40	2, 941, 817	34. 56	8, 513, 123
1861	3, 160, 747	39. 74	1, 738, 377	21. 85	3, 055, 140	38. 41	7, 954, 264
1862	3, 372, 583	42. 86	1, 351, 054	17. 17	3, 145, 770	39. 97	7, 869, 407
1863	3, 911, 683	40. 90	1, 894, 713	19. 80	3, 759, 610	39. 30	9, 566, 006
1864	4, 161, 970	40. 89	2, 054, 669	20. 19	3, 960, 836	38. 92	10, 177, 475
1865	4, 356, 959	45. 14	2, 040, 913	21. 14	3, 254, 519	33. 72	9, 652, 391
1866	5, 787, 902	45. 56	2, 179, 364	17. 15	4, 736, 616	37. 29	12, 703, 882
1867	5, 161, 671	39. 74	2, 502, 054	19. 27	5, 325, 000	40. 99	12, 988, 725
1868	5, 330, 737	38. 62	2, 502, 582	18. 13	5, 968, 146	43. 25	13, 801, 465
1869	5, 775, 138	41. 66	1, 949, 673	14. 06	6, 141, 369	44. 28	13, 866, 180
1870	4, 968, 157	30. 70	3, 239, 374	20. 02	7, 974, 660	49. 28	16, 182, 191
1871	6, 552, 772	41. 74	2, 235, 707	14. 24	6, 911, 242	44. 02	15, 699, 721
1872	6, 694, 890	34. 03	3, 873, 339	19. 70	9, 101, 549	46. 27	19, 669, 778
1873	7, 212, 601	33. 97	3, 705, 596	17. 46	10, 309, 755	48. 57	21, 227, 952
1874	6, 866, 877	34. 09	3, 773, 836	18. 73	9, 504, 408	47. 18	20, 145, 121
1875	6, 281, 712	31. 87	2, 834, 605	14. 38	10, 596, 155	53. 75	19, 712, 472
1876	6, 221, 934	33. 63	3, 854, 919	20. 84	8, 424, 158	45. 53	18, 501, 011
1877	8, 195, 042	39. 35	4, 332, 760	20. 80	8, 300, 377	39. 85	20, 828, 179
1878	6, 282, 226	35. 68	3, 237, 449	18. 40	8, 085, 587	45. 92	17, 605, 262
1879	8, 960, 829	34. 28	4, 595, 567	17. 58	12, 586, 293	48. 14	26, 142, 689
1880	7, 554, 742	32. 23	4, 463, 221	19. 05	11, 419, 279	48. 72	23, 437, 242
1881	9, 253, 958	32. 46	5, 294, 676	18. 58	13, 951, 383	48. 96	28, 500, 017
1882	9, 459, 288	32 48	5, 689, 437	19. 54	13, 971, 371	47. 98	29, 120, 096
1883	10, 074, 726	31. 69	6, 113, 809	19. 23	15, 604, 492	49. 08	31, 793, 027
1884	9, 478, 314	30. 85	5, 562, 226	18. 11	(a)15, 677, 753	51. 04	30, 718, 293
1885	9, 488, 426	30. 01	5, 898, 634	18. 65	(a)16, 236, 470	51. 34	31, 623, 530
1886	9, 381, 407	20. 19	5, 723, 129	17. 81	(a)17, 031, 826	53. 00	32, 136, 362
Total	221, 746, 545	37. 33	112, 218, 366	18. 90	260, 006, 791	43. 77	593, 971, 702

a Includes Loyalsock field.

Under the head of Lehigh region in the above table is included the eastern end of the Southern or Pottsville coal basin between Tamaqua and Mauch Chunk. In this district, which is known as the Panther Creek Coal basin, the development of the region first commenced, and until 1828 more than one-half of the anthracite production of the entire region came from this basin.

From 1828 to 1857, inclusive, the Schuylkill region, including the Southern coal field west of Tamaqua and the Western Middle coal field, produced more than one-half of all the coal mined, and until 1867 this same region produced more than either one of the other two regions. In 1868 the Wyoming region took its rank as the greatest producer of the three regions, and has maintained it until the present time.

Since 1883 the Wyoming region, which in the above table is made to include the Lackawanna district, has produced more than one-half of the total anthracite mined in the State.

The number of tons of coal and the percentage of the entire product mined by each of the different operating coal companies and individuals in each field, and the number of tons and the percentage of the entire production handled by the different transportation companies by these same fields, are shown in the following table:

Railroad and colliery division of production of individual coal fields for 1885 *and* 1886.

NORTHERN COAL FIELD, RAILROAD DIVISION.

Railroads.	1885.		1886.	
	Long tons.	Percentage.	Long tons.	Percentage.
Delaware, Lackawanna and Western, main line	2, 593, 180	36. 51	2, 568, 525	37. 68
Delaware, Lackawanna and Western, Lackawanna and Bloomsburg division	3, 688, 617		4, 307, 516	
Delaware and Hudson Canal Company	2, 584, 907	15. 02	2, 797, 648	15. 33
Delaware and Hudson Canal Company and Lackawanna and Bloomsburg division of Delaware, Lackawanna and Western railroad	795, 395	4. 62	765, 645	4. 20
Delaware and Hudson Canal Company and Lehigh and Susquehanna	253, 745	1. 47	280, 807	1. 54
Delaware and Hudson Canal Company and Lehigh Valley	52, 996	0. 31	77, 633	0. 42
Lehigh and Susquehanna	2, 436, 495	14. 15	2, 442, 697	12. 39
Lehigh and Susquehanna and North and West branch	128, 899	0. 75	141, 196	0. 77
Lehigh Valley	1, 452, 254	8. 43	1, 754, 870	9. 62
North and West branch (Pennsylvania)	1, 275, 765	7. 41	1, 485, 474	8. 14
Pennsylvania Coal Company	1, 304, 932	7. 58	....	....
Erie and Wyoming Valley	517, 718	3. 00	1, 454, 880	7. 97
New York, Lake Erie and Western (Jefferson branch)	96, 629	0. 56	135, 144	0. 74
Local sales (shipped by wagon)	33. 534	0. 19	35, 840	0. 20
Total	17, 215, 066	100. 00	18, 247, 875	100. 00

NORTHERN COAL FIELD, COLLIERY DIVISION.

Operators.	1885.		1886.	
	Long tons.	Percentage.	Long tons.	Percentage.
Delaware, Lackawanna and Western	2, 168, 017	12. 60	2, 453, 699	13. 45
Delaware and Hudson Canal Company	3, 048, 237	17. 70	3, 220, 237	17. 65
Delaware and Hudson, and Delaware, Lackawanna and Western	192, 176	1. 12	159, 478	0. 88
Lehigh and Wilkes-Barre Coal Company	1, 716, 682	9. 97	2, 044, 370	11. 20
Susquehanna Coal Company	1, 466, 735	8. 51	1, 631, 860	8. 94
Lehigh Valley Coal Company	830, 755	4. 83	1, 016, 972	5. 57
Pennsylvania Coal Company	1, 711, 379	9. 94	1, 357, 708	7. 44
Hillside Coal and Iron Company	371, 867	2. 16	438, 204	2. 40
Individual operators	5, 709, 218	33. 17	5, 925, 347	32. 47
Total	17, 215, 066	100. 00	18, 247, 875	100. 00

Railroad and colliery division of production of individual coal fields, &c.—Continued.

EASTERN MIDDLE COAL FIELD, RAILROAD DIVISION.

Railroads.	1885.		1886.	
	Long tons.	Percentage.	Long tons.	Percentage.
Lehigh Valley	2, 991, 416	56. 12	2, 938, 706	58. 85
Lehigh and Susquehanna	1, 282, 109	24. 06	946, 223	18. 95
Lehigh Valley and Lehigh and Susquehanna	728, 979	13. 67	737, 787	14. 78
Sunbury, Hazleton and Wilkes-Barre	327, 103	6. 15	370, 645	7. 42
Total	5, 329, 607	100. 00	4, 993, 361	100. 00

EASTERN MIDDLE COAL FIELD, COLLIERY DIVISION.

Operators.	1885.		1886.	
	Long tons.	Percentage.	Long tons.	Percentage.
Lehigh and Wilkes-Barre Coal Company	500, 391	9. 39	356, 833	7. 15
Individual operators	4, 829, 216	90. 61	4, 636, 528	92. 85
Total	5, 329, 607	100. 00	4, 993, 361	100. 00

WESTERN MIDDLE COAL FIELD, RAILROAD DIVISION.

Railroads.	1885.		1886.	
	Long tons.	Percentage.	Long tons.	Percentage.
Philadelphia and Reading	5, 525, 749	67. 78	5, 461, 415	67. 24
Philadelphia and Reading and Northern Central	330, 272	4. 05	281, 835	3. 47
Lehigh Valley	1, 523, 256	18. 68	1, 599, 455	19. 69
Northern Central	619, 271	7. 60	655, 352	8. 07
Lehigh Valley and Northern Central	24, 455	0. 30	....	....
Philadelphia and Reading, Northern Central, and Lehigh Valley	129, 934	1. 59	124, 582	1. 53
Total	8, 152, 937	100. 00	8, 122, 639	100. 00

WESTERN MIDDLE COAL FIELD, COLLIERY DIVISION.

Operators.	1885.		1886.	
	Long tons.	Percentage.	Long tons.	Percentage.
Philadelphia and Reading Coal and Iron Company	4, 417, 421	54. 18	4, 609, 645	56. 75
Lehigh Valley Coal Company	460, 814	5. 65	486, 301	5. 99
Mineral Railroad and Mining Company	437, 167	5. 36	352, 911	4. 35
Individual operators	2, 837, 535	34. 81	2, 673, 782	32. 91
Total	8, 152, 937	100. 00	8, 122, 639	100. 00

Railroad and colliery division of production of individual coal fields, &c.—Continued.

SOUTHERN COAL FIELD, RAILROAD DIVISION.

Railroads.	1885.		1886.	
	Long tons.	Percentage.	Long tons.	Percentage.
Philadelphia and Reading	1, 669, 805	48. 33	1, 800, 404	52. 53
Lehigh and Susquehanna	1, 224, 468	35. 44	1, 219, 167	35. 57
Northern Central	561, 654	16. 23	407, 864	11. 90
Total	3, 455, 927	100. 00	3, 427, 435	100. 00

SOUTHERN COAL FIELD, COLLIERY DIVISION.

Operators.	1885.		1886.	
	Long tons.	Percentage.	Long tons.	Percentage.
Philadelphia and Reading Coal and Iron Company	1, 249, 503	36. 15	1, 348, 549	39. 35
Lehigh Coal and Navigation Company	1, 224, 468	35. 43	1, 219, 167	35. 57
Summit Branch Railroad Company	344, 480	9. 97	193, 799	5. 65
Lykens Valley Coal Company	217, 174	6. 28	214, 065	6. 25
Individual operators	420, 302	12. 17	451, 855	13. 18
Total	3, 455, 927	100. 00	3, 427, 435	100. 00

WESTERN NORTHERN COAL FIELD, RAILROAD DIVISION.

Railroads.	1885.		1886.	
	Long tons.	Percentage.	Long tons.	Percentage.
Lehigh Valley	75, 011	100. 00	61, 767	100. 00

WESTERN NORTHERN COAL FIELD, COLLIERY DIVISION.

Operators.	1885.		1886.	
	Long tons.	Percentage.	Long tons.	Percentage.
State Line and Sullivan Railroad Company	75, 011	100. 00	61, 767	100. 00

The number of tons of coal and the percentage of the total production shipped by the different transportation companies individually and by two or more companies combined are shown in the following table. These statistics are generally published in the coal trade journals in a table in which a fixed tonnage is assigned to each independent company. This is not strictly correct since a number of the railroads collect from the collieries a certain amount of coal which goes to market by short lines in the coal fields belonging to other transportation companies. With this explanation the following table will be perfectly understood:

Railroad division of the production of anthracite coal field for 1885 *and* 1886.

Names of railroads.	1885.		1886.	
	Tons.	*Percentage.*	*Tons.*	*Percentage.*
Philadelphia and Reading railroad	7, 195, 554	21. 02	7, 261, 819	20. 84
Delaware, Lackawanna, and Western railroad	6, 281, 797	18. 36	7, 822, 264	22. 44
Lehigh Valley railroad	6, 041, 937	17. 66	6, 354, 798	18. 23
Central Railroad of New Jersey	4, 943, 072	14. 44	3, 661, 864	10. 51
Pennsylvania railroad	2, 783, 793	8. 13	2, 919, 335	8. 38
Delaware and Hudson Canal Company	2, 584, 907	7. 55	2, 797, 648	8. 03
Pennsylvania Coal Company	1, 304, 932	3. 81	....	....
Delaware and Hudson Canal Company and Delaware, Lackawanna and Western railroad	795, 395	2. 32	765, 645	2. 20
Lehigh Valley Railroad and Central railroad of New Jersey	728, 979	2. 13	737, 787	2. 12
Erie and Wyoming Valley railroad	517, 718	1. 51	1, 454, 880	4. 17
Philadelphia and Reading railroad and Pennsylvania railroad	330, 272	. 97	281, 835	. 81
Delaware and Hudson Canal Company and Central railroad of New Jersey	253, 745	. 74	280, 807	. 80
Philadelphia and Reading railroad, Pennsylvania railroad and Lehigh Valley railroad	129, 934	. 38	124, 582	. 36
Central railroad of New Jersey and Pennsylvania railroad	128, 899	. 37	141, 196	. 40
Jefferson Branch, New York, Lake Erie and Western railroad	96, 629	. 28	135, 144	. 39
Delaware and Hudson Canal Company and Lehigh Valley railroad	52, 996	. 16	77, 633	. 22
Lehigh Valley railroad and Pennsylvania railroad	24, 455	. 07	....	....
Local sales (shipped by wagon)	33, 534	. 10	35, 840	. 10
Total	34, 228, 548	100. 00	34, 853, 077	100. 00

All the transportation companies in the region, however, have relations with coal operating companies or with individual operators by which the shipment of coal from the collieries of these companies and individual operators is shipped exclusively over the respective lines controlled by the different transportation companies. The total production of coal from these collieries is given in the following table:

Colliery division of production of the anthracite coal fields for 1885 *and* 1886.

Operating companies.	1885.		1886.	
	Long tons.	*Percentage.*	*Long tons.*	*Percentage.*
Individual operators	13, 796, 271	40. 31	13, 687, 512	39. 27
Philadelphia and Reading Coal and Iron Company	5, 666, 924	16. 56	5, 958, 194	17. 07
Delaware and Hudson Canal Company	3, 048, 237	8. 90	3, 220, 237	9. 24
Pennsylvania Railroad Coal Companies	2, 465, 556	7. 20	2, 392, 635	6. 87
Lehigh and Wilkes-Barre Coal Company	2, 217, 073	6. 48	2, 401, 203	6. 90
Delaware, Lackawanna and Western Railroad Company	2, 168, 017	6. 33	2, 453, 699	7. 04
Pennsylvania Coal Company	1, 711, 379	5. 00	1, 357, 708	3. 90
Lehigh Valley Coal Company	1, 291, 569	3. 77	1, 503, 273	4. 31
Lehigh Coal and Navigation Company	1, 224, 468	3. 58	1, 219, 167	3. 50
Hillside Coal and Iron Company	371, 867	1. 09	438, 204	1. 26
Delaware and Hudson Canal Company and Delaware, Lackawanna and Western Railroad Company	192, 176	. 56	159, 478	. 46
State Line and Sullivan Railroad Company	75, 011	. 22	61, 767	. 18
Total	34, 228, 548	100. 00	34, 853, 077	100. 00

The county boundaries of that portion of the State in which the anthracite region is located are not recognized by the coal trade in the classification of either the coal fields or the coals which they produce; neither are they recognized as distinct counties in the division of the field into inspectors' districts. The production of coal, however, in the individual counties is of interest in showing the relative importance of the anthracite mining industry to the counties in which it is located. This production is shown in the following table:

Total production of Pennsylvania coal fields, by counties.

Counties.	1884.		1885.		1886.	
	Long tons.	*Per cent.*	*Long tons.*	*Per cent.*	*Long tons.*	*Per cent.*
Susquehanna	77, 058	0. 24	84, 459	0. 24	97, 072	0. 28
Lackawanna	7, 093, 190	21. 73	7, 174, 294	20. 96	7, 275, 853	20. 88
Luzerne	13, 382, 912	41. 00	14, 329, 645	41. 86	14, 928, 206	42. 83
Sullivan	86, 018	. 26	75, 011	. 22	61, 767	. 17
Carbon	1, 155, 916	3. 54	1, 210, 284	3. 53	1, 304, 114	3. 74
Schuylkill	7, 165, 532	21. 96	7, 700, 005	22. 49	7, 915, 650	22. 71
Columbia	745, 826	2. 28	610, 552	1. 81	601, 729	1. 73
Northumberland	2, 331, 108	7. 14	2, 482, 644	7. 25	2, 260, 822	6. 49
Dauphin	603, 939	1. 85	561, 654	1. 64	407, 864	1. 17
Total	32, 641, 499	100. 00	34, 228, 548	100. 00	34, 853, 077	100. 00

Various classifications have been made of the coal produced in the anthracite fields. This subject is referred to at great length in a paper which I read before the American Institute of Mining Engineers, at the Denver meeting. (See Transactions, Vol. XI., pp. 136–158; also Annual Report of the Geological Survey of Pennsylvania, 1885, p. 300, on the Classification and Composition of Pennsylvania Anthracites.)

The coals from the region have been intelligently classified by Mr. Joseph S. Harris, in referring to the characteristics of the coals produced from the properties of the Philadelphia and Reading Coal and Iron Company. He refers to the coals as follows:

(1) *Hard white ash.*—"It is in great request for blast furnace and locomotive purposes, having, to an unusual degree, the qualities of resisting change of form under high heat and pressure, and, owing to its high percentage of carbon, it is valuable for producing steam; but for domestic use on a small scale and for open-grate fires it does not ignite readily enough to be a favorite."

(2) *Free-burning white ash.*—"The distinction between it and the hard-burning white-ash coal is that under such a fire as is ordinarily used for smelting metals or producing steam the impurities melt or clinker, which is not the case with the harder coal. This practical test is not, however, a very exact one. Some of the anthracites can be clinkered with a strong draught and with a thick bed of fire, and would, by a person who used them under such circumstances, be classed as free burning, while another, whose method of burning was more economical, would call them hard. Analysis shows that the free-burning white-ash coals are quite as rich in fixed carbon, and that they have even higher heating power, as tested by the amount of water evaporated, than the harder variety, but their limited range of usefulness, which is due to their clinkering, prevents their price rising as high as the hard white-ash coals."

(3) *Schuylkill red ash.*—"Is easily ignited, easy to keep burning, and where used in open grates makes less floating dust than white-ash coal, because its ash is composed of larger particles, and on account of the

oxide of iron which constitutes its coloring matter has greater specific gravity than the ash of the white."

(4) *Shamokin.*—"It follows in hardness and in ease of ignition next after the free-burning white-ash coals, and is used still more especially for domestic purposes, its lower percentage of carbon making it ill-adapted for purposes requiring intense heat."

(5) *Lorberry red ash.*—"It burns with a little flame, and is much in request for domestic uses in the eastern market."

(6) *Lykens Valley red ash.*—"It burns with considerable flame, and is greatly liked in the eastern market for open grates, or other domestic uses, and for steam and heating purposes, wherever quick heat is required."

(7) *Trevorton or North Franklin white ash.*—"The coal is pure, but its heating properties are rather low, and it is of so friable a nature that it does not stand transportation well."

(8) The Wyoming red ash, (9) Lehigh red ash, and (10) Loyalsock white ash are not referred to in Mr. Harris's report. The Wyoming red ash is similar in its general characteristics to the Schuylkill red ash. The Lehigh red ash is very similar to the hard white ash produced from the same region, with the exception of the color of the ash, due to the presence of iron, the same as in the softer red ash from Schuylkill, while the Bernice white ash, as a fuel, is rated by many coal men as being similar to the Lykens Valley coal, except in the color of the ash. The geological structure and physical characteristics of the Bernice and Lykens Valley beds are, however, quite different.

The following table shows the amount of the different kinds of coal produced in the different fields, the number of producing collieries in each field from which the different varieties of coals come, and the proportion produced, both in tons and per cent. of total production, in 1884, 1885, and 1886:

Production of the different classes of coal during the last three years.

Coal fields.	Character of coal.	1884. Number of collieries.	1884. Production.	1884. Percentage of total production.
			Long tons.	
Northern	Free-burning white ash	155	14,683,312	44.98
	Wyoming red ash	14	1,727,965	5.30
Total		169	16,411,277	50.28
Eastern Middle	Hard white ash	44	3,588,190	10.99
	Lehigh red ash	11	1,510,494	4.63
Total		55	5,098,684	15.62
Western Middle	Hard white ash	46	4,572,762	14.01
	Free-burning white ash	20	1,796,738	5 50
	Shamokin	29	1,409,854	4.32
	Trevorton	2	116,695	.36
Total		97	7,896,049	24.19

Production of the different classes of coal during the last three years—Continued.

Coal fields.	Character of coal.	1884. Number of collieries.	Production.	Percentage of total production.
			Long tons.	
Southern	Lykens Valley red ash	8	1,145,008	3.50
	Hard white ash	15	1,045,687	3.20
	Free-burning white ash	38	629,473	1.93
	Schuylkill red ash	14	227,467	.71
	Lorberry red ash	4	101,836	.31
Total		79	3,149,471	9.65
Western Northern	Lykens Valley white ash	1	86,018	0.26
Grand total		401	32,641,499	100.00
		1885.		
			Long tons.	
Northern	Free-burning white ash	131	15,485,033	45.24
	Wyoming red ash	14	1,730,033	5.05
Total		145	17,215,066	50.29
Eastern Middle	Hard white ash	39	3,715,897	10.85
	Lehigh red ash	11	1,613,710	4.72
Total		50	5,329,607	15.57
Western Middle	Hard white ash	46	4,780,671	13.97
	Free-burning white ash	17	1,807,961	5.28
	Shamokin	16	1,452,596	4.24
	Trevorton	1	111,709	.33
Total		80	8,152,937	23.82
Southern	Lykens Valley red ash	6	1,219,030	3.56
	Hard white ash	12	1,289,023	3.77
	Free-burning white ash	17	619,213	1.81
	Schuylkill red ash	8	236,360	.69
	Lorberry red ash	4	92,301	.27
Total		47	3,455,927	10.10
Western Northern	Lykens Valley red ash	1	75,011	.22
Grand total		323	34,228,548	100.00
		1886.		
			Long tons.	
Northern	Free-burning white ash	128	16,266,201	46.67
	Wyoming red ash	14	1,981,674	5.69
Total		142	18,247,875	52.36
Eastern Middle	Hard white ash	38	3,470,719	9.96
	Lehigh red ash	11	1,522,642	4.37
Total		49	4,993,361	14.33
Western Middle	Hard white ash	40	5,123,309	14.70
	Free-burning white ash	15	1,585,492	4.55
	Shamokin	15	1,295,275	3.72
	Trevorton	1	118,563	.34
Total		71	8,122,639	23.31
Southern	Lykens Valley red ash	6	1,074,917	3.08
	Hard white ash	14	1,563,312	4.48
	Free-burning white ash	11	547,041	1.57
	Schuylkill red ash	8	157,078	.45
	Lorberry red ash	2	85,087	.24
Total		41	3,427,435	9.82
Western Northern	Lykins Valley white ash	1	61,767	.18
Grand total		304	34,853,077	100.00

It is found in practice that after the coal is passed through the breaker and screened into different sizes for shipment, the purity of the different sizes, as regards fixed carbon and ash, is very different. This is indicated by the following analyses of specimens collected from the Hauto screen-building of the Lehigh Coal and Navigation Company:

Analyses of different sizes of coals.

Kind of coal.	Water.	Volatile matter.	Fixed carbon.	Sulphur.	Ash.	Total.	Color of ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
Egg	1.722	3.518	88.489	.609	5.662	100	Light cream.
Stove	1.426	4.156	83.672	.572	10.174	100	Cream.
Chestnut	1.732	4.046	80.715	.841	12.666	100	Cream.
Pea	1.700	3.894	79.045	.697	14.664	100	Cream.
Buckwheat	1.690	4.058	76.918	.714	16.620	100	Cream.

These coals are separated into different sizes according to the mesh of the screen over which they pass. The sizes noted in the above table passed over and through sieve meshes of the following dimensions:

Sizes of coal-sieve meshes.

	Through.	Over.
	Inches.	*Inches.*
Broken or grate	4	2.5
Egg	2.5	1.75
Stove	1.75	1.25
Chestnut	1.25	.75
Pea	.75	.50
Buckwheat	.50	.25

The amount of different kinds of coal under this classification, produced by the different consumers and the number of collieries producing each kind of coal for 1884, 1885, and 1886, are shown in the following table:

Number of collieries producing each kind of coal, the amount in tons, and percentage of each, in 1884, 1885, *and* 1886.

Character of coal.	Number of collieries.	Production.	Percentage of total production.
1884.		*Long tons.*	
Free-burning white ash	213	17,109,523	52.41
Hard white ash	105	9,206,639	28.20
Wyoming red ash	14	1,727,965	5.30
Lehigh red ash	11	1,510,494	4.63
Shamokin	29	1,409,854	4.32
Lykens Valley red ash	8	1,145,008	3.50
Schuylkill red ash	14	227,467	.71
Trevorton	2	116,695	.36
Lorberry red ash	4	101,836	.31
Bernice white ash	1	86,018	.26
Total	401	32,641,499	100.00

Number of collieries producing each kind of coal, &c.—Continued.

Character of coal.	Number of collieries.	Production.	Percentage of total product.
1885.		*Long tons.*	
Free-burning white ash	165	17,912,207	52.33
Hard white ash	97	9,785,591	28.59
Wyoming red ash	14	1,730,033	5.05
Lehigh red ash	11	1,613,710	4.72
Shamokin	16	1,452,596	4.24
Lykens Valley red ash	6	1,219,030	3.56
Schuylkill red ash	8	236,360	.69
Trevorton	1	111,709	.33
Lorberry red ash	4	92,301	.27
Bernice white ash	1	75,011	.22
Total	323	34,228,548	100.00
1886.			
Free-burning white ash	154	18,398,734	52.79
Hard white ash	92	10,157,340	29.14
Wyoming red ash	14	1,981,674	5.69
Lehigh red ash	11	1,522,642	4.37
Shamokin	15	1,295,275	3.72
Lykens Valley red ash	6	1,074,917	3.08
Schuylkill red ash	8	157,078	.45
Trevorton	1	118,563	.34
Lorberry red ash	2	85,087	.24
Bernice white ash	1	61,767	.18
Total	304	34,853,077	100.00

A comparative idea of the value of the different kinds of anthracite may be had from the following table:

Prices of anthracite at New York City in 1882, 1883, 1884, 1885, and 1886.

Grades.	Lump.		Grate.		Egg.		Stove.		Nut.	
	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.
1882.										
Free-burning	$3.90	$4.30	$3.90	$4.30	$3.90	$4.55	$4.00	$4.85	$3.90	$4.75
Hard white ash	4.85	5.15	4.25	4.50	4.25	4.70	4.25	4.90	3.90	4.70
1883.										
Free-burning	3.90	4.30	3.90	4.30	4.00	4.55	4.20	4.85	4.20	4.75
Hard white ash	4.85	5.15	4.10	4.50	4.10	4.70	4.35	4.90	4.10	4.70
1884.										
Free-burning	3.80	3.30	3.80	3.80	3.80	3.80	4.15	4.40	4.00	4.15
Hard white ash	4.75	4.75	4.10	4.10	4.10	4.10	4.15	4.40	4.00	4.15
1885.										
Free-burning	3.30	3.45	3.00	3.25	3.00	3.40	3.50	4.10	3.10	3.60
Hard white ash	4.25	4.75	3.35	3.50	3.25	3.40	4.00	4.25	3.40	3.75
1886.										
Free-burning	3.25	3.45	2.80	3.55	2.85	3.80	3.00	4.15	3.00	3.85
Hard white ash	4.25	4.25	3.35	3.75	3.35	4.00	3.65	4.15	3.00	3.65

In the latter part of 1886 suits were entered by the Commonwealth of Pennsylvania against the various railroads and coal companies forming what was known as the Trunk Line Pool and the Coal Combination for certain alleged infringements of the conditions of the charters of the companies forming these pools and violations of the State Constitution

On December 28, Mr. Joseph S. Harris, president of the Lehigh Coal and Navigation Company, the oldest and one of the most important coal mining companies in the anthracite region, made an affidavit before the common pleas court of Dauphin county in regard to the condition of the anthracite coal trade, the history of its development, and the necessity and advantages of concerted action on the part of the mining transportation companies.

This affidavit, although of course an *ex parte* statement, contains important facts of interest to the general public. On account of Mr. Harris' long connection with the anthracite region, his statements have a special value to persons interested in anthracite mining, and it has been thought worth while to quote the more important ones in this place.

Mr. Harris says:

"The production for the year 1886 was the largest ever attained in the history of the trade, and prices have been lower during this year than the average of any year since 1862, excepting the year 1879, and, in point of fact, anthracite and bituminous coals are almost the only commodities which have not shared in the general advance of prices which have taken place during the last year. An attempt was made to secure an advance of 25 cents a ton in March, 1886, but it did not prove immediately successful. The incidental advantages of a large output are so great that there is always the strongest incentive to ship more coal than the market will take, and the net results of April, May, and June, were, with my own company, and, I believe, with the trade in general, less satisfactory than for the first three months of the year. This was to some extent owing to the necessity of having contracts ahead for the sale of coal, but there was no substantial improvement in the trade until after July 1, and I believe it to be true of the whole trade; down to that period the owners of the anthracite mines of Pennsylvania mined, transported, and sold about 15,000,000 tons of coal without getting back the cost of production and transportation, and this without any allowance for the value of the coal in the ground, or interest on the capital invested.

"The mining of anthracite is attended with very large outlays of capital, especially in the Southern coal fields, in which the Lehigh Coal and Navigation Company's property is situated, where the beds of coal are of great thickness, are steeply inclined, and have been worked to great depths, so that, not counting the investment in coal lands, the money that must be spent in developing the mines alone has for some years stood at the figure of from $2.50 to $3.00 per ton of annual capacity, or from $2,500,000 to $3,000,000 for a productive capacity of 1,000,000 tons per annum. The element of expense in producing coal, which may be called "fixed cost," that is, cost which goes on whether there is any production or not, such as keeping the mines in repair, keeping the water pumped out, feeding horses and mules, paying foremen, etc., is larger in mining than in almost any other business, and larger at the mines of the Lehigh Coal and Navigation Company for the reasons given, than in most other mines, having been, as shown by a careful analysis, $33,150 per month in 1884, and $27,560 per month in 1885, or an average for these two years of, say, $30,355 per month. If the mines are worked to a capacity of, say, 50,000 tons per month, this fixed cost would be a charge of 60.7 cents per ton, while if they are producing 120,000 tons per month, about their present capacity, the item of fixed cost would be reduced to 25.3 cents per ton, making a saving in cost of 35.4 cents in this item alone. That this is not an exaggerated estimate is proved by the fact that in 1884, in the three months January to March inclusive, when the average monthly production was 42,82[illegible] tons, the average cost per ton was $2.10, while for the three months September to November inclusive, the average monthly production was 98,690 tons and the average cost $1.38 per ton, a reduction of 72 cents per ton in cost. Again, in 1885, in the three months January to March inclusive, the average monthly production was 63,262 tons, and the average cost per ton $1.62, while in the three months August to October inclusive, the average production was 119,630 tons and the cost $1.24 per ton, a reduction of 38 cents per ton, and in 1886 the average production from April to June inclusive was 67,704 tons, and the cost $1.82 per ton, while in the three months August to October inclusive, the average production was 106,675 tons, and the cost $1.38 per ton, a reduction of 44 cents per ton. In each year the three consecutive months of lowest production have been compared with the three consecutive months of highest production.

"From this statement two results necessarily follow: That it is to the advantage of the Lehigh Coal and Navigation Company, as well as to the advantage of its customers, that it should develop its property so that it should be capable of a large production, and that the production should be kept up as steadily as possible. The gain by large production is so great that it is the plainest dictate of self interest to get out of the mine every ton that can be sold. Therefore this company, in common with all other companies, has gone on developing its mines until from a monthly capacity of 67,290 tons in 1877, it reached in 1885 a monthly capacity of 118,964 tons, an increase of 77 per cent. in eight years. The growth in the demand for anthracite in the same period has risen about 51 per cent., so that it is on this account less possible now than it was eight years ago to keep the mines steadily employed. Careful investigation leads me to conclude that in 1883 the mines then opened had an annual productive capacity of 34,875,000 tons, and that those opened in 1884 had an annual capacity of 38,129,000 tons, while the requirement of the market in those years was 31,798,000 tons for 1883, and 30,718,000 tons for 1884, showing a surplus of capacity of 3,082,000 tons in 1883, and 7,411,000 tons in 1884, or an average for the two years of, say, 5,250,000 tons surplus of capacity over actual demand.

This surplus capacity was not excessive, as we must be prepared at all times to meet a suddenly increasing demand. The production of anthracite increased from 17,605,262 tons in 1878 to 26,142,689 tons in 1879, and when a similar increase shall again be demanded the production cannot be increased at will, nor in a short time. There are now, December, 1886, mines in the Hazleton region which were drowned last winter which are not yet recovered; and to open a new mine in the deeper part of the anthracite basin requires two or three years, so that no amount of capital can be relied on to increase quickly the productive capacity of the anthracite region to a great extent, and the work must be kept ahead of the demands of the market if the price is to be kept from making sudden advances. But the capacity of the mines must be kept above the average requirements, without regard to any provision for a largely increased demand, on account of the different needs of different seasons of the year. The monthly demand in the four years, 1882 to 1885, inclusive, has averaged in the three months, January to March, inclusive, 1,974,000 tons, and in the three months, September to November, inclusive, 3,110,000 tons; whence it follows that it is necessary that mines of a monthly capacity of nearly 3,000,000 tons must be kept ready for operation, though the average monthly demand for these years was only 2,564,000 tons. That the mining capacity is not greatly in excess of the actual requirements is shown by the fact that in no year has there failed to be a full demand in some months for all that the mines could supply, and in some months of fullest work the stocks were drawn down. Under no system that could be devised, therefore, would it be possible to have just enough mines open to supply the demand and keep the men steadily employed.

"In this respect our present practice is much better than that which obtained years ago. The miners of the Lehigh Coal and Navigation Company, until within twenty years, had to stop work from December to the following April, four months every year, during which navigation on the canals was closed, and that they are not steadily employed is a hardship which they share with every mason, bricklayer, and brickmaker in the country. Competition, by lessening profits, has compelled every mine-owner to do all in his power to work his mines steadily and largely, and no pressure that can be put upon the mine-owner by any governmental authority can greatly increase his desire in these respects.

"The problem that presented itself to the managers of the mining companies in 1884 was this: Under the then existing methods of working the mines, whenever the supply of coal began to press heavily upon the means of storing it, all parties suspended work, usually for three days in each week, until the demand began to draw down the visible supply. This led each producer to desire to produce as much coal as possible in the days in which work was done and thus to increase the productive capacity of his mines, until, whereas in 1881, 42 days' stoppage was enough to keep the shipping points in working condition;

in 1882, 48 days were necessary, and this grew to 60 days in 1883, and 102 days in 1884, so that one-third of the time of the workmen was unemployed, and the capacity of the mines had grown to nearly 20 per cent. above the requirements of the market. Experience has shown that for some years back under all systems of working the larger producing interests have varied but little in the percentage of the total output provided by each, and it was thought that if, while allowing the market to take what coal it would, each party would provide but its usual share of the total, regulating its production as best might suit itself, coal could be produced cheaper, the incentive to constantly increase capacity would be lessened, the men could be more steadily employed, and the production and demand could more readily adjust themselves to each other. The different interests agreed to try this experiment for the year 1885; some parties shut up mines that could be profitably closed, and the productive capacity of the mines fell from 38,129,000 tons in 1884 to 36,482,400 tons in 1885, or from an excess over demand of 19.4 per cent. in 1884 to an excess of 13.3 per cent. in 1885. It was estimated in the beginning of the year that the market would require 30,000,000 tons of coal, but no attempt was made to keep the output below the demand, and it actually took 31,623,530 tons.

"After making allowance for the increase or diminution of the stock of coal at the shipping points, the amount which went into consumption for several years past has been as follows: In 1883, 31,606,813 tons; in 1884, 30,630,644 tons; in 1885, 31,743,666 tons, and in 1886 probably 32,250,000 tons, showing that during the last two years in which restriction of output is charged more coal was marketed than during the two preceding years, and in fact more than ever marketed before.

"So, too, the amount of coal shipped by the Lehigh Coal and Navigation Company was in 1883, 907,126 tons; in 1884, 969,366 tons; in 1885, 1,068,840 tons, and will be in 1886 about 1,100,000 tons.

"That the output has never been restricted below the requirements of the market is shown by the fact that there has always been a large unsold supply on hand. In the ordinary workings of the anthracite trade every producer sells all the coal that he can throughout the country to what is called the "line trade," and only sells to the stocking grounds such coals as he cannot otherwise dispose of, because the coal costs about 20 cents per ton to stock and pick up, and stock coal generally sells for less than fresh-mined coal. The coal in stock at any time therefore represents the amount for which no immediate sale can be found. In 1883 this stock varied from 502,159 tons to 748,330 tons; in 1884 it varied from 588,229 tons to 885,715 tons, while in 1885 it ranged from 420,564 tons to 988,782 tons, and in 1886 from 393,202 tons to 996,946 tons, so that this average stock unsold has not diminished in the last two years.

"The price at which coal should be marketed has never been discussed at any meeting of the representatives of the anthracite producers, nor has any action ever been taken thereon at any such meeting except at the one held March 22, 1886. The rates of transportation have never at any time been discussed, and in fact there is no concert whatever between the transporting companies as to rates except within limited areas. The greater part of the coal is carried to market at rates which are not the subject of agreement or conference between the different companies. But it is not true, as alleged in the Commonwealth's bill, that the prices of coal and of transportation have been advanced to an unjust extent or to any extent.

"In March, 1883, the rail rate on coal from Mauch Chunk to Philadelphia was $1.80 per ton. In August, 1883, this rate was advanced to $1.90 per ton. In October, 1883, it was advanced to $2 per ton. In March, 1884, it was reduced to $1.80 per ton. In July, 1885, it was reduced to $1.60 per ton, and in March, 1886, to $1.50 per ton, which is the present rate; so that since the beginning of 1883 the reduction has been 30 cents per ton.

"Similarly the rate on coal from the Lehigh region to New York tide via the Central Railroad of New Jersey, which in 1883 varied from $1.60 to $1.67 per ton, and in 1884 from $1.41 to $1.64 per ton, ruled in 1885 from $1.28 to $1.37 per ton, and in 1886 from $1.11 to $1.40 per ton, showing that in the last two years the rates to New York tide were considerably lower than in the previous years. To the rates here named must be added for wharfage and shipping a sum varying in the years named from 14 to 20 cents to get the 'free on board' price, and a further sum of 15 cents to 20 cents to put the coal 'alongside the piers' in New York.

"As to the price realized for coal: the average price realized for the Lehigh Coal and Navigation Company's coal 'free on board' in New York harbor has fallen each year since 1881, being in that year down to and including pea coal $3.95 per ton, while in 1882 the average was $3.88, in 1883 it was $3.74, in 1884 it was $3.47, in 1885 it was $3.07, while in 1886 to the end of October, the latest date to which accounts are completed, it is about $2.80.

"The great fall in the prices realized for coal was accompanied by a reduction in the wages of miners of about 10 per cent., but they were so much benefited by the steady work given under the present system that the earnings per capita of the men and boys employed on the Lehigh Coal and Navigation Company's property averaged more in 1885 than in 1884, and notwithstanding all the influences that have been brought to bear on the workmen during the past year or two to make them dissatisfied, they have in the main continued steadily at work, and while they have shared with their employers lower prices, they have, as already stated, earned more per capita in the year 1883, the first of the years as to which complaint is made, than in the year 1884, and speaking from an intimate knowledge of their conditions, I assert that the members of the community engaged in anthracite mining show from year to year that they are improving in intelligence, sobriety, and material comfort.

"The reduction in cost has only been brought about by the economies which were rendered possible by concerted action. To show that the public has had at least its share of the benefits resulting from this lowering of cost, it will be sufficient to state that the profit realized on the mining of coal by the Lehigh Coal and Navigation Company in 1885 was about 28 cents per ton, which profit has fallen this year so that it will not exceed 15 cents per ton, and may not reach that amount."

PENNSYLVANIA BITUMINOUS COAL.

The bituminous coal area of Pennsylvania lies in the notheastern end of the Appalachian coal field, and occupies the western portion of the State, west of the crest of the Allegheny mountains. The area of the field which contains the productive coal beds may be confined to 32 counties, only 26 of which produced coal for the market during the year 1886. A number of counties may, however, be included within the confines of the field which are not in the number just enumerated. A very small coal area, only a few acres, extends from McKean county over the State line into the State of New York. This area contains only a thin coal bed included in the Basal Conglomerate, which is non-productive.

The workable coal beds have always been considered to be confined to the Coal Measures proper extending from top of the Pottsville Conglomerate No. XII., or the representative of the Millstone Grit, up to the top of what has been called the Upper Barren Measures. The investigations of the Second Geological Survey of the State have, however, placed several productive coal beds within the conglomerate series, and within the past two years several beds of workable thickness and containing a good quality of coal have been opened along the face of the Allegheny mountains near Altoona, in the Pocono Sandstone No. X., which lies immediately on top of the Catskill formation, the upper member of the Old Red Sandstone formation.

Professor Lesley, in referring to the division of the coal formation, says:

"The large subdivisions of the coal formation were called by the geologists of the First Survey by the following names, which so clearly describe their characters that they will probably hold good to the end of time:

"1. The Upper Barren Measures, which have been divided by the Second Survey into an upper Greene County group, and a lower Washington County group, the bottom of the whole being the massive Waynesburg sandstone.

"2. The Upper Productive or Monongahela River coal series, containing the Waynesburg, Uniontown, Sewickley, and Redstone coal-beds, and the Pittsburgh coal bed at its base.

"3. The Lower Barren Measures, from the Pittsburgh coal bed down to the base of the Mahoning sandstone, containing no workable coal bed in the Pittsburgh region.

"4. The Lower Productive or Allegheny River series, subdivided by the First Survey into three groups, accepted by the Second Survey, viz., the Freeport group at the top, with three coal beds; the Kittanning group in the middle, with three coal beds; and the Clarion group at the bottom, with three coal beds. But of these nine coal beds, not more than two, or at most three, are anywhere found workable directly over one another, so great is their variability in size and quality from mile to mile in any direction.

"5. The Pottsville Conglomerate series (No. XII.), subdivided into three sandstone formations, upper, middle and lower, separated by shales containing small beds of coal, thin limestones, and poor ironstones, and resting on the Sharon bed, celebrated for its furnace or block coal; a bed which widely spreads itself through Ohio, but is worthless in Pennsylvania, except in Mercer county."

The First Geological Survey recognized this as the bottom of the coal formation, and it practically remains so to this day, there being no *workable bed* of coal, so far discovered in Pennsylvania, except near Altoona, from the Sharon coal down through 25,000 feet.

The Second Geological Survey, however, has seen good reason for applying the term "Coal Measures" to several thousand feet of rocks underlying the Pottsville Conglomerate in middle Pennsylvania; for a group of coal beds crops out at least 600 feet beneath the Conglomerate along the face of the Allegheny mountains, and one or two of these beds are now being mined.

Where the Sideling Hill tunnel of the East Broad Top railroad cuts this group of beds they number nineteen in all, and all of them are worthless. But when we go far south into Tennessee and Alabama, we find at this low geological horizon a considerable number of valuable coal beds, constituting in fact the real Productive Coal Measures of the Gulf States. Our nomenclature must, therefore, be modified; and the coal formation, as a whole, must be extended downward to include the Mauch Chunk red shale formation, No. XI., and the Pocono sandstone formation, No. X.

It may be asked whether these worthless No. X. coal beds spread beneath the Pittsburgh region; and, if so, at what depth? The answer is, that they are represented by one or both of two black shale intervals in the Pittsburgh Boyd's Hill gas-well record (994 to 1,076 feet and 1,405 to 1,558 feet), *i. e.*, between 841 and 1,435 feet beneath low-water level in the river. This represents a depth of between 1,200 and 1,800 feet beneath the Pittsburgh coal bed. In the center of the State the No. X. coals occupy the interval between 3,000 and 3,313 feet beneath the Pittsburgh coal bed.

It is evident that the lower members of the Carboniferous system thin to less than one-half, in a direction westward, in the distance of 100 miles between Huntingdon county and Pittsburgh. We may therefore expect to find other great formations doing the same.

Within the Coal Measures proper there are probably 100 different individual coal beds which in special localities have a thickness of over 1 foot. Not more than one-fifth of these beds, however, can be considered workable in a commercial sense, that is, have a thickness of over 2 feet, which is a minimum thickness, under the most favorable circumstances at which any of the Pennsylvania beds may be worked. At the present time under ordinary circumstances a bed of 3 feet in thickness is about as thin a bed as can be profitably worked.

The areas in the State which are underlaid by workable beds and the tonnage of the available coal which can be mined out of these areas have been the subject of speculation from the commencement of the surveys of the First Geological Survey of the State between 1830 and 1840. Numerous estimates have been made which have been for the most part crude approximations. The only systematic estimates which have been made are those of Dr. H. M. Chance, late Assistant on the Pennsylvania Survey. These investigations were made in 1881, and were based upon the geologically colored maps published by the Geological Survey of the bituminous coal counties.

Dr. Chance, in speaking of this work, says:

"I have not attempted to calculate the several coal areas with any great degree of accuracy. With few exceptions the areas are expressed in acres reduced from measurements based on a unit of five square miles, hence these acreages nearly all appear as multiples of 3,200 acres. The maps from which the calculations were made are drawn on a scale of two miles to one inch, and as they are necessarily only approximately correct both in the ground plan and coloring, a finer differentiation would but lend false pretensions of accuracy to work necessarily involving errors of considerable magnitude. Seams less than 2 feet thick have been ignored. The areas of beds from 2 to 3 feet thick are calculated down to water level; their areas beneath water level have been ignored. Seams from 3 to 5 feet thick are estimated to a depth of 150 feet beneath water level. The areas of seams more than 5 feet thick are computed to a depth of 400 feet beneath water level when their quality and thickness are known. The areas of beds more than 4 feet thick, lying above water level, but overlaid by a great thickness of superimposed measures, have been calculated so as to include a distance of from 1 to 2 miles from their outcrop lines, varying with the dip."

I consider the results of Dr. Chance's work not only interesting, but of considerable practical value, and desire to record his results in this place.

Estimated tonnage of available bituminous coal in Pennsylvania, by Dr. H. M. Chance.

Classification of coal beds.	Thickness.		Available tonnage.
	Feet.		
Upper Barren measures:			
Washington bed	3 to 3½		787, 200, 000
Upper Productive measures:			
Waynesburg bed	3	5	2, 126, 400, 000
Uniontown bed	2	3	312, 000, 000
Sewickley bed	3		432, 000, 000
Redstone bed	2	3	326, 400, 000
Pittsburgh bed	6	12	10, 438, 800, 000
			13, 635, 600, 000
Lower Barren measures:			
Brush Creek, Coleman beds, etc	....		878, 400, 000
Lower Productive measures:			
In Westmoreland, Fayette, and Allegheny counties	....		2, 064, 000, 000
Millerstown bed	3		28, 800, 000
Freeport upper bed	3	5	3, 764, 800, 000
Freeport lower bed	2	6	2, 385, 600, 000
Kittanning upper bed	2	4	1, 596, 000, 000
Kittanning middle bed	2	3	829, 800, 000
Kittanning lower bed	2	6	4, 225, 200, 000
Clarion coals	2	3	696, 000, 000
Brookville bed	2	4	1, 627, 200, 000
			17, 217, 400, 000
Conglomerate series:			
Mercer coals	2	3	932, 600, 000
Quakertown bed	2		57, 600, 000
Sharon coal horizon	2	3	38, 400, 000
			1, 028, 600, 000
Total			33, 547, 200, 000

Dr. Chance estimates that the bituminous coal areas of Pennsylvania cover about 9,000 square miles. In giving the amount of coal available in each county, which is reproduced in the tables below, Dr. Chance prefaces his statements with the following explanation:

"The Upper Productive series extends over but a small fractional portion of this area; the Barren measures cover a considerable area, hiding beneath a thick covering large areas of the coals of the Lower Productive measures, otherwise easily accessible. The limits adopted in making these estimates necessarily compel the exclusion of many such areas in computing the available coal.

"Estimates in detail for each county are given in the following tables in alphabetical order. It may appear that in many cases very small areas are assigned to persistent seams occurring over large areas. The explanation of this will be found in the impure or variable character of the bed, or its depth beneath water level, or beneath superimposed measures over a portion of the area. The casual observer is apt to form a favorable opinion of the quality, thickness, and regularity of coal seams not warranted by the actual facts. Finding several banks working on the same bed at different localities in a county or township, at all of which the bed is of fair quality and thickness, he is naturally led to infer that the seam will be found of equal value over all the area he has examined; but he has perhaps had no opportunity of examining an equal or greater number of trial openings, at which the bed was found to be worthless, for these have all been abandoned, have fallen shut, or the openings have been almost obliterated. Unless this fact is kept constantly in view and due regard is given to the variable nature of most of our bituminous coals (especially the smaller seams), estimates based on bed measurements made at working banks will almost invariably exaggerate the true amount of available coal of marketable quality."

Estimated amount of available bituminous coal in each county of Pennsylvania.

Counties.	Name of bed.	Average thickness of coal.	Acres.	Tons.	Square miles 1 foot thick.
		Feet.			
Allegheny	Redstone	2	32,000	96,000,000	100
	Pittsburgh	10	112,000	1,680,000,000	1,750
	Lower Productive coals	6	80,000	720,000,000	750
	Total			2,496,000,000	2,600
Armstrong	Barren Measures	2½	6,400	24,000,000	25
	Freeport Upper	4	128,000	768,000,000	800
	Freeport Lower	3	48,000	216,000,000	225
	Kittanning Upper	3	64,000	288,000,000	300
	Kittanning Middle	3	32,000	144,000,000	150
	Kittanning Lower	3	80,000	360,000,000	375
	Clarion coal	2½	12,800	48,000,000	50
	Brookville	2½	6,400	24,000,000	25
	Total			1,872,000,000	1,950
Beaver	Pittsburgh bed	8	800	9,600,000	10
	Brush creek	3	16,000	72,000,000	75
	Freeport Upper	3	35,200	158,400,000	165
	Freeport Lower	2½	12,800	48,000,000	50
	Kittanning Upper	2	64,000	192,000,000	200
	Kittanning Lower	2	51,200	153,600,000	160
	Clarion coal	2	6,400	19,200,000	20
	Total			652,800,000	680
Blair	Freeport Upper	4	3,200	19,200,000	20
	Freeport Lower	2	3,200	9,600,000	10
	Kittanning Lower	3½	4,800	25,200,000	26
	Brookville	4	6,400	38,400,000	40
	Total			92,400,000	96
Bradford	Kittanning Lower (bed B)	4	4,480	26,900,000	28
	Brookville (bed A)	2	6,400	19,200,000	20
	Total			46,100,000	48
Butler	Lower Barrens	3	48,000	216,000,000	225
	Millerstown bed	3	6,400	28,800,000	30
	Freeport Upper	4	70,400	422,400,000	440
	Freeport Lower	6	3,200	28,800,000	30
	Kittanning Upper	3	83,200	374,400,000	390
	Kittanning Middle	3	44,800	201,600,000	210
	Kittanning Lower	3	32,000	144,000,000	150
	Clarion	2	48,000	144,000,000	150
	Brookville	3	32,000	144,000,000	150
	Total			1,704,000,000	1,775
Cambria	Freeport Upper	3½	89,600	470,400,000	490
	Freeport Lower	2½	64,000	240,000,000	250
	Kittanning Lower (bed B)	3½	128,000	672,000,000	700
	Brookville (bed A)	3	83,200	374,400,000	390
	Total			1,756,800,000	1,830
Cameron	Kittanning Middle	3	3,200	14,400,000	15
	Kittanning Lower	3	9,600	43,200,000	45
	Clarion coal	3	16,000	72,000,000	75
	Total			129,600,000	135

Estimated amount of available bituminous coal, etc.—Continued.

Counties.	Name of bed.	Average thickness of coal.	Acres.	Tons.	Square miles 1 foot thick.
		Feet.			
Centre	Freeport Upper	4	12,800	76,800,000	80
	Freeport Lower	4	32,000	192,000,000	200
	Kittanning Lower	4½	51,200	345,600,000	360
	Brookville	3	44,800	134,400,000	210
	Total			748,800,000	850
Clarion	Freeport Upper	3½	3,200	16,800,000	17½
	Freeport Lower	4	3,200	19,200,000	20
	Kittanning Middle	2	25,600	76,800,000	80
	Kittanning Lower	3	96,000	432,000,000	450
	Clarion	2	32,000	96,000,000	100
	Brookville	2½	12,800	48,000,000	50
	Total			688,800,000	717½
Clearfield	Freeport Upper	4	22,666	133,600,000	139
	Freeport Lower	4	64,000	384,000,000	400
	Kittanning Lower	4½	89,600	604,800,000	630
	Brookville	3	64,000	288,000,000	300
	Total			1,410,400,000	1,469
Clinton	Kittanning Lower (bed B)	3	9,600	43,200,000	45
	Brookville (bed A)	2	6,400	19,200,000	20
	Total			62,400,000	65
Crawford	Sharon, Horizon	3	3,200	14,400,000	15
Elk	Freeport Upper	5	3,200	24,000,000	25
	Freeport Lower	5	6,400	48,000,000	50
	Kittanning Upper	2½	16,000	60,000,000	62½
	Kittanning Middle	2½	28,000	105,000,000	112½
	Kittanning Lower	3	48,000	216,000,000	225
	Clarion	2	57,600	172,800,000	180
	Mercer coals	3	64,000	288,000,000	300
	Total			913,800,000	955
Forest	Sharon and Mercer horizons	2	1,280	3,800,000	4
Fayette	Upper Barrens	3	25,600	115,200,000	120
	Waynesburg	5	35,200	264,000,000	275
	Uniontown	3	48,000	216,000,000	225
	Sewickley	3	48,000	216,000,000	225
	Redstone	3	25,600	115,200,000	120
	Pittsburgh	12	160,000	2,880,000,000	3,000
	Lower Productive beds	4	128,000	768,000,000	800
	Total			4,574,400,000	4,765
Greene	Waynesburgh	5	160,000	1,200,000,000	1,250
	Uniontown	2	32,000	96,000,000	100
	Sewickley	3	48,000	216,000,000	225
	Pittsburgh	8	96,000	1,152,000,000	1,200
	Total			2,664,000,000	2,775
Indiana	Pittsburgh bed	7½	12,800	144,000,000	150
	Barren Measures	4	32,000	192,000,000	200
	Freeport Upper	4	192,000	1,152,000,000	1,200
	Freeport Lower	2½	64,000	240,000,000	250
	Kittanning Upper	2	32,000	96,000,000	100
	Kittanning Lower (bed B)	3	64,000	288,000,000	300
	Brookville	2½	19,200	72,000,000	75
	Total			2,184,000,000	2,275
Jefferson	Freeport Upper	3	48,000	216,000,000	225
	Freeport Lower	4	160,000	960,000,000	1,000
	Kittanning Upper	3	19,200	86,400,000	90
	Kittanning Middle	3	16,000	72,000,000	75

Estimated amount of available bituminous coal, etc.—Continued.

Counties.	Name of bed.	Average thickness of coal.	Acres.	Tons.	Square miles 1 foot thick.
		Feet.			
Jefferson	Kittanning Lower	2	80,000	240,000,000	250
	Brookville	3	44,800	201,600,000	220
	Mercer coals	3	48,000	216,000,000	225
	Total			1,992,000,000	2,085
Lawrence	Kittanning Middle	3	48,000	216,000,000	225
	Kittanning Lower	2	32,000	96,000,000	100
	Clarion	2	12,800	38,400,000	40
	Mercer Upper	3	6,400	28,800,000	30
	Mercer Lower	2	6,400	19,200,000	20
	Total			398,400,000	415
Lycoming	Kittanning Upper (bed D)	4	3,200	19,200,000	20
	Kittanning Lower (bed B)	3½	6,400	33,600,000	35
	Total			52,800,000	55
Mercer	Kittanning Lower	2½	3,200	12,000,000	12½
	Clarion	3	16,000	72,000,000	75
	Mercer Upper	2½	25,600	96,000,000	100
	Mercer Lower	2½	64,000	240,000,000	250
	Quakertown	2	19,200	57,600,000	60
	Sharon	3	3,200	14,400,000	15
	Total			492,000,000	512½
McKean	Clarion	3	3,200	14,400,000	15
	Mercer coals	2	9,600	28,800,000	30
	Total			43,200,000	45
Potter	Kittanning Lower (bed B)	3	3,200	14,400,000	15
	Brookville (bed A)	2	3,200	9,600,000	10
	Total			24,000,000	25
Sullivan	Kittanning Lower (bed B)	3	2,560	11,520,000	12
Somerset	Pittsburgh	8⅝	(Platt.)	42,000,000	44
	Lower Barrens	6	41,600	374,400,000	390
	Freeport Upper	4	51,200	307,200,000	320
	Kittanning Upper (bed D)	4	80,000	480,000,000	500
	Kittanning Lower (bed B)	3½	64,000	336,000,000	350
	Brookville (bed A)	3	51,000	230,400,000	240
	Total			1,770,000,000	1,844
Tioga	Kittanning Lower (bed B)	6	12,800	115,200,000	120
	Brookville (bed A)	3	3,200	14,400,000	15
	Total			129,600,000	135
Venango	Kittanning Lower	2½	3,200	12,000,000	12½
	Clarion	2	6,400	19,200,000	20
	Brookville	2	3,200	9,600,000	10
	Mercer coals	2½	3,200	12,000,000	12½
	Total			52,800,000	55
Washington	Washington	3½	128,000	672,000,000	700
	Waynesburgh	3	128,000	576,000,000	600
	Pittsburgh	6	320,000	2,880,000,000	3,000
	Total			4,128,000,000	4,300
Westmoreland	Waynesburgh	3	19,200	86,400,000	90
	Redstone	3	25,600	115,200,000	120
	Pittsburgh	8	137,600	1,651,200,000	1,720
	Lower Productive coals	4	96,000	576,000,000	600
	Total			2,428,800,000	2,530
Warren	Sharon horizon	2	3,200	9,600,000	10

For 1884 the Bureau of Industrial Statistics of Pennsylvania reported 18,084,941 tons as a total, and for 1885, 20,647,720 tons, while in the former year, from facts which I privately collected, the production was at least 25,000,000 tons, and in the latter year 26,000,000 tons. In other words, the production for 1885 was 1,000,000 tons in excess of the production for 1884, while the bureau reported the increase during the same time as over 2,500,000 tons. The total amount of coal reported by the mine inspectors as being produced from the bituminous mines in 1885 was between 15,000,000 and 16,000,000.

The United States Geological Survey found it impossible to get any statistics from either the mine inspectors or the Bureau of Industrial Statistics of the production of the Pennsylvania mines in 1886, and in consequence the Survey entered into a correspondence with each individual mine operator. The statistics which are given below have been compiled from the returns, which were secured in great detail from every bituminous mine which is known to exist at the present time within the boundaries of the State.

The following table gives a summary of these returns and a study of the details of this table shows some interesting facts which, although known to many individuals directly connected with the coal trade, have never before been absolutely proven by statistics.

During 1886, Allegheny county contained the greatest number of mines; Westmoreland produced the greatest amount of coal; the local consumption of coal in Allegheny county was the greatest; the greatest amount of coke produced was in Fayette county; the greatest number of tons of coal shipped was from Allegheny county, and the highest average price paid per ton at the mines was in Mercer.(a) The total value of the coal produced at the mines was greatest in Westmoreland county.

The production of bituminous coal in Pennsylvania in 1886.

Counties.	Number of operators.	Number of mines.	Total production.	Average price per ton at mines.	Total value at mines.
			Short tons.		
Allegheny	68	85	4, 202, 086	$0. 925	$3, 886, 930
Armstrong	6	7	210, 856	. 68	143, 382
Beaver	6	6	208, 820	. 98	204, 644
Bedford	5	5	173, 372	. 685	118, 760
Blair	8	11	305, 695	. 755	230, 931
Bradford	3	6	206, 998	1. 17	242, 188
Butler	6	8	162, 306	. 83	134, 714
Cambria	21	28	1, 222, 028	. 645	788, 209
Cameron	1	1	3, 200	1. 25	4, 000
Centre	5	9	313, 383	. 632	197, 954
Clarion	9	14	429, 544	. 675	289, 941
Clearfield	27	61	3, 753, 986	. 655	2, 458, 861
Elk	4	6	526, 036	. 78	409, 316
Fayette	41	61	4, 494, 613	. 69	3, 101, 283
Greene	2	2	5, 600	. 92	5, 152
Huntingdon	6	8	313, 581	. 655	205, 395
Indiana	3	3	108, 615	. 89	92, 014

a Cameron is not considered in this comparison, since the amount of coal produced is hardly worth consideration.

The production of bituminous coal in Pennsylvania in 1886—Continued.

Counties.	Number of operators.	Number of mines.	Total production.	Average price per ton at mines.	Total value at mines.
			Short tons.		
Jefferson	4	10	1,023,166	.68	695,753
Lawrence	4	4	101,154	.915	92,556
McKean	1	1	617	.90	553
Mercer	15	17	537,712	1.23	661,386
Somerset	7	14	349,926	.56	195,958
Tioga	4	7	1,384,800	1.00	1,384,800
Venango	1	1	2,500	.70	1,750
Washington	32	35	1,612,407	.885	1,426,980
Westmoreland	41	66	5,446,480	.88	4,792,902
Total	330	476	27,094,481	.8033	21,766,312

In addition to the amount of coal produced at each mine reported by the operators, a number of additional facts have been obtained. I wish here to acknowledge my indebtedness to Prof. J. P. Lesley, State Geologist of Pennsylvania, for many of the facts contained in the following descriptions of bituminous coal producing counties, which, together with those contained in the geological county reports, will prove of especial interest in this connection. A few of the most significant facts are noted below:

ALLEGHENY COUNTY.

(Coal produced in 1886, 4,202,086 short tons.)

The principal coal bed mined is the Pittsburgh, which forms the base of the Upper Productive Coal Measures. At Pittsburgh this bed lies in the hills surrounding the city at a height of 350 feet above low-water level. Several other coal beds crop out in the hillside, but no workable beds exist down to the Upper Freeport coal bed, which lies at least 200 feet beneath the city of Pittsburgh, and makes its appearance at water level in the Allegheny River valley, 2 miles above Springfield, in East Deer township, north of which this bed takes the place of the Pittsburgh in the mining operations. The average composition of the coal from the Pittsburgh bed ranges from 59 to 64 per cent. of solid carbon, 30 to 24 per cent. of volatile matter, 3 to 6 per cent. of ash, and about 1 per cent. of sulphur, and the same amount of water.

The New York and Cleveland Gas Coal Company, operating 5 mines, produced during the year 600,000 tons, being the greatest amount of coal produced by any one company.

The thickness of that portion of the Pittsburgh coal bed which is mined varies from 4 to 6 feet. The coal shipped from this county is especially adapted for steam purposes, and the greater part of it is used in that way. The coal mined in Allegheny county, with the exception of that which is used locally, is mostly shipped west, supplying markets as far south as New Orleans, as far west as Illinois, and as far north as lake points.

The Monongahela River coal region, which contains the mines along the river in Allegheny, Westmoreland, Fayette, Washington, and Greene counties, ships its coal both by railroad and by boat by means of the slackwater navigation of the Monongahela river, the river being navigable for boats carrying 800 tons during all times of the year. The coal consumed in Pittsburgh is supplied mainly by railroad, and a large portion of the coal shipped by river goes to the markets along the Ohio and Mississippi rivers. The shipments by railroad to Pittsburgh and vicinity, on account of the general introduction of natural gas, have progressively decreased during the past three years, and the shipments, principally by boat, to more distant points have increased during the same time.

Shipments of coal by slackwater navigation since 1860.

Years.	Short tons.	Years.	Short tons.
1860	1, 517, 909	1874	2, 503, 504
1861	834, 630	1875	2, 275, 265
1862	743, 358	1876	2, 495, 800
1863	1, 134, 150	1877	2, 677, 460
1864	1, 402, 828	1878	2, 797, 530
1865	1, 580, 791	1879	2, 623, 232
1866	1, 704, 212	1880	3, 361, 934
1867	1, 202, 908	1881	3, 450, 186
1868	1, 812, 040	1882	4, 057, 384
1869	2, 100, 504	1883	4, 339, 492
1870	2, 303, 856	1884	3, 170, 900
1871	1, 944, 852	1885	3, 298, 200
1872	2, 291, 220	1886	4, 123, 945
1873	2, 094, 312		

ARMSTRONG COUNTY.

(Coal produced in 1886, 210,856 short tons.)

The Pittsburgh coal bed occupies a very small area in the southeastern corner of this county. The Barren Measures which lie stratigraphically between this bed and the Lower Productive Coal Measures spread over a large area of the southern part of the county and are about 600 feet thick in the vicinity of Freeport, where the two coal beds which take their names from this town are mined, and in the vicinity of Kittanning where three coal beds, which in the same way take their name from that town, are mined. The two Clarion coal beds, which occur stratigraphically below the ferriferous limestone, outcrop above water level only in the northern townships.

The largest individual production during the year in the county was that of the Oak Ridge Mining Company, which produced 96,981 tons. The beds which are at present mined vary in thickness from 3 to 5 feet. The coal produced is used almost exclusively for steam purposes, a very small amount being used for gas. The entire production of the county is less than the amount produced by a number of individual operators in Allegheny, Westmoreland, and Fayette counties. This coal is shipped mostly to Buffalo and to intermediate consumers.

BEAVER COUNTY.

(Coal produced in 1886, 208,820 short tons.)

The workable coal beds of Beaver county belong exclusively to the Lower Barren Measures. A few of the hilltops near the Mercer county line are underlaid by patches of the Pittsburgh bed to the extent of about 800 acres. The middle Kittanning coal bed, in the vicinity of Darlington, attains a thickness of 20 feet, due to the conversion of a part of its roof shales into cannel coal. Before the discovery of petroleum in 1879, oil was manufactured from these shales. These shales constitute the most prolific fossil horizon in the bituminous coal fields of the State.

The State Line Coal Company was the largest producer in the county during the year 1886, and mined 149,866 tons, of which 119,166 tons consisted of screened coal. The workable beds vary in thickness from 2 to 8 feet. The production of the county is almost entirely consumed by Cleveland, Buffalo, the Mahoning valley, Ohio, and intermediate consumers. Mr. J. F. Mansfield, operating at Cannelton, produced during the year 15,000 tons of cannel coal. The average thickness of the bed was 8 feet and the average selling price of the coal at the mines $1.75.

BEDFORD COUNTY.

(Coal produced in 1886, 173,372 short tons.)

The southwestern portion of the Broad Top semi-bituminous coal field is located in the northeastern corner of this county and about 1,200 feet of the Coal Measures remain uneroded, coal beds in the Lower Productive Measures being worked along Six Mile and Sandy runs.

The average coal from the Kelly beds shows about 74 per cent. of solid carbon, 19 per cent. of volatile matter, 5½ per cent. of ash, 1 per cent. of sulphur, and little or no water. The coal is admirably adapted for steam purposes and is used at the Hopewell and Riddlesburg iron furnaces.

The largest operators in the county are Messrs. Sweet & Brown. The total production of their mines for 1886 was 83,000 tons. The coal is shipped almost exclusively to Philadelphia and Baltimore.

BLAIR COUNTY.

(Coal produced in 1886, 305,695 short tons.)

The Lower Productive Coal Measures are exposed along the crest and face of the Allegheny mountains in this county. The summit tunnel of the Pennsylvania railroad, at an elevation of 2,126 feet above tide, cuts through the Upper Freeport bed, exhibiting a thickness of 5 feet. The dip of the bed is toward the west at the rate of about 1°. Below this, other beds are exposed, their thickness ranging from 2 to 4 feet. These outcrop around the heads of the ravines along the face of the mountains.

One of the most interesting geological occurrences in Pennsylvania is that of a number of workable coal beds in the Pocono Sandstone No. X. The existence of these beds has been known for many years, and they were reported on by Professor Lesley as early as 1852. They were not proved commercially valuable however until during the past two years.

The Tipton Run Coal Company during 1886 mined 12,450 tons from one of five distinct coal beds, which the company's explorations have proved to exist within the vicinity of the mines. For a full report of these beds reference should be made to the Annual Report of the Pennsylvania Geological Survey for 1885. The Elizabeth Coal Company of Tyrone is the largest individual producer in the county. The workable coal beds vary from 2½ to 6 feet in thickness. Some of the coals coke readily, and the production of the company is used either for coking, steam, or domestic purposes. The coal is shipped as far east as Philadelphia and as far west as Chicago.

BRADFORD COUNTY.

(Coal produced in 1886, 206,998 short tons.)

This county contains the most northeastern workable bituminous coal beds in the State. Professor Lesley in speaking of the coal areas in this county says:

"A long plate of Pottsville Conglomerate 100 feet thick, and nearly solid, makes the broad, flat top of the northern mountains, supporting isolated patches of the Lower Productive Coal Measures, one bed of which, from 6 to 10 feet thick of excellent semi-bituminous coal, has been extensively mined for the markets of New York State."

There are at present three coal operations in the county, the largest being that of the Towanda Coal Company. This company produced 145,208 tons during 1886. The coal is used almost exclusively for steam and smithing purposes in the local market and in New York State.

The production of the Towanda Coal Company since 1865 is shown by the following table:

Production of the Towanda Coal Company, 1865 to 1886.

Years.	Short tons.	Years.	Short tons.
1865	6,886	1876	160,343
1866	3,881	1877	164,344
1867	27,668	1878	165,025
1868	67,080	1879	237,608
1869	176,307	1880	246,064
1870	196,310	1881	223,172
1871	249,240	1882	210,917
1872	263,960	1883	226,806
1873	252,329	1884	181,786
1874	215,572	1885	246,397
1875	200,424	1886	145,208

Between 1856 and 1857 the Barclay Coal Company mined 412,640 tons of coal from its property, which was subsequently leased and worked by the Towanda Coal Company. The Schrader Coal Company's property adjoins that of the Towanda Coal Company. It is now exhausted, the mines having been abandoned in 1884. The total production of these mines from 1874 to 1884, inclusive, was 1,696,042 tons.

BUTLER COUNTY.

(Coal produced in 1886, 162,306 short tons.)

The southern half of the county is covered by the Barren Coal Measures, the general dip of which is toward the north, no traces of these measures being found north and east of Crooked creek. The Lower Productive Measures crop out along the banks of Conoquenessing and its numerous branches. The Upper Freeport coal bed is found in a little valley in the northern part of the county. The three Kittanning coal beds resemble one another and have a pretty persistent thickness of about 3 feet each. The Clarion bed is about 4 feet thick in many places, but produces a poor coal, it being generally high in sulphur.

The largest operation in the county during the year was that of the Mahoning Valley Iron Company, which produced 37,917 tons. The beds which are mined vary in thickness from 3 to 6 feet, the latter thickness being reported by Mr. A. B. Walker, of the Keystone Coal and Coke Company. A large part of the product of this company, and also of the Mahoning Valley Iron Company, is manufactured into coke, the remainder of the coal being used for steam purposes. The coal from this county is shipped to Buffalo, Erie, Cleveland, Youngstown and intermediate consumers.

CAMBRIA COUNTY.

(Coal produced in 1886, 1,222,028 short tons.)

This county contains the works of the Cambria Iron Company, one of the largest iron and steel manufacturing companies of the world. Although this company produces less than one-fourth of the total amount of coal mined in the county, its operations have no doubt stimulated the development of these coal fields. The dip of the Lower Productive Coal Measures along the Allegheny mountains, is from 1° to 2° toward the west. The Pennsylvania railroad descends the valley of the Conemaugh southwest to Johnstown, with very nearly the same grade as the dip of the Upper Freeport coal bed. The local geology in the vicinity of Johnstown has been worked up in great detail by Mr. John Fulton. In this vicinity about 259 feet of the Barren Coal Measures underlie the highest hilltops.

The average composition of the coal mined in the county is from 17 to 27 per cent. of volatile matter, 1 per cent. of water, and commonly from 4 to 6 per cent. of ash, the remaining percentage being composed of fixed carbon and a very small amount of sulphur.

The largest mine in the county is the Rolling Mill mine of the Cambria Iron Company, the production of which during 1886 was over 180,000 tons. The workable coal beds vary in thickness from 2½ to 5 feet. The product of the county is used mostly for producing steam, and is also used for coking and for smithing and domestic purposes. It is shipped west as far as Chicago and the Mississippi valley and east of Philadelphia and Baltimore.

The Cambria Iron Company now (February, 1887) uses natural gas from the Grapeville gas field exclusively for fuel, and has practically closed all the Johnstown coal mines.

CAMERON COUNTY.

(Coal produced in 1886, 3,200 short tons.)

The highest workable coal bed in this county is the Lower Kittanning, which has been extensively explored and mined in the Cameron basin. It is locally known as the Cameron or Dagus bed, and has an average thickness of 3 feet. The only coal mined in the county during the year was 3,200 tons, by the Cameron Iron and Coal Company, which was used at the oil pumping stations of the National Transit (pipe line) Company. The coal is of inferior quality as compared to the purer coals mined in the State farther to the southwest, with which the Cameron coal comes into open competition in the Buffalo markets. The Cameron Iron and Coal Company has no commercial iron ore on its lands, and the quality and quantity of the coal which they contain are such as to make the outlook for the future operations of this company anything but promising.

CENTRE COUNTY.

(Coal produced in 1886, 313,383 short tons.)

This county contains the Snow Shoe basin, which has been noted for many years as producing a favorite coal in the market. The Upper Kittanning coal bed is the most important in the region and varies in thickness from 5 to 7 feet. The Upper Freeport coal bed, which has a thickness of from 3 to 4 feet, caps the highest knobs in the coal area, and the Lower Freeport coal bed, which is so important in the Karthaus district, is very much thinner in the Snow Shoe basin. Four other beds from 3 to 4 feet in thickness are reported in the district. The average analysis of the coal shows about 70 per cent. of fixed carbon, 25 per cent. of volatile matter, 1 per cent. of sulphur, and less than 1 per cent. of water. A recent analysis of the coal mined by W. J. Jackson & Co. shows the following:

Analysis of coal from Centre county, Pennsylvania.

	Per cent.
Fixed carbon	68.44
Volatile matter	23.37
Water	.64
Sulphur	.58
Ash	6.97
Total	100.00

The largest operator in the county is the Lehigh Valley Coal Company, whose production during the year was 116,992 tons. The coal is admirably adapted for coking, steam, and kindred purposes, and is shipped almost entirely to eastern markets.

The shipments of coal from the Snow Shoe region over the Pennsylvania railroad since 1873 are shown in the following table:

Shipments of coal from the Snow Shoe region by the Pennsylvania railroad.

Years.	Short tons.	Years.	Short tons.
1873	95, 257	1880	56, 020
1874	63, 540	1881	128, 263
1875	62, 426	1882	233, 708
1876	51, 399	1883	257, 230
1877	42, 985	1884	183, 271
1878	29, 168	1885	148, 500
1879	56, 654	1886	113, 967

CLARION COUNTY.

(Coal produced in 1886, 429,544 short tons.)

Most of the hilltops in the southern townships of this county are capped by a remnant of the Lower Barren Measures. All the rest of that portion of the county south of the Clarion river is underlaid by the Productive Coal Measures.

The Pottsville Conglomerate outcrops in the northern part of the county near the Forest county line. The Lower Kittanning bed is more extensively mined than any other in the county. It is from 3½ to 5 feet thick and contains from 36 to 41 per cent. of volatile matter. Recent analyses of the Kittanning and Clarion coal beds, respectively, reported by the Mineral Ridge Coal Company, are as follows:

Analyses of the Kittanning and Clarion coals.

	Kittanning.	Clarion.
	Per cent.	*Per cent.*
Fixed carbon	52. 0	58. 5
Volatile matter	34. 5	35. 0
Ash	13. 5	6. 5
Totals	100. 0	100. 0

The workable beds in the county range from 3 to 6 feet in thickness. The Fairmount Coal and Iron Company produced during the year 125,705 tons, being the largest production of any one company. The coal from this county is well adapted for coking and steam purposes and is shipped mostly to New York and Canadian consumers.

CLEARFIELD COUNTY.

(Coal produced in 1886, 3,753,986 short tons.)

The development of the coal industry in this county has been more remarkable than that of any county in the State, as shown by the following statistics of the amount of coal carried over the Tyrone and Clearfield branch of the Pennsylvania railroad during the past twenty-five years:

Coal carried over the Tyrone and Clearfield branch railroad during the last twenty-five years.

Years.	Short tons.	Years.	Short tons.
1862	7,239	1875	928,297
1863	24,330	1876	1,281,861
1864	65,380	1877	1,374,927
1865	60,629	1878	1,295,201
1866	107,878	1879	1,631,120
1867	166,364	1880	1,739,873
1868	170,335	1881	2,401,987
1869	259,994	1882	2,838,970
1870	379,863	1883	2,857,710
1871	542,896	1884	3,173,363
1872	431,915	1885	2,901,613
1873	592,860	1886	2,273,147
1874	639,630		

Beech Creek Railroad tonnage.

Years.	Short tons.	Years.	Short tons.
1882	....	1885	774,055
1883	....	1886	1,050,238
1884	234,751		

The famous Moshannon or Lower Freeport bed is mined extensively in this county. It varies in thickness from 3 to 5 feet and produces one of the most noted and favorite of the steam coals. Next to this bed the Lower Kittanning is the most important bed mined in the county. The largest bituminous producing company in Clearfield county and the next to the largest in the State, is the Berwind-White Company, which produced during the year 1886, 816,415 tons of coal. The bulk of the coal production of the company is used for steam purposes, although the character of the coal is such that it forms a desirable fuel for any purpose.

The coal from this county is shipped largely to eastern markets, from which it is transported by water to as distant points, probably, as any coal mined in any one locality in the United States.

ELK COUNTY.

(Coal produced in 1886, 526,036 short tons.)

The Lower Productive Coal Measures have a greater development in this county than anywhere else within the boundaries of the State, that is, in the total thickness of all the strata from the bottom to the top of the group, and in the number of coal beds contained. The thickness of the individual coal beds, however, is not as great as in many other sections of the State. The only coal bed which is at present mined to any extent within the county is the Lower Kittanning. A large area within the Meade Run coal basin is underlaid by the Freeport coal beds with thicknesses varying from 3 to 5 feet and containing coal of such composition as to make it comparable with the coals from Clearfield and Jefferson counties. The largest producer in the county is the Northwestern Mining and Exchange Company, which is one of the operating coal companies controlled by the New York, Lake Erie and Western railroad. The production of this company during the past year was 304,740 tons. The thickness of the Lower Kittanning coal bed, which is locally known within the county as the Dagus bed, varies from 3 to 5 feet. The coal is adapted to coking, steam, and domestic uses, and is shipped entirely to New York, Canadian, and intermediate consumers.

FAYETTE COUNTY.

(Coal produced in 1886, 4,494,613 short tons.)

The coal-producing areas of this county are divided into three groups, known respectively as the Second, Third, and Fourth basins.

In the Second or Ligonier basin are contained the Lower Productive Coal Measures. The Pittsburgh or Connellsville coal bed extends through the center of the Third basin for a distance of about 33 miles and with a width of about 4 miles, and in the Fourth basin occur the representatives of all the coal measures in the other two basins, and large areas are also underlaid by the strata of the Upper Barren Measures. The great coal bed of the county is the Pittsburgh or Connellsville coal bed, which is sometimes 6 feet thick. The exceptional quality and extent of this bed within the county has prevented the mining to any extent of any of the other coal beds from the Waynesburgh bed down to the base of the Lower Productive Coal Measures. The Pittsburgh bed varies in thickness at the different mines from 7 to 9 feet.

The following are the analyses of the Connellsville bed at the different mines of the H. C. Frick Coke Company:

Analyses of Connellsville coal from the H. C. Frick Coke Company's mines in Fayette county, Pennsylvania.

Name of mine.	Location.	Fixed carbon.	Volatile matter.	Ash.	Sulphur.	Total.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Henry Clay	Broad Ford	61.49	32.40	5.10	1.01	100.00
Frick	....do	60.92	32.60	5.40	1.08	100.00
Valley	Valley Works	63.78	30.60	4.50	1.12	100.00
Trotter	Trotter Station	63.34	30.20	5.40	1.06	100.00
Eagle	Sherrick	62.68	27.90	7.50	1.92	100.00
Summit	Summit	59.80	33.80	5.40	1.00	100.00
Tip Top	Tinshnan	60.90	32.10	5.60	1.40	100.00
Morgan	Morgan	58.10	33.60	7.10	1.20	100.00
Foundry	Sherrick	65.36	28.40	4.90	1.34	100.00
White	....do	63.30	28.80	6.80	1.10	100.00

About 75 per cent. of the coal produced in the county is manufactured into coke. The largest individual operating coal company in the county is the H. C. Frick Coke Company, which mined during the year 994,273 tons of coal. The coal shipped from the county enters the same markets as the coal from Allegheny county, and the Fayette coke is shipped to points throughout nearly the entire United States.

GREENE COUNTY.

(Coal produced in 1886, 5,600 short tons.)

Geologically the highest coal strata of the Coal age are found in this county, which occupies the extreme southwestern corner of the State. The strata which immediately underlie the surface of the county are as barren of workable coal beds as any other part of the Carboniferous system, and the Pittsburgh coal bed and the beds of the Lower Productive Measures exist at such depths beneath the surface of the country, that it will be many years before they can be mined in order to compete with the coals mined above water level in the more northern counties. Professor Lesley has estimated that at the point where Aleppo, Jackson, Gilmore, and Spring Hill townships join, the surface is so high geologically that it would be necessary to sink a shaft 1,200 feet deep to reach the Waynesburgh coal bed and 1,700 feet deep to reach the Pittsburgh coal bed.

The entire production of the county during the year was 5,600 tons, of which Messrs. Johnson & Leonard produced 3,800 tons. The production was so small as only to require the employment of six miners. The coal is consumed in the local market.

HUNTINGDON COUNTY.

(Coal produced in 1886, 313,581 short tons.)

The northern end of the Broad Top semi-bituminous coal field is embraced within the southern limits of this county.

All the coal beds which are worked are included in the Lower Productive Measures. There are six large coal openings; five of them are situated on the west side of the mountain, and find an outlet for their coals over the Huntingdon and Broad Top railroad to Huntingdon on the Pennsylvania railroad, and one, the largest in the county, that of the Rockhill Iron and Coal Company, with its mines in the vicinity of Robertsdale, finds an outlet for its coal over the East Broad Top railroad to the Pennsylvania railroad at Mount Union. The production of this company for the year was 118,897 tons.

Most of the coals are easily coked and with good results. Over 6,000 tons of the Rockhill Iron and Coal Company's coal was converted into coke during the year, and the entire product of the mines of R. H. Powell Sons & Co., which was 44,473 tons, was coked for furnace use.

The workable coal beds range from 3 to 7 feet in thickness. The entire product of the county, with the exception of what is used locally, is shipped to eastern markets.

The Broad Top semi-bituminous coal is shipped over the Huntingdon and Broad Top and East Broad Top railroads, respectively. The shipments by the former road since 1873 and by the latter road since it was opened in 1875 are shown by the following tables:

Coal carried by the Huntingdon and Broad Top railroad to the Pennsylvania railroad at Huntingdon.

Years.	Short tons.	Years.	Short tons.
1873	350, 245	1880	174, 736
1874	226, 693	1881	204, 819
1875	204, 921	1882	271, 216
1876	159, 779	1883	196, 534
1877	140, 143	1884	192, 706
1878	150, 204	1885	176, 075
1879	141, 594	1886	385, 796

Coal carried by the East Broad Top railroad to the Pennsylvania railroad at Mount Union.

Years.	Short tons.	Years.	Short tons.
1875	43, 567	1881	91, 745
1876	66, 104	1882	99, 095
1877	54, 738	1883	44, 737
1878	63, 068	1884	43, 514
1879	67, 929	1885	51, 878
1880	72, 450	1886	51, 050

In this connection it is interesting to note the shipments of Cumberland (West Virginia) coal over the former railroad and the Pennsylvania railroad from Huntingdon junction:

Shipments of Cumberland coal over the Pennsylvania and Huntingdon and Broad Top railroads.

Years.	Short tons.	Years.	Short tons.
1873	114, 589	1880	242, 593
1874	67, 671	1881	313, 600
1875	175, 154	1882	208, 031
1876	145, 796	1883	471, 785
1877	187, 488	1884	394, 114
1878	164, 598	1885	460, 289
1879	171, 930	1886	239, 891

INDIANA COUNTY.

(Coal produced in 1886, 103,615 short tons.)

The whole surface of this county is underlaid by Coal Measures with the exception of nine spots, five of which are in the prominent gaps in the mountains and four over anticlinal axes.

In the southern, central, and southwestern parts of the county the coal basins are deep enough to take in considerable areas of the Pittsburgh coal bed in the highest hilltops. East of Blairsville this bed lies 200 feet above the river and is overlaid by 150 feet of the Barren Coal Measures.

There were three prominent mining operations carried on in the county during the year, at all of which coal was mined from the Pittsburgh bed, the average thickness of the bed being about 6 feet. The coal beds of the Lower Barren Measures which underlie large areas of the county will undoubtedly constitute the largest source of supply for future years. These beds will have to be mostly worked by shafts on account of existing below water level.

The Saltsburg Coal Company, the largest producer in the county, produced during the year 75,000 tons. This company ships its coal both east and west. The coal from its mines is consumed mostly by the Pennsylvania Railroad Company.

JEFFERSON COUNTY.

(Coal produced in 1886, 1,023,166 short tons.)

The development of the coal industry in Jefferson county during the past two years has been rapid. The coal beds of the Lower Productive Measures are found in most parts of the county with the exception of the extreme northwestern corner next adjoining Forest, and a small area next adjoining Clearfield in the eastern part of the valley of the Clarion river. The coal bed at present mined is the Lower Freeport, which is the noted bed of the Reynoldsville basin. It has a workable thickness in all parts of the county. This bed is the representative of the Moshannon bed of the Clearfield region.

The three beds of the Kittanning group and the Clarion-Brookville beds are found in many parts of the county of workable thickness and contain good coal, although they are not generally desirable beds to mine, due to their lack of persistency both as to thickness and quality.

The largest operation in the county during the year was that of the Rochester and Pittsburgh Coal and Iron Company, which worked four mines and produced nearly 600,000 tons of coal. The production of Messrs. Powers, Brown & Co. was about one-half as much as the production of the Rochester Company. The Jefferson County coal is adapted for steam, gas, and coking purposes.. The coal mined during the year was shipped to New England, Canada, points in western New York, and intermediate markets.

LAWRENCE COUNTY.

(Coal produced in 1886, 101,154 short tons.)

The most northern workable coal areas along the western State line are in Lawrence county. In the southern part of the county, on the hill tops, occur the lowest strata of the Barren Coal Measures. The Upper Freeport coal bed, which is locally known as the "five and four foot" bed, is over 6 feet thick in several mines near the northern line of Little Beaver township. The Darlington or Kittanning bed varies from 2 to 4 feet thick, and produces a good coal at several mines in the Beaver valley. In the Slippery Rock valley this bed, however, is very sulphury. In Plain Grove township the same bed is block coal.

Two other coal beds of the Kittanning group are locally mined in many parts of the county. The largest operation in the county is that of Messrs. Lee & Patterson, who produced during the year 40,000 tons of coal. The following is an average analysis of the coal from this mine:

Analysis of coal from the Lee and Patterson mine, Lawrence county, Pennsylvania.

	Per cent.
Fixed carbon	55.5
Volatile matter	40.65
Ash	3.15
Sulphur	2.35

The Lawrence County coal is used for steam and gas purposes, and is consumed principally by local trade. Shipments are, however, made to Erie and Youngstown.

McKEAN COUNTY.

(Coal produced in 1886, 617 short tons.)

In this county occur only the lowest coal beds of the Lower Productive Coal Measures. The Lower Kittanning coal bed occurs in some localities under very small areas, but is too thin and contains coal too impure to be commercially valuable. The Alton bed, which is included in the Pottsville Conglomerate series, was mined for many years at the Alton and Buttsville mines, in Lafayette township, and the Clarion coal bed has been mined for a number of years to a greater or less extent at Claremont, by the Buffalo Coal Company. The only operation in the county during the year was that of this company, the total amount of coal mined being only 617 tons. The entire production was consumed on the Claremont branch of the Buffalo, New York and Philadelphia railroad.

The maximum production of coal from the county was attained in 1881. The shipments since 1875 are shown in the following table:

Shipments of coal from McKean county, Pennsylvania.

Years.	Short tons.	Years.	Short tons.
1875	33,501	1881	110,099
1876	81,830	1882	73,834
1877	73,222	1883	84,899
1878	72,098	1884	78,870
1879	85,745	1885	44,312
1880	100,046	1886	617

The opening of the Bradford branch of the New York, Lake Erie and Western railroad across McKean county and the introduction of natural gas for fuel and of better coals from Elk, Jefferson, and Clearfield counties have practically closed the McKean County mines.

MERCER COUNTY.

(Coal produced in 1886, 537,712 short tons.)

In this county extensive mining operations are carried on in the lowest coal beds of the Lower Productive series.

The Brookville or Pardoe coal bed is mined in many places in Findley, Jackson, and Lake townships, where it ranges from 3½ to 4 feet thick. These coal beds occur immediately on top of the Homewood sandstone, underneath which lie the two Mercer coal beds. Further down in the series occurs the Quakerstown coal, and still lower the Sharon block coal. All of these beds produce coals which are highly prized by special consumers, the products of the mines being shipped to points as far north as Buffalo and as far west as Chicago. The coal is well adapted for general uses. The largest producing company is the Mercer Iron and Coal Company, whose mines are located at Stoneboro; the total production during the year was 104,937 tons. Most of the coal from this county goes to lake points.

SOMERSET COUNTY.

(Coal produced in 1886, 349,926 short tons.)

The extreme northeastern end of the Cumberland semi-bituminous coal basin, which within the county is 10 miles long and 2½ miles wide, is found in this county. This basin is separated from the Allegheny mountains on the west by a broad valley formed of Catskill rocks. West of the Allegheny mountains are two important coal basins, one between the Allegheny mountains and Negro mountain, and the second between Negro mountain and Laurel hill. In these two latter basins occur representatives of all the Lower Productive Coal Measures and large areas underlaid by the Pittsburgh coal bed. The latter bed is the one at present mined, and that portion of the bed which is worked ranges from 5 to 9 feet thick. The coal is adapted to steam and domestic uses. The bulk of the coal mined in the county is sent to the Baltimore market and to local points along the Baltimore and Ohio railroad.

The greatest production from any one operation was that of the six mines of James Cochran & Company. The total production of these mines was 148,528 tons for the year.

TIOGA COUNTY.

(Coal produced in 1886, 1,384,800 short tons.)

The coal areas in this county are smaller in proportion to the amount of coal produced than in any county in the State, and the county stands sixth in the amount of coal mined during the year.

The coals belong to the Lower Productive series and are separated into two prominent areas, the Blossburg region in the southeastern part of the county and the Gains region in the western part. The latter area is very much smaller and produces only 1½ per cent. of the total product of the county. The prominent area is the Blossburg basin which is about 16 miles long and about 4 miles wide. This basin was carefully studied by the noted geologist, Richard C. Taylor, in 1832, and has been longer and more favorably known than any one mining district in the State.

There is a vertical thickness of between 300 and 400 feet of coal-bearing strata containing at least nine coal beds, ranging in thickness from 2 to 5 feet, and containing from 20 to 22 per cent. of volatile matter and 6 to 8 per cent. of ash.

The Blossburg seam is the best known bed, and is composed of several distinct coal benches, and varies in thickness from 2½ to 4 feet. The three prominent mining companies of this region had very nearly the same production for the year, the output of each company being not far from 450,000 tons, the largest production being that of the Morris Run Coal Company, which was 479,366 tons. The coal from Tioga county is shipped to New York and Canada, and as far west as Chicago and other lake points.

The production of the Blossburg region since 1872 has been as follows:

Years.	Short tons.	Years.	Short tons.
1872	849, 262	1880	921, 555
1873	991, 057	1881	1, 178, 581
1874	796, 388	1882	1, 165, 604
1875	581, 782	1883	1, 217, 870
1876	616, 984	1884	1, 018, 342
1877	602, 245	1885	1, 074, 581
1878	652, 597	1886	1, 384, 800
1879	874, 010		

The Blossburg company made and sold during 1886, 51,812 tons of coke.

VENANGO COUNTY.

(Coal produced in 1886, 2,500 short tons.)

In the hilltops in the southern part of this county are included very small areas underlaid by the lower strata of the Lower Productive Coal Measures. These areas are confined principally to Irwin, Clinton, Scrubgrass, Dotters, and Porterfield townships.

In the eastern part of Cranberry township, about 8 miles southeast of Oil City, are two small areas, reported to be underlaid by the bottom of the Lower Productive Coal Measures. In all of these townships there have been enumerated twenty-six patches underlaid by coal strata. The most southerly patches exist in knobs high enough to take in small areas of the ferriferous limestone with the overlying Kittanning coal bed.

The amount of coal which has been mined in the county has been very small, and has been consumed principally for steam purposes at oil wells drilled in the immediate vicinity. But one mining operation from which coal was shipped has been reported for 1886.

WASHINGTON COUNTY.

(Coal produced in 1886, 1,612,407 short tons.)

This county lies between Beaver and Allegheny on the north, Westmoreland and Fayette on the east, and Greene on the south.

The general description of the Coal Measures in these counties applies to adjoining parts of Washington. The geology of the county is a continuation to the northward of that of Greene county, with the general notable difference that the Upper Barren Measures are much thinner, being confined chiefly to the Lower or Washington county group, the lowest beds of which are left on the hilltops, south of the Pittsburgh, Cincinnati and Saint Louis railway.

The Upper Productive Coal Measures, with the Pittsburgh coal bed at its base, crop out from under the Washington group in the northern and eastern townships. The Pittsburgh coal bed outcrops along the Monongahela river below Millsborough, and from Brownsville down stream, along Chartiers creek for a distance of 7 miles, along Cross creek from Patterson to the State line, along Harman's and Raccoon creeks, and around the summits in Hanover township. The lower levels are occupied by the Lower Barren Coal Measures.

The largest coal operation during the year was that at W. P. Rend's mines at McDonald, popularly known as the Laurel Hill mines, the total production being 240,000 tons. This coal was shipped principally to Chicago, Cleveland, and Columbus markets. There are in all thirty-two individual coal operations in the county.

WESTMORELAND COUNTY.

(Coal produced in 1886, 5,446,480 short tons.)

The greatest production of coal in any one county in the State was that produced from Westmoreland—Fayette county ranking second in production, Allegheny third, and Clearfield fourth.

The coal geology of the county is a continuation of that of Fayette. Professor Lesley, in referring to the geology of these two counties, says; "In the northern part of Ligonier valley, on the Ligonier-Fairfield line, the Pittsburgh coal bed has been preserved in a long high range and in some isolated hilltops. Another remarkable diversity of structure is presented along the west side of the valley in an extraordinary steepening of the commonly 20° to 30° east dip of the rocks to 80°, the Conglomerate, No. XII., forming a line of low sharp knobs on the slope of the mountain; and this explains why the basin east of it is locally deep enough to hold all the Barren Measures and even some of the beds above the Pittsburgh coal. Chestnut ridge, finely gapped by the Loyalhanna, shows the usual arches of Conglomerate (XII.) red shale and iron ore (XI.) and Pocono sandstones (X.). West of Chestnut ridge runs the remarkably straight and regular Blairsville basin, with the Derry and Latrobe mines to the north, and the Jacobs Creek mines to the south, in the Pittsburgh coal bed, as at Connellsville, sustaining a vast number of coke ovens. Next west of this basin (5 miles wide at the south and 3 at the north, and 20 miles long) runs the Blairsville anticlinal, crossing the Loyalhanna near Bradey's old mill and the Pennsylvania railroad just east of Carr's tunnel; the arch on the Loyalhanna being high enough to expose all the Barren measures, and even the Freeport Upper coal bed, the stream cutting deep between cliffs of Mahoning sandstone. Approaching the Sewickley, with equal dips of 4° on both sides, it flattens away. West of it is the Greensburg basin of the Pittsburgh coal bed and overlying measures, (4 miles wide by 12 long) and another smaller patch north of New Alexandria. West of this runs the Saltsburg anticlinal arch across the county, exposing most of the Barren Measures, under which appear the Freeport coals in the deep valley of the Loyalhanna; at the head of Little Sewickley creek the anticlinal being very flat, and only slightly represented on the Youghiogheny above the mouth of Jacobs creek. West of the Saltsburg belt lies the great (Lisbon) basin of the Pittsburgh coal bed (12 feet thick), the northern point of which overlooks the Kiskiminitas river 3 miles below Saltsburg, and widens southward to 3 miles in Franklin township, 4 miles in Penn, 7 miles across Huntingdon into Hempfield, with its eastern edge running on south to the mouth of Jacobs creek, and spreading across the Youghiogheny and Allegheny rivers westward into Allegheny and Washington counties. As it deepens southward the basin begins to preserve patches of the Redstone coal (4 feet thick and 50 feet above the Pittsburgh bed); then patches of the Fish-pot limestone (25 feet thick); then the Sewickley coal (3 feet); then the Great limestone (80 feet); then the Uniontown limestone (20 feet), and its overlying coal (3 feet) roofed with the Waynesburg limestone (20 feet), and its overlying coal (6 feet) roofed with the Waynesburg sandstone (70 feet), a total of Upper Productive Coal Measures overlying the Pittsburgh bed of 425 feet."

There are forty individual coal operations in the county. The largest number of tons produced by any one operation being from the mines of McClure and Company, the production of this company being about three-quarters of a million tons, all of which was manufactured into coke. Most of the product of the county was taken from the Pittsburgh coal bed, the coal being one of the best coking and gas coals found in the State. The coke from the county is shipped to widely distant markets, and coal for the manufacture of gas is shipped to the Lakes for distribution in the West, to New England, and to points in the middle and southern States.

What is frequently designated by the coal trade as the Westmoreland region comprises that portion of the county from which the gas coals are principally shipped. The shipments over the Pennsylvania railroad from this region for the past thirteen years are shown in the following table:

Shipments of Westmoreland county coal over the Pennsylvania railroad.

Years.	Short tons.	Years.	Short tons.
1874	952, 971	1881	982, 293
1875	796, 968	1882	1, 278, 121
1876	906, 139	1883	1, 399, 702
1877	786, 039	1884	1, 320, 186
1878	692, 586	1885	1, 293, 813
1879	816, 302	1886	1, 305, 732
1880	943, 177		

BOUNDARIES OF INSPECTION DISTRICTS.

The bituminous regions of the State are divided into eight mine inspection districts, as follows:

First district.—Greene county, Washington county, that part of Westmoreland county west of the Youghiogheny river, and that part of Fayette county which lies along the Monongahela river.

Second district.—That part of Allegheny county east of the Allegheny, Monongahela, and Youghiogheny rivers; Westmoreland county, except the mines along the West Penn railroad, and those mines along the main line of the Pennsylvania railroad west of Brinton station.

Third district.—That part of Beaver county north of the Ohio river, Lawrence county, Butler county, and Armstrong county, the mines in Westmoreland county which lie along the West Penn railroad, Mercer county, Venango county, and Clarion county.

Fourth district.—Bradford county, Sullivan county, Tioga county, Lycoming county, Clinton county, McKean county, Cameron county, Elk county, and Jefferson county; that part of Clearfield county along the Allegheny Valley railroad.

Fifth district.—Somerset county and Fayette county, except mines along the Monongahela river.

Sixth district.—Huntingdon county, Bedford county, Blair county, Cambria county, Indiana county, Clearfield county along the Bell's Gap railroad to Irvona, and Westmoreland county along the main line of the Pennsylvania railroad east of Brinton station.

Seventh district.—Allegheny county west of the Allegheny, Monongahela, and Youghiogheny rivers.

Eighth district.—Centre county, and Clearfield county, except the parts along the Allegheny Valley railroad and along the Bell's Gap railroad to Irvona.

On account of the incomplete returns in the inspectors' reports of the production of coal from the individual mines in each district or of the total production of each district, and on account of the impracticabil[illegible] of grouping the mines reported to the Geological Survey under the eight districts, it is impossible to show the relative importance of the districts by an exhibit of their respective coal productions. Some idea can, however, be gotten from the following table, which shows for 1885 the number of producing mines in each district taken from the inspectors' reports, together with the number of persons employed, and the proportion of fatal and non-fatal accidents:

Inspectors' returns by districts in Pennsylvania for 1885.

	First district.	Second district.	Third district.	Fourth district.	Fifth district.	Sixth district.	Seventh district.	Eighth district.	Totals and averages.
Mines in district	66	74	67	56	66	70	85	76	560
Persons employed in the mines	3, 214	5, 928	3, 080	4, 708	2, 790	3, 220	8, 730	5, 324	36, 994
Persons employed outside	1, 000	1, 570	434	910	1, 234	658	794	551	7, 151
Tons of coal mined to each fatal accident	233, 352	245, 608	321, 729	360, 000	1, 533, 235	651, 257	278, 048	241, 112	483, 043
Tons of coal mined to each non-fatal accident	107, 931	196, 486	160, 864	288, 000	153, 323	236, 821	235, 272	214, 322	199, 377
Employés to each fatal accident	702	469	586	702	2, 012	970	866	367	834
Employés to each non-fatal accident	324	375	351	562	201	353	733	326	403

The Pennsylvania Railroad Company is the largest single shipper of bituminous coal in the State.

Tonnage of coal and coke originating on the main line and branches between Harrisburg and Pittsburgh.

Districts.	1885.		1886.	
	Coal.	Coke.	Coal.	Coke.
Originating on the Pennsylvania Railroad division:	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
Snow Shoe, semi-bituminous	148, 500	25, 643	113, 967	29 036
Karthaus	120, 969	....	154, 086	....
Tyrone and Clearfield	2, 873, 876	....	2, 273, 147	24
Gallitzin and Mountain	550, 244	193, 091	672, 564	201, 868
West Pennsylvania	219, 750	64, 901	318, 493	110, 168
Southwest Pennsylvania	102, 689	1, 999, 923	158, 185	2, 715, 895
Westmoreland region	1, 293, 813	252, 397	1, 305, 733	339, 965
Monongahela region	267, 502	108, 706	414, 611	157, 061
Pittsburgh region	236, 703	....	278, 671	628
North and West branch	1, 294, 334	....	1, 388, 340	....
Sunbury, Hazleton, and Wilkes-Barre	321, 192	....	359, 384	....
Other localities	....	....	9, 451	....
Originating off the Pennsylvania Railroad division:				
Anthracite	3, 087, 831	....	2, 965, 124	....
Bituminous	1, 062, 193	57, 652	1, 327, 740	70, 466
Total	11, 579, 596	2, 702, 313	11, 739, 496	3, 620, 111

TENNESSEE.

Total production in 1886, 1,714,290 short tons; spot value, $1,971,434.

The coal of this State is confined to what is known as the Cumberland table land, an elevated and sharply outlined plateau, which is a prolongation of the southern end of the Kentucky field. Its area is about 1,500 square miles, and it is embraced within the following counties: Scott, Morgan, Cumberland, Fentress, Van Buren, Grundy, Bledsoe, Sequatchie, Marion, Overton, Putnam, White, Warren, Corby, Franklin, Claiborne, Campbell, Anderson, Rhea, and Hamilton. At its northern boundary the coal field is 71 miles broad and at its southern boundary 50 miles.

The Cumberland plateau has generally a broad, flat top. Its eastern escarpment is nearly straight, with bulges in graceful curves in portions of Anderson, Rowan, and Campbell counties. The western edge of the plateau is indented by numerous coves and valleys, which are separated by spurs projecting toward the west. Both the east and west edges generally break away into sandstone cliffs from 20 to 200 feet in height, commencing about the middle of the State and extending southwest into Alabama. The plateau is broken into by the Sequatchie valley, having a length of about 60 miles and a width that averages over 4 miles. That part of the plateau to the west of the valley retains the name Cumberland, and that to the east is generally known as Walden's ridge.

The average height of the Cumberland plateau is 2,000 feet above ocean level. Some of the more elevated ridges in the southeastern part rise to considerably greater heights, as at Crow's mountain (3,320 feet), and as at Coal creek (3,500 feet).

For convenience of description the coal measures have been divided into the Upper and Lower series. The Upper series have an average thickness in the Sequatchie section of about 200 feet, and the Lower series about 225 feet, the Upper series being capped by a conglomerate 50 feet thick and the Lower series resting on top of the Mountain limestone, the two series being separated by a conglomerate 70 feet thick. In the Upper series are included what have been known locally as coal beds A, B, and C, and in the Lower series coal beds D, E, F, and G.

Although considerable geological work has been done in the Tennessee coal field by different explorers and large mining enterprises have extensively developed a number of coal beds, yet much more systematic geological exploration and mining developments are needed before our knowledge of this coal field can in any sense be considered to be complete.

There are now 20 corporate companies engaged in mining coal in the State, and 34 separate mines which are owned and operated by these companies. Mr. J. C. Guild, State mine inspector, from whom most of the statistics of the State have been obtained, has divided the coal field into three divisions, according to the railroad over which their product is transported, as follows:

District I. includes those mines near the Nashville, Chattanooga and Saint Louis railway, namely, the Tennessee Coal, Iron and Railroad Company and the Etna Coal Company.

District II. includes those on or near the line of the Cincinnati Southern railroad, namely, the Tabler-Crudup Coal and Coke Company, the Soddy Coal Company, Walden Ridge Mining Company, Dayton Coal and Iron Company, Roane Iron Company, Poplar Creek Coal Company, Mount Carbon Coal Company, Winter's Gap Coal Company, and Glen Mary Coal and Coke Company.

District III. includes the mines situated on the Knoxville and Ohio division of the East Tennessee, Virginia and Georgia railroad, namely, the Standard Coal and Coke Company, Jellico Mountain Coal and Coke Company, Knoxville Iron Company, Coal Creek Consolidated Mining Company, Coal Creek Coal Company, New River Coal Company, and Heck and Petree.

The following table is an exhibit of the production of coal and coke in these three districts for 1885 and 1886. The decrease in the total production from district No. 2 was due mostly to the fire in the Rockwood mines:

Production of coal and coke, 1885 and 1886.

District.	1885.			1886.		
	Coal.	Coal manufactured into coke.	Total.	Coal.	Coal manufactured into coke.	Total.
I	181,854	204,575	386,429	188,424	260,082	448,506
II	544,694	270,430	815,124	438,917	311,259	750,176
III	393,452		393,452	515,608		515,608
Total	1,120,000	475,005	1,595,005	1,142,949	571,341	1,714,290

The following table gives a list of the mines, the operating company, the county in which situated, and the average number of the miners employed during the year:

Mines being operated in Tennessee.

FIRST DISTRICT.

Counties.	Operators.	Name of mine.	Shipping railroad.	No. of miners.
Grundy	Tennessee Coal, Iron, and Railroad Company.	No. 1	Tennessee Coal, Iron, and Railroad Company's road.	73
		No. 2	do	35
		No. 3	do	10
		Bat's Nest	do	12
		Rattlesnake	do	40
		Lone Rock	do	(a)195
		East Fork	do	38
		Petersburg	do	23
		John'n Entry	do	20
Marion	Etna Coal and Coke Company	Etna	Nashville and Chattanooga.	68

a Convicts.

Mines being operated in Tennessee—Continued.

SECOND DISTRICT.

Counties.	Operators.	Name of mine.	Shipping railroad.	No. of miners.
Hamilton	Tabler-Crudup Coal and Coke Company.	No. 1	Cincinnati Southern	20
	Soddy Coal Company	Nos. 1, 2, 3, and 4	do	325
	Walden's Ridge Iron Company	No. 1	do	45
Rhea	Dayton Coal and Iron Company	Nos. 1, 2, and 3	do	160
Roane	Roane Iron Company	One mine	do	100
Anderson	Poplar Creek Coal Company	do	Walnut Ridge	30
	Mount Carbon Coal Company	do	do	
	Winter's Gap Coal Company	do	do	25
	Eureka Coal Company	do	do	Closed.
	Oliver Coal Company	do	do	
Scott	Glen Mary Coal and Coke Company.	do	Cincinnati Southern	200

THIRD DISTRICT.

Counties.	Operators.	Name of mine.	Shipping railroad.	No. of miners.
Campbell	Standard Coal and Coke Company	One mine	K. and O. Division East Tennessee, Virginia and Georgia.	175
	Jellico Mountain Coal and Coke Company.	do	do	180
Anderson	Knoxville Iron Company	do	do	(a)125
	Coal Creek Consolidated Iron Company.	Black Diamond	do	Closed.
	do	Empire	do	75
	Coal Creek Coal Company	Fraterville	do	80
	New River Coal Company	Bet'r Chance	do	25
	Heck & Petree	Bowling	do	25

a Convicts.

About 3,000 persons, including 2,200 miners, are given employment by the mining industries of the State.

The price per ton differs greatly at the different mines, being fixed by the thickness of the coal and the ease with which it is mined.

Prices paid for mining coal in Tennessee.

	Cents per ton.		Cents per ton.
Tennessee Coal, Iron and Railroad Company (*a*)	39	Mount Carbon Coal Company	55 to 75
Ætna Coal Company	70	Eureka Coal Company	50 to 75
Tabler-Crudup Coal and Coke Company	60	Oliver Coal Company	50 to 75
Soddy Coal Company	55 to 60	Glen Mary Coal Company	75
Walden Ridge Mining Company	55 to 65	Standard Coal Company	75
Dayton Coal and Iron Company	60 to 100	Coal Creek Consolidated Mining Company	62½
Roane Iron Company	37½	Coal Creek Mining Company	62½
Poplar Creek Coal Company	50 to 75	New River Coal Company	62½
Knoxville Iron Company (*b*)		Heck and Petree	62½
Winter's Gap Coal Company	75		

a For run of mine. *b* All convicts.

It is difficult to form any correct idea, from the above table, as to the monthly wages which miners can command in the different districts without carefully considering the character of the coal in each district and the conditions under which mining is conducted. For instance, from the above table it would appear that the lowest daily or monthly wages were paid by the Tennessee Coal, Iron, and Railroad Company and the Roane Iron Company. This, however, is not the fact. The coal mined by these two companies is extremely soft, and the bulk of the production of the mines is small coal and only fit for the coke ovens. In other mines, however, where higher daily or monthly wages would appear to be paid, the small coal is left in the mines and the miners only receive pay per ton on the lump coal.

The following table, compiled by Mr. Guild, gives analyses of coals from prominent openings and of coke made from certain coals:

Analyses of Tennessee coals.

Name of coal.	Fixed carbon.	Volatile matter.	Ash.	Sulphur.	Water.	Phosphorus.	
Coal Creek	57.520	38.82	3.090	0.200	1.040	....	
Do	57.690	37.80	2.550	....	....	....	
Poplar Creek	60.670	36.53	1.750	0.780	1.750	....	Potter & Riggs.
Do	59.470	40.00	0.530	1.260	....	....	Joliet I. and S. Co.
Careyville (new mine)	56.850	38.89	3.190	....	1.070	....	
Helenwood	54.240	41.29	2.640	....	1.830	....	
Jellico	60.600	36.44	1.600	1.160	2.360	....	Dr. Peter.
Poplar Creek	56.120	39.33	2.810	....	1.240	....	Regis Chauvenet.
Crooke Coal and Coke Company.	61.660	34.53	2.140	0.088	1.670	0.017	Furnished by Mr. H. S. Chamberlain, president Roane Iron Company. No analysis given.
Roane Iron Company (Rockwood).	60.110	26.62	11.520	1.049	1.750	....	
Roane Iron Company	60.750	32.59	5.270	....	1.390	....	
Stanley (near Chattanooga)	61.730	26.70	10.210	0.530	1.360	....	
Sewanee (Tracy mines)	62.000	25.41	10.820	....	1.770	....	Robertson.
Do	63.500	29.90	6.600	Trace.	....	....	H. T. Yaryan.
Soddy mines (Sewanee seam)	64.390	27.82	6.640	....	1.150	....	
Emery mines (Sewanee seam)	63.100	27.70	7.700	0.530	0.150	....	Prof. T. E. Wormley.
Etna mines (Kelly seam)	74.200	21.39	2.700	0.700	1.300	0.005	McCreath & Pohle.

Analyses of Tennessee cokes.

Name of coal.	Fixed carbon.	Ash.	Sulphur.	Moisture.	Phosphorus.	
Sewanee seam (Tracy City)	83.364	15.440	0.142	....	....	W. J. Land.
Etna (Kelly)	94.560	4.650	0.790	....	0.008	University of Cincinnati.
Rockwood	84.187	14.141	0.182	....	....	W. J. Land.
Dayton	84.150	14.880	....	....	....	
Poplar Creek	90.060	5.000	0.570	0.010	0.010	Potter & Riggs.
Do	95.240	4.760	....	....	....	Regis Chauvenet.

The distribution of mines by counties is shown in the following table:

Distribution of coal mines in Tennessee, by counties.

District.	Counties.	County seat.	Number of companies.	Number of openings.
I	Grundy	Altamont	1	9
	Marion	Jasper	1	1
II	Hamilton	Chattanooga	3	6
	Rhea	Washington	1	3
	Rhone	Kingston	1	1
	Anderson	Clinton	5	5
	Scott	Huntsville	1	1
III	Campbell	Jacksboro'	2	2
	Anderson	Clinton	5	6
	Total		20	34

Messrs. A. S. McCreath and E. V. d'Invilliers, in speaking of the fuel supply of the Tennessee furnaces, say:

"The coke supplied to the Tennessee furnaces is made entirely from coal within the State. Unfortunately, in the field most conveniently located with relation to the red ores of the State—that of Walden's ridge—the coals are thin, irregular, and high in sulphur and ash. Geologically, they may be referred to the Lowest Coal Measures. These coals occur also in the Sequatchie valley and in Dade county, Georgia, near Chattanooga, as a point of consumption. But little information could be obtained as to the relative position of the coal bed furnishing the raw material, or the character of the coal itself.

Mr. H. S. Fleming, chemist of the Dayton Coal and Iron Company, limited, at my request has furnished me with some valuable and interesting notes relative to the coal and coke operations of his own and adjoining companies. The following report is compiled from his notes:

The Dayton Coal and Iron Company owns nearly 60,000 acres of coal land on Walden's ridge. Several coal openings have been made at different levels; only one of these is now worked—that on the Richland coal seam, on Richland creek, which has cut a deep gorge in the ridge. The coal opening is 3 miles from Dayton; the strata are comparatively level; the coal bed averages 27 inches in thickness; some of the entries have run into a "marsh," and are working a bed 40 inches thick. The miners earn from 50 cents to $1.25 per ton, depending on the thickness of the coal bed; the floor of the coal bed is a compact fire-clay, this is moved for 40 cents a ton. The bed dips west and south, producing natural drainage.

Analyses of the coal and coke from the Richland opening, Tennessee.

	Coal.	Coke.
	Per cent.	*Per cent.*
Volatile matter	25.29	1.43
Fixed carbon	64.39	77.38
Sulphur	2.48	1.83
Ash	10.32	19.36

Specific gravity, 1.36.

The high ash in this coal comes from a *knife-blade* slate running through the lower part of the seam. The coke is very strong and heavy, and carries well a heavy burden in the blast furnace.

The Nelson mine is on the eastern edge of Walden's ridge; it was opened in March, 1885, and several entries were opened; on the outcrop the coal bed was 6 feet thick; in some distance from the outcrop it is only 4 feet thick. In one place the coal bed has an abnormal thickness of 27 feet. The eastern edge of the ridge has been so tilted up and broken that several rock faults have already been found. The coal has a crushed appearance, especially where it is thickest. The company did not commence using coal from this mine until November, 1886, so that only a small proportion went into the coke. If necessary, the present mine plant could mine nearly four hundred tons a day. The mine has a natural drainage through a side entry cut for that purpose, Miners get 37 cents a ton for mining. The floor is fire-clay, somewhat similar to that at the Richland opening; the roof is a heavy sandstone.

Analyses of coal and coke from the Nelson mine, Tennessee.

	Coal.		Coke.
	Top of seam.	Bottom of seam.	
	Per cent.	*Per cent.*	*Per cent.*
Volatile matter	29.45	31.57	1.20
Fixed carbon	67.42	57.25	88.99
Sulphur	.63	.31	.56
Ash	3.11	11.17	9.25

Specific gravity, 1.307.

The top of the seam is a firm, hard coal, and the bottom is a soft an shaly coal.

The following are some partial analyses from this district:

	Coal (Dade Coal Company).	Glen Mary coke.	Daisy coke (Tabler-Crudup Coal and Coke Company.	Coke from Poplar Creek coal. (*a*)	Coke from Jellico coal. (*b*)
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	1.29				
Volatile matter	23.05	1.50	1.71		
Fixed carbon	60.50	85.64	78.18		
Sulphur		1.14	2.62	1.60	
Ash	15.16	11.70	20.09	15.53	19.81

a Coke of medium strength. *b* Poor coke; breaks in long, slender fingers.

The Dayton Coal and Iron Company has two hundred and fifteen coke ovens now in use, and has just completed one hundred and fifty more; the coal and coke are entirely used by the two large furnaces connected with this plant, some little coal is sold to the town of Dayton, to the miners, and to the Tennessee River steamboats.

Thers has never been any difficulty with miners on questions of pay. One strike occurred in July, 1886, but the cause was discharging unruly miners; after one week all the striking miners came back to work at the company's terms.

Besides mines now working there are several abandoned ones. One in Cranmore's cove, 3 miles from Dayton, where several thousand tons were taken out, the seam goes into Walden's ridge with a dip of 45°, and was abandoned on account of the water. A coal bed 6 feet, 8 inches thick shows on the outcrop, and 5 feet 4 inches in the mine; the coal is similar to that in the Nelson seam.

At Spring City, on the Cincinnati Southern railroad, a mine was opened some years ago; fifty coke ovens were also put up. The coal was 48 inches thick and ran at a steady thickness; a heavy fault was found some 300 yards in, and after some wild prospecting the mine was abandoned; both ovens and mines have caved in.

Five miles below Dayton, on the line of the Cincinnati Southern railroad at Graysville, several new openings have been made, some show 6 and some 3 feet of coal; as yet nothing but prospecting is being done, but the openings will probably develop into large mines; the strata are more nearly level here, so there will be less trouble with faults.

The Richland mine produced 88,000 long tons and the Nelson produced 12,000 long tons during 1886; all of this coal was coked, principally for the company's use. The average selling price of the coal during the year at the mouth of the mine was 12 cents a bushel. The miners make from 37 cents to $1.25 per ton and the laborers $1 per day.

TEXAS.

Total production in 1886, 100,000 short tons; spot value, $185,000.

No reliable statistics of the amount of coal mined in this State are available. In fact, very little is known in regard to the geology of the coal and lignite beds and their associated strata. As far as known, the coal areas may be divided into three prominent groups: (1) The Eolignitic area, (2) Central area, and (3) the Mountainous area.

Mr. E. T. Dumble, secretary of the Texas State Geological and Scientific Association, in speaking of the first area, says:

"The Eolignitic formation of Texas, as far as determined, is bounded (approximately) by a line beginning in Sabine county, on the Sabine river, and running west and southwest near Crockett, Navasota, Ledbetter, Weimar, and Helena, thence to Pearsall and northwest by Elgin, Marlin, Richland, Salem, and Clarksville to Red river, and includes in whole or in part fifty counties. There may be other detached areas of the formation, and there are areas within these boundaries where this formation is covered by those of later date, and others where it has disappeared through erosion. We recognize three seams of lignite, though there are probably more. These vary in thickness from a few inches to 20 and 25 feet, 8 and 10 feet being often found. It is found throughout the greater part of the territory indicated, in outcroppings and in well-diggings. There has been very little systematic mining done.

"The lignite varies in quality from a lignitic shale to a glanz-coal, closely resembling albertite, but having cubical fracture. It varies also in the amount of sulphur it contains, some of it being almost free from pyrites, while other beds are strongly impregnated. It contains considerable moisture, and slakes and crumbles so rapidly on exposure to the air that it has not been used to any extent as fuel.

"The only way in which it is likely to come into use is as a prepared or artificial fuel, manufactured into a fuel-gas, or for the products from its destructive distillation, although it might be used with economy near the locality at which it is mined, by using fireboxes especially constructed for it.

"It has been used at Bastrop to a limited extent as a steam fuel and for domestic purposes, but no mining has been done further than digging the lignite, as it was wanted, from an exposure on the Colorado river and Cedar creek a short distance from Bastrop.

"At Rockdale several shafts have been sunk, and some lignite mined, most of which was shipped to Austin, where part of it was used for domestic purposes, but the greater portion was made use of in burning brick.

"At Calvert there have been sveeral attempts, during the past fifteen years, to get the lignite into general use, but without success. It has been shipped in small quantities to points on the Houston and Texas Central railway from Dallas to Houston, and trial after trial made of it, but it has never been pronounced a success. This is probably due in part to the attempt to burn it under the same conditions as, and in fire-boxes arranged, for bituminous coal, instead of studying the requirements of the lignite and meeting them.

"The only other mining that we have knowledge of was done at Atascosa, where a considerable amount of lignite was mined, which was marketed in San Antonio. We have no information, however, of the amount mined nor of the present condition of the mine.

"There have been a number of prospecting shafts sunk in different localities, but I think the above will cover all mining operations."

The analyses given below are of partially air-dried specimens (with the exception of that from Calvert), consequently they do not show the amount of moisture usually found in the freshly mined material.

Analyses of Texas lignite.

	Rockdale.	Calvert. (*a*)	Calvert. (*b*)	Angelina county.	Sulphur Springs.	Atascosa.
Water	12.60	20.30	11.00	12.40	10.20	14.00
Volatile matter	37.40	35.94	39.50	36.37	39.92	16.00
Fixed carbon	41.75	31.56	45.00	37.77	44.13	56.00
Ash	8.25	12.20	4.50	13.46	5.75	14.00
Total	100.00	100.00	100.00	100.00	100.00	100.00

a Average of 10 tons. *b* Prof. E. T. Cox (selected specimen).

Specific gravity: Calvert, 1.232; Angelina county, 1.22; Sulphur Springs, 1.22.

Mr. Dumble, in speaking of the lignite at Rockdale, in Milan county, and at Atascosa, in Bexar county, says:

"A shaft 3 miles from Rockdale has been sunk 140 feet deep, passing through four seams of lignite 6½, 5, 3, and 3½ feet thick, respectively, in descending order, the last two divided only by 10 inches of fireclay. This shaft was opened in 1882, but has been idle since last June."

The amount of lignite shipped during 1886 was 180 tons, and the total shipments since 1882 have been 1,400 tons.

A shaft sunk one-fourth of a mile from the above reached a good bed of lignite at a depth of 25 feet, from which a few tons were mined.

At the town of Atascosa there are three seams of lignite, about 4 feet each in thickness. There are two collieries at this locality, the Lytle and Kirkwood, both of which are being worked on a limited scale.

The Kirkwood colliery is leased by John Crosby and produced during the year 1,205 tons, all of which was shipped to San Antonio. The average price received for the coal at the mine was $1.35. The lignite beds vary in thickness from 5½ to 7 feet, and are included in the Tertiary rocks. The bed is mined by a drift, horse power being used in hauling. Mining is carried on at this colliery between April and November; the product at present is used principally by ice factories, but is being introduced into breweries, foundries, saw-mills, etc. From two to eight men are employed at mining, receiving 60 cents per ton for clean coal. A miner can dig from 4 to 6 tons in 10 hours.

The Central area is located in the counties of Clay, Jackson, Young, Stephens, Shackelford, Eastland, Callahan, Brown, Coleman, and in several adjoining counties. Hon. S. H. Stout, of Cisco, in referring to mining in this area during 1886 says: "There was quite a depression in coal mining during the year, owing to the drought in this region. The only coal being mined in Eastland county is that which is necessary to the supply of Cisco, Abilene, and Colorado City. So far as is known no coal was mined in the other counties within the Central area."

A fair estimate of the amount of coal mined in the vicinity of Shackelford would not exceed 15,000 long tons.

The third and most important coal area in the State is the Mountainous area, lying along the Rio Grande and between this river and the Pecos.

The coal beds of Santo Tomas, Eagle Pass, Sabinas (Mexico), Sierra Blanca, Los Chisos, and other coals along the Rio Grande have been proved by Dr. I. C. White and Mr. Robert Hill, of the United States Geological Survey, to be a continuation of the later Mesozoic coals of the Rocky Mountain region.

On the line of the Rio Grande and Eagle Pass railway, near Laredo, several mines have been opened. Two mines, known as the Hunt mines, are on the railroad company's land. The thickness of the coal beds here varies from 1½ to 3 feet. The property is leased by Carr Bros., successors to Springall & Co., and 3,500 tons of coal were mined during the year. The average price at which it sold at the mouth of the mines was $1.85, the product being shipped to San Antonio. The bed is 5½ feet thick. From 6 to 12 inches of the top of the bed is left in as a roof. The bed is overlaid by a sandstone from 8 to 15 inches thick, is a true lignite, and is used principally for steam purposes. It is mined by a drift, and steam power is used for hoisting. Eighteen miners are employed, and are paid 60 cents a ton for the clean coal mined.

Hon. W. M. Chandler, of El Paso, in speaking of the coals in Texas west of the Pecos river, says: "There have been shipped about 100 tons of coal from the bed at Eagle Springs, 20 miles east of Sierra Blanca. The coal is taken from a thin irregular bed standing nearly vertical."

The following analyses of lignites from different points in Texas have been supplied by Dr. Edgar Everhart, professor of chemistry at the University of Texas:

Analyses of lignites from different points in Texas.

Locality.	Fixed carbon.	Volatile matter.	Ash.	Water.	Total.	Sulphur.
Lignite from Robertson county	29.34	44.89	9.91	15.86	100.00	......
Lignite from Cherokee county	28.75	18.80	36.03	16.42	100.00	......
Lignite from Milam county	30.65	45.17	5.39	18.79	100.00	1.04
Lignite from Hopkins county	21.66	50.28	5.14	22.92	100.00	0.67
Lignite from northwest of Texas	36.87	43.40	3.25	16.48	100.00	0.75
Lignite from north Texas	40.77	31.11	7.66	20.46	100.00	1.82
Do	37.19	30.98	14.06	17.77	100.00	2.36
Do	42.03	29.66	12.43	15.88	100.00	2.90
Semi-bituminous coal from Burnet county	43.03	38.97	13.62	4.38	100.00	4.14
Do	40.40	39.89	15.58	4.13	100.00	5.22
Coal from Palo Pinto county, near Gordon	63.64	32.64	2.86	0.86	100.00	0.25

Dr. Everhart, in speaking of the lignites of Texas, says: "The lignites of the State contain, as a general rule, a large percentage of sulphur. When exposed to the moisture of the atmosphere they crumble to pieces. A characteristic phenomenon exhibited by the lignites here is that when they are held for a moment in water they will emit a very distinct crackling sound and will crumble in the hand almost like slaked lime." I have observed this same characteristic in many of the lignites from Wyoming and the Rocky Mountain region.

The total production of coals and lignites in the State during 1886 did not probably exceed 100,000 tons.

UTAH.

Total production in 1886, 200,000 short tons; spot value, $420,000.

Very limited coal developments have been made in this Territory. The first operations were started in the vicinity of Coalville, in Summit county, northwest of Salt Lake City, in 1864, at mines which are now being operated by the Home Coal Company.

The present coal mines are confined to Summit, San Pete, and Emery counties. The Home Coal Company operates the Wasatch and Crismon mines conjointly in the vicinity of Coalville, and during the year produced 24,417 tons of merchantable coal, which was shipped principally to Parke City and Salt Lake City. Very little coal is sold at the mines, and the fuel used at the mines consists of screenings from the refuse slack coal. During the year the average selling price of coal on cars delivered at the mouth of the mine was $2.25. The bed is about 12 feet thick and is composed more of lignite than of coal. The product is principally adapted for use as a domestic fuel and for stationary boilers.

The company employs about twenty-five miners, who are paid 90 cents a ton for breaking the coal and loading it in the mine cars. The ton used contains 2,150 pounds. The average wages of laborers other than these miners is $1.85 a day. Two hundred and fifty days were worked during the year.

The Grass Creek mines in the vicinity of Coalville produced during the year 29,131 tons, of which 26,295 tons were shipped to outside markets and 436 tons consumed at the mines. The average thickness of the bed at these mines is 10 feet, and the average number of miners employed was twenty-four.

The Winter Quarter mines of the Pleasant Valley Coal Company are situated at Scofield, in Emery county. The production of this company during 1886 was 71,418 tons, being greater than the production of any other one company. The coal is shipped principally to points in Utah, in western Colorado, and to Butte, in Montana.

The average selling price of the coal delivered on cars at the mouth of the mines during the year was $2.05. The thickness of the bed was 11 feet, and the following is an analysis of the coal furnished by Mr. W. F. Colton, secretary of the company:

Analyses of lignite from the Winter Quarter mines, Utah.

	Per cent.
Water	6.55
Volatile matter	39.75
Fixed carbon	47.65
Ash	6.05
Total	100.00

This coal, or rather lignite, is supposed to be a superior steam fuel.

The mine of the Utah Central Railroad Company is also located at Scofield, in Emery county. The total production of this mine during the year was 34,676 tons, 500 tons of which were consumed at the mine, the remainder being sold at an average of $2 per ton at the mouth of the mine for shipment to Salt Lake City, Provo, and Ogden. The bed is 28 feet thick, without any partings of rock, clay, or shale. About 25 feet of the bed is mined, 3 feet being left on the roof. The company employed about 60 miners during the winter months and 30 during the summer months, wages for the miners being 70 cents per ton.

An analysis of the upper part of the bed which is left in the mine, made by Mr. A. S. McCreath, showed as follows:

Analysis of roof coal from Scofield, Emery county, Utah.

	Per cent.
Water	5.798
Volatile matter	40.487
Fixed carbon	51.950
Ash	1.765
Total	100.000

Mr. W. D. Sharp, superintendent of the coal department of the Utah Central railway, reports that the top layer of coal which is left in the mine is much brighter than the coal below it, and is free from white spots (probably sulphate of lime), which are found in other parts of the bed.

The Central Pacific Coal and Coke Company, limited, owns about 10,000 acres of coal lands in San Pete county, which produced during the year about 2,000 tons of coal, which was consumed entirely by the San Pete Valley railway. The bed is from 6 to 8 feet thick and is locally considered a semi-bituminous coal. It is stated that this coal is the only coal which has so far been mined in Utah which will make a desirable coke. The miners receive $1.90 per ton for mining, screening, and loading on the cars.

The total production of the Territory, including that given above and that from small mines from which no returns have been obtained, is estimated at 200,000 tons.

Table giving the coal product of Utah by companies in 1886.

Name.	Short tons.
Pleasant Valley Coal Company	71, 814
Utah Central Coal Company	34, 676
San Pete Coal and Coke Company	1, 800
Grass Creek Coal Company	29, 131
Home Coal Company	24, 417
Small mines unreported	38, 162
Total	200, 000

VIRGINIA.

Total production in 1886, 684,951 short tons; spot value, $684,951.

The coal fields of this State may be divided into three prominent areas.

First, the Richmond coal field, situated in the Triassic or New Red Sandstone areas in the vicinity of Richmond. Coal beds, smaller than those in the Richmond basin, have also been found in the Triassic area, extending from the Potomac river below Harper's Ferry south to the boundary of Orange county, and a small area in the southwestern part of Albemarle county, and in a smaller area extending from West Appomattox county southwest to the State line along the Dan river. With the exception of the Triassic area known as the Richmond basin, no coals of workable dimensions have been found in these areas.

Second, the sub-Carboniferous coal fields occurring in the western part of the State along the frontier of that division of the State known as "The Appalachia." These coal beds are found in the Pocono or Vespertine formation No. X., which is the bottom member of the sub-Carboniferous rocks, Third, the Pocahontas field, which is underlaid by the Lower Productive Coal Measures extending over parts of Tazewell, Russell, Buchanan, Dickinson, Wise, Scott, and Lee counties. The present mining developments are, however, confined to Tazewell county.

The first mention of coal in North America was by Father Hinnepan, in 1698, at or near the present town of Ottawa, in Illinois. The first definite discovery of coal can, however, be credited to Col. William Byrd, who made a report May 10, 1701, to the colonial council of Virginia, in which he relates the discovery of coal in the Richmond basin. The coal was, however, not worked for general sale to the public until between 1770 and 1780.

The interest in this coal field now is of a historical and geological character, since the working of the coal beds, principally at the Midlothian colliery, has been practically abandoned. Mr. Job Atkins, mining engineer at the Midlothian colliery, has recently made a report on the coal beds of the basin, in which he claims that this colliery can be reworked and other coal beds can be opened up at a handsome profit to a judicious and careful operator.

In Rockingham and Augusta counties coal beds have been known to exist for many years. They are, however, not considered sufficiently persistent in their occurrence to be profitably mined. In Montgomery county a number of operations are carried on along Brush and Price mountains. The coal beds along these two mountains are considered by the Myers Brothers, one of the largest mining firms, to be the same. The greatest dip of the bed along Brush mountain is about 30° towards the south, and along Price mountain about 30° towards the north. The beds have so far only been mined above water level. The coal beds are considered to underlie Price valley between these two mountains. The Brush Mountain coal makes a more satisfactory fuel than the coal along Price mountain.

The coals from this district are at present shipped under great disadvantages, owing to the distance of the mines from the railroad. Improvements are now in course of construction by which it is proposed to convey the coal from the mines to the railroad by wire cables. The following table, which states the production of coal in Virginia for 1886, gives the names of the present individual operators in the districts referred to.

Total production of coal in Virginia in 1886, by counties.

Counties.	Name.	Total production.	Local consumption.	Manufactured into coke.	Total shipped.
		Short tons.	*Short tons.*	*Short tons.*	*Short tons.*
Tazewell	Southwest Virginia Improvement Company.	639, 751	6, 792	93, 550	539, 409
Chesterfield	Brighthope Railway Company.	28, 000	2, 800		25, 200
Montgomery	Brush Mountain } Price Mountain }	5, 950	2, 450		3, 500
	Hugh Price	100			100
	Jas. B. Price	100			100
	J. M. Krumer	1, 000	600		400
	Kintzer & Schaeffer	1, 600	600		1, 000
	Samuel Smith	50			50
	Kanode Bros	450	400		50
	Smith & Bell	400	400		
	William Smith's heirs	100	100		
	Schlussers	100	100		
	J. H. Kipps	1, 050	800		250
	Linkons & Kipps	400	300		100
	C. Price	100			100
	W. C. G. Myers	300	300		
	Moon & Co	500			500
	Hoge Tyler	3, 000			3, 000
	Myers Bros	1, 800	200		1, 600
	Kintzer & Price	200			200
	Totals for State	684, 951	15, 842	93, 550	575, 559

The most important coal field in Virginia is that known as the Pocahontas Flat Top coal field, which came into prominence as a semi-bituminous coal field in 1883. It is situated along the line separating the two Virginias, in Tazewell county, Virginia, and Mercer and McDowell counties, West Virginia. The first shipments of coal from this field were made by the Southwest Virginia Improvement Company in June, 1883. During that year shipments from the mines were only sufficient to supply the wants of the Norfolk and Western railroad. During 1886 there were eight distinct operators in this district, as follows: Southwest Virginia Improvement Company, John Cooper & Co., Caswell Creek Coal and Coke Company, William Booth & Co., Stephenson, Mullin & Co., Mill Creek Coal and Coke Company, Mercer Coal and Coke Company, and Moore, Deaton Bros. & Co. All of these operations with the exception of the Southwest Virginia Improvement Company, are situated in West Virginia.

In addition to the above, five new operations are being projected which it is expected will begin to ship coal during 1887, as follows: I. A. Crozer, Shamokin Coal and Coke Company, Elk Horn Coal and Coke Company, Goodwill & Douty, and Marshall & Goodwill.

An average analysis of ten samples of coal made by Mr. A. S. McCreath, from various points in the field, shows as follows:

Average analysis of ten samples of coal from the Pocahontas field, Virginia.

	Per cent.
Water	6.940
Volatile matter	18.832
Fixed carbon	74.066
Sulphur	.761
Ash	5.647

The development of the coal-mining industry in this field has been wonderful, as shown by the output for the past four years.

The shipments over the Norfolk and Western railroad have been furnished by Mr. F. J. Kimball, president of the company, as follows:

Shipments of coal over the Norfolk and Western Railroad, from 1883 *to* 1886.

Years.	Tons.
1883 (from month of June)	105,805
1884	272,173
1885	651,987
1886	924,361

The Southwest Virginia Improvement Company during 1886 had in operation 200 coke ovens, and there are now in course of construction to be completed during the coming year over 1,000 coke ovens, as follows:

Coke ovens in course of construction.

Companies.	Number of ovens.
Southwest Virginia Improvement Company	200
Stephenson, Mullen & Co	66
Mill Creek Coal and Coke Company	100
William Booth & Co	25
Freeman & Jones	40
Mercer Coal and Coke Company	80
Goodwill & Douty	100
Marshall & Goodwill	100
Elkhorn Coal and Coke Company	100
Shamokin Coal and Coke Company	100
Samuel Crozer	100
Total	1,011

In a paper recently read before the American Institute of Mining Engineers, by A. S. McCreath and E. V. d'Invilliers, in referring to the fuel supply and iron furnaces of the Southwest Virginia Improvement Company, they say:

"The coke for furnaces in Southwest Virginia will be entirely drawn from the Flat Top field. On January 1, 1887, the daily production of coal from the great Pocahontas or No. 3 bed was about 3,500 tons net. The coke produced either by the Southwest Virginia Improvement Company or from individual lessees of the Bluestone Coal Company amounted to 60,000 tons in 1886. Two hundred (200) ovens supplied the coke, although the rapid development of the business has called for the erection of 1,090 more, already contracted for, and to be ready for operation during the coming year.

"In the purity and general excellence of its coke and the cheapness with which the raw coal is mined, Virginia is well in advance of either Alabama or Tennessee; so that there is no question that up to this time the Cripple Creek furnaces could have a supply of coke unexcelled by the product of either of those States. The distance to point of consumption is greater than for the furnaces in either of those districts which we have taken for comparison; but the natural advantage of mining at Pocahontas must count for something in the long run, and it is quite probable that to-day the cost of a ton of coke, considering its effective duty, would be no greater delivered at the tunnel-head at Central or Pulaski than it is at Chattanooga or Birmingham.

"The quality of this Virginia coal and coke is already well known, and its reputation is established by practical use in the Roanoke and Lynchburg furnaces, and at various foundries in the South.

"It is unnecessary to comment upon the quality of a coke showing over 92 per cent. of fixed carbon, and with such a low percentage of sulphur; and its burden-bearing qualities in the furnace have already established it in the list of first-class furnace fuels. The coke is now delivered on board cars at the mines at $1.75 per ton. The No. 3 or Pocahontas coal bed of the Flat Top field is advantageously situated for mining above water level through a large area, yielding about 10,000 tons per acre, from a bed 10 to 12 feet thick; in some portions of the field split into two distinct workable seams, and yielding about 9 feet of coal. Its favorable position, not requiring pumping, and the ease with which it can be worked, renders it an exceedingly cheap fuel as compared with the fuel of the Chattanooga and Alabama districts; and the quantity of this excellent coal is so great as to assure a future coke supply."

The following table gives a comparision of the coke manufactured at Birmingham, Chattanooga, Pocahontas, and Connellsville from analyses made by Mr. Andrew S. McCreath:

Analyses of coke by Mr. Andrew S. McCreath.

	Birmingham district.	Chattanooga district.	Pocahontas district.	Connellsville district.
Water	0.157	0.447	0.347	0.060
Volatile matter	.803	1.101	.757	.428
Fixed carbon	87.299	80.513	92.550	88.962
Sulphur	1.195	1.595	.597	.810
Ash	10.545	16.344	5.749	9.740

WASHINGTON TERRITORY.

Total production in 1886, 423,525 short tons; spot value, $952,931.

The coal fields of the Territory have recently come into greater prominence on account of the increased facilities for transportation.

Mr. Bailey Willis has made an elaborate report on the coal fields of the Territory, which is published in the fifteenth volume of the Tenth Census reports, from which the following extracts have been made:

"The coal measures of the Puget Sound basin consist of alternating beds of yellow and gray fine-grained sandstones and very fine gray arenaceous shales, interstratified with many beds of carbonaceous shale and with coal. The individual strata of sandstone and shale from 20 to 200 feet thick, maintain the same general character wherever observed, and no well-defined horizon has been found which might serve as an index to correlate the widely separated exposures.

"The thickness of the Laramie group, as determined by Mr. George H. Eldridge in Montana, is about 8,500 feet in the Bull mountains, and very much less near the old shore lines. On the Pacific coast it greatly exceeds the above maximum, but it is not possible without further study to state even an approximate total on account of the uncertain relations of the much-disturbed strata obscured by volcanic flows, recent drift, and a dense forest.

"The best sections are those obtained in the Wilkeson and Green River fields. Of these one gives a minimum of 13,200 feet, with a probable maximum of 14,500 feet; a second, still less complete, measures 7,700 feet; and a third, on Green river, lies between 6,200 and 8,200 feet; and these sections do not in either case reach the limits of the coal measures, as the base of each is an anticlinal axis and the top of the highest exposure, geographically speaking, beneath the volcanic flows or drift beds. Such figures challenge confirmation, but they are the result of accurate surveys and careful observation, and are only invalidated by the possibility of undiscovered faults, of which the sections have yielded no proof under close examination.

"Looking at the Puget Sound basin as a whole, the coal measures extend from beyond the British boundary south almost to the Columbia, and from the Pacific ocean eastward up onto the Cascade range to elevations varying from 800 to 5,000 feet above the sea; but, buried on the one hand beneath recent gravel-beds, and overflowed on the other by erupted masses, the visible part of the formation appears as an interrupted belt along the base of the Cascades and encircling the Olympic mountains.

"The Bellingham Bay lignite mines are opened on an isolated outcrop surrounded by a region of forest-covered drift beds. They were known in 1851, and 20,500 tons were shipped to San Francisco in 1869, but the mines were shut down in 1878. Their nearest associated coals are to the west, on Vancouver's island, and southeast at the "Coal mine" on Skagit river 40 miles from its mouth. The latter covers a small area south of the Skagit. It is bounded on the east by a contact with crystalline schists which extend far northwest of Mount Baker; on the west and south by drift beds, and on the north the coal is lost beneath the swamp lands along the river. The coal is of bituminous character, and quite different in chemical composition from the inferior lignites which crop out on both branches of the Stilaguamish river.

"From the latter southward there is a region little known geologically, over which the drift-beds extend up to the outliers of the Cascades, and the coal measures appear, if at all, only as a very narrow strip, until they are exposed in the cañon of Green river. Within this stretch, however, are the disconnected outcrops on which the Newcastle and Renton mines are sunk 15 miles southeast of Seattle. Both of these mines produce an excellent lignite, which does not air-slake. Between them and the Green River field is the outcrop of a bed, called the McAlister, on Cedar river.

"Green river cuts through the coal measures from east to west for about 9 miles in a straight line, but much farther by the river, giving a section from the contact with eruptive rocks on the east to the drift beds on the west. This section includes coals generally called bituminous, which produce a fragile coke, but have a lignitic luster, and very poor typical lignites, the latter overlying the former in the western portion of the section. The field is bounded north, west, and south by overlying drift, which extends 20 miles in the latter direction to the most northern outcrops of the Wilkeson coal. This is a soft, coking, highly bituminous coal, jet black, and of cubical fracture, which produces a strong, close-grained, sonorous coke. Its general character is maintained throughout the field from Wilkeson south to the Nisqually river, about 24 miles, except where it is locally altered to semi-anthracite or columnar coke by the action of intruded rocks. The field is from 1 to 6 miles wide, and is limited on the east by the volcanic rocks of Mount Rainier and its lesser craters, and on the west by eruptive rocks, which 30 miles west of Mount Rainier form an unnamed group of mountains 5,000 feet high.

"Still west of these little known heights, and south of Puget Sound is the most extensive lignite area in Washington Territory. It reaches from Castle Rock station, on the Northern Pacific railroad, north to the Sciatco mines on the Skookumchuck river, and northwest to the Olympic range, along the upper Satsop river. Its eastern boundary is where the lignite measures join the volcanic rocks which separate them from the coking coal of the Wilkeson field, but the lignite remains unaltered up to the contact. The proximity of this field to the line of the railroad has led to its being carefully prospected. Wherever the beds have been opened they produce a bright clean lignite, which air-slakes and possesses a low heating power.

Analyses of representative samples of Washington Territory coals and lignites.

	Moisture.	Volatile hydrocarbons	Fixed carbon.	Ash.	F. C. / V. H. C.	Coke.
	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	
Lignites:						
Miles City, Dakota	14.10	36.95	35.76	13.19	0.97	None.
Newcastle, Washington	4.16	44.84	43.86	7.14	0.98	None.
Green River field, Washington:						
Seam (?), G. R. C	7.27	36.02	28.48	28.23	0.79	None.
Seam 33, G. R. C	9.98	40.63	41.07	8.32	1.01	None.
Seam (?), G. R. C	8.68	35.90	47.07	8.35	1.31	None.
Bituminous lignites:						
Green River field, Washington:						
Seam XVIII, G. R. C	2.50	45.71	48.37	3.42	1.06	Poor.
Seam IX, G. R. C	4.82	42.02	37.12	16.04	0.88	None.(*a*)
Seam VI, G. R. C	3.34	39.39	41.49	15.78	1.05	None.(*a*)
Seam III, G. R. C	3.24	39.52	48.39	9.85	1.22	Worthless.
Upper Yakima River, Washington	0.80	40.87	46.39	11.94	1.13	Fair.
Carbon station, Wyoming	8.10	34.70	51.65	5.55	1.48	....
Rock Springs, Wyoming	7.00	36.81	54.46	1.73	1.48	....
Bituminous coals:						
Wilkeson field, Washington:						
Wingate seam, Carbonado	1.80	42.27	52.11	3.82	1.23	Very good.
Seam CXXIII, W. C	3.98	28.64	54.10	13.28	1.88	None (?).(*b*)
Seam XVIII, W. C	1.33	25.88	60.67	12.12	2.34	Excellent.
Seam V, W. C	1.16	29.09	60.38	9.37	2.07	Excellent.
Seam I, W. C	1.54	28.17	59.70	10.59	2.12	Poor (?).(*b*)
Seam LVIII, B. B. C	0.61	29.58	56.18	13.63	1.89	Black and friable.
Altered by intrusive rocks:						
Seam XLIV, B. B. C	0.44	5.84	73.98	19.74	12.67	None.
Seam "d" Carbon river, W. C.	2.56	8.43	83.27	5.74	9.87	None.
Skagit river, Washington	1.17	14.40	64.56	19.87	4.48	Rather poor.
Raton, New Mexico	2.00	37.10	51.60	9.30	1.39	Good.
El Moro, New Mexico	1.66	34.48	60.08	3.78	1.74	Good.

a Produced fragile coal in field test. *b* Produced first class coke in field test.

NOTE.—G. R. C., Green River column; W. C., Wilkeson column; B. B. C., Busy Brook column. Analyses of coal from Carbon Station, Rock Springs, Raton, and El Moro, taken from Mineral Resources of the United States, 1882.

"The coals of Washington Territory range in quality all the way from lignite, which still retains a woody structure, to anthracite. In the above table a number of representative analyses are given, and those of some similar coals of Wyoming and New Mexico are added for comparison. The "lignites," "bituminous lignites," and "bituminous coals" grade into each other, but they may here be defined to mean:

"Lignite, a coal of brilliant luster, conchoidal fracture, brown streak, homogeneous or woody structure, which cracks into small, irregular fragments when exposed to changes of temperature and moisture, and which does not coke.

"Bituminous lignite, a coal of lignitic luster and streak, homogeneous structure, irregular, slightly conchoidal fracture, which does not air-slake, and forms a more or less fragile coke.

"The Newcastle, Washington Territory, lignite is intermediate between these two classes. It does not air-slake, but, on the other hand, it does not coke, and it is known in the Pacific coast markets as a high-grade lignite.

"Bituminous coals have a black streak, more or less cubical fracture, and form a sonorous, close-grained coke.

"The differences of character of the Washington Territory coals are ascribed to three principal causes: differences of age, the influence of volcanic rocks, and the metamorphic action incident to the crumpling of the strata.

"The fields which have been wholly or partially modified by these causes are the Wilkeson, the Green River, and the Skagit. Separated from each other and from the lignite areas by broad stretches of drift and by volcanic flows, they afford no data from which their relations might be deduced, except the lithological characteristics and fossils of their strata.

"The similarity of composition and interbedding of the sandstones and shales, wherever they have been observed, points, so far as it goes, to identity of age, and considering the great thickness of the sections of the strata in the different fields, it is difficult to believe that they can be superimposed to the extent necessary to account for the varieties of coal. The fossils, so far as they have been examined, belong to one period.

"The great thickness of strata in the Green River and Wilkeson fields justifies us in expecting differences between the upper and lower coals in either section; and the expectation is apparently borne out in the former field, where the upper beds are of typical and rather inferior lignite, and the lower are bituminous lignites. But the poorest lignites are at the same time confined to the least disturbed portion of the field, and the more bituminous beds are very similar in composition throughout the lower 3,000 feet of the series, which have suffered a uniform faulting and folding. This evidence applies equally, therefore, to supposed differences of age or to the differences of metamorphism.

"The same is true of the Skagit coal, which may on the one hand be the lowest portion of the coal measures known in close contact with schists, upon which it was deposited, or, on the other hand, a bed belonging anywhere in the coal series, modified by proxy to a very extensive fault.

"The thickness of the coal strata in the Wilkeson field is double that of those in the Green river field, and the differences of composition between the upper and lower coals should be correspondingly greater.

"Volcanic rocks occur in contact with the coal measures as flows and as intrusive dikes. They have modified the character of the coal by pressure and heat, and the influence of a superficial flow would, in both these respects, be less than that of the molten rock before extrusion. Coal beds altered by dikes in their immediate vicinity are frequent in the Wilkeson field, but in every such case the alteration is confined to a few hundred feet on either side of the contact. The dike is known to be a mile wide, and it joins other flows and dikes to the westward. But this same bed of coal, here altered to semi-anthracite of brilliant luster and anthracitic fracture, produced coking coal of the character common to the whole field less than a quarter of a mile from this outcrop, and 'Bed C, Carbon river, W. C.,' separated from it by but 500 feet of shale and sandstone, is unaltered.

"A cause so local in its action, under the most favorable conditions, could not have produced the widespread and uniform differences between the Wilkeson, Green River, and lignitic coals.

"*The Wilkeson coal field.*—This field, as now known, is an isolated strip of coal measure strata, extending north from the Nisqually river, in township 15 north to township 19 north, and within range 6 east of the Willamette meridian. Wilkeson, the place of first discovery of the coal, and the end of the branch road built by the Northern Pacific Railroad Company to the coal mines, is near the northern end of the field, 31 miles by rail southwest of Tacoma, on Puget sound. Carbonado, the town erected at the mines of the Central Pacific Railroad Company, is about 3 miles southwest of Wilkeson, on the edge of Carbon River cañon and near the western border of the coal field. South Prairie creek, 2 miles north of Wilkeson, and on which the South Prairie mines are opened, may be considered the northern boundary of the field, since it disappears to the northward under the drift of the White River plain and valley, which is only interrupted by a few outcrops of volcanic rock. Thus defined the Wilkeson coal field is about 27 miles long, north and south, and from 1 to 6 miles wide, east and west, with an area of approximately 100 square miles, of which perhaps one-fifth can be developed and made profitably productive. As stated, the northern boundary is somewhat indefinite, but its eastern, southern, and western limits are absolute contacts with erupted mountain masses, in which this slender strip of sedimentary rocks has been almost engulfed. These contacts are nevertheless seldom to be observed, since glacial deposits and forest growth bury all solid rock below 5,000 feet under a covering that only patient work with ax, pick, and shovel can penetrate. Only in the bold walls of the lower cañons of Carbon river, of the Puyallup and Mishall creek, and on the high summits of the volcanic peaks are there any outcrops.

"*The Green River coal field.*—The Green River coal field takes its name from the clear mountain stream which cuts a deep east and west section into the coal measures 30 miles northeast of Tacoma, and about the same distance southeast of Seattle. This exposure is the first appearance of sedimentary rocks north of Wilkeson. A few low hills near Green river, within what may be called the coal field, several pinnacles of volcanic rock near White river, and the lignite outcrops on Cedar river, are the only breaks in the great drift plain traversed by the streams which flow into Elliot bay.

"As may be inferred, the limits of the coal field on the northwest and south are simply the disappearance of the strata under the all-obscuring gravel sheet. The eastern border is a much more definite contact with the bold outliers of the Cascade range, composed of volcanic breccia.

"The area of so indefinite a coal field can only be stated approximately as 50 square miles, of which but a small part is likely to be profitably productive.

"Viewed broadly the Green river coal field may be looked upon as a flexed and correspondingly metamorphosed corner of the extensive lignite field, into which it passes on the west and north. Inasmuch as these qualities which give the coal a greater value than lignite are dependent on the degree of this flexure, the worth of lands beyond its visible boundaries is doubtful, and a hint of the limits thus set to the valuable coal area is to be found in the presence of lignites a mile west of the Franklin colliery and on Cedar river.

"The bituminous lignite of Green river is a hard, brilliant coal, of moderate heating power. It differs essentially from the Wilkeson coal in that it is harder and does not make a serviceable coke. It will find a ready market in all cases where the demand for cleanliness and cheerfulness overrules the economy of the greater heating power of the more highly bituminous coals."

Mr. James F. Jones, in charge of the coal operations in the vicinity of Seattle on the Northern Pacific Railroad has, at my request, contributed the following report on the Washington Territory and British Columbia coal fields.

A tax of four mills is imposed upon every ton of coal mined in Washington Territory, and it is compulsory with the operator to return statements under oath with the payments, at the end of each quarter, to the Territorial treasurer.

The following are the returns made for the year ending December 31, 1886:

Production of coal in Washington Territory in 1886.

Name of mine.	By whom owned or controlled.	Production.
		Long tons.
New Castle mine	Controlled by the Oregon Improvement Company and returns are made jointly. (*a*)	95,789
Franklin mine		
Cedar Mountain mine	Owned by the Cedar Mountain Coal Company	17,406
Black Diamond mine	Owned by Black Diamond Coal Company	65,700
Total from King county		178,895
Carbon Hill mine	Owned by Pacific Improvement Company, San Francisco, California.	144,226
South Prairie mine	Owned by South Prairie Coal Company	54,441
Tacoma mine	Owned by Tacoma Coal and Coke Company	585
Total from Pierce county		199,252
Roslyn mine	Owned by North Pacific Coal Company, and located east of the Cascade mountains.	1,555
Total from the Territory		379,702

a New Castle shipment about 79,059 tons; Franklin shipment about 16,730 tons.

The Territorial mine inspector reports for the same period:

	Tons.
From King county	187,888.20
From Pierce county	199,256.11
From the Territory he gives a total of	388,699.56

The difference, 8,997.56 long tons, between the inspectors' and the treasurer's statements is to be found in the fact that the operators do not return to the treasurer an account of the coal consumed at the mines by the miners and machinery, and in the Roslyn mine output.

The inspector's report gives a loss of one life for every 65,000 tons of coal mined. The average number of men engaged in mining, during the year 1886, was 920, and the average output per man engaged was 422.5 tons.

The rates of wages paid at the mines are given below:

Miners by the day, $3; on contract, $40 to $150 per month. Laborers, inside, $2 to $2.75 per day; outside, $1.75 to $2.25 per day. Engine drivers, $2.75 to $3 per day. Machinists, $2,50 to $5 per day. Trappers or door boys, $1 per day. Mine bosses and superintendents, $90 to $300 per month. Clerks, $50 to $150 per month. Resident physicians, $100 to $255 per month. No Chinese are employed at the mines, since the raid made upon them in the fall of 1885 and the spring of 1886. While employed they were engaged through a contractor at about 80 cents a day. Some of the strongest and most active would command from $1.25 to $1.75 per day.

The mines are located at points ranging from 10 to 34 miles from tide water on Puget sound. Seattle and Tacoma are the shipping ports. Freight charges on the railroads to tide water vary from 55 cents to $1 per ton of 2,240 pounds. The distance from the shipping ports on Puget sound to San Francisco is between 800 and 900 miles by water, and to Portland, by water about 450 miles, and by rail from 140 to 170 miles. Rail connection is not yet completed to San Francisco, and no coal of any consequence has been shipped by rail to Portland. Freight charges on coal from Puget sound to San Francisco are from $1.75 to $2.25 per ton; $2 is the prevailing price.

Those owning their own vessels pay probably no more than $1.50. The risk of crossing the Columbia River bar makes the freight rate by water to Portland no less than to San Francisco, excepting to those owning their own ships.

Coal is sold, on the sound, for steam and house purposes, for from $3 to $5 a long ton, and at San Francisco and Portland, coarse, $4.25 to $6, and nut $2.75 to $3.75. The cost per ton, free on board on cars at the mines, varies from $1 to $2.50. The average for a period of 4 or 5 years, including improvement and repairs and exclusive of royalty, will not be much below $1.75. The bulk of the Sound coal is marketed in San Francisco and Portland.

The magnificent forest so extensive in this Territory, on the western slope of the Cascades, with its luxurious and dense growth of vegetation, makes a formidable obstruction to the development of, and to the determination of the extent of this coal field. Coal of more or less importance, however, is known to exist from the northern to the southern boundary lines of the Territory, through a belt ranging from 10 to 30 miles wide. The field east of the Cascades was practically entered in 1886 by the Northern Pacific Coal Company, and as yet there is but little known of the extent of the field. The scarcity of timber east of the mountain adds much value to this field.

The general coal formation in the Territory is plicated much the same as that of the anthracite of Pennsylvania, with the sides of the basins dipping at all angles from 15° to 90°.

The number of coal beds in the field is undetermined; but, judging from the great number of exposures, and the varied character of the beds and rocks, it is great. Those already examined vary in thickness from 1 to 45 feet. The thick beds are very imperfect, yielding no more than one or two workable benches, 3 to 6 feet of merchantable coal. The smaller beds are frequently found in perfect condition.

The New Castle mine.—Coal is now taken from one bed 10 to 11 feet in thickness, having an excellent sandstone roof and floor dipping 40°. This bed splits into two members about a mile from the hoisting slope, and the cost of mining, with the present rate of wages, increases about 30 per cent. in consequence. There are exposures of some eight beds in this formation; two only, in addition to the one referred to above, have been worked, one 24 feet and the other 4 feet in thickness. The larger is very imperfect. The two beds 10 to 11 feet and 24 feet thick are on fire, seriously injuring the property. Considerable iron pyrites is present in this coal, which fact, added to the chaff-like character of the coal for igniting, causes much annoyance and cost to the mine from fires. Coal, or the mine refuse, piled in large quantities quickly ignites. The product of the mine is very good house and steam coal, but it requires as much preparation at the mines as the anthracite, excluding the crushing process. Operations began in 1871. Total production to the end of 1885 is about 1,540,000 tons, two-thirds coarse and one-third nut coal. One-fourth of the extracted product is wasted on the dirt bank. The distance from the mine to tide water is 18 miles.

The Franklin mine shipped its first coal in July, 1885, and the product for that year was 10,031 tons. Its location is on Green river, 34 miles from Seattle. Five beds of coal have been discovered, ranging from 4½ to 45 feet in thickness. The product is taken from the smallest bed, known locally as the "McKay vein." The dip is 45°. The coal is marketed as "run of the mines" for steam and domestic purposes. It is richer in fixed carbon and lower in ash than the New Castle coal, but it is not so coarse.

The Black Diamond mine is in the same field and on the same railroad as the Franklin mine, 3 miles nearer market; the coal is also of the same kind. The first shipment was made from the mines in April, 1885, and the tonnage at the end of that year was 49,360 tons. Three coal beds, 4 to 7 feet in thickness, have been developed by slopes, dipping from 10° to 30°. The mine has about 800 tons daily capacity.

The Cedar Mountain mine is located on Cedar river, 12 miles nearer the market than the Black Diamond mine, and on the same railroad. The coal is of the same kind and has the same market value as the New Castle coal. The first shipment was made in July, 1884, and the tonnage at the end of the year was 31,384 long tons. The coal measures dip to the east 20°, and the thickness of the coal bed worked is 11 feet, practically perfect coal from top to bottom. Another bed of smaller dimensions has been discovered, but not worked. The capacity of the mine is about 300 tons daily.

The Carbon Hill mine is located on the Northern Pacific railroad in a deep cañon on the Carbon river, 34 miles east of Tacoma. Its daily capacity is about 800 tons. The coal is mined largely through drifts from four beds, 3½, 4½, 10, and 12 feet in thickness. Other beds have been more or less developed. The dip of the measures varies from 30° to 80°. The coal is soft and friable, containing a large amount of bitumen; if washed, a fair grade of coke can be made from the coal of some of the beds. The coal, as brought out of the mines, requires considerable preparation. It is shipped in bulk as run of the mines to San Francisco, and consumed by the Central Pacific Railroad Company. The Pacific Improvement Company, an offspring of the last-named company, is the owner of the property. Operations were begun in 1880, and the product to the end of 1885 amounted to about 475,000 tons.

The Tacoma mine at Wilkeson is on the same railroad as the last-named mine, and three miles nearer Tacoma. From eight to ten coal beds have been developed and exposed; one only has been worked, it is 6 feet in thickness; the thickness of the others varies from 3 to 14 feet. The worked bed is imperfect, but the marketable coal is very rich in bitumen; when used in an ordinary furnace, or house stove, it becomes semi-fluid. An attempt has been made to coke this coal, with promising results. It has been known for some years that this field contains coal beds that will yield coke, qualified for iron manufacturing purposes. Operations began in 1876, but owing to peculiar circumstances very poor results have been obtained. The tonnage, including that of the Vulcan, amounting to 4,500 tons, shipped in 1883, is estimated at 20,000 tons. The two mines, Tacoma and Vulcan, are practically the same and are located on the opposite sides of an anticlinal axis, both shipped over the same bunker.

The South Prairie mine is located on the Northern Pacific railroad, 28 miles from Tacoma. It began operations in 1881. The mine opening is a water-level drift; the thickness of the coal bed is 4 feet. The dip is from 45° to 80°. The coal is sold for steam, house, and gas purposes, commanding a higher price than any other in the Territory. The tonnage for 1884 was 29,468, and for 1885, 40,161 tons.

The Talbot mine is located at Renton, 10 miles from Seattle. The coal is like that at New Castle and Cedar mountain, and is of the kind known commercially as Seattle coal. It began operations in 1875 and concluded in 1879, being then merged into the Renton mine. The shipment during its life is estimated at 10,000 tons.

Renton mine is located at Renton. Its product was taken from one bed 7 to 9 feet in thickness, perfect in character, possessing a very weak and troublesome roof; it is the same bed as worked at the Talbot. Operations began in 1874, and were abandoned in 1885 on account of insufficient pumping capacity and low price of coal. The mine opening is a slope dipping from 10° to 25°. The mine was owned and operated by the Renton Coal Company. The total tonnage from the mine as compiled from the best available data is 159,481 tons.

The Bellingham Bay mine is located on the edge of Puget sound, in Whatcom county, and it was the first mine opened in the Territory, its commencement dating back to 1860. It had a life of eighteen years and was abandoned in 1878, having produced, according to the reported shipments, 233,043 tons; the mine opening is a slope 300 yards long, on an average dip of 33°. The western wing of the mine passed under the bay. Mine fires, from spontaneous combustion, caused much annoyance and expense to the operator. The coal bed is 14 feet in thickness and its character and quality is like the Seattle coal.

After considerable labor in compiling data the writer estimated, in 1885, the total product from all the mines in the Territory, to January 1, of that year, and covering a period of twenty-four years, to be 2,200,000 tons. All the coal of this Territory as far as developed is technically lignite, but is generally of such superior quality as to be readily accepted, commercially, for a good grade of bituminous coal. The product, however, from the different sections of the field is so varied and distinct as to cause three natural divisions, or districts, in the field, on the western slope of the mountain. The first embracing New Castle, Renton, Talbot, Cedar River and Bellingham Bay mine coals, known as the Seattle coals. The second embracing the Franklin and Black mine coals, known as the Green River Field coal. The third embracing the Carbon Hill, South Prairie, and Wilkeson mine coals, known as Wilkeson Field coal.

The First district yields practically a dry coal easily ignited, high in ash and hydrocarbons, and low in fixed carbon. It is high in moisture. It is usually coarse, in good condition, and is a favorite domestic and steam coal, commanding ready sale.

The Second district yields coal richer in fixed carbon, comparatively low in ash, moisture moderately low, friable, yielding a large percentage of slack; it is a favorite steam coal and the lump makes an excellent domestic coal. The coke product is light, porous, weak and inferior, but a trifle better than that from the Seattle coal.

The Third or Wilkeson field yields a coal that is the richest in fixed carbon and bitumen; the ash is, however, excessive; from this field coal for iron manufacturing and the smelting of other ores will be sought.

The different coals no doubt occupy different positions or zones in the formation; and it is probable that the Seattle will be found in the upper, the Green River in the intermediate, and the Wilkeson in the lower.

The coal from the east of the mountains as far as developed is much like that described for the Green River field.

The coal from the Wilkeson field will at no distant day be largely developed, for the purpose of reducing the Bessemer ores so abundantly and richly deposited upon the edge of the coal field. A railroad 12 miles long is already projected from the Northern Pacific railroad to Snoqualmie, to reach the iron-ore field, to bring this ore into market as well also other valuable ores known to exist in the same mountain range.

Messrs. Coulter and Sons commenced to open a coal mine in the early part of 1886 upon a short branch railroad connecting with the Northern Pacific railroad at Seatco, in Thurston county. The bed is reported to be 5 feet in thickness, free from imperfection, with the coal of the same quality as the Seattle coal. The product has not yet been marketed. The dip of the measures is from 8° to 20°.

No report of the coal business of Washington Territory would be complete without reference to that of British Columbia, one of its most formidable rivals in the market, and its nearest neighbor.

British Columbia.—The present productive coal field is located on Vancouver island, at and near Nanaimo, on the eastern border of Saint George's channel. The chief market for the product of this field is in California. Three mines are in operation and their names and product are given below:

Production of coal in British Columbia in 1886.

	Short tons.
Nanaimo colliery	112,761
Wellington colliery	185,846
East Wellington colliery	28,029
Total output	326,636

The exports into the United States from these mines during 1886 was equal to 75 per cent. of the output, the total export being 77 per cent.

Exports of coal from British Columbia in 1886.

	Short tons.
Nanaimo colliery	79,637
Wellington colliery	144,526
East Wellington colliery	25,024
Total	249,187

The total output and export for four years are below stated:

Output and export of coal from British Columbia for four years.

Years.	Output.	Export.
	Short tons.	*Short tons.*
1883	213,000	128,503
1884	394,070	306,474
1885	365,596	237,797
1886	326,636	249,187

At the Nanaimo mine the coal beds are from 5 to 12 feet in thickness; at Wellington 10 to 14 feet; and at East Wellington 2½ to 6 feet. The mine openings are slopes and shafts, all, without exception, requiring large pumping and hoisting machinery. The employés at the mines are: Chinese, 530; Indians and boys, 18; and whites 721. The wages paid per day are: white men, $2 to $3.75; Chinese, $1 to $1.25; and Indians, $2. Miners earn $3 to $5 per day. The mines are located from one-half to 5 miles from tide water, and the cost per ton of mining and delivering on board ship is from $1.50 to $2.75, averaging probably from $2 to $2.50, including all cost excepting royalty. The mining companies own their own railroad to shipping ports.

The distance from Nanaimo to San Francisco is about the same as from the ports of the Washington Territory coal fields, and the freight charged is about the same from both fields.

The coal from this field possesses some of the characteristics of lignite. It bears transportation well, and is delivered in the market in excellent condition, especially that from the Wellington mines, which always commands the highest prices in San Francisco and sells very readily. It is, however, a good coking coal.

The coal formation is a continuation of that found in Washington Territory, and extends to the northern end of the island. The coal is less disturbed and it has suffered less crimping than that of Washington Territory. The general inclination of the beds is from 5° to 30° to the south, and it is not very improbable that it passes under Washington Territory.

North of Vancouver Island, in the partly submerged peaks of the Coast Range mountains, in Queen Charlotte Island, anthracite is reported by the Government geologists to crop out. After expending some $60,000 in prospecting and mining this coal spasmodically during the past twenty years no good results to the owners have as yet been accomplished. The formation, however, would seem to extend under Vancouver Island, and in that case, and from what has already been stated above, it would be reasonable to suppose that it extends also under Washington Territory.

The quality and condition of the Nanaimo coal gives it a preference in the market over the Washington Territory coals.

Analyses of coal.

Mine.	Fixed carbon.	Volatile matter.	Ash.	Moisture.	Sulphur.	Authority.
New Castle mine, No. 2 vein	43.36	42.97	9.54	4.13	......	Transcontinental survey, Pumpelly.
Do	43.38	44.84	7.14	4.16	......	Do.
Do	45.97	35.49	6.44	11.60	......	Probably Hilgard.
Franklin mine:						
McKay bed, No. 14	51.82	40.07	4.10	4.01	......	Do.
No. 12 bed	50.78	34.63	10.93	3.66	......	Do.
No. 10 bed	57.68	33.92	5.07	3.33	......	Do.
McKay bed	44.42	48.66	4.19	2.75	......	Transcontinental survey, Pumpelly.
New Castle mine, Bagley vein	40.20	43.79	11.85	4.18	......	Do.
Carbon Hill mine, Wingate vein.	52.11	42.27	3.82	1.80	......	Do.
Bellingham Bay mine	45.69	33.26	12.66	8.39	....	
Wellington mine, British Columbia.	55.50	34.70	9.80	....	......	Probably British Columbia geological survey.
Nanaimo mine, British Columbia.	48.48	38.10	11.72	1.70	......	Do.
Wilkison mine:						
Smith vein	60.67	25.88	12.12	1.33	......	Transcontinental survey.
Goodwin vein	54.01	27.29	17.40	1.30	......	Do.
Gale vein	58.86	24.77	15.27	1.10	......	Do.
Kelly vein	48.14	32.06	18.61	1.19	......	Do.
"P" vein	60.38	29.09	9.37	1.16	......	Do.
"P" vein coke	84.49	5.52	7.85	2.14	......	Do.

WEST VIRGINIA.

Total production in 1886, 4,005,796 short tons; spot value, $3,805,506.

The general boundaries of the coal fields of the State have been briefly outlined by Mr. M. F. Maury in substance as follows:

The eastern boundary begins at the south, on the mountain just east of the Blue Stone river, and proceeds thence to Little Sewell mountain, on the top of which the lowest seam of the lowest coal measures may be seen; thence, but not by a very clearly defined line, with the common boundary of Nicholas and Greenbrier and Webster and Pocahontas counties to Rich mountain, in Randolph county; following this last-named ridge to Laurel mountain, the dividing line between Upshur county on the west and Randolph and Barbour counties on the east; and thence with the Briery mountain into Preston county, and so on to the Pennsylvania State line. To the east of this boundary there are small outlying patches of coal, as in Greenbrier county, in Meadow mountain, and possibly in Pocahontas county and in some of the synclinal valleys of Tucker county; but these patches are unimportant as compared to the vast area to the west, and in but few instances will they yield coal of any value except for local use. This statement will not, however, apply to the small area in Mineral and Grant counties, which is entirely separated by sub-Carboniferous outcrops from the main West Virginia coal field.

In every county west of this general eastern boundary to the Ohio river will valuable coal be found, if not outcropping in the hills, then below the surface and accessible by shafting, so that out of fifty-four counties in the State only Monroe, Pendleton, Hardy, Hampshire, Morgan, and Jefferson counties may be considered as lacking in workable coal beds.

For convenience of description the coal formation may be divided into five groups, as follows:

1. The Pottsville Conglomerate group is composed of alternating beds of conglomerate and sandstone, the former characterizing the group with beds of shale and slates, which contain in many places valuable workable coal beds. The thickness of the group varies from 100 to 1,000 feet.

2. The Lower Coal Measures, resting upon the great Millstone grit or Pottsville conglomerate series, containing very many important and valuable coal seams and having a thick series of sandstones, known as the Mahoning, capping the group.

3. The Lower Barren Measures, composed of reddish and blueish shales and slates, sandstones, and limestones—the latter in some parts of the State being very important—usually destitute of workable coal beds, and terminating above at the Pittsburgh coal bed.

4. The Upper Coal Measures, containing several important coal seams, of which the Pittsburgh or the Cumberland big seam lies at the base.

5. The Upper Barren Measures, composed of sandstones and shales, nearly destitute of workable coal beds.

The statistics of the State have been compiled from the report of Mr. H. J. Tucker, State inspector of mines. The State returns are made in long tons, and the statistics given below are given in short tons for more convenient comparison with the statistics in the adjoining States.

Kanawha county contains the greatest number of mines. The production of both coal and coke was largest in Fayette county.

These statistics are shown in the following table:

Statistics of coal production in West Virginia in 1886.

Counties.	Number of mines.	Production not coked.	Production coked.	Total production.	Production of coke.
		Short tons.	*Short tons.*	*Short tons.*	*Short tons.*
Brooke	3	22,880	....	22,880	....
Ohio, Marshall	13	251,333	....	251,333	....
Marion	7	163,475	8,904	172,379	5,600
Preston	3	88,603	82,118	170,721	51,647
Mineral	4	361,312	....	361,312	....
Tucker	2	22,400	....	22,400	....
Taylor, Harrison	7	191,924	42,673	234,597	26,838
Mason, Putnam	12	150,878	....	150,878	....
Kanawha	29	876,785	....	876,785	....
Fayette	27	1,141,410	272,368	1,413,778	171,301
Mercer	5	327,664	1,069	328,733	672
Total	112	3,598,664	407,132	4,005,796	(*a*) 256,058

a This amount differs slightly from that compiled by Mr. Weeks and given under coke, but the closeness of agreement between these independent estimates testifies to the value of both.—D. T. D.

The names of the individual collieries in each county, the number of employés, both inside and outside, the name of the coal bed mined at each colliery, with its thickness, the kind of coal produced, and the number of coke ovens attached to the different collieries where coke is manufactured, are all detailed in the following table:

Detailed statement of the collieries in West Virginia in 1886.

NORTHERN PART OF STATE.

Name of counties and collieries.	Employés. Inside.	Outside.	Total.	Name of coal bed.	Thickness of coal bed.	Kind of coal.	Number of coke ovens.
Brooke county.					Ft In.		
Wellsburg shaft	12	4	16	Pittsburgh	3 6	Steam	......
Wellsburg	23	5	28	....do	5 0	Gas	......
Coopers	16	2	18	....do	5 0	....do	......
Ohio county.							
Top mill	14	4	18	....do	......	....do	......
Fulton	13	......	13	....do	5 6	....do	......
Manchester	10	1	11	....do	5 0	....do	......
Whitaker	26	5	31	....do	5 0	....do	......
Crescent	13	1	14	....do	5 6	....do	......
Belmont	10	......	10	....do	5 0	....do	......
Riverside	11	1	12	....do	5 0	....do	......
La Belle	16	1	17	....do	5 0	... do	......
South Side	12	5	17	....do	5 6	....do	......
Elm Grove shaft	14	3	17	....do	5 0	....do	......
Marshall county.							
Bogg's Run	25	2	27	....do	5 6	....do	......
Benwood Iron Works	12	2	14	....do	5 6	....do	......
Moundsville shaft	80	6	86	....do	5 8	....do	......
Marion county.							
West Fairmount shaft	......	......	......	....do	9 0	....do	......
Central	14	2	16	....do	7 0	....do	10
Aurora	26	3	29	... do	7 0	....do	......
Montana	14	1	15	....do	7 0	....do	20
Palatine	39	6	45	....do	7 0	....do	......
Gaston	75	12	87	....do	8 0	....do	......
New England	......	......	......	....do	7 6	....do	......
Preston county.							
Irondale	36	4	40	Upper Freeport	4 6	Steam and coking	51
Mountain Brook shaft	53	18	71	....do	4 6	....do	33
Austen	48	4	52	....do	4 6	....do	65
Mineral county.							
Armstrong	86	12	98	Cumberland	14 0	Steam	......
Atlantic	100	10	110	... do	12 0	....do	......
Elk Garden, No. 1	161	33	194	....do	12 0	....do	......
Elk Garden, No. 2	58	7	65	....do	12 0	....do	......
Tucker county.							
Elk Garden, No. 4	......	......	......	......	......	......	......
Davis	23	4	27	......	4 10	......	......
Taylor county.							
Tyconnel, Nos. 1 and 2	60	16	76	Pittsburgh	9 0	Gas	25
Harrison county.							
Ocean	56	4	60	....do	9 0	....do	......
Despard	66	10	76	....do	9 0	....do	18
Harrison County	25	2	27	....do	9 0	....do	6
Pinnickinnick	42	1	43	....do	9 0	....do	......
Farland's	9	9	18	....do	9 0	....do	15
Welsonburg	25	15	40	....do	8 0	....do	30
Mason county.							
New Haven	41	8	49	....do	4 6	Steam	......
Hartford City	29	3	32	....do	4 6	....do	......
California	30	5	35	....do	4 10	....do	......
Seboh	33	7	40	....do	4 10	....do	......
Mosquito	19	1	20	....do	4 6	....do	......
German furnace	16	1	17	....do	4 6	....do	......
Hope	19	1	20	....do	4 8	....do	......
Sterling	......	......	......	....do	4 6	....do	......
Clifton	18	3	21	....do	4 6	....do	......
New Castle	......	......	......	....do	4 6	....do	......
Camden	50	12	62	....do	3 10	....do	......
Total	1,578	256	1,834	......	......	......	273

Detailed statement of the collieries in West Virginia in 1886—Continued.

SOUTHERN PART OF STATE.

Name of counties and collieries.	Employés. Inside.	Employés. Outside.	Employés. Total.	Name of coal bed.	Thickness of coal bed. Ft. In.	Kind of coal.	Number of coke ovens.
Putnam county.							
Energetic	18	3	21	Pittsburgh	4 6		
Star	175	10	185	do	5 6	Block	
Black Band	50	7	57	do	3 0	do	
Beane's	78	6	84	Campbell's Creek.	5 6	Splint	
Boyce	85	28	113	do	5 0	do	
Calderwood	108	21	129	do	4 0	do	
Kanawha county.							
Dana Brothers	81	22	103	do	4 0	do	
Pioneer No. 4	79	13	92	do	4 0	do	
Dickinson's	14	4	18	do	4 0	do	
Bennington				do	3 0		
Winifrede Nos. 1, 2, and 3	300	25	325	Winifrede	5 0	Splint	
Black Diamond	80	14	94	do	4 0	do	
Peerless	88	19	107	Peerless	2 6	Gas	
Stevens Coal Company	70	8	78	Winifrede	4 6	Splint	
Coalburg, Nos. 1 and 2	133	24	157	Coalburg	4 1	do	
North Coalburg	51	13	64		6 0	do	
Peabody	85	10	95	Coalburg	4 0	do	
Cedar Grove	62	10	72	Cedar Grove	3 4	Steam	
East Bank	36	6	42	Coalburg	4 2	Splint	
Blacksburg	36	5	41	Cedar Grove	2 10	Steam	
Kelly's Creek	36	9	45	do	2 10	do	
Crown Hill	105	15	120	Cannelton	4 0	Splint	
Wacomah	73	9	82	Coalburg	4 0	do	
Kanawha	114	13	127	Winifrede	4 0	do	
Union	70	15	85	do	5 6	do	
Cannel	109	32	141	Cannelton		Cannel	
Mount Morris	57	13	70	Coal Valley	5 6	Gas	
Excelsior	46	5	51	do	3 2	do	
Eureka	64	7	71	do	5 6	do	
Carver's	70	10	80	do	5 2	do	
Stranghaus	70	7	77	do	4 10	do	
Coal Valley	27	4	31	do	5 0	do	
Crescent	97	28	125	do	5 0	do	30
Faulkner's Nos. 1 and 2	103	8	111	do	5 0	Steam and coking.	
Eagle	110	10	120	Eagle	5 0	do	24
St. Clair	60	20	80	do	5 0	do	60
Fayette county.							
Powellton	42	35	77	Coal Valley	4 6	Gas and coking	100
Great Kanawha	68	26	94	do	4 6	do	36
Hawk's Nest	120	25	145	do	7 0	Steam and coking.	80
Gaymont	31	8	39	Sewell	3 0	do	32
Sunnyside	30	2	32	do	3 2	do	
Elmo	34	4	38	do	3 0	do	
Fayette	33	5	38	do	3 6	do	12
Nuttallburgh	81	42	123	do	3 9	do	61
Keeny's Creek	70	7	77	do	3 6	do	
Caperton	139	15	154	do	4 0	do	
New River	105	12	117	do	3 10	do	
Sewell Nos. 1 and 2	73	66	139	do	3 0	do	120
Fire Creek	150	38	188	Fire Creek	3 0	do	96
Echo	69	30	99	do	3 0	do	50
Stone Cliff Nos. 1 and 2	95	40	135	do	3 6	do	60
Beechwood				do	3 10	do	
Quinnimont	62	38	100	Quinnimont	2 8	do	82
Stirling No. 1	157	35	192	Pocahontas	8 0	do	
Stirling No. 2	35	14	49	do	8 0	do	28
Mercer county.							
Buckeye	54	9	63	do	6 0	do	10
Caswell	125	15	140	do	7 6	do	
Reliance	90	6	96	do	7 0	do	
Total	4,503	925	5,428				881
Total for State	6,081	1,181	7,262				1,154

The following statement of coal and coke shipped over the Chesapeake and Ohio railway from mines in West Virginia, during the year 1886, was furnished by General William C. Wickham, the second vice-president:

Coal shipments over the Chesapeake and Ohio Railway from West Virginia in 1886.

Kind of coal.	Short tons.
Cannel	17,407
Gas	348,942
Splint and block	200,580
New River, etc	619,586
Coke	185,255
Total	1,371,770

The output of coal along the Big Kanawha river has continued to increase year by year, until it has become a formidable rival in the lower markets of the Monongahela region in Pennsylvania. The building of the locks and dams along the river has caused the opening up of a number of new mines and the completion of No. 2 dam at Cannelton during the summer of 1887 will enable a number of large coal companies now shipping by rail to come into the river trade.

Mr. A. M. Scott, of Charleston, in charge of the Kanawha River improvements, furnishes the following official figures of the coal output for the years 1885–'86, ending June 1, from the 36 miles below the Kanawha falls, including the gas and splint coals: By river, 17,861,613 bushels; by rail, 13,953,745 bushels; total, 31,815,358 bushels. The shipments from the same district in 1880 were: By river, 9,628,696 bushels; by rail, 6,631,660 bushels; total, 16,260,356 bushels. Thus it will be seen last year shows an increased shipment over 1880 of 15,555,002 bushels.

The original plan in making the river improvements was to build locks and dams, as follows:

Dam No. 1 was to be up near the Kanawha falls, but it may not be built now, as it would not be of much use. No. 2 is at Cannelton and Coal Valley, 26½ miles above Charleston; the lock is about completed, and the work has been commenced on the dam. No. 3 at Paint creek is in operation; No. 4, at Cabin creek, is in operation; No. 5, at Brownstown, is in operation; No. 6, below Charleston, just about completed; No. 7 and No. 8, between Charleston and Point Pleasant, not yet commenced. The object of these improvements, begun several years ago by the United States Government, was to give a constant navigable depth of at least 6 feet throughout the whole length of the Kanawha to its mouth at the Ohio river, to be accomplished by large locks and dams. Those already built have been about 350 by 50 feet in the clear. The peculiarity of most of the dams is that they can be lowered when the stage of water in the river over the shoals will suffice. This gives them the name of "movable dams," and enables an open river to be had when the water is high enough, as is done by the Davis Island dam near Pittsburgh. Dams 3 and 4, both above Paint creek, are fixed, as the declivity of the river in that section is too great to permit the advantageous use of the movable system.

The following analyses of West Virginia coals and cokes are reproduced from various sources:

Analyses of West Virginia coals and cokes.

Name of coal and coke.	Fixed carbon.	Volatile matter.	Water.	Sulphur.	Ash.	Total.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Gaston coal	54.92	39.60	....	0.89	4.59	100
Clarksburg coal	41.66	56.74	....	....	1.60	100
Austen coal	66.28	31.12	0.12	....	2.48	100
Austen coke	90.56	....	.25	....	9.19	100
Elk Garden 14-foot bed coke	89.61	.86	.30	.94	8.24	99.95
Upper Potomac 15-foot bed coke	90.90	.82	.23	1.26	6.77	99.98
Kanawha and New River coals.						
Davis Creek	57.48	38.58	2.24	.45	1.70	100.45
Coalburg	62.00	32.50	4.00	.45	1.50	100.45
Cedar Grove	60.67	36.83	....	....	2.50	100
Coal Valley	61.60	35.20	1.32	.65	1.87	100.64
Hawk's Nest	65.99	32.61	1.45	.74	2.15	102.94
Nuttall	70.66	25.35	1.35	.53	2.10	99.99
Sewell	73.26	23.12	.81	.57	2.24	100
Fire Creek	75.499	22.425	.735	.536	.805	100
Quinnimont (lump)	79.25	18.65	.76	.46	1.11	100.23
Pocahontas (Flat top)	74.06	18.83	.69	.76	5.64	99.98
Kanawha and New River cokes.						
Davis Creek	93.88	1.14	....	.16	4.98	100.16
Great Kanawha	89.92	1.399	.076	.216	8.605	100.216
Nuttall	91.32	....	....	.92	7.53	99.77
Sewell	94.82	....	.28	.70	4.12	99.92
Fire Creek	91.940	.492	.102	.538	6.928	100
Quinnimont	93.85	....	....	.30	5.85	100
Pocahontas (Flat top)	92.095	.99	.54	.895	5.48	100

WYOMING.

Total production 1886, 829,355 short tons; spot value, $2,488,065.

The report for Wyoming Territory has been furnished by Mr. F. F. Chisolm, as follows:

The coal fields of the Territory are of great extent, but no systematic surveys have been made of all the areas which will permit of an estimate as to their size or the relative value of the beds which they contain. The existence of the coal deposits has been known since 1850, but no development of the beds was made until 1868, when the Union Pacific railroad was completed to Carbon, 100 miles west of Laramie. The coal is a typical lignite, and forms a desirable fuel for steam and domestic uses; it is, however, non-coking, and valueless for the manufacture of gas by the ordinary coal-gas process.

The following are analyses of specimens from three localities:

Analyses of coal from Wyoming.

Constituents.	Mines.			
	Almy.	Carbon No. 1.	Carbon No. 2.	Rock Springs.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Water	15.40	8.10	6.10	7.00
Volatile matter	33.90	34.70	38.80	36.81
Fixed carbon	44.78	51.65	49.30	54.46
Ash	5.92	5.55	5.80	1.73
Total	100.00	100.00	100.00	100.00

In speaking of the composition of the coals, Mine Inspector P. J. Quealey says: "The quality of Wyoming coals is demonstrated by the fact that our Rock Springs coal is sold in Colorado, where they boast of having a native supply of bituminous and anthracite coals, and also superior grades of lignites. Our coal is also sold as far east as Omaha, Nebraska, being transported over 400 miles to Colorado and over 800 miles to Omaha. According to the estimate we have about 6,800 square miles of coal. Even in its present primitive state of development coal mining is the chief industry and coal export the principal commodity of our Territory."

In 1886 there were practically no changes in the coal mining industry in this Territory. There were only insignificant troubles with miners, and these did not affect the output of the mines perceptibly. No new mines were opened, except that near the new town of Douglas, in eastern Wyoming. The production, aside from the regular shippers, is small, and its total amount can not be ascertained, since much of this coal is mined by ranchmen and others for their own use, and no record is kept of the number of tons taken out.

The production of the various mines in Wyoming from the time of opening to the close of 1886 is as follows:

Product of the Carbon mines, Wyoming.

Years.	Short tons.	Years.	Short tons.
1868	6,560	1878	62,418
1869	30,482	1879	75,424
1870	54,915	1880	100,433
1871	31,748	1881	156,820
1872	59,237	1882	200,123
1873	61,164	1883	248,380
1874	55,880	1884	319,883
1875	61,750	1885	226,863
1876	69,060	1886	214,233
1877	74,343		

Product of the Rock Spring mines, Wyoming.

Years.	Short tons.	Years.	Short tons.
1868	365	1878	154,282
1869	16,933	1879	193,252
1870	20,945	1880	244,466
1871	40,566	1881	270,425
1872	34,677	1882	287,510
1873	44,700	1883	304,[illegible]
1874	58,476	1884	318,197
1875	104,664	1885	328,[illegible]
1876	134,952	1886	359,234
1877	146,494		

Product of the Union Pacific mines at Almy, Wyoming.

Years.	Short tons.	Years.	Short tons.
1869	1,967	1878	59,096
1870	12,454	1879	71,576
1871	21,171	1880	100,234
1872	22,713	1881	110,157
1873	22,847	1882	117,211
1874	23,006	1883	111,713
1875	41,805	1884	150,880
1876	60,756	1885	164,441
1877	54,643	1886	155,547

Product of the Central Pacific mines at Almy, Wyoming.

Years.	Short tons.	Years.	Short tons.
1870	16,981	1879	60,739
1871	53,843	1880	82,684
1872	105,118	1881	90,779
1873	130,989	1882	94,965
1874	181,699	1883	78,450
1875	92,589	1884	68,471
1876	69,782	1885	70,216
1877	67,373	1886	100,341
1878	57,404		

The Twin Creek mine was worked for a short time only during 1885. The coal from this mine is much inferior to that from Rock Spring and Almy, containing large quantities of water and ash. The product at this mine has been as follows:

	Short tons.
1882	8,855
1883	36,651
1884	45,189
1885	17,207

RECAPITULATION.

Years.	Carbon.	Rock Spring.	Almy. Union Pacific mines.	Almy. Central Pacific mines.	Twin Creek.	Total.
	Short tons.	Short tons.	Short tons.	Short tons.	Short tons.	Short tons.
1868	6,560	365				6,925
1869	30,482	16,933	1,967			49,382
1870	54,915	20,945	12,454	16,981		105,295
1871	31,748	40,566	21,171	53,843		147,328
1872	59,237	34,677	22,713	105,118		221,745
1873	61,164	44,700	22,847	130,989		259,700
1874	55,880	58,476	23,006	81,699		219,061
1875	61,750	104,664	41,805	92,589		300,808
1876	69,060	134,952	60,756	69,782		334,550
1877	74,343	146,494	54,643	67,373		342,853
1878	62,418	154,282	59,096	57,404		333,200
1879	75,424	193,252	71,576	60,739		400,991
1880	100,433	244,460	100,234	82,684		527,811
1881	156,820	270,425	110,157	90,779		628,181
1882	200,123	287,510	117,211	94,065	8,855	707,764
1883	248,380	304,495	111,713	78,450	36,651	779,689
1884	319,883	318,197	150,880	68,471	45,189	902,620
1885	226,863	328,601	164,441	70,216	17,207	807,328
1886	214,233	359,234	155,547	100,341		829,355

The number of employés in the coal mines varies greatly from summer to winter. The greatest number of men employed is about 1,100. The wages paid vary from 90 cents to $1.10 per ton of coal. The value of the product of the Territory in 1886, at $3 per ton, is $2,488,065.

THE MANUFACTURE OF COKE.

By Jos. D. Weeks.

In this report, as in previous ones of the series, the word "coke" is used to denote that coke made from bituminous coal in ovens, pits, ricks, or "on the ground," and which, for convenience, may be termed "oven coke." Except in one paragraph, which will have its appropriate heading, the statistics and statements in no way refer to that other commercial coke, which is a residual or by-product of the manufacture of illuminating gas, and which may be termed "gas coke."

The unit of quantity throughout this chapter is the short ton of 2,000 pounds. The year, unless otherwise stated, is the calendar year ending December 31.

Statistics of the production of coke in the United States in 1886.—In the following table are consolidated by States and Territories the statistics of the production of coke in the United States for the year 1886:

Statistics of the manufacture of coke in the United States arranged by States and Territories, in 1886.

States and Territories.	Number of establishments.	Ovens, December 31.		Coal used.	Coke produced.	Yield of coal in coke.	Total value of coke.	Value coke per ton.
		Built.	Building.					
				Tons.	*Tons.*	*Per ct.*		
Alabama	14	1,301	1,012	635,120	375,054	59	$993,302	$2.65
Colorado	7	483	0	228,060	142,797	62.6	569,120	3.99
Georgia	2	300	0	136,133	82,680	60	179,031	2.17
Illinois	9	335	0	17,806	8,103	46	21,487	2.65
Indiana	4	100	18	13,030	6,124	47	17,953	2.93
Indian Territory	1	40	0	10,242	6,351	62	22,229	3.50
Kansas	4	36	0	23,062	12,493	54.2	19,204	1.54
Kentucky	6	76	2	9,055	4,528	50	10,082	2.23
Montana	4	16	0	0	0	0	0	0
New Mexico	2	70	0	18,194	10,236	56	51,180	5.00
Ohio	15	560	0	59,332	34,932	59	94,042	2.69
Pennsylvania	108	16,314	2,558	8,290,849	5,406,597	65.2	7,664,023	1.42
Tennessee	12	1,485	126	621,669	368,139	59	687,865	1.87
Texas	1	0	0	0	0	50	0	0
Utah	1	20	0	0	0	0	0	0
Virginia	2	350	100	200,018	122,352	61.1	305,880	2.50
Washington	1	11	21	1,400	825	58.7	4,125	5.00
West Virginia	29	1,100	317	425,002	264,158	62	513,843	1.94
Total	222	22,597	4,154	10,688,972	6,845,369	64	11,153,366	1.63

From the above table it will appear that by far the largest proportion of the coal manufactured into coke in the United States comes from the various Coal Measures of the Appalachian basin, and, as an analysis of the statistics of the different districts will show, chiefly from the great Pittsburgh coal bed. Of the 10,688,972 tons of coal burned into coke in the United States in 1886 but 320,849 tons, or 3 per cent., were from other coal fields. Of this 320,849 tons, 246,254 tons were from the coal fields of Colorado and New Mexico; 33,304 tons were from the Missouri basin, which would include the coal used in Kansas and the Indian Territory; 26,861 tons were from the Illinois fields, including that used in Illinois and western Kentucky; 13,030 tons were from the Indiana Coal Measures, and 1,400 tons from Washington Territory. It will also appear from this statement that all of the coal used in the manufacture of coke in the United States, with the exception of, roundly, 75,000 tons, came from the Appalachian and Colorado coal fields; the measures of the extensive coal fields in the great valley of the Mississippi, outside of the fields along the base of the mountains, furnished but 74,595 tons of coal to be burned into coke in the year 1886.

As noted above, most of the coal burned into coke in the United States came from the great Pittsburgh coal bed. This includes all that was burned in the Connellsville district, 6,305,460 tons; all in the Upper Connellsville district, 681,985 tons; all in the Pittsburgh district, 228,874 tons; a total in these districts alone of 7,216,319, or nearly 68 per cent. of all of the coal coked. Ranking next to this is the Pratt seam in Alabama, most of the 635,120 tons of coal coked in that State being from this seam. Third in point of consumption in the manufacture of coke is the Sewanee seam of Tennessee, and fourth the New River coking coal of West Virginia.

In production of coke Pennsylvania still outranks all of the other States, by producing 5,406,597 tons, or nearly 79 per cent. of the 6,845,369 tons produced in the United States in 1886. As will also appear from an examination of the details of the manufacture of coke in this State, at least two of the coking districts into which it is divided, the Connellsville and the Upper Connellsville, produced more coke than any State except Pennsylvania. In the Connellsville district 4,180,521 tons of coke were produced in 1886; in the Upper Connellsville, 422,968 tons.

The above table also indicates considerable activity at the close of the year in the extension of coke plants, the number of ovens building being 4,154, equal to one-fifth of the number of ovens built at the close of 1886. Of building ovens about 62 per cent. were in Pennsylvania and 24 per cent. in Alabama. Since the close of the year, especially in Alabama, West Virginia, and some parts of Pennsylvania, quite a number of new coke works have been begun and extensions have been undertaken at old establishments, so that the year 1887 promises to be the year of the largest extension of ovens in the history of the coking industry in the United States.

Statistics of coking in the United States, 1880 *to* 1886.—In the following table are consolidated the statistics of coking in the United States for the years 1880 to 1886. These relate not only to the production and value of coke, but also to the consumption of coal and its percentage yield in coke, as well as to the number of establishments making coke and the number of ovens built and building at the close of each year.

Statistics of the manufacture of coke in the United States, 1881 *to* 1886 *inclusive.*

	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	197	215	231	250	233	222
Ovens built	14,119	16,356	18,304	19,557	20,116	22,597
Ovens building	1,005	712	407	812	432	4,154
Coal used, short tons	6,546,662	7,577,648	8,516,670	7,951,974	8,071,126	10,688,972
Coke produced, short tons	4,113,760	4,793,321	5,464,721	4,873,805	5,106,696	6,845,369
Total value of coke at ovens	$7,725,175	$8,462,167	$8,121,607	$7,242,878	$7,629,118	$11,153,366
Value of coke at ovens, per ton	$1.88	$1.77	$1.49	$1.49	$1.49	$1.63
Yield of coal in coke, per cent	63	63	64	61	63	64

From this table it appears that the number of establishments in the United States has decreased in the past year from 233 in 1885 to 222 in 1886. This decrease is more apparent than real, it being due to the consolidation of several establishments under one management. As compared with previous years there has really been, on the basis of making returns in previous years, an increase.

The number of ovens built has increased from 20,116 in 1885 to 22,597 in 1886; the production of coke from 5,106,696 tons in 1885 to 6,845,369 tons in 1886. The coal consumed in the manufacture of coke increased from 8,071,126 tons in 1885 to 10,688,972 tons in 1886; the total value of the coke from $7,629,118 to $11,153,366, and the value per ton from $1.49 to $1.63. With the exception of the number of establishments and the value of the coke per ton at the ovens, the figures relative to the manufacture of coke in 1886 are in excess of those of any previous year. Measured by total production, the year 1883 was the most important of any prior to 1886. In that year there were produced 5,464,721 tons of coke, as against 6,845,369 tons in 1886.

In the seven years covered by the report, the number of ovens has increased from 12,372 to 22,597, or nearly 83 per cent.; the coke produced from 3,338,300 tons to 6,845,369 tons, or more than 100 per cent.; the value of the coke, however, has not increased in as great ratio, that produced in 1880 being worth $6,631,267, or $1.99 a ton, while that produced in 1886 was worth $11,153,366, or $1.63 a ton.

Total number of coke works in the United States.—The following table gives the total number of establishments manufacturing coke in the United States for each year from 1880 to 1886:

Number of establishments in the United States manufacturing coke from 1880 *to* 1886.

States and Territories.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Alabama	(a) 4	4	5	6	8	11	14
Colorado	1	2	5	7	8	7	7
Georgia	1	1	1	1	1	2	2
Illinois	6	6	7	7	9	9	9
Indiana	2	2	2	2	2	2	4
Indian Territory	1	1	1	1	1	1	1
Kansas	2	3	3	4	4	4	4
Kentucky	5	5	5	5	5	5	6
Montana	0	0	0	1	3	2	4
New Mexico	0	0	2	2	2	2	2
Ohio	15	15	16	18	19	13	15
Pennsylvania	124	132	137	140	145	133	108
Tennessee	6	6	8	11	13	12	12
Texas	0	0	0	0	0	0	1
Utah	1	1	1	1	1	1	1
Virginia	0	0	0	1	1	1	2
Washington	0	0	0	0	1	1	1
West Virginia	18	19	22	24	27	27	29
Total	186	197	215	231	250	233	222

a The number of establishments on December 31, of each year.

From the above table it will be seen that the falling off in the total number of works that was noted in 1885 as compared with 1884 has continued in 1886, though, as is explained elsewhere, this is more apparent than real. This falling off is entirely in Pennsylvania, the number of establishments reported in 1885 being 133, and in 1886 but 108, every other State showing either the same number of establishments as in 1885 or an increase. Owing to the consolidation of works in Pennsylvania, especially in the Connellsville region, under one ownership, it was found exceedingly difficult to secure a report of the number of distinct banks of ovens, and hence, so far as the Connellsville region is concerned, all the contiguous works owned by one party are regarded as a single establishment.

The number of establishments in the country for the years since 1850, for which there are any returns, is as follows:

Number of coke establishments in the United States since 1850.

Years.	Number.	Years.	Number.
1850 (census year)	4	1882, December 31	215
1860 (census year)	21	1883, December 31	231
1870 (census year)	25	1884, December 31	250
1880 (census year)	149	1885, December 31	233
1880, December 31	186	1886, December 31	222
1881, December 31	197		

Total number of coke ovens in the United States.—The following table gives the total number of coke ovens in the United States on December 31 of each of the years from 1880 to 1886, and also their distribution by States and Territories. In addition to the coke made in ovens, some has been made in pits and on the ground, but as the number of pits varies greatly at different times no attempt has been made to give their total number. The reports also show that much less "pit coke" was made in 1886 than in any of the previous years for which reports are given.

Number of coke ovens in the United States on December 31 *of each of the years from* 1880 *to* 1886.

States and Territories.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Alabama	316	416	536	767	976	1,075	1,301
Colorado	200	267	344	352	409	434	483
Georgia	140	180	220	264	300	300	300
Illinois	176	176	304	316	325	320	335
Indiana	45	45	37	37	37	37	100
Indian Territory	20	20	20	20	20	40	40
Kansas	6	15	20	23	23	23	36
Kentucky	45	45	45	45	45	33	76
Montana	0	0	0	2	5	2	16
New Mexico	0	0	0	12	70	70	70
Ohio	616	641	647	682	732	642	560
Pennsylvania	9,501	10,881	12,424	13,610	14,285	14,553	16,314
Tennessee	656	724	861	992	1,105	1,387	1,485
Texas	0	0	0	0	0	0	0
Utah	20	20	20	20	20	20	20
Virginia	0	0	0	200	200	200	350
Washington	0	0	0	0	0	2	11
West Virginia	631	689	878	962	1,005	978	1,100
Total	12,372	14,119	16,356	18,304	19,557	20,116	22,597

With four exceptions, which are of but little importance, there was an increase in the number of ovens in each State at the close of 1886, as compared with December 31, 1885, the number of ovens increasing from 20,116 in 1885 to 22,597 in 1886, an increase of a little over 12 per cent. In 1885 but three States, Pennsylvania, Tennessee and Alabama, had over 1,000 ovens; West Virginia, which had, in 1884, 1,005, falling below 1,000 in 1885. In 1885, however, the number of ovens increased to 1,100, making this State the fourth as regards the number of ovens, the rank of the four States being in this respect, Pennsylvania first, with 16,314 ovens, or 72 per cent. of the total; Tennessee second, with 1,485 ovens, or 6.6 per cent. of the total; Alabama third, with 1,301 ovens, or 6 per cent. of the total, and West Virginia fourth, with 1,100 ovens, or 5½ per cent. of the total. Most of the ovens in the United States are of the beehive or solid wall type, by far the larger number being of the regular beehive shape. Others are a modified form of the beehive or solid wall oven, the oven being long or muffle-shaped. The Belgian or retort oven meets with little or no favor in the United States. But one works, that of the Cambria Iron Company, at East Conemaugh, where coke is made for use in the manufacture of spiegeleisen, uses the Belgian oven now from choice. At the works at Pittsburgh, at which a most careful and extended series of experiments was made to test the value of retort ovens in coking Pittsburgh coal, the experiments have been definitely abandoned, the retort ovens are torn down, and beehive ovens substituted. In the Broad Top region of Pennsylvania there are Belgian ovens in which coke was made in 1886, but the proprietors of the works at which these ovens are situated, having decided to extend their works, are building beehive ovens. As stated in the last volume of Mineral Resources of the United States, the retort oven of the Soldenhoff-Coppeè type is looked upon with favor for coking certain West Virginia coals.

There are no ovens in the United States for utilizing the by-products or residuals of the coking process, though some experiments in this direction have been made with Connellsville coal and others are in progress with Pittsburgh coal. It is also stated that some ovens on the Hall plan are to be built near Chicago. It is believed, however, that the first cost of the ovens, as well as the cost of repairs, is too great to lead at present to the adoption of these ovens in the American coke fields.

Number of ovens building in the United States.—In the following table is given the number of ovens that were actually in course of construction in the United States at the close of each of the years from 1880 to 1886:

Number of coke ovens building in the United States at the close of each of the years from 1880 *to* 1886.

States and Territories.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Alabama	100	120	0	122	242	16	1,012
Colorado	50	0	0	0	24	0	0
Georgia	40	40	44	36	0	0	0
Illinois	0	0	0	0	0	0	0
Indiana	0	0	0	0	0	0	18
Indian Territory	0	0	0	0	0	0	0
Kansas	0	0	0	0	0	0	0
Kentucky	0	0	0	0	0	0	2
Montana	0	0	0	0	12	0	0
New Mexico	0	0	12	28	0	0	0
Ohio	25	0	0	0	0	0	0
Pennsylvania	836	761	642	211	232	317	2,558
Tennessee	68	84	14	10	175	36	126
Utah	0	0	0	0	0	0	0
Virginia	0	0	0	0	0	0	100
Washington	0	0	0	0	0	0	21
West Virginia	40	0	0	0	127	63	317
Total	1,159	1,005	712	407	812	432	4,154

There is no attempt in this table to indicate the increase in the total number of ovens during the year. This is shown under the previous sub-title, "Total number of coke ovens in the United States." In this table is given only the number of ovens reported as being in course of construction at the close of 1886. As compared with 1885 the total number of ovens in course of construction at the close of 1886 is ten times greater. Every State that has any prominence in coke manufacture, or in which there is any promise that the industry will assume any importance, had ovens in course of construction at the close of 1886, while but four, and those the chief coke producing States, Pennsylvania, Alabama, Tennessee, and West Virginia, had ovens building at the close of 1885. The number in course of construction at the close of 1886 is also four times greater than the number building at the close of any previous year covered by the above table. Of the ovens building, as noted elsewhere, 2,558, or 63 per cent., are in Pennsylvania, and 1,012, or 25 per cent., in Alabama. The close of 1887 will find a large increase in the number of coke ovens built in the United States.

Total production of coke in the United States.—The production of coke in the United States for the years 1880 to 1886, inclusive, was as follows:

Amount of coke produced in the United States, 1880 *to* 1886 *inclusive, by States and Territories.*

States and Territories.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
Alabama	60, 781	109, 033	152, 940	217, 531	244, 009	301, 180	375, 054
Colorado	25, 568	48, 587	102, 105	133, 997	115, 719	131, 960	142, 797
Georgia	38, 041	41, 376	46, 602	67, 012	79, 268	70, 609	82, 680
Illinois	12, 700	14, 800	11, 400	13, 400	13, 095	10, 350	8, 103
Indiana	0	0	0	0	0	0	6, 124
Indian Territory	1, 546	1, 768	2, 025	2, 573	1, 912	3, 584	6, 351
Kansas	3, 070	5, 670	6, 080	8, 430	7, 190	8, 050	12, 493
Kentucky	4, 250	4, 370	4, 070	5, 025	2, 223	2, 704	4, 528
Montana	0	0	0	0	75	175	0
New Mexico	0	0	1, 000	3, 905	18, 282	17, 940	10, 236
Ohio	100, 596	119, 469	103, 722	87, 834	62, 709	39, 416	34, 932
Pennsylvania	2, 821, 384	3, 437, 708	3, 945, 034	4, 438, 464	3, 822, 128	3, 991, 805	5, 406, 597
Tennessee	130, 609	143, 853	187, 695	203, 691	219, 723	218, 842	368, 139
Utah	1, 000	0	250	0	0	0	0
Virginia	0	0	0	25, 340	63, 600	49, 139	122, 352
Washington	0	0	0	0	400	311	825
West Virginia	138, 755	187, 126	230, 398	257, 519	223, 472	260, 571	264, 158
Total	3, 338, 300	4, 113, 760	4, 793, 321	5, 464, 721	4, 873, 805	5, 106, 696	6, 845, 369

The maximum production of coke in the United States was reached in 1886, it being 6,845,369 tons, as compared with 5,464,721 tons in 1883, the year of the largest production prior to 1886. The production of 1885 was 5,106,696 tons, or 1,738,673 tons less than in 1886.

Pennsylvania still retains its supremacy as the great coke-producing State of the Union. The production of the State in 1884 was 78.4 per cent. of the total production of the country; in 1885 it was 78.2 per cent., while in 1886 it had risen to 79 per cent.

The following table gives the relative rank of the States and Territories in the production of coke in 1884, 1885, and 1886:

Rank of the States and Territories in production of coke in 1884, 1885, *and* 1886.

States and Territories.	1884.	1885.	1886.	States and Territories.	1884.	1885.	1886.
Pennsylvania	1	1	1	New Mexico	9	9	10
Alabama	2	2	2	Illinois	10	10	11
West Virginia	3	3	4	Kansas	11	11	9
Tennessee	4	4	3	Indiana	......	......	13
Colorado	5	5	5	Kentucky	12	13	14
Georgia	6	6	7	Indian Territory	13	12	12
Virginia	7	7	6	Washington	14	14	15
Ohio	8	8	8	Montana	15	15	......

The changes as compared with 1885 are as follows: West Virginia and Tennessee have exchanged places, Tennessee now being third and West Virginia fourth. Georgia has dropped from sixth to seventh, and Virginia risen from seventh to sixth; New Mexico has dropped from ninth to tenth; Illinois has dropped from tenth to eleventh, and Kansas risen from eleventh to ninth; Indiana, which made no coke in 1884 or 1885, ranks thirteenth, and Kentucky has dropped from thirteenth to fourteenth; Washington Territory drops to fifteenth, and Montana leaves the list of producers.

Value and average selling price of coke.—In the following table is given the total value of coke produced in the United States for each of the years from 1880 to 1886:

Total value at the ovens of the coke made in the United States in the years from 1880 *to* 1886, *by States and Territories.*

States and Territories.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Alabama	$183,063	$326,819	$425,940	$598,473	$609,185	$755,645	$993,302
Colorado	145,226	267,156	476,665	584,578	409,930	512,162	569,120
Georgia	81,789	88,753	100,194	147,166	169,192	144,198	179,031
Illinois	41,950	45,850	29,050	28,200	25,639	27,798	21,487
Indiana	0	0	0	0	0	0	17,953
Indian Territory	4,638	5,304	6,075	7,719	5,736	12,902	22,229
Kansas	6,000	10,200	11,460	16,560	14,580	13,255	19,204
Kentucky	12,250	12,630	11,530	14,425	8,760	8,499	10,082
Montana	0	0	0	0	900	2,063	0
New Mexico	0	0	6,000	21,478	91,410	89,700	51,180
Ohio	255,905	297,728	266,113	225,660	156,294	109,723	94,042
Pennsylvania	5,255,042	5,898,579	6,133,698	5,410,387	4,783,230	4,981,656	7,664,023
Tennessee	316,607	342,585	472,505	459,126	428,870	398,459	687,865
Utah	10,000	0	2,500	0	0	0	0
Virginia	0	0	0	44,345	111,300	85,993	305,880
Washington	0	0	0	0	1,900	1,477	4,125
West Virginia	318,797	429,571	520,437	563,490	425,952	485,588	513,843
Total	6,631,267	7,725,175	8,462.167	8,121,607	7,242,878	7,629,118	11,153,366

While this table gives the totals of the values as returned in the schedules, the figures do not always represent the same thing. A statement as to the actual selling price of coke at the ovens was asked for, and in most cases, including, possibly, 80 per cent. of all the coke produced, the figures are actual selling prices. In some cases, however, the value is an estimate. Considerable of the coke made in the United States is produced by the proprietors of blast furnaces for consumption in their own furnaces, none being sold. The value, therefore, given for this coke would be an estimate based, in some instances, where there are coke works in the neighborhood selling coke for the general market, upon the prices obtained for this coke. In other cases the value is estimated at the actual cost of coke at the furnace, plus a small percentage for profit on the coking operation, while in still other cases the value given is only the actual cost of the coke at the ovens.

The preceding table gives the total value of the coke by States and Territories and also for the United States. In the following table is given the average value per short ton:

Average value per short ton at the ovens of the coke made in the United States in the years from 1880 *to* 1886, *by States and Territories.*

States and Territories.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Alabama	$3 01	$3 00	$2 79	$2 75	$2 50	$2 50	$2 65
Colorado	5 68	5 29	4 67	4 36	3 45	3 88	3 99
Georgia	2 15	2 15	2 15	2 20	2 13	2 04	2 17
Illinois	3 30	3 10	2 55	2 10	1 96	2 68	2 65
Indiana	0	0	0	0	0	0	2 93
Indian Territory	3 00	3 00	3 00	3 00	3 00	3 60	3 50
Kansas	1 95	1 80	1 70	1 96	2 02	1 65	1 54
Kentucky	2 88	2 89	2 83	2 87	3 94	3 14	2 23
Montana	0	0	0	0	12 00	11 72	0
New Mexico	0	0	6 00	5 50	5 00	5 00	5 00
Ohio	2 54	2 49	2 57	2 57	2 49	2 78	2 69
Pennsylvania	1 86	1 70	1 55	1 22	1 25	1 25	1 42
Tennessee	2 42	2 33	2 52	2 25	1 95	1 31	1 87
Utah	10 00	0	10 00	0	0	0	
Virginia	0	0	0	1 75	1 75	1 75	2 50
Washington	0	0	0	0	4 75	4 75	5 00
West Virginia	2 30	2 30	2 26	2 19	1 19	1 86	1 94
Total average	1 99	1 88	1 77	1 49	1 49	1 49	1 63

It will be noted that for the first time in four years there has been an increase in the average value of the coke produced, the years 1883, '84, and '85 showing the same average value, $1.49 a ton, and the average value in 1886 being $1.63 a ton. It seems hardly necessary to say that this average value is obtained, not by taking the average of the prices given in this table, but by dividing the total value of the coke produced by the total number of tons of coke; in other words, the $1.63 is a true average price, not an average of prices.

Amount of coal consumed in the manufacture of coke.—In the following table is given the total number of tons of coal which entered into the manufacture of coke in the United States for the years from 1880 to 1886. In this statement is included all of the coal charged into the ovens, without any reference to its condition when so charged. A large proportion of the coal used is "run of the mine"; that is, all of the coal as it comes from the pit—lump, nut, and slack—is charged without screening into the ovens, the coal in these cases being mined only for the purpose of being made into coke. This is especially true of the Connellsville, the Allegheny Mountain, and the Reynoldsville-Walston districts in Pennslyvania, the New River district in West Virginia, and the Warrior district in Alabama, as well as several others. On the other hand, a large amount of coking, as will appear from the statement made in connection with the industry in different districts, is for the purpose of utilizing the slack coal produced in mining. This is true of the Pittsburgh district in Pennsylvania, as well as of many of the localities producing but a small amount of coke. It is not found practicable, however, as suggested above, to distinguish between the coal which was used as "run of the mine" and that which was used as "slack."

Amount of coal used in the manufacture of coke in the United States from 1880 *to* 1886, *by States and Territories.*

States and Territories.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
Alabama	106, 283	184, 881	261, 839	359, 699	413, 184	507, 934	635, 120
Colorado	51, 891	97, 508	180, 549	224, 089	181, 968	208, 069	228, 060
Georgia	63, 402	68, 960	77, 670	111, 687	132, 113	117, 781	136, 133
Illinois	31, 240	35, 240	25, 270	31, 370	30, 168	21, 487	17, 806
Indiana	0	0	0	0	0	0	13, 030
Indian Territory	2, 494	2, 852	3, 266	4, 150	3, 084	5, 781	10, 242
Kansas	4, 800	8, 800	9, 200	13, 400	11, 500	15, 000	23, 062
Kentucky	7, 206	7, 406	6, 906	8, 437	3, 451	5, 075	9, 055
Montana	0	0	0	0	165	300	0
New Mexico	0	0	1, 500	6, 941	29, 990	31, 889	18, 194
Ohio	172, 453	201, 145	181, 577	152, 502	108, 164	68, 796	59, 332
Pennsylvania	4, 347, 558	5, 393, 503	6, 149, 179	6, 823, 275	6, 204, 604	6, 178, 500	8, 290, 849
Tennessee	217, 656	241, 644	313, 537	330, 961	348, 295	412, 538	621, 669
Utah	2, 000	0	500	0	0	0	0
Virginia	0	0	0	39, 000	99, 000	81, 899	200, 018
Washington	0	0	0	0	700	544	1, 400
West Virginia	230, 758	304, 823	366, 653	411, 159	385, 588	415, 533	425, 002
Total	5, 237, 741	6, 546, 762	7, 577, 646	8, 516, 670	7, 951, 974	8, 071, 126	10, 688 972

The amount of coal necessary to produce a ton of coke in 1886 was 1.55 tons, or 3,100 pounds; in 1885, 1.58 tons, or 3,160 pounds; in 1884, 1.63 tons, or 3,260 pounds.

Yield of coal in coke.—The table given below shows the average yield of the coal coked in the United States for the seven years covered by this report. By the yield is meant the percentage of the constituents of the coal that remained in the coke after the process of coking.

Percentage yield of coal in the manufacture of coke in the United States in the years 1880 *to* 1886, *by States and Territories.*

States and Territories.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Alabama	57	59	58	60	60	59	59
Colorado	49	50	57	60	64	63	62. 6
Georgia	60	60	60	60	60	60	60
Illinois	41	42	45	43	43	48	46
Indiana	0	0	0	0	0	0	47
Indian Territory	62	62	62	62	62	62	62
Kansas	64	64. 4	65	62. 9	62¼	53⅔	54. 2
Kentucky	60	60	59	60	64	53	50
Montana	0	0	0	0	46	58½	0
New Mexico	0	0	66⅔	57¼	57½	56¼	56
Ohio	58	59	57	58	58	57	59
Pennsylvania	65	64	64	65	62	64. 6	65. 2
Tennessee	60	60	60	62	63	53	59
Texas	....	....	....	....	....	....	50
Utah	50	0	50	0	0	0	0
Virginia	0	0	0	64½	64¼	60	61. 1
Washington	0	0	0	0	57½	57	58. 7
West Virginia	60	61	63	63	62	63	62
Total average	63	63	63	64	61	63	64

Some of the percentages of this table are in part estimates. As has been stated, a great deal of the coal coked is slack, and this is frequently charged into the ovens without weighing. In such cases only an estimate of the amount used could be given.

There has been an increase of 1 per cent. in the average yield of coal in coke in 1886, as compared with 1885; that is, the yield in 1885 was 63 per cent., and in 1886, 64 per cent. This is due chiefly to the reported increased yield in Pennsylvania. Attention was called in the report for 1884 to the fact that the apparent yield of coal in coke in Pennsylvania dropped suddenly from 65 per cent. in 1883 to 62 per cent. in 1884. This was manifestly an error. As the yield in all of the years prior to 1884 was not less than 64 per cent., and was in one case 65 per cent., it was assumed that the real yield in Pennsylvania in 1884 should be 64 per cent. The reported yield of coal in coke in Pennsylvania in 1886 fully justifies this belief, it being 65.2 per cent. as compared with 64.6 in 1885. There is considerable question as to the accuracy of the figures for yield. It is believed, however, that each year, especially in the large coking districts, the figures are approaching substantial accuracy, and in view of the fact that greater care is being paid, especially in the Connellsville region, to measuring and weighing the coal, it is believed that the report for 1887 will be, so far as Pennsylvania is concerned, substantially correct, and as so much of the coke made in the country is produced in this State, the figures of yield for the United States will be quite reliable.

Imports and exports of coke.—The following table gives the amount of coke imported and entered for consumption in the United States from 1869 to 1886 inclusive. In the statement is included not only that entered for consumption, but the withdrawals from warehouse for consumption. The years are the Government fiscal years ending June 30. In the reports of the Treasury Department the quantities are long tons. These have been reduced to short tons to make the table commensurate with the other tables in this chapter:

Coke imported and entered for consumption in the United States, 1869 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Quantity.	Value.	Fiscal years ending June 30—	Quantity.	Value.
	Short tons.			*Short tons.*	
1869	....	$2,053	1878	6,616	$24,186
1870	....	6,388	1879	6,035	24,748
1871	....	19,528	1880	5,047	18,406
1872	9,575	9,217	1881	15,210	64,987
1873	1,091	1,366	1882	14,924	53,244
1874	634	4,588	1883	20,634	113,114
1875	1,046	9,648	1884	14,483	36,278
1876	2,065	8,657	1885	20,876	64,814
1877	4,068	16,686	1886	27,222	78,678

The imported coke goes chiefly to the Pacific coast, where it is mainly used in smelting argentiferous lead ores. The coke so imported is almost entirely English and Welsh. Some coke from Nova Scotia is also imported into New England.

The export of coke, which, as will be seen from the table, has always been insignificant, ceased entirely in 1886. What proportion, if any, of the amounts shown in the table, is the value of foreign coke re-exported, is not known;

Value of coke exported from the United States, 1882 *to* 1886 *inclusive.*

Fiscal years ending June 30.	Value.
1882	$1, 123
1883	3, 281
1884	4, 042
1885	5, 062
1886	0

ALABAMA.

The recent remarkable developments of the blast-furnace industry in Alabama will necessarily have an important influence upon the coke industry of that State. Though with scarcely an exception the new blast furnaces under construction are being built to use coke as a fuel, they were not so far advanced at the close of 1886 as to materially affect the coke statistics for that year, with the exception of the number of ovens building at its close. On December 31, 1885, there were 1,075 ovens built and but 16 building. At the close of 1886 the number of ovens built had increased but 226, the total being 1,301; but the number of ovens building had increased from 16 at the close of 1885 to 1,012 at the close of 1886.

Indeed, the notable feature of the report of the coking operations in this State for 1886 is this number of ovens building at the close of the year, the number being but 281 less than the total number of ovens built in the State at the same date. The number contracted for and under construction in 1887 would very materially increase the number building, making the number in course of construction April 1, 1887, very much in excess of the number built December 31, 1886.

Of the 1,301 ovens built at the close of 1886, 1,080 are in the Warrior field, 150 in the Cahaba district, and 71 in the Coosa. All of the 1,012 ovens reported as building on December 31, 1886, are in the Warrior district. As compared with the close of 1885, there has been an increase during the year 1886 of 166 ovens in the Warrior district, 50 in the Cahaba field, and 10 in the Coosa district. Most of the ovens are beehive. At the works of the Woodward Iron Company there are 80 known as the "cylinder," and at the works of the Saint Clair Coal Company, at Ragland, in the Coosa district, there are 10 Thomas ovens. The 100 ovens of the Pratt Coal and Iron Company, at Helena, were idle the entire year. Every other coke works in the State was in operation at least some part of the year, with the exception of that of the Cahaba Coal Mining Company, at Blockton, which has never had any ovens, but has made coke on the ground when in operation.

The total production of coke in Alabama in 1886 was 375,054 tons, as compared with 301,180 tons in 1885, an increase of 73,874 tons, or 24½ per cent. Of this, 336,054 tons, or nearly 90 per cent., were produced in the Warrior district.

There were used in the production of these 375,054 tons of coke 635,120 tons of coal, the yield of coal in coke at the various establishments ranging from 55 per cent. to 66⅔ per cent., the average yield being 59 per cent.

The total value of the coke at the works was \$993,302, an average of \$2.65 a ton, the value at the different works ranging from \$2.40 to \$2.75.

The following are the statistics of the manufacture of coke in Alabama from 1880 to 1886:

Statistics of the manufacture of coke in Alabama, 1880 *to* 1886.

	1880.	1881.	1882,	1883.	1884.	1885.	1886.
Number of establishments...	4	4	5	6	8	11	14
Ovens built	316	416	536	767	(a)976	(a)1,075	(a)1,301
Ovens building..............	100	120	....	122	242	16	1,012
Coal used, short tons	106,283	184,881	261,839	359,699	413,184	507,934	635,120
Coke produced, short tons ...	60,781	109,033	152,940	217,531	244,009	301,180	375,054
Total value of coke at ovens.	\$183,063	\$326,819	\$425,940	\$598,473	\$609,185	\$755,645	\$993,302
Value of coke at ovens, per ton	\$3.01	\$3.00	\$2.79	\$2.75	\$2.50	\$2.50	\$2.65
Yield of coal in coke, per cent.	57	59	58	60	60	59	59

a One establishment made coke on the ground.

As in previous years, the chief supply of coal for coking was obtained from the Pratt seam of the Warrior field, nearly all of the 574,120 tons of coal which were made into coke in the Warrior district being from this seam. At New Castle, in Jefferson county, coal from what is known as the "New Castle seam" is coked, but the proportion of coke made from the coal of the other seams of the Warrior field which are known to possess good coking qualities is small. About 80 per cent. of the coke used at the furnaces in the neighborhood of Birmingham is from the Pratt mines. The Woodward Iron Company, the largest producers of coke in 1886 outside of establishments furnished with coal from the Pratt mines, is mining coal on its own property a few miles south of Birmingham, but from the same seam which is worked at the Pratt mines. This seam, as described in the recent report by Mr. E. V. d'Invilliers on the cokes of this district, varies from 4 feet 6 inches to 5 feet 6 inches in thickness, but rarely averages over 4½ feet. It carries a 2 to 3 inch slate parting at about 7 inches from the top which is everywhere persistent. The yield of the seam averages about 4,000 tons to an acre of merchantable coal. Only the nut and slack, constituting about 66⅓ per cent. of the yield of the mines, are utilized at the ovens. The Pratt company furnishes considerable raw coal to furnaces that have their own coke plants; others buy coke direct.

Regarding the quality of the coal and coke, I reproduce the following statement from a paper by Messrs. A. S. McCreath and E. V. d'Invilliers, read at the Scranton meeting of the American Institute of Mining Engineers:

"Under the active demand for the coal and coke of the Pratt mines, too little attention is frequently paid to eliminating this hurtful ingredient from the product of the mines, and, as a consequence, the percentage of ash and sulphur is frequently excessive."

In this paper by Messrs. d'Invilliers and McCreath the following analyses of samples of coke taken from stock piles at different furnaces are given:

Analyses of coke from the Pratt coal bed, Warrior coal field, Alabama.

	No. 1.	No. 2.	No. 3.	No. 4.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Water	.192	.130	.180	.128
Volatile matter	.758	1.130	.640	.685
Fixed carbon	88.875	86.478	89.164	84.678
Sulphur	1.182	1.049	.670	1.879
Ash	8.993	11.213	9.346	12.630
Total	100.000	100.000	100.000	100.000

No. 1. Pratt coke from Mary Pratt furnace stock pile; Pratt Coal and Iron Company's mines.
No. 2. Pratt coke from Sloss furnace ovens at furnace.
No. 3. Pratt coke from Woodward Iron Company stock pile; from Woodward mines.
No. 4. Coalburg coke, Williamson furnace stock pile; Coalburg mines, Pratt seam, 15 miles from Birmingham.

"Sample No. 3 of the above analyses, from the Woodward furnace was made from the Pratt seam on the company's lands, about 2 miles west of the furnace site. Its superiority, as shown by the analyses, is no doubt due more to the greater care taken in the preparation of the coal for coking than to any inherent improvement in the quality of the seam in this part of the field. All the coke made from this Pratt seam is well spoken of, and its appearance and behavior in the furnace would seem to justify its reputation as the best fuel yet marketed in Alabama."

In 1886, for the first time, the Cahaba field assumed some importance as a coke manufacturing district, though the entire production of coke in this field during the year was only some 20,000 tons. This was all made in ovens. The Cahaba Coal Company, which has in past years made some coke in pits, "on the ground," produced no coke in 1886. The Brierfield Coal and Iron Company, at whose ovens the coke produced in this district was made, works three seams at its mines. There are on the land four seams within 175 feet of horizontal distance, but only three have been worked. These seams are in the pitched outlying series of the southwest part of the Cahaba field, standing at an angle of 65°. The seams worked are called B, C, and D. The C seam makes the best coke and can be used without washing. The average thickness of these seams is 4½ feet. The coke is made from the washed slack from B and C. An analysis of the Brierfield coke is as follows:

Analysis of Brierfield (Cahaba district) Alabama coke.

	Per cent.
Fixed carbon	92.39
Ash	6.91
Sulphur	.32
Total	99.62

Professor Colton regards this coke as the best in Alabama, if not in the South.

In the Coosa district two coke works are in operation, those of the Broken Arrow Coal and Coke Company and the Saint Clair Coal and Coke Company; the former operates sixty beehive ovens, the latter ten Thomas ovens. The coal of this district is the most easterly coking coal with railroad connections in Alabama. The coke should find a ready market at the five or six furnaces that are best served from this field, none of them being more than 75 miles distant.

The seam worked at Ragland is quite regular, not varying over 8 inches in thickness in any one place, and thus far has shown itself to be free from faults. The vein is about 36 inches thick. The Thomas ovens at this works were erected not with a view of improving the coke, as the coke in physical structure, it is claimed, is equal to the Connellsville, but to use mechanical means to draw the coke as well as to increase the yield of coke per square foot of oven and to reduce the percentage of carbon lost in coking. It is claimed that the results have justified the proprietors in introducing these ovens. The Thomas oven, it may be said, is simply an elongation of the beehive oven with a mechanical arrangement to draw the coke.

COLORADO.

Colorado still retains the position it occupied in 1884 and 1885 as the fifth in the list of coke-producing States. Its production of coke for 1886 was 142,797 tons, the largest in its history, being 10,837 more than 1885 and 8,800 tons over 1883, the year of the largest production previous to 1886. The total value of the coke produced was $569,120 as against $512,162 in 1885. The average value per ton in 1886 was $3.99, as compared with $3.88 in 1885. The range of value was from $3.87 to $10. There were 228,060 tons of coal used in the production of this coke, the yield of coal in coke being 62.6 per cent.

The number of ovens increased from 434 at the close of 1885 to 483 at the close of 1886, an increase of 49. This increase was all in the Crested Butte field, which contains without doubt, so far as our information goes, the best seams of coking coal found west of the Mississippi. The number of ovens in this district, 130, at the close of 1886, will probably be doubled, at least, in 1887. The Grand River Coal and Coke Company contemplates the building of 100 to 200 ovens, and coke manufacturers of the Connellsville (Pennsylvania) district either have secured or have tried to secure coal property for coking in this district.

The statistics of the production of coke in Colorado for the years 1880 to 1886 are as follows:

Statistics of the manufacture of coke in Colorado, 1880 *to* 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	1	2	5	7	8	7	7
Ovens built	200	267	344	352	409	434	483
Ovens building	50	0	0	0	24	0	0
Coal used, short tons	51, 891	97, 508	180, 549	224, 089	181, 968	208, 069	228, 060
Coke produced, short tons	25, 568	48, 587	102, 105	133, 997	115, 719	131, 960	142, 797
Total value of coke at ovens	$145, 226	$267, 156	$476, 665	$584, 578	$409, 930	$512, 162	$569, 120
Value of coke at ovens, per ton	$5. 68	$5. 29	$4. 67	$4. 36	$3. 45	$3. 88	$3. 99
Yield of coal in coke, per cent	49	50	57	60	64	63	62. 6

The coals and cokes of this region have been described in previous volumes of "The Mineral Resources of the United States." The character of the cokes of the El Moro and Crested Butte fields is well known. But little is known, however, of the coke of the Durango district. It has heretofore been claimed that this coke was high in ash and sulphur, but that the cost of transportation of coke from other sections was so great as to justify the use of this coke, though containing the impurities named. Later developments, however, indicate that the coke is not as impure as has been supposed. The coke made at the works of the Grand View Mining and Smelting Company, seven miles north of Rico, contained, until 1886, quite a high per cent. of ash, from 18 to 25 per cent., and was very siliceous, owing to the percolation into the coal beds of water, carrying fine sand in suspension. As greater depth has been attained, however, the quality of the coal has improved. It cokes more thoroughly, the percentage of ash has been diminished about one-third, and is less siliceous; it is believed that washing the coal intended for coking, which will be done in 1887, will materially improve the quality of the coke. An analysis of coke from this district, made at the San Juan and New York Mining and Smelting Company's works, shows but 13 per cent. of ash.

GEORGIA.

In Georgia there has been no increase in the number of coke works or ovens, all the ovens in the State being owned by one company, though there are two distinct works, one with 286 ovens, and the other, some 2 miles distant, with 14 ovens. This latter bank of ovens has not been in operation for the past two years. The coke reported, therefore, was all made at the works with 286 ovens. Little or none of this coke is sold in the general market, the company making it uses most of it at their two furnaces, the Rising Fawn furnace, at Rising Fawn, near the coke ovens, and the Chattanooga furnace, in Chattanooga, Tennessee.

The statistics of the manufacture of coke in this State for the years 1880 to 1886, are as follows:

Statistics of the manufacture of coke in Georgia, 1880 *to* 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	1	1	1	1	1	2	2
Ovens built	140	180	220	264	300	300	300
Ovens building	40	40	44	36	0	0	0
Coal used, short tons	63,402	68,960	77,670	111,687	132,113	117,781	136,133
Coke produced, short tons	38,041	41,376	46,602	67,012	79,268	70,669	82,680
Total value of coke at ovens	$81,789	$88,753	$100,194	$147,166	$169,192	$144,198	$179,031
Value of coke at ovens, per ton	$2.15	$2.15	$2.15	$2.20	$2.13	$2.04	$2.17
Yield of coal in coke, per cent.	60	60	60	60	60	60	60

The following is an analysis of the Dade coal, taken from the stock piles of the Chattanooga Iron Company's furnace. The analysis is from the paper by Messrs. McCreath and d'Invilliers, on "Some Southern Cokes and their Irons," read before the American Institute of Mining Engineers.

Analysis of the Dade coal.

	Per cent.
Water	.542
Volatile matter	1.091
Fixed carbon	79.941
Sulphur	.670
Ash	21.756

ILLINOIS.

During the year 1886 the number of coke ovens in Illinois increased from 320, the number at the close of 1885, to 335, the number of establishments remaining the same. The production of coke, however, has declined from 10,350 tons in 1885 to 8,103 tons in 1886. Indeed, the production of coke in Illinois in 1886 was smaller than that in any of the seven years for which statistics are given. Of the 335 ovens in the State, but 46 were operated during the year.

In the production of the 8,103 tons of coke, 17,806 tons of coal were used, the yield of coal in coke being 46 per cent., the lowest yield of any State. This coke was valued at $21,487 at the ovens, an average of $2.65 per ton.

Nothing need be added to the statements that have already been made in previous volumes of the "Mineral Resources of the United States" relative to the character of the coals and cokes of this State, and the causes of the want of success in the attempts to produce coke in Illinois.

The following are the statistics of the manufacture of coke in Illinois for the years from 1880 to 1886:

Statistics of the manufacture of coke in Illinois, 1880 to 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	6	6	7	7	9	9	9
Ovens built	176	176	304	316	325	320	335
Ovens building	0	0	0	0	0	0	0
Coal used, short tons	31,240	35,240	25,270	31,170	30,168	21,487	17,806
Coke produced, short tons	12,700	14,800	11,400	13,400	13,095	10,350	8,103
Total value of coke at ovens	$41,950	$45,850	$29,050	$28,200	$25,639	$27,798	$21,487
Value of coke at ovens, per ton	$3.30	$3.10	$2.55	$2.10	$1.96	$2.68	$2.65
Yield of coal in coke, per cent.	41	42	45	43	43	48	46

INDIANA.

Many attempts have been made to coke Indiana coal, but, until recently, with comparatively little success commercially. As early as 1837, four years before the first coke oven was built in the Connellsville region, coke was made at Coke Oven Hollow, Parke county, Indiana, for use in the foundries of the neighborhood. It is interesting to note here that many of the earlier attempts to make coke have grown out of the demand for this fuel for foundry purposes. In 1845 coke was made in Sullivan county for use in the Terre Haute foundries, and in 1849 at Arney's coal bank in Owen county and at Bloomington, for use in the Bloomington foundries. The discovery of block coal, however, and the building of railroads through the State, which enabled the furnaces and foundries to secure a supply of a better fuel than the locally-made coke, led to the abandonment of all of these coke works, and in the census year but a thousand tons of coke were made in this State, and none since, except at an experimental plant, until 1885.

The experimental plant referred to was that of the North Chicago Rolling Mill Company, at which the screenings of Coal Creek coal from Fountain county were used. Belgian ovens with Endre's modification were employed. The coke, however, besides being high in sulphur, was spongy and soft, and would not, alone, carry a burden in the blast furnace. When used with from 85 to 90 per cent. of Connellsville coke, however, fairly good results were obtained in the furnace.

This plant of 12 ovens, as well as the plant of 25 ovens of the Central Iron and Steel Company at Brazil, are still standing, though no coke has been made in the latter since 1879, and at the former since 1881 or 1882. As they are still standing, however, they are reported as in existence.

That no coke has been made in Indiana in these years is not due to the absence of coking coal from the measures of this State. Professor Cox, in his report on the Geology of Indiana, states that "the seams of coking coal in Indiana are locally not less than 15 in number," some of which, he asserts, are from 7 to 8 feet thick.

In 1885 was begun what seems to be the most successful attempt at coke manufacture in this State in recent years. During the summer of this year the Laclede Coal and Coke Company erected at Ayrshire, in Pike county, an experimental block of 8 ovens, for the purpose of testing the coking qualities of the Ayrshire vein. The result was so satisfactory that during the fall of the same year 28 additional ovens were built and put in blast. During 1886 the plant has been increased to 54 ovens, the oven used in all cases being the beehive, 11 feet 6 inches in diameter by 6 feet in height.

In these ovens nothing but nut and slack is used. The slack as it comes from the mine goes direct to the washers, of which three are used, each having a capacity of about three tons per hour. When "run of the mine" is used, all the coal passing over the screen of 1-inch mesh goes to the crusher to be reduced.

The vein of Ayrshire coal is 4 feet 9 inches in thickness, and is opened on the outcrop at the level of the railroad track by a tunnel. It is the "L" coal of the Indiana series, equivalent to No. 7 of the Illinois. It is laminated, free burning, giving a white or gray ash with little or no cinder. The coke is bright, of a metallic luster, strong and tenacious, though quite cellular.

The following analysis of the coal was made by Prof. W. B. Potter, of Washington University, Saint Louis:

Analysis of Ayrshire, Indiana, coal.

	Per cent.
Moisture	6.73
Volatile matter	38.57
Fixed carbon	48.55
Sulphur	1.50
Ash	4.65
	100.00

The following are analyses of this coke, No. 1, by R. Chauvenet and Bros., Saint Louis; No. 2, from all washed coal, by the Calumet Iron and Steel Company of Chicago:

Analyses of Ayrshire, Indiana, coke.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Water	0.34	0.14
Volatile matter	1.73	1.00
Fixed carbon	88.93	87.15
Ash	9.00	11.70
	100.00	99.99
Silica in ash	4.32	....
Sulphur	1.13	0.73

At Petersburg, Pike county, the Petersburg Coal and Coke Company had, at the close of 1886, 9 ovens built and 18 in process of construction, all beehive, but the burning of coke was not begun until May 1, 1887. The coal used is "K" of the Indiana series. The seam is 6 to 10 feet thick. The coal is not as free burning as that at Ayrshire, though it seems to be a fairly good coking coal. It, however, contains considerable sulphur and requires crushing and washing to make a coke for the manufacture of iron.

The controlling interest in the new Pitsburgh Coal and Coke Company of Alum Cave, Indiana, has recently been secured by Chicago and Philadelphia parties. They propose to at once construct from 50 to 100 coke ovens for the purpose of manufacturing coke for the Chicago market, mainly for the use of water-gas companies.

The statistics of the manufacture of coke in Indiana for the year 1886 are as follows:

Statistics of the manufacture of coke in Indiana for 1886.

	1886.
Number of establishments	4
Ovens built	100
Ovens building	18
Coal used, short tons	13,030
Coke produced, short tons	6,124
Total value of coke at ovens	$17,953
Value of coke at ovens, per ton	$2.93
Yield of coal in coke, per cent	47

INDIAN TERRITORY.

The coke works of the Osage Coal and Mining Company, located at McAlester, still continues the only one in the Indian Territory. The coal used at these works and the coke made have been fully described in previous volumes of "Mineral Resources of the United States." The coke is made entirely from slack.

Though there was no increase in the number of coke ovens during 1886, the production of coke was nearly doubled, the increase being from 3,584 tons in 1885 to 6,351 tons in 1886.

The statistics of the manufacture of coke in the Territory for the years 1880 to 1886 are as follows:

Statistics of the manufacture of coke in Indian Territory, 1880 *to* 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	1	1	1	1	1	1	1
Ovens built	20	20	20	20	20	40	40
Ovens building	0	0	0	0	0	0	0
Coal used, short tons	2,494	2,852	3,266	4,150	3,084	5,781	10,242
Coke produced, short tons	1,546	1,768	2,025	2,573	1,912	3,584	6,351
Total value of coke at ovens	$4,638	$5,304	$6,075	$7,719	$5,736	$12,902	$22,229
Value of coke at ovens, per ton	$3	$3	$3	$3	$3	$3.60	$3.30
Yield of coal in coke, per cent	62	62	62	62	62	62	62

In the returns received no statement as to coal used was included. A yield of 62 per cent. has been assumed.

IOWA.

No coke was made in Iowa in 1886, nor, indeed, has there ever been any made in this State on a commercial scale. A number of experiments to test the coking qualities of Iowa coals have been made at various times. Some years since coke ovens were built near Ottumwa for the purpose of utilizing the slack from several coal banks. The enterprise was not successful, and the ovens were abandoned and have been in ruins for years.

In 1884 an oven was built on the lands of the Red Rock Coal and Mining Company, near Des Moines. The oven was a small one of the beehive pattern, holding about a ton of coal, and built of common brick. It was erected simply to test the coking qualities of the coal. The product was a fair coke for domestic purposes, but probably was of no value as a fuel for metallurgical operations. The experiments were not continued, as the slack which it was proposed to use in the ovens could be disposed of at a fair price.

KANSAS.

The production of coke in Kansas increased in 1886 more than 50 per cent. over that of 1885, though it still remains true that the coke is made chiefly to utilize the slack coal from the mines in the southeastern part of the State. There has been an increase of 13 in the number of ovens during the year, the number at the close of 1886 being 36. At all but one works coke is made for consumption at the lead-smelting works of the owners of the ovens.

The statistics of the manufacture of coke from 1880 to 1886 are as follows:

Statistics of the manufacture of coke in Kansas, 1880 *to* 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments....	2	3	3	4	4	4	4
Ovens built....................	6	15	20	23	23	23	36
Ovens building..................	0	0	0	0	0	0	0
Coal used, short tons..........	4, 800	8, 800	9, 200	13, 400	11, 500	15, 000	23, 062
Coke produced, short tons....	3, 070	5, 670	6, 080	8, 430	7, 190	8, 050	12, 493
Total value of coke at ovens..	$6, 000	$10, 200	$11, 460	$16, 560	$14, 580	$13, 255	$19, 204
Value of coke at ovens, per ton.	$1. 95	$1. 80	$1. 70	$1. 96	$2. 02	$1. 65	$1. 54
Yield of coal in coke, per cent.	64	64. 4	65	62. 9	62. 5	53⅔	54. 2

Some of the coke reported made in 1880 and 1881 was produced at one establishment in pits.

KENTUCKY.

Of the 6 coke works in Kentucky, 3, with 35 ovens, are on the Ohio river just across from Cincinnati, and use only the dust or slack coal from other States. All but 200 of the 4,528 tons of coke made in this State in 1886 were made in these 35 ovens.

In 1886 considerable attention was given to making coke from the coal of the southwestern portion of the State. More than twenty-five years ago coke was made from these coals for use in the old Airdrie furnace, near Paradise, in Muhlenburg county, which adjoins Christian, and two small works, one with 7 and the other with 3 ovens, the former at Mercer station, in Muhlenburg county, and the other at Earlington, in Hopkins county, have been reported as in existence, but no coke has been made in either for some years. In the summer of 1886 the Clifton Coal Company at Mannington, in Christian county, began the erection of 34 ovens, which were fired up for the first time on December 19, 1887. The vein from which the coke is made is supposed to be No. 7 of the western Kentucky coal field. It is from 4 feet to 6 feet 2 inches, with slate partings. Where the coal has much cover it is quite pure. It is fairly bituminous and "goes off" readily when charged into the ovens. It is crushed and washed with a Stutz washer before charging. The following are analyses of it unwashed and washed:

Analyses of Clifton, Kentucky, unwashed and washed coal.

	Unwashed.	Washed.
	Per cent.	*Per cent.*
Volatile matter	33.32	35.24
Carbon	47.45	52.53
Sulphur	3.21	1.92
Ash	16.02	10.31
Total	100.00	100.00

Analyses of the coke from tests of the coal made at Pittsburgh, Pennsylvania, and at Tracy City, Tennessee, are as follows:

Analyses of Clifton, Kentucky, coke.

	Made at Pittsburgh.	Made at Tracy City.
	Per cent.	*Per cent.*
Fixed carbon	83.14	83.42
Volatile matter	1.28	1.62
Ash	13.60	12.94
Sulphur	1.98	2.02
Total	100.00	100.00

Recent tests show that the carbon has been increased, the ash reduced, and that the sulphur does not reach 1.5 per cent.

The coke is hard and strong, with a bright silvery luster.

The results obtained at the Clifton works have justified the St. Bernard Coal Company in again beginning experiments with its coals. This company intends to give all the coals on their property a thorough test. Nearly all the coals made a good coke physically. The desire is to find one that will be free enough from sulphur to make a furnace coke without washing.

The statistics of the manufacture of coke in Kentucky from 1880 to 1886 are as follows:

Statistics of the total manufacture of coke in Kentucky, 1880 to 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	5	5	5	5	5	5	6
Ovens built	45	45	45	45	45	33	76
Ovens building	0	0	0	0	0	0	2
Coal used, short tons	7,206	7,406	6,906	8,437	3,451	5,075	9,055
Coke produced, short tons	4,250	4,370	4,070	5,025	2,223	2,704	4,528
Total value of coke at ovens	$12,250	$12,630	$11,530	$14,425	$8,760	$8,489	$10,082
Value of coke at ovens per ton	$2.88	$2.89	$2.83	$2.87	$3.94	$3.14	$2.23
Yield of coal in coke, per cent	60	60	59	60	64	53	50

In a paper published in the "Coke Supplement" of the *American Manufacturer*, Prof. John R. Procter, State geologist of Kentucky, treats at length of the coking coals of this State. From his paper the following statement is condensed:

"During the summer of 1881 the Kentucky State Geological Survey discovered a thick coal near the southeastern border of the State, which, from repeated analyses, gave such excellent results that in the following year tests were made proving this to be a superior coking coal. This coal has been traced over a wide area and its coking properties tested.

"Professor Crandall gives eight coals of workable thickness above the conglomerate or 'millstone grit;' and in the section between Pine and Cumberland mountains, in Letcher and Harlan counties, as many as twelve workable beds of coal have been identified. The coking seam named 'Elkhorn' seam, from the stream in Pike county, where it was first discovered, is coal No. 3, counting upwards from the conglomerate. It has been traced as a thick bed above drainage through the greater parts of Pike, Letcher, and Harlan counties, and over a large part of Floyd, Knott, Leslie, Perry, and Bell counties. It has also been identified as a workable coal in Wolfe, Clay, and Breathitt counties. This coal attains its maximum thickness in Pike, Letcher, and Harlan counties, but is thick enough for profitable mining, where transportation may be afforded, in all of the counties mentioned above.

"The following sections will convey an idea of the large area of this remarkable coal: No. 1, on lower Elkhorn Fork of Big Sandy river; No. 2, head of Elkhorn, Pike county; No. 3, Boone's Fork of Kentucky river, Letcher county; No. 4, Upper Cumberland river, Harlan county:

Sections of Kentucky coal measures.

	No. 1.	No. 2.	No. 3.	No. 4.
	Inches.	*Inches.*	*Inches.*	*Inches.*
Coal	41	43	46	108
Shale	10	$3\frac{1}{2}$	2	....
Coal	72	49	47	....

"The conglomerate is brought up by the uplift at the 'Breaks of the Big Sandy,' thus marking the eastern limit of the Elkhorn bed so far as it has been traced by the Geological Survey.

"The following analyses, made by the Kentucky Geological Survey from carefully-averaged samples, show the excellent quality of this coal over a wide area:

Analyses of Kentucky coking coals.

Counties.	Report number.	Volatile combustible matter.	Fixed carbon.	Ash.	Sulphur.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Letcher	2353	34.30	58.10	6.50	.890
Pike	2404	26.80	67.60	3.80	.967
Pike	2401	33.50	60.54	3.96	4.29
Wolfe	2549	37.50	55.70	3.40	.895
Bell	2582	37.90	57.78	3.12	1.030
Bell	2584	38.60	57.30	2.70	.629
Harlan	2704	36.70	58.86	2.24	.277
Harlan	2705	67.10	58.24	3.36	1.290
Knox	2718	35.30	61.90	.80	.766

"Repeated and practical tests have demonstrated beyond question that a superior coke can be made from this coal, and the cokes have been tested for strength and porosity with most satisfactory results.

"The following analyses, selected at random from a large number, show that the cokes from this coal possess three requisites of a good coke—high fixed carbon, low sulphur, and low ash:

Analyses of Kentucky cokes.

Counties.	Fixed carbon.	Ash.	Sulphur.	Made from coal.
	Per cent.	*Per cent.*	*Per cent.*	
Pike	94.14	4.66	1.484	2404
Pike	95.40	3.50	.517	2401
Wolfe	91.00	4.60	.503	2449
Bell	95.80	4.00	1.710	2582
Bell	94.00	5.60	.629	2584
Harlan	93.10	6.30	.546	2704
Harlan	93.60	6.00	1.068	2705
Knox	96.00	3.50	.217	2718

"At least one coal above the Elkhorn bed, in Bell and Harlan counties, gives promise of being a good coking coal, and also one of the upper coals in Knott and adjoining counties."

MISSOURI.

The Excelsior Coal Company, of Higginsville, Missouri, has erected an oven to test the coking qualities of its coal. The result is regarded as favorable, and the company believes that the coal will make an excellent quality of coke. The coal will be thoroughly tested before proceeding further.

Many experiments in coking Missouri coal had been previously made, but the coke usually contained so much sulphur that it was worthless as a furnace fuel, and there have been no attempts to manufacture coke in this State on a commercial scale.

MONTANA.

No coke was made in this Territory in 1886.

In expectation that some of the experiments in coking the coals will be successful commercially, the statistics are still carried forward.

The statistics of the manufacture of coke in Montana from 1880 to 1886 are as follows:

Statistics of the manufacture of coke in Montana, 1880 *to* 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	0	0	0	1	3	2	4
Ovens built	0	0	0	2	5	2	16
Ovens building	0	0	0	0	12	0	0
Coal used, short tons	0	0	0	0	165	300	0
Coke produced, short tons	0	0	0	0	75	175	0
Total value of coke at ovens	0	0	0	0	$900	$2,063	0
Value of coke at ovens, per ton	0	0	0	0	$12	$11.72	0
Yield of coal in coke, per cent	0	0	0	0	46	58.5	0

NEW MEXICO.

There was no change in the number of works or of ovens built in New Mexico in 1886. The San Pedro Coal and Coke Company, at San Antonio, on the Rio Grande river, still remains the only works with ovens in the Territory. This is also the only works at which, so far as could be learned, any coke was made in 1886.

It will be noted that there was a marked decrease in the production of 1886, it having declined from 17,940 tons in 1885 to 10,236 tons in 1886.

The following are the statistics of the manufacture of coke in New Mexico from 1880 to 1886. The value of the coke is an estimate.

Statistics of the manufacture of coke in New Mexico, 1880 *to* 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	0	0	2	2	2	2	2
Ovens built (*a*)	0	0	0	12	70	70	70
Ovens building	0	0	12	28	0	0	0
Coal used, short tons	0	0	1,500	6,941	29,990	31,889	18,194
Coke produced, short tons	0	0	1,000	3,905	18,282	17,940	10,236
Total value of coke at ovens	0	0	$6,000	$21,478	$91,410	$89,700	$51,180
Value of coke at ovens per ton	0	0	$6	$5.50	$5	$5	$5
Yield of coal in coke, per cent	0	0	66⅔	57½	57½	56½	56

a At one works there are ten stone pits, with an average capacity of 10 tons each.

OHIO.

Slight importance of Ohio as a coke-producing State.—Though Ohio was among the first of the States to manufacture coke, this industry has never been an important one, either with reference to the actual amount of coke produced or the relative rank it occupied in the list of coke-producing States. In the last seven years for which accurate statements of production are given, there has been a gradual reduction in the output, with the exception of one year, 1881, until in 1886 but 34,932 tons were made in the entire State, as compared with 62,709 tons in 1884, a reduction of nearly 50 per cent. But 24,366 tons of this were made from Ohio coal, that made at Cincinnati, and amounting to 10,566 tons, being made entirely from the dust or screenings of coal at the coal yard of that city, most of which was from coal from Pennsylvania and West Virginia. Outside of Cincinnati, coke was made at but four places and five works in the State, viz., one at Leetonia, two at Steubenville, one near Bridgeport, and one at Irondale. The first of these is in the Washingtonville district; all the others in the Steubenville district. A very little was made in an experimental way by the Nelsonville Coal and Coke Company at Happy Hollow in the Hocking Valley. The amount was so small that it has not been included in the report.

Seams of coal coked in Ohio.—The seams of coal that have been coked with any success in this State are No. 4, corresponding to the Lower Kittanning of Pennsylvania, No. 6, corresponding to the Middle Kittanning, and No. 7, the equivalent of the Upper Freeport. The coal coked at Leetonia, at which point the best coke made in the State is produced, is from No. 4, the Lower Kittanning. This coal is used to but a small extent in Pennsylvania for coking, and the same is true of the Middle Kittanning, used at Hammondsville, and at Zanesville, while the Upper Freeport, the Hocking Valley coal at Happy Hollow, is the bed used largely in the Allegheny Mountain, Snow Shoe, and Broad Top districts. The Steubenville coke is made from the Lower Freeport, the same vein that is used at the important Walston mines of the Rochester and Pittsburgh Coal and Iron Company, near Punxsutawney, Pennsylvania.

Character of Ohio coke.—As has been heretofore stated in these reports, Ohio coke is, as a rule, soft and brittle, high in sulphur, and in some cases in ash also, though this is not always true, some of the Ohio cokes, that from Leetonia, for example, being among the commercial cokes lowest in ash and sulphur found in the country. These weak, soft cokes do not stand transportation, nor do they carry the furnace burden as well as cokes of other States.

Causes of inferiority of coke.—When the inferiority of the coke is due to excess of sulphur or ash, either the coal itself or careless mining is responsible. When the cause is the coal, the impurities may be removed by washing; when it is careless mining, greater care may give a purer coke. When the coke is reasonably pure, but soft and brittle, it may possibly be due to the lack of that constituent in the coal that gives strength and hardness, or it may be due to imperfect methods of coking. There is no doubt that too little study has been given to adapting the oven and method of coking to Ohio coals. The ovens most commonly used have been the beehive, though at two places, at Vinton furnace and at Zanesville, very thorough trials have been made with the Belgian ovens. In the use of the beehive ovens there seems to have been but little attempt to study adaptability of form or methods of burning to the coal used. The beaten track that has been successful in other localities, where the coal charged into the ovens has been in many cases an essentially different fuel, has been followed, and the result has been that not even that success has been attained which might have been secured had there been a more careful study of the coal and a more earnest effort to discover that form of oven and the details of burning best adapted to the materials used.

Whatever may be the reason, the fact remains that with a large coal area, containing the same seams of coal that are successfully coked in other States, the coke industry of Ohio is an insignificant one, and it is impossible to escape the conviction that one cause, at least, is the close adherence to old forms and to methods that have been adopted in other localities, and a consequent lack of intelligent study of the coals of Ohio, and the form of oven and methods of burning best adapted to these coals.

Ovens and coke made.—In the *Ohio Mining Journal*, for February 15, 1887, Hon. Thos. B. Bancroft, mine inspector of Ohio, discusses coke making in that State, chiefly, however, from an historical standpoint. Mr. Bancroft takes the same view as to the failures to produce good coke in Ohio which is stated above. He says:

"With the exception of the operations at Zanesville and Vinton furnace, beehive ovens only have been used, and the result in every instance, with these ovens, has been a friable coke. Most of the attempts at coking in the State have been made with the coals from veins No. 6 and 7, and have followed one beaten track, offering no opportunity to decide whether any better method could have been adopted for coking them, or whether other veins might not have been more profitably employed.

"It may be laid down as an axiom that all Ohio cokes are friable and do not bear transportation. It may also be said that experience has shown that veins No. 6 and 7 are the best adapted for coking where improved ovens and machinery are not used in the process; and that those of the Ohio coals that cement well in coke contain too much sulphur, while those that are free from sulphur have not sufficient bitumen to cement them, either of which deficiencies renders a coke of but little value in a blast furnace."

First coke made in Ohio.—In his paper, Mr. Bancroft states that the first coke made in Ohio was in 1840, at Leetonia. In this he is in error. In my report to the Tenth Census on the manufacture of coke (page 26) reference is made, on the authority of the first annual report of the geological survey of Ohio, to the fact that as early as 1837 Hon. Daniel Upson, of Portage county, made a coke from the coal of his mine in Tallmadge, which was used in a blast furnace at Akron, and also as a substitute for anthracite coal in cupola furnaces. In the second report, published in 1838, Professor Mather refers to the fact that at the date of his first report (1837) coke was used in three blast furnaces.

Mr. Bancroft states that the longest continued coking operations in Ohio are those at Leetonia, of Messrs. Young & Chamberlain, begun in 1857, and those at Steubenville, of the Jefferson Iron Works, begun in 1863.

Belgian ovens in Ohio.—From the statements of Mr. Bancroft relative to the attempts made to coke Ohio coals in Belgian ovens we make the following abstract:

The first of these attempts was at the Vinton furnace, in the Hanging Rock region, in 1875 and 1876.

The Vinton furnace, which had been using Connellsville coke, felt compelled, as the result of the panic of 1873, to endeavor to coke the coal from the seams on its own property. Experiments in coking in ricks and beehive ovens were unsatisfactory "owing to the dryness of the coal, which prevented its cementing, and rendered it unfit to bear a burden in the furnace." Several veins of coal upon their lands were tried, but the result in every case was the same.

Some coal from the "Vinton" vein was sent as a last resort to Johnstown, Pennsylvania, to be tried in the Belgian ovens at that place. The result was a bright, clear, compact coke. Crushing machinery, a Bradford washer, and Belgian ovens were at once erected at Vinton. Twenty Belgian ovens, 22 feet long, 8 feet high, and 22 inches wide, were built at a cost of $750 each, and coking was begun. For economy in haulage a vein nearer the furnace than that from which the coal sent to Johnstown was taken was used, and it is charged that it was the change in coal that caused the failure of the ovens. Faults and upheavals were developed in the vein, and the funds of the company being exhausted, operations were suspended after some three weeks' work with this inferior coal. The coke made, though very inferior, is stated to have been hard and solid and capable of bearing a furnace burden.

Mr. Bancroft remarks upon the outcome of this trial that "the result of this experiment, made at a cost of about $40,000, has demonstrated that by this means solidity can be obtained in coke made from Ohio coals and the sulphur can be so reduced by washing the coal, together with the volatile sulphur that passes off in extinguishing the coke, as to be unobjectionable in the working of the furnace. The parties who made these experiments are still convinced that lack of funds alone prevented their going on to a successful solution of the question. A record was kept of the cost of working, and although by no means at its minimum, owing to the ovens not being at their best, nor any regular system adopted for working them, it was found that the whole expense attending it was about three-fourths of a cent per bushel, and a bushel of coal made about the same volume of coke. The product, owing to the defective quality of the coal, was unfit for smelting purposes, and made an inferior quality of mill iron. Had the original vein been used instead of the one that was adopted, there is no doubt but the product would have been equal to the coke made from it at Johnstown."

The attempt to use the Belgian ovens at Zanesville in 1884 was unsuccessful. The ovens do not appear to have been well built nor the coking operations perfectly conducted. There were but single doors, the ovens were operated irregularly, numerous leaks were developed, and there were many imperfections in the process. Notwithstanding this, the coke made in these ovens from washed coal appears to have been a better fuel than that from the unwashed or than that made in beehive ovens.

Coking districts.—The coke industry of Ohio has declined so greatly in importance that it has not been considered necessary to retain the division into four districts, Washingtonville, Steubenville, Hocking Valley, and Cincinnati, observed in previous volumes of "Mineral Resources." The State will be divided into two districts, one, the Cincinnati, including the ovens in Ohio in and near that city, and the other including all of the ovens of the State not included in the Cincinnati district. Since nearly if not quite all of the coal coked in the Cincinnati district is from coal produced outside of the State, the Ohio district statistics alone will give the production of coke from Ohio coal.

Ohio district.—This district includes all of the ovens that have been classified in previous reports under the Washingtonville, Steubenville, and Hocking Valley districts, that is, all of the ovens coking Ohio coals.

In what was the Washingtonville district of previous reports but one works was in operation in 1886, the Cherry Valley, which is the oldest of Ohio coke works, having been operated since 1857, that is, for thirty years. The other works in this district, belonging to the Grafton Iron Company, made no coke in 1886, though one of the furnaces of the company was in blast, using Connellsville coke. Most of the coke made at the Cherry Valley works is used in the blast furnaces of the owners. A small amount, not exceeding a car-load daily, is sold for blacksmithing and heating purposes.

In the Steubenville district some coke was made at four different works, none of which made 2,000 tons, the total production of the district amounting to but 4,351 tons. At the Jefferson Iron Company's works coke was only made in December; at the Pittsburgh and Wheeling Company's works slack only was used; at the Irondale works but three of the eight ovens, left from fifty built in 1870, were operated, the coke, which is of an excellent quality, being for use in the rolling mill at that point; at the fourth works, that of the Steubenville Coal and Mining Company, the coke business is only an adjunct to coal mining.

No coke, except in an experimental way, was made at the only works in the Hocking valley, that of the Nelsonville Coal and Coke Company. The twenty ovens built in 1880 are still standing; crushing and washing machinery have been erected, and it is believed that good coke will be made as a result.

The statistics of the manufacture of coke in Ohio, from Ohio coal, from 1880 to 1886, are as follows:

Statistics of the manufacture of coke in the Ohio district, Ohio, 1880 *to* 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	11	11	$12	13	14	8	10
Ovens built	584	609	615	625	675	560	478
Ovens building	25	0	0	0	0	0	0
Coal used, short tons	156, 312	180, 438	161, 890	118, 524	76, 030	51, 316	42, 317
Coke produced, short tons	90, 270	106, 232	91, 677	67, 728	43, 869	28, 454	24, 366
Total value of coke at ovens	$213, 650	$243, 289	$218, 676	$159, 670	$95, 222	$73, 850	$40, 899
Value of coke at ovens per ton	$2. 37	$2. 39	$2. 39	$2. 36	$2. 17	$2. 60	$1. 68
Yield of coal in coke, per cent	57	59	57	57	58	55	57¾

Cincinnati district.—As is stated above, all of the coke made in this district is from the dust and screenings of the coal yards of Cincinnati, and of the coal boats and barges that bring coal from the upper Ohio, chiefly from Pittsburgh and the Kanawha. The largest block of ovens in this district is that at North Bend, on the Ohio river, a short distance below Cincinnati. These have been idle for some time, but were fired late in December, using Youghiogheny and Monongahela river slack. The statistics of manufacture in this district from 1880 to 1886 are as follows:

Statistics of the manufacture of coke in the Cincinnati district, Ohio, 1880 *to* 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	4	4	4	5	5	5	5
Ovens built	32	32	32	57	57	82	82
Ovens building	0	0	0	0	0	0	0
Coal used, short tons	16, 141	20, 607	19, 687	33, 978	32, 134	17, 480	17, 015
Coke produced, short tons	10, 326	13, 237	12, 545	20, 106	18, 840	10, 962	10, 566
Total value of coke at ovens	$42, 255	$54, 439	$47, 437	$65, 990	$61, 072	$35, 873	$31, 633
Value of coke at ovens per ton	$4. 09	$4. 11	$3. 78	$3. 28	$3. 24	$3. 27	$2. 99
Yield of coal in coke, per cent	64	64	64	59	59	63	62. 1

It will be noted that the statistics of the district for 1886 do not differ materially from those of 1885, the production of coke in 1886 being but 396 tons less than in 1885. The average price per ton of the coke was 28 cents less, and the yield of coal in coke a small fraction, nine-tenths of 1 per cent. less.

Totals for Ohio.—In the following table the statistics of coke making in the several districts of Ohio for the years 1880 to 1886 are consolidated:

Statistics of the manufacture of coke in Ohio, 1880 *to* 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	15	15	16	18	19	13	15
Ovens built	616	641	647	682	732	642	560
Ovens building	25	0	0	0	0	0	0
Coal used, short tons	172, 453	201, 045	181, 577	152, 502	108, 164	68, 796	59, 332
Coke produced, short tons	100, 596	119, 469	103, 722	87, 834	62, 709	39, 416	34, 932
Total value of coke at ovens	$255, 905	$297, 728	$266, 113	$225, 660	$156, 294	$109, 723	$94, 042
Value of coke at ovens per ton	$2. 54	$2. 49	$2. 57	$2. 57	$2. 49	$2. 78	$2. 69
Yield of coal in coke, per cent	58	59	57	58	58	57	59

The figures of 1886 differ but little from those of 1885, there being a reduction in every total except "number of establishments and yield of coal in coke." The increase in establishments is due to the fact that at two works that were reported as abandoned last year a few ovens have been built and small amounts of coke made.

The most notable difference is in the average value per ton of coke, which has fallen from $2.78 in 1885 to $2.69 in 1886. The values by districts were $2.99 in the Cincinnati, $2.75 in the Washingtonville, and $1.35 in the Steubenville. The yield of coal in coke varied from 56 per cent. in the Washingtonville to 62.1 per cent. in the Cincinnati; Steubenville giving 60½ per cent.

PENNSYLVANIA.

The same division into districts that has been observed in previous volumes of the "Mineral Resources of the United States" is continued in this, though the names of two of the districts have been changed in order better to identify them. The district known in previous reports as the "Irwin-Latrobe" is now called the "Upper Connellsville;" what was known as the "Snow Shoe District" is now called the "Clearfield-Centre," from the two counties in which the ovens are located. The names of the other districts remain as heretofore. These divisions into districts are based in part upon geological and topographical distinctions and in part upon the routes to market of the coke produced.

Total coke production in Pennsylvania.—Consolidating the statistics of the different districts of Pennsylvania given below, the following are the statistics of the production of coke in Pennsylvania from 1881 to 1886:

Statistics of the manufacture of coke in Pennsylvania, 1881 *to* 1886.

	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	132	137	140	145	133	108
Ovens built	10, 881	12, 424	13, 610	14, 285	14, 553	16, 314
Ovens building	761	642	211	232	317	2, 558
Coal used, short tons	5, 393, 503	6, 149, 179	6, 823, 275	6, 204, 604	6, 178, 500	8, 290, 849
Coke produced, short tons	3, 437, 708	3, 945, 034	4, 438, 464	3, 822, 128	3, 991, 805	5, 406, 597
Total value of coke at ovens	$5, 898, 579	$6, 133, 698	$5, 410, 387	$4, 783, 230	$4, 981, 656	$7, 664, 023
Value of coke at ovens per ton	$1. 70	$1. 55	$1. 22	$1. 25	$1. 25	$1. 42
Yield of coal in coke, per cent	64	64	65	62	64. 6	65. 2

As will be seen from the above table, Pennsylvania still retains its pre-eminence as the greatest coke manufacturing State, 5,406,597 tons, or nearly 79 per cent., of the 6,845,360 tons produced in the United States in 1886 having been made in the ovens of Pennsylvania. There are also 16,314, or 72.2 per cent., of the 22,597 ovens in the State. It will thus appear that as the percentage of ovens in this State is less than the percentage of production, the production per oven in Pennsylvania in 1886 was greater than in the rest of the country.

With the exception of the Broad Top district and the insignificant Beaver district, every district in Pennsylvania increased its make of coke in 1886 over its production in 1885; this increase in some cases, as for example in the Pittsburgh district, being nearly 100 per cent. The total production of coke in 1885 was 3,991,805 tons; in 1886 this had increased to 5,406,597 tons, an increase of 1,414,792 tons, or over 35 per cent. in the year. As the total increase in the production of coke in the United States in 1886 over 1885 was 1,738,673 tons, it will thus appear that of this increase Pennsylvania's share was 81 per cent. As the total production of coke outside of Pennsylvania in 1886 was only 1,428.472 tons, the increase in production in Pennsylvania in 1886 over 1885 was thus over 20,000 tons more than the total production of all of the other States in 1886.

During the year 1886 the number of ovens in the State increased from 14,553 to 16,314, the latter being the number on December 31, 1886. The number of ovens building at the close of the year was 2,558, more than half the total number building in the whole United States, and two and a half times the number in course of erection in any other one State, the next highest number being in Alabama, where 1,012 were building on December 31, 1886. The coal used in the production of coke in 1886 was 8,290,849 tons, the yield of coal in coke being 65.2 per cent. This is the largest yield of any of the States. It is believed that this is in part an estimate, and that the actual yield would not quite equal this. It is exceedingly difficult to arrive at the figures of yield in this State. It is only recently that exact weights and measures have been adopted in the Connellsville region, which produces so large a proportion of the coke made in Pennsylvania. It is believed that the report for next year will show more nearly than heretofore the exact yield of coal in coke. It is but fair to say, however, that at certain works where most exact and careful weights have been taken, both of the coal charged and of the coke made, the yield has been in excess of 65 per cent., reaching in some cases 66 per cent., so that this figure of 65.2 per cent., in view of the fact that so much of the coke is from the Connellsville region, may not be in excess of the actual facts.

The value of the coke per ton, it will be noted, has increased from $1.25 in 1885 to $1.42 in 1886.

The Connellsville district.—The Connellsville region or district, the most important coke-producing center in the United States, and one of the most important in the world, has been so thoroughly described in previous volumes of the "Mineral Resources of the United States" as to require only the briefest reference. It may be well to say here, however, that the Connellsville basin is in the southwestern part of Pennsylvania, some 50 or 60 miles from Pittsburgh. It is a slender prong, separated from the Upper Coal Measures, and may be regarded as extending from just south of Latrobe, on the Pennsylvania railroad, in a southwesterly direction, to the Virginia line, forming a basin some 3 miles wide and 50 miles long, almost without a fault, the beds yielding from 8 to 10 feet of workable coal. The same trough that contains the Connellsville coal extends northwesterly from Latrobe, but the Connellsville region proper is regarded as extending no farther north than the vicinity of Latrobe. We have designated the district north of the Connellsville proper as the Upper Connellsville. It is known locally as the "Washed Coal district."

In this Connellsville district 4,180,521 tons, or 77 per cent., of the 5,406,597 tons of coke made in Pennsylvania were produced. As 6,845,369 tons of coke were produced in the United States, it will appear that the Connellsville region produced 61.1 per cent. of all made in the country. This is an increased percentage of the total production of the United States. In 1885 the production of the Connellsville region was 60.5 per cent. of the total production in the United States; in 1886, 61.1 per cent. This indicates that, notwithstanding the marked development in other regions, the Connellsville continues to more than hold its own. Indeed, the coke made here is the typical blast-furnace fuel of the country, and most other regions are satisfied if they can justly claim that their coke equals the Connellsville.

The following are the statistics of the manufacture of coke in the Connellsville region proper from 1881 to 1886:

Statistics of the manufacture of coke in the Connellsville region, Pennsylvania, 1881 *to* 1886.

	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	70	72	74	76	68	36
Ovens built	8, 208	9, 283	10, 176	10, 543	10, 471	11, 324
Ovens building	654	592	101	200	48	1, 895
Coal used, short tons	4, 018, 782	4, 628, 736	5, 355, 380	4, 829, 054	4, 683, 831	6, 305, 460
Coke produced, short tons	2, 639, 002	3, 043, 394	3, 552, 402	3, 192, 105	3, 096, 012	4, 180, 521
Total value of coke at ovens	$4, 301, 573	$4, 473, 789	$4, 049, 738	$3, 607, 078	$3, 776, 388	$5, 701, 086
Value of coke at ovens per ton	$1. 63	$1. 47	$1. 14	$1. 13	$1. 22	$1. 36
Yield of coal in coke, per cent	$65\frac{2}{3}$	$65\frac{3}{4}$	$66\frac{1}{3}$	66. 1	66. 1	66. 3

The different works belonging to the same owner are classed as one establishment.

The production of coke in the Connellsville region in 1886 was the largest in any one year of its history. The largest amount made in any previous year was 1883, when 3,552,402 tons were made. The production of 1886 was nearly 18 per cent. in excess of this.

During this year there has been but little restriction of production by the Pittsburgh Syndicate similar to that noted in the last volume of "Mineral Resources of the United States." Early in the year there was a strike, which resulted in reduced production to some extent. The strike lasted from January 18 to February 20.

During the year 1886 the Pittsburgh Syndicate continued in successful operation, controlling the product of three-fourths of all of the ovens of the district, and virtually fixing the price of coke.

During the larger part of the year the syndicate price of blast-furnace coke, free on board at the ovens, was $1.50 per ton; the average selling price for the year, however, was $1.36. During the past six years the price of blast-furnace coke, free on board at the ovens, has been as follows:

Monthly prices of Connellsville blast-furnace coke, free on board at ovens.

Months.	1881.		1882.		1883.		1884.	1885.	1886.
January	$1.50 to	$1.75	$1.70 to	$1.80	$1.15 to	$1.20	$1.00	$1.10	$1.20
February	1.50	1.75	1.70	1.80	1.20	1.10	1.00	1.10	1.20
March	1.50	1.75	1.70	1.75		1.05	1.00	1.10	1.35
April	1.60	1.75	1.70	1.75		1.05	1.10	1.20	1.35
May	1.60	1.65	1.65	1.70	0.95	1.05	1.10	1.20	1.50
June	1.60	1.65	1.50	1.65		0.90	1.10	1.20	1.50
July	1.50	1.60	1.35	1.50		0.90	1.10	1.20	1.50
August		1.60		1.35		0.90	1.10	1.20	1.50
September		1.60	1.25	1.35		1.00	1.10	1.20	1.50
October	1.60	1.65		1.25		1.00	1.10	1.20	1.50
November	1.60	1.65	1.25	1.35		1.00	1.10	1.20	1.50
December	1.60	1.70	1.15	1.35		1.00	1.10	1.20	1.50

These prices, it should be noted, are open rates. In many cases, especially in times of advance, it will be found that contracts have been made for deliveries covering the year, so that, as a rule, the actual price received for the coke is less than the open rates.

Upper Connellsville district.—This district is the one reported upon in previous volumes of the "Mineral Resources of the United States" as the "Irwin-Latrobe" (Pennsylvania Railroad) district. It is one of the most important coking districts in the amount of production in the country, second only to the Connellsville. Its production in several years past has been in excess of that of any State except Pennsylvania, and among the districts of Pennsylvania it is surpassed only by the Connellsville.

The district includes the ovens along the line of the Pennsylvania railroad from Larimer to Blairsville. These ovens are situated in three of the coal basins of Western Pennsylvania, the Upper Connellsville, the detached Greensburg basin, and the upper part of the Irwin basin. In this district a large proportion of the coke is made from washed slack, and at most of the ovens the coal used, whether slack or run of the mine, is washed before coking. The large coke works of Carnegie Bros. & Co., near Larimer, having 300 ovens, used nothing but washed slack from the mines of the Penn and Westmoreland Gas Coal Company in the vicinity. The coke made, however, is a most excellent one, it being claimed that the washing in some cases makes the coke a better fuel than the Connellsville, being harder, lower in ash, and of greater calorific efficiency.

The following are the statistics of the manufacture of coke in the Upper Connellsville district for the years 1880 to 1886:

Statistics of the manufacture of coke in the Upper Connellsville district, 1880 *to* 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	8	10	11	11	11	11	12
Ovens built	757	986	1, 118	1, 118	1, 118	1, 168	1, 337
Ovens building	0	0	0	0	0	40	29
Coal used, short tons	319, 927	588, 924	650, 174	668, 882	496, 894	555, 735	691, 331
Coke produced, short tons	229, 433	343, 728	375, 918	389, 053	294, 477	319, 297	442, 968
Total value of coke at ovens	$397, 945	$548, 362	$536, 503	$422, 174	$311, 665	$346, 168	$572, 073
Value of coke at ovens per ton	$1. 73	$1. 60	$1. 43	$1. 08	$1. 06	$1. 08	$1. 29
Yield of coal in coke, per cent	59	58	58	58	59	57	64. 1

It will be noted that the number of ovens in this district has increased from 1,168 at the close of 1885 to 1,337 at the close of 1886; that the production has increased over 100,000 tons or from 319,297 to 442,968, very nearly 39 per cent. There has also been a notable increase in the yield of coal in coke. This is possibly due to the fact that in previous years the yield of the unwashed coal was given, while in some cases in 1886 the yield given is that of the coal after washing. If this supposition is correct, the waste in washing being included in 1885 and not in 1886 would account for the increased yield in 1886.

Allegheny Mountain district.—The third in importance of the coking districts of Pennsylvania is the Allegheny Mountain. In this district are included the ovens along the line of the Pennsylvania railroad east of Blairsville, including those on both sides of the Allegheny mountains in Cambria and Blair counties, and those of Somerset county. During the year there has been a slight increase in the number of ovens and production of coke, the ovens increasing from 523 in 1885 to 579 at the close of 1886, with 14 ovens in course of construction, as against 82 at the close of 1885. The number of ovens, however, has not yet reached the number at the close of 1884, at which time there were 614. The production of coke has increased from 212,242 tons in 1885 to 227,369 in 1886. It is but fair to say, however, that such improvements are in progress in this district as will probably materially increase the production in 1887.

The following are the statistics of the manufacture of coke in the Allegheny Mountain and Somerset district of Pennsylvania for the years from 1880 to 1886:

Statistics of the manufacture of coke in the Allegheny Mountain district of Pennsylvania, 1880 to 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	8	9	10	10	12	11	10
Ovens built	291	371	481	532	614	523	579
Ovens building	0	0	0	0	0	82	14
Coal used, short tons	201, 345	225, 563	284, 544	200, 343	241, 459	327, 666	351, 076
Coke produced, short tons	127, 525	144, 430	179, 580	135, 342	156, 290	212, 242	227, 369
Total value of coke at ovens	$289, 929	$329, 198	$377, 286	$240, 641	$203, 213	$286, 539	$374, 013
Value of coke at ovens per ton	$2. 27	$2. 28	$2. 10	$1. 78	$1. 30	$1. 30	$1. 64
Yield of coal in coke, per cent	63	64	63	68	65	65	64. 8

It is probable that with the possible exception of the Pittsburgh district, more thorough and careful experiments have been made with what is known as the Belgian or flue oven in this district than in any other. At one time there were 100 Belgian ovens in blast at Johnstown, but they have been torn down, and no coke is now made in these ovens in this district except a small amount that is made by the Cambria Iron Company at their East Conemaugh works. This coke is used in making spiegel in the furnaces of the company at this point, and for this purpose it appears to have some peculiar advantages. The coal is dry, making rather a soft coke, which could not be used to advantage in a furnace making ordinary pig iron.

The production of coke in this district in 1886 was considerably restricted by a strike which lasted during June and July. At several works, as noted above, quite a number of ovens have been built during 1887, so that the production of 1887 will be considerably in excess of that of 1886. The market for the coke from this district is either the local furnaces or at eastern furnaces.

It will also be noted that but four States give a total production in excess of the production of this district, viz.: Pennsylvania, Alabama, Tennessee, and West Virginia.

Clearfield-Centre district.—In previous volumes of Mineral Resources this district has been known as the Snow Shoe district. In the last two years there has been a notable increase in the importance of this district as a coke-producing region. In 1885 the number of ovens increased from 60 to 245, the production of coke being doubled. In 1886 a third works was added, making the total number of ovens 299, with 20 others in course of construction. As this third works, however, did not begin producing coke until the last week in December, it has had no effect upon the statistics of production for 1886. The production, however, increased from 48,103 tons in 1885 to 55,810 tons in 1886.

The statistics of the manufacture of coke in the Clearfield-Centre district of Pennsylvania for the years from 1880 to 1886 are as follows:

Statistics of the manufacture of coke in the Clearfield-Centre district Pennsylvania, 1880 *to* 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	1	2	1	1	1	2	3
Ovens built	0	50	50	60	60	245	299
Ovens building	0	0	0	0	0	0	20
Coal used, short tons	200	20,025	25,000	26,500	33,000	69,720	84,870
Coke produced, short tons	100	13,350	17,160	18,696	23,431	48,103	55,810
Total value of coke at ovens	$200	$22,695	$27,406	$28,044	$32,849	$70,331	$94,877
Value of coke at ovens, per ton	$2	$1.70	$1.60	$1.50	$1.40	$1.46	$1.70
Yield of coal in coke, per cent	50	67	69	71	71	69	66

Broad Top district.—In this country are included all the ovens in what is known as the Broad Top coal field, the ovens being situated in Bedford and Huntingdon counties.

There was but little change in the statistics of the coke production in this district in 1886 over those of 1885. There is one more coke works reported, with 18 ovens, but it made no coke in 1886, being completed at the close of the year. The number of ovens has increased from 537 to 562, with 100 building, but the production has decreased from 112,073 tons to 108,294 tons. This is the only district of any importance in Pennsylvania in which there has been reduced production.

The statistics of the production of coke in the Broad Top region of Pennsylvania in the years from 1880 to 1886 are as follows:

Statistics of the manufacture of coke in the Broad Top region, Pennsylvania, 1880 *to* 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	5	5	5	5	5	5	5
Ovens built	188	188	293	343	453	537	562
Ovens building	105	105	50	110	0	0	100
Coal used, short tons	92,894	111,593	170,637	220,932	227,954	190,836	171,137
Coke produced, short tons	51,130	66,560	105,111	147,154	151,959	112,073	108,294
Total value of coke at ovens	$123,748	$167,074	$215,079	$271,692	$264,569	$185,656	$187,321
Value of coke at ovens, per ton	$2.40	$2.51	$2.05	$1.84	$1.74	$1.65	$1.73
Yield of coal in coke, per cent	55	59	62	66	66	58	63.3

The values given in the above table are in some cases the cost at the ovens; in others an assumed price over cost. So little of the coke is sold, most of it being used by the owners of the coke works, that no market price can be given.

Pittsburgh district.—In this district are included all of the ovens in Allegheny and Washington counties, those on the Monongahela river in Fayette county, and those along the Baltimore and Ohio railroad outside of the Connellsville region. In this district no lump coal or run of the mine is used, with the possible exception of one works. The coke is made from the washed slack of the Pittsburgh bed.

During the year there has been a notable increase in ovens and production in this district, the number of ovens increasing from 416 to 730. New construction is contemplated that will materially increase this number of ovens.

It is probable that the use of natural gas in Pittsburgh has had much to do with the increase of coking in that city. The large amount of slack that had been used in the rolling mills and other industrial establishments of this city became of no value, unless other uses could be found for it, and an increased use of this slack in coking has been the result.

The statistics of the manufacture of coke in the Pittsburgh district of Pennsylvania for the years from 1880 to 1886 are as follows:

Statistics of the manufacture of coke in the Pittsburgh district, Pennsylvania, 1880 *to* 1886

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	21	21	21	20	20	17	18
Ovens built	534	538	557	542	535	416	730
Ovens building	0	0	0	0	0	4	0
Coal used, short tons	194, 393	178, 509	114, 956	119, 310	97, 367	91, 101	228, 874
Coke produced, short tons	105, 974	96, 310	64, 779	66, 820	53, 357	46, 930	138, 646
Total value of coke at ovens	$254, 500	$206, 965	$134, 378	$126, 020	$99, 911	$72, 509	$221, 617
Value of coke at ovens, per ton	$2. 40	$2. 15	$2. 07	$1. 89	$1. 87	$1. 55	$1. 88
Yield of coal in coke, per cent	55	54	61	56	55	51. 5	60. 6

As will be noted, the production of coke has increased nearly three times, or from 46,930 tons in 1885 to 138,646 tons in 1886. It will also be noted that the constant decrease in production which the statistics for the past six years have shown, has been arrested, and the production for 1886 is in excess of that of 1880, the largest production of any previous year, when the total made was 105,974 tons.

Beaver district.—The coke industry in this district, in which are included the ovens in Beaver and Lawrence counties, is of but little importance. There has been a decrease of one in the number of establishments during the year, and of two in the number of ovens, while the production, which was only 411 tons, is slightly less than that of 1885.

Some of the ovens at the Norway works near New Castle have been lighted up since January 1, 1887, and it is possible that this year will show a greatly increased production.

The following are the statistics of the manufacture of coke in the Beaver district of Pennsylvania for the years from 1880 to 1886:

Statistics of the manufacture of coke in the Beaver district, Pennsylvania, 1880 *to* 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	5	5	5	5	4	4	3
Ovens built	106	106	106	107	89	89	87
Ovens building	0	0	0	0	0	0	0
Coal used, short tons	8, 013	6, 887	11, 699	19, 510	2, 250	686	698
Coke produced, short tons	4, 880	4, 333	7, 960	12, 395	1, 390	438	411
Total value of coke at ovens	$10, 150	$9, 013	$15, 124	$21, 062	$2, 168	$696	$646
Value of coke at ovens, per ton	$2. 08	$2. 08	$1. 90	$1. 70	$1. 56	$1. 59	$1. 57
Yield of coal in coke, per cent	61	63	68	64	62	63	59

Allegheny Valley district.—In this district are included the coke works in Armstrong and Butler counties, and one of those in Clarion county, the other ovens in the latter county being included in the Reynoldsville-Walston district.

The production of coke in this district has nearly doubled during the year, having increased from 15,326 tons in 1885 to 28,948 tons in 1886. The production in 1886, however, was less than that for any of the years from 1880 to 1884. To the decline of the blast furnace industry in the Allegheny valley this decreased production is to be attributed.

The following are the statistics of the manufacture of coke in the Allegheny Valley district of Pennsylvania from 1880 to 1886:

Statistics of the manufacture of coke in the Allegheny Valley district, Pennsylvania, 1880 to 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	5	5	6	6	7	5	5
Ovens built	97	109	159	159	209	208	208
Ovens building	0	0	0	0	0	0	0
Coal used, short tons	45,355	55,676	76,000	64,810	55,110	28,630	51,580
Coke produced, short tons	23,470	29,650	41,897	34,868	31,430	15,326	28,948
Total value of coke at ovens	$49,068	$64,664	$80,294	$62,982	$54,859	$30,151	$44,422
Value of coke at ovens, per ton	$2.10	$2.18	$1.92	$1.81	$1.75	$1.97	$1.54
Yield of coal in coke, per cent	52	53	55	54	57	53.5	56

Reynoldsville-Walston district.—This is growing to be one of the most important coking districts in Pennsylvania. In it are included all of the ovens of the Rochester and Pittsburgh railroad, as well as those of the Low Grade division of the Allegheny Valley railroad and the Dagus mines of the Lake Erie and Western.

The following are the statistics of the manufacture of coke in the Reynoldsville-Walston district of Pennsylvania for the years from 1880 to 1886:

Statistics of the manufacture of coke in the Reynoldsville-Walston district, Pennsylvania, 1880 to 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	3	4	5	6	7	8	9
Ovens built	117	125	177	229	321	600	783
Ovens building	0	2	0	0	0	143	500
Coal used, short tons	45,055	99,489	87,314	76,580	159,151	183,806	271,037
Coke produced, short tons	28,090	44,260	44,709	37,044	78,646	114,409	161,828
Total value of coke at ovens	$46,359	$80,785	$80,339	$65,584	$113,155	$153,795	$217,834
Value of coke at ovens, per ton	$1.65	$1.85	$1.80	$1.77	$1.44	$1.34½	$1.35
Yield of coal in coke, per cent	62	44	51	48	49	62	59.7

It will be noted that during the year there has been an increase of one in the number of establishments, this being the Adrian Coke works of the Rochester and Pittsburgh Coal and Iron Company, at which 300 ovens were building at the close of the year. The number of ovens has increased during the year from 600 to 783, and the production of coke from 114,409 tons to 161.828 tons, or over 41 per cent. In this district

500 ovens were in course of construction at the close of the year, 200 at the Walston Coal works of the Rochester and Pittsburgh Coal and Iron Company and 300 at their Adrian works. This will make the total number of ovens operated by this company 1,000. The coal and cokes of this district were so thoroughly described in the last report that it is needless to refer to them here.

Blossburg district.—In this district, in which are included the ovens in the Blossburg coal fields, there are but two coke works, these making coke chiefly for the New York markets. The returns for 1886 show a marked increase in production during the year, it having increased from 26,975 tons in 1885 to 81,801 tons in 1886, the number of ovens being reported as 405 in 1886 against 296 in 1885. This increase, however, is more apparent than real, as it has been the custom of the works in this district only to report the number of ovens in use, the rest being regarded as abandoned if they required repairs. The increase, therefore, has been chiefly due to the repairing of old ovens rather than the erection of new ones.

The following are the statistics of the manufacture of coke in the Blossburg district of Pennsylvania from 1880 to 1886:

Statistics of the manufacture of coke in the Blossburg district, Pennsylvania, 1880 *to* 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	1	1	1	2	2	2	2
Ovens built	200	200	200	344	344	296	405
Ovens building	0	0	0	0	32	0	0
Coal used, short tons	72, 520	88, 055	100, 119	71, 028	62, 365	46, 489	136, 136
Coke produced, short tons	44, 836	56, 085	64, 526	44, 690	39, 043	26, 975	81, 801
Total value of coke at ovens	$134, 500	$168, 250	$193, 500	$122, 450	$93, 763	$59, 423	$174, 532
Value of coke at ovens, per ton	$3	$3	$3	$2. 74	$2. 40	$2. 17	$2. 13
Yield of coal in coke, per cent	62	64	64	63	63	58	60

TENNESSEE.

Probably the first attempt to manufacture coke for blast-furnace purposes in any of the States south of Virginia was by Mr. R. Cravens for use at the Old Bluff hot-blast charcoal furnace. This furnace was situated at Chattanooga, on the Tennessee river, under the bluff, and was built in 1854. The Iron Manufacturers' Guide, of Prof. J. P. Lesley, which gave a statement for 1858, speaking of this furnace, says: "The bituminous coal of the Raccoon mines, now leased and worked by the Etna Mining Company, can be brought to the furnace by railway. It is excellent for coke, and some thoughts are entertained of turning the present furnace into a coke furnace." Mr. Henry E. Colton, in the "Coke Supplement" of the *American Manufacturer*, states that coke was made for use in this furnace near the site of the present Rockwood furnaces, and from coal from the same seam as that now worked there, the coke being brought down to Chattanooga. The experiment was not a success, the same difficulty being encountered that was present in all of the early attempts to convert charcoal furnaces into coke furnaces—a want of strength of blast and a stack adapted to coke.

The first coke ovens in Tennessee were erected about 1858, when the Etna coal property was purchased and a number of ovens built to make coke for foundry use. During the war operations were suspended; but in 1867 and 1868 they were again commenced, and the coke now made at these mines has a reputation second to none in the country. As stated, the ovens at the Etna mines were built to make coke for foundry use. It was not until the erection of the No. 1 furnace of the Roane Iron Company at Rockwood, Tennessee, in 1870, that works were built for manufacturing coke for blast-furnace fuel. The mines of the Tennessee Coal, Iron and Railroad Company, now the largest producers of coke in the South, and, with the exception of two, possibly three, firms of the Connellsville region, the largest manufacturers of coke in the country, were opened in 1861, but it was not until 1872 that there was any attempt to make coke for use in blast furnaces. Experiments made by Col. A. S. Colyar on the coking qualities of this coal led to the erection of the first coke furnace at Chattanooga, that of the Chattanooga Iron Company. Relative to the Sewanee seam, which is the principal seam from which coke is produced in Tennessee, Mr. H. E. Colton, in the article already referred to, says:

"The Sewanee seam belongs to the Lower Coal Measures of Pennsylvania, and is thought to be the same as Seam B. It covers a larger area than any other coal seam in Tennessee. It is found almost horizontal in the plateau region, while in Walden's ridge it is found pitched at a considerable angle. Actual workings have proved that it becomes nearly or quite horizontal at a certain depth downward. At Rockwood it dips rapidly and for some depth. At Soddy the dip is not so sharp nor so deep, and after being nearly horizontal it commences to rise slightly towards the great Sequatchie Valley uplift. This seam can safely be relied upon for an average of 3½ feet of good coal. It has very little sulphur, but the coke contains from 12 to 15 per cent. of ash; this is due to lack of proper attention in mining, as the coal itself, by analysis, does not yield an amount of ash to justify this quantity in the coke. Washing was tried at Tracy City and abandoned, the only reason assigned being that the smaller bulk of fuel in the blast furnace was not sufficient to compensate for the loss in the coal. As the Tennessee Coal, Iron and Railroad Company uses nearly all the coke it makes in its own furnaces, these points are solely its own business. There is no doubt that this coke would be greatly improved by washing the coal, and, for sale to outside parties, it must eventually be done. The great area underlaid by this seam of coal, the ease and cheapness with which it can be mined, must, in the near future, largely increase the product from it, and the coke must also be improved. At the Soddy Coal Company's mines it has been washed with very decidedly good results. This seam of coal extends in the pitched strata of Walden's ridge from near Cumberland gap to the point where these strata begin to lessen in dip, and become nearly horizontal southwest of Dayton, a distance of over 120 miles. At Big Creek gap, in Campbell county, it is well developed, showing plainly between the uplifted rocks; it was mined to some extent for General Burnside's army.

"In the great plateau region beyond the Sequatchie Valley fold it is found everywhere above a certain elevation to a point northward at the basin's limit, and it underlies the great body of Upper Measures in Morgan, Anderson, and Campbell counties. It is an immense storehouse of fuel, and with care in mining and in manipulating in the ovens a far better coke can be made from it than has ever yet been produced."

Relative to the other seams of coal used for coke in Tennessee, Mr. Colton states: "There are three other seams of coal now being used for the manufacture of coke in Tennessee. These are the seam at Glen Mary, the Daisy seam at the Tabler-Crudup mines, the Kelly seam, and the Oak Hill at the Etna mines. It is my opinion that the Daisy seam and the Oak Hill are the same, and that a small seam mined at Soddy for a mixture, especially when it is desired to make foundry coke, is the same as the Kelly, but somewhat altered.

"The Glen Mary seam has not been fully identified with any of the seams on the eastern rim of the field. It averages about 30 inches thick, affords a hard, bright, cubical, and rather soft coal in two layers, between which is a thin parting. The slack is used for coking, and from it has been made the best coke yet produced in Tennessee for furnace use. Nearly all made there now goes to Dayton, to be mixed with the coke from their own coal. The coke has a bright silvery luster, a clear metallic ring, and breaks into long fingers. The Dayton Coal and Iron Company for a time mined a thin seam, which is probably the same as the Kelly at Etna, but are now operating in a seam which is probably identical with that worked at Soddy and Rockwood. The Daisy seam has hardly been fully tested, carelessness and want of skill having caused some of the first coke produced to be poor. It also contains considerable sulphur. The Kelly seam at the Etna mines furnishes a coking coal which for foundry purposes stands at the head of all the southern cokes, it has even competed successfully with Connellsville in the western smelting works. The seam, however, is thin and the mining costly, but the price obtained for both coal and coke is so much greater than that from other mines that the extra cost is more than covered. It is too costly to be used alone as a furnace coke, and for this purpose it is mixed with a seam above called the Oak Hill seam, and then the coke has too much sulphur to be used alone, but is used as a mixture with other cokes having little sulphur and more ash, and also less burden-carrying capacity. At the Etna property the place of the Sewanee seam is occupied by a seam of coal only about 18 inches thick at the outcrop.

"Northeast of the Emery river and east of the line of the Cincinnati Southern railway, in Tennessee, is a large area of coal-bearing strata containing nine seams of coal over 3 feet thick, and which have a total thickness of 36 feet, besides which there are many smaller seams of excellent quality and some so situated that they can be cheaply mined. A large part of this region has been pierced by one railroad for sixteen years, and since 1881 has been accessible by two more, yet to-day there is not positive evidence that there is in those strata a first-class coking coal. The Oakdale Iron Company erected sixty ovens and for a year or more made an excellent coke from the Big (Pittsburgh) seam on Poplar creek, but so imperfect were the furnace records kept that it is now not known how it worked on the burden it carried. It is simply known that it was a good coke. In appearance it was unlike any other coke produced in the South and had less ash. At Coal creek, on the Knoxville and Ohio railroad, four ovens were erected and sporadic attempts made in coking the coal from the seam worked there, which is also the equivalent of the Pittsburgh seam. The results were variable, and proved nothing either good or bad. All this vast property from Poplar creek far up into Campbell county, consisting of 100,000 acres of coal and iron lands, has now passed into the hands of Gen. Samuel Thomas, president of the East Tennessee, Virginia and Georgia Railroad, who, with ample capital, will fully test all this field. It is my opinion, from a long series of examinations made in it, that a coal will be found which will make a coke fully equal to the best Connellsville.

"There is an area of coal lands in East Tennessee entirely unexplored, which seems to be somewhat dissimilar to the lands last discussed, and from which no coal has ever been taken except for country use. This region is east of the line of the Knoxville and Ohio railroad from Knoxville to Kentucky, which road has its course directly on the line of the fault or uplift which cuts this field off from that of Coal creek and Poplar creek. It is usually called the Big Creek or Walnut Mountain coal region, but is, in my opinion, the southern prolongation of the now much talked of Flat Top coal field of Virginia. I have no doubt it contains one or more good coking coals."

Relative to the cokes of this State, Messrs. McCreath and D'Invilliers, in the paper read before the American Institute of Mining Engineers, several times referred to, give the following statement and analyses:

"Several cokes were sampled at the Citico and Chattanooga furnaces, the analyses of which are given below. But little information could be obtained as to the relative position of the coal bed furnishing the raw material or the character of the coal itself.

"The results of analyses of samples of coke, all selected from stock piles at the furnaces, are as follows:

Analyses of Tennessee coke.

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Water	.856	.218	.172
Volatile matter	1.160	1.055	1.098
Fixed carbon	85.450	79.839	80.823
Sulphur	1.451	2.132	2.127
Ash	11.083	16.756	15.780
Total	100.000	100.000	100.000

No. 1. Etna coke, Citico furnace, from the Etna mines, 13 miles from Chattanooga.
No. 2. Daisy coke, Citico furnace, from the Daisy mines, 15 miles from Chattanooga.
No. 3. Soddy coke, Citico furnace, from the Soddy mines, 20 miles from Chattanooga.

The following are the statistics of the manufacture of coke in Tennessee from 1880 to 1886:

Statistics of the manufacture of coke in Tennessee, 1880 to 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	6	6	8	11	*a*13	12	12
Ovens built	656	724	861	992	1,105	1,387	1,485
Ovens building	68	84	14	10	175	36	126
Coal used, short tons	217,656	241,644	313,537	330,961	348,295	412,538	621,669
Coke produced, short tons	130,609	143,853	187,695	203,691	219,723	218,842	368,139
Total value of coke at ovens	$316,607	$342,585	$472,505	$459,126	$428,870	$398,459	$687,865
Value of coke at ovens, per ton	$2.42	$2.38	$2.52	$2.25	$1.95	$1.82	$1.87
Yield of coal in coke, per cent	60	60	60	62	63	53	59

a One works made coke in pits.

These statistics, when compared with 1885, or indeed with any previous year, show a most gratifying increase. The number of establishments remains the same as in 1885, but there has been an increase in the number of ovens from 1,387 at the close of 1885 to 1,485 at the close of 1886, and in the number of ovens building at the close of each year from 36 to 126. The production of coke has increased from 218,842 tons in 1885 to 368,139 tons in 1886, an increase of 68 per cent. The largest production in any one previous year was in 1884, when the production was a little less than 1,000 tons in excess of that of 1885, it being 219,723 tons. The yield of coal in coke, which had dropped from 63 per cent. in 1884 to 53 per cent. in 1885, has now risen to 59 per cent., which is probably nearer the correct figure than 53 per cent.

Three works equipped with 192 ovens made no coke in 1886.

TEXAS.

No coke has ever been made in this State on a commercial scale. A number of experiments have been made with the coals to test their coking qualities, but until recently the results have not been such as to justify beginning its manufacture. During the last year the Rio Grande and Eagle Pass Railway Company has erected some ovens at its coal mines at Laredo and tested the coal with fairly good results, the coal yielding 50 per cent. in coke. The company contemplates building ovens in the near future.

UTAH.

No coke has been made in this State since 1882. The twenty Coppée ovens erected some years ago in the San Pete valley are the only ones at present in the State.

The character of the coals of Utah, and the coke made from them, has been exhaustively treated in previous reports.

In view of the fact that no coke has been made since 1882, the table of statistics is not continued.

VIRGINIA.

The only coke made in Virginia during the years covered by this report from coal mined in the State was produced at Pocahontas, from Flat Top coal, by the Southwest Virginia Improvement Company. In addition to the ovens of this company, there is at Low Moor, in Alleghany county, just across the the border from West Virginia, a bank of 150 ovens, drawing their supplies of coal from the New River district of West Virginia, the ovens being for convenience located at Low Moor, near the blast furnace in which their product is consumed. In previous years the product of these ovens has been reported in connection with West Virginia. For 1886, however, the figures are included in the statistics of Virginia.

The following are the statistics of the production of coke in Virginia for the years from 1880 to 1886:

Statistics of the manufacture of coke in Virginia, 1880 *to* 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	0	0	0	1	1	1	2
Ovens built	0	0	0	200	200	200	350
Ovens building	0	0	0	0	0	0	100
Coal used, short tons	0	0	0	39, 000	99, 000	81, 899	200, 018
Coke produced, short tons	0	0	0	25, 340	63, 600	49, 139	122, 352
Total value of coke at ovens	0	0	0	$44, 345	$111, 300	$85, 993	305, 880
Value of coke at ovens, per ton	0	0	0	$1. 75	$1. 75	$1. 75	2. 50
Yield of coal in coke, per cent	0	0	0	65	64¼	60	61. 2

As compared with the statistics of the works reported in previous years as the only works in Virginia, there has been an increase in production in 1886 over 1885 of over 12 per cent., bringing the production nearly up to that of 1884.

The character of the coal and coke from the Pocahontas district has been thoroughly discussed in previous volumes of "Mineral Resources." Here it need only be said that in purity and general excellence the coke of Virginia made from the coal of the Flat Top coal field is probably superior to that made in any other portion of the Southern States, with the exception of West Virginia. The No. 3 or Pocahontas coal bed of the Flat Top field is advantageously situated for mining above water level through a large area. Mr. d'Invilliers estimates that it will yield about 10,000 tons of coal per acre from a bed 10 to 12 feet thick, which is in some portions of the field split into two distinct workable seams, and yields about 9 feet of coal. Its favorable position, not requiring pumping, and the ease with which it can be worked, renders it an exceedingly cheap fuel as compared with that of the Chattanooga and Alabama districts, and the quantity of this excellent coal is so great as to assure a future coke supply.

The two following analyses are from the paper of Messrs. McCreath and d'Invilliers:

Analyses of Pocahontas (Virginia) coke.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Water	.182	.196
Volatile matter	.719	.494
Fixed carbon	92.248	92.585
Sulphur	.565	.677
Ash	6.286	6.048
Total	100.000	100.000

No. 1. Southwest Virginia Improvement Company ovens, Pocahontas; sampled January, 1887.
No. 2. Southwest Virginia Improvement Company ovens, Pocahontas; sampled June, 1886.

WASHINGTON TERRITORY.

The coke works of the Tacoma Coal and Coke Company at Wilkeson, Pierce county, Washington Territory, is still the only one so far as has been ascertained on the Pacific coast. In 1884, the first year for which we have any returns from this Territory, all the coke was produced in pits, as was most of that made in 1885. Near the close of 1885, however, 2 ovens were built and operated a short time with such gratifying success that 9 more were constructed during the year 1886, making 11 in all, and 21 additional were building at the close of 1886, which will give a plant of 32 ovens when they are completed. The 11 ovens in operation at the close of 1886 were not started up until the latter part of October. The figures given in the following statistics represent, therefore, only about two months run.

The following are the statistics of the manufacture of coke in Washington Territory for the years from 1884 to 1886, the only years in which coke has been made:

Statistics of the production of coke in Washington Territory in 1884, 1885, *and* 1886.

	1884.	1885.	1886.
Number of establishments	1	1	1
Number of ovens built	0	2	11
Number of ovens building	0	0	21
Coal used in the production of coke, short tons	700	544	1,400
Coke produced, short tons	400	311	825
Total value of coke at ovens	$1,900	$1,477	$4,125
Value of coke at ovens, per ton	$4.75	$4.75	$5.00
Yield of coal in coke, per cent	57½	57	58.9

WEST VIRGINIA.

The localities in which coke is made in West Virginia are, in this report, divided into four districts, instead of three, as in previous volumes of "Mineral Resources." The districts are known as the Kanawha, the New River, the Flat Top, and the Northern. The first two are compact and continuous. They include the ovens along the line of the Chesapeake and Ohio railroad, from west of Low Moor, in Virginia, to the Kanawha valley. The Flat Top region includes the ovens in the new Flat Top district, which is in reality a part of the New River district, while the fourth district, the Northern, is a scattered one, including the ovens in Preston, Taylor, Harrison, and Marion counties, and those at Wheeling, in Ohio county. Nearly or quite all of these ovens are located on the Baltimore and Ohio railroad. From an article by Maj. Jed Hotchkiss, in the "Coke Supplement" of the *American Manufacturer*, we condense the following statement relative to the coking coals and the cokes of West Virginia, outside of the Northern district:

"It is somewhat remarkable that the coking coals of the Virginias and those of Pennsylvania, those that have been proven by the practical tests of fuel consumers the best coking coals of this country, are found in opposite ends of the great Carboniferous series; the former in the Lower Coal Measures, those of formation No. XII. of the Rogers Brothers, and the latter in the Upper Coal Measures, those of formation No. XV. The best Pennsylvania coking coal, that of the Connellsville field, is found near the eastern side of the northern portion of the Great Coal Basin of the Ohio (the Apalachian of most writers); the best Virginia coking coal, that of the New River and the Flat Top Mountain fields, is found on the very eastern border of the same famous and wonderful coal basin, about 200 miles west of south from the Connellsville field.

"As will hereafter appear, two varieties of coals are now coked in West Virginia. These are the semi-bituminous coals of New river and the Flat Top fields, which are generally recognized as distinctively coking coals, and the bituminous coals of two of the beds of the lower portion of the middle, or Kanawha, measures. By far the larger portion of the coal used in the Virginias for coking purposes is of the former, the semi-bituminous, variety; and when Virginia coking coals are mentioned it is generally understood that the No. XII., or semi-bituminous, coals are meant.

"These coking coals are generally spoken of as "New River" coals or as "Flat Top" coals, though they are mined from the same beds in the same formation, but the former from the northern and the latter from the southern portion of the same coal-bearing area. The coals of the former are now mined along New river, on the eastern division (formerly the Chesapeake and Ohio) of the railways of the Newport News and Mississippi Valley company; those of the latter from the eastern slopes of Great Flat Top mountain, on the waters of Bluestone river or

New river, and on the New River branch of the Norfolk and Western railroad; hence the different commercial designations for the same coals.

"The semi-bituminous, or No. XII., coking coals of Virginia and West Virginia are found in their best condition and largest development, judging by the present state of information concerning them, in parts of Tazewell county, Virginia, and of Mercer, Summers, Greenbrier, Fayette, Raleigh, Wyoming, and McDowell counties, West Virginia. The length of the field from northeast to southwest is about 60 miles; its average breadth, from southeast to northwest, is not far from 16 miles, making the limits of its area about 1,000 square miles. These dimensions establish the fact that this is the largest field of distinctively coking coals in the United States. The eastern border of this field is sharply defined by the Great Flat Top mountain and its extensions on the southwest side of New river and by Big Sewell mountain, and its extensions on the northeast side of that river.

"The definition of the western border of this field is a difficult matter, because the formation carrying these coals generally dips, at first moderately and then rapidly, to the northwest, and so carries these coal beds under the drainage levels of the great trans-Appalachian plateau at different distances from their eastern outcrop, depending on the depths to which the streams have eroded their channels.

"The thickness of formation No. XII., as exposed on New river by the measurements of Prof. I. C. White, is 1,310 feet; it is fully as thick where exposed in the Flat Top field between Bluestone river and the watershed of Great Flat Top mountain to the northwest. In this No. XII., the Lower Coal Measures of the Virginias (which the geologists of the Second Geological Survey of Pennsylvania call the Pottsville Conglomerate) there are three workable beds of coal.

"These coal beds find their greatest development in the vicinity of Pocahontas, where the lower one, the 'Quinnimont' of New river, the 'No. 3,' or 'Pocahontas,' of the Flat Top region, attains the grand thickness of 12 feet of practically solid coal. These beds become thinner in passing to the northward; the upper one, the 'Nuttall,' which is a little over 5 feet thick on Crane creek of the Bluestone, in the extension of Indian ridge (the 'divide' between the Big Sandy and the Guyandot waters), in the southern part of this field, thins to three feet of clear coal in the new Tyree mine of the Longdale Iron Company, in the northern part of the same field. They also thin somewhat in passing from the eastern to the western outcrops. The coal beds of these Lower (or No. XII.) Coal Measures, in descending order, are:

"The 'Nuttall,' 'Sewell,' or 'Upper' bed of the New River region; the 'No. 10' of the Crane Creek section of the Flat Top region.

"The 'Fire Creek' or 'Middle' bed of the New River region; the 'Nos. 6 and 7' (this bed being double at that place) of the Crane Creek section of the Flat Top region.

"The 'Quinnimont' or 'Lower' bed of the New River region; the 'Pocahontas,' or 'No. 3' of the Flat Top region, at Pocahontas, and the 'Nos. 3 and 4' of the Crane Creek section, the bed there having become double."

Total coke production in West Virginia.—Consolidating the statistics of the different districts given below, the following are the statistics of the production of coke in West Virginia from 1880 to 1886:

Statistics of the manufacture of coke in West Virginia, 1880 *to* 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	18	19	22	24	27	27	29
Ovens built	631	689	878	962	1,005	978	1,100
Ovens building	40	0	0	0	127	63	317
Coal used, short tons	230,758	304,823	366,653	411,159	385,588	415,533	425,002
Coke produced, short tons	138,755	187,126	230,398	257,519	223,472	260,571	264,158
Total value of coke at ovens	$318,797	$429,571	$520,437	$563,490	$425,952	$485,588	$513,843
Value of coke at ovens, per ton	$2.30	$2.30	$2.26	$2.19	$1.91	$1.86	$1.94
Yield of coal in coke, per cent.	60	61	63	63	62	63	62

In all respects, except in yield of coal in coke, the report for 1886 shows an increase over that for 1885, making the production of the last year the largest in the history of the State. The number of establishments has increased from 27 to 29. The number of ovens built at the close of 1886 is 1,100, compared with 978 at the close of 1885, while the number building at the close of 1886 has increased to 317, as compared with 63 at the close of 1885. The coke produced was 264,158 tons in 1886, as compared with 260,571 tons in 1885, and if the production of the Low Moor ovens, which in previous years has been given in this State, were added, these figures would be materially increased.

The Kanawha district.—In this district are included the ovens from Ansted, down the Kanawha, all drawing their coal from the formations described above. The statistics of the manufacture of coke in the Kanawha district of West Virginia for the years from 1880 to 1886, were as follows:

Statistics of the manufacture of coke in the Kanawha district, West Virginia, 1880 *to* 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	4	4	5	5	6	7	7
Ovens built	18	18	(*a*) 138	(*a*) 147	(*a*) 177	(*b*) 181	302
Ovens building	0	0	0	0	15	63	170
Coal used, short tons	6,789	11,516	40,782	58,735	60,281	65,348	89,410
Coke produced, short tons	4,300	6,900	26,170	37,970	39,000	37,551	54,329
Total value of coke at ovens	$9,890	$16,905	$62,808	$88,090	$76,070	$63,082	$17,649
Value of coke at ovens, per ton	$2.30	$2.45	$2.40	$2.32	$1.95	$1.68	$2.17
Yield of coal in coke, per cent	63⅓	60	64	64⅔	64⅔	57	60.7

a Eighty of these ovens are Coppée, the balance beehive.
b Sixty of these ovens are Coppée, the balance beehive.

While the number of establishments remains the same there has been a very gratifying increase in the amount of coke produced in the year, as well as in the other elements that make up the above table. The number of ovens has increased from 181 at the close of 1885, to 302 at the close of 1886, and the number building from 63 to 170, while the production of coke has increased from 37,551 tons in 1885, to 54,329 tons in 1886. In 1865, 3 of the 7 works reported made no coke, 2 being in course of construction at the close of the year. But one of the 7 works was idle during all of 1886.

New River district.—The New River coking district includes the ovens along the line of the Chesapeake and Ohio railroad, from Quinnimont to Nuttallburgh.

The statistics of the manufacture of coke in the New River district of West Virginia from 1880 to 1886 are as follows:

Statistics of the manufacture of coke in the New River district, West Virginia, 1880 *to* 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	6	6	6	6	8	8	8
Ovens built	468	499	518	546	547	519	513
Ovens building	40	0	0	0	12	0	5
Coal used, short tons	159, 032	219, 446	233, 361	264, 171	219, 839	244, 769	203, 621
Coke produced, short tons	98, 427	136, 423	148, 373	167, 795	135, 335	156, 007	127, 006
Total value of coke at ovens	$239, 977	$334, 652	$352. 415	$384, 552	$274, 988	$325, 001	$281, 778
Value of coke at ovens, per ton	$2.44	$2. 45	$2. 38	$2. 29	$2. 03	$2. 08	$2. 22
Yield of coal in coke, per cent	62	62	64	64	62	63¾	62

The apparent decrease in the number of ovens, production of coke, etc., in this district in 1886, as compared with 1885, is due to the fact that the Low Moor ovens, which have heretofore been reported in the New River district, have been transferred to Virginia. Otherwise the production of the New River district would have shown a gratifying increase.

Flat Top district.—The statistics of the manufacture of coke in the Flat Top district of West Virginia for 1886 are as follows:

Statistics of the manufacture of coke in the Flat Top district of West Virginia for 1886.

	1886.
Number of establishments	2
Ovens built	10
Ovens building	38
Coal used, short tons	1, 075
Coke produced, short tons	658
Total value of coke at ovens	$1, 316
Value of coke at ovens, per ton	$2. 00
Yield of coal in coke, per cent	61. 2

As coke was made in this district for the first time in 1886, the table only covers the operations for that year. It is also to be noted that while a large number of ovens was contemplated in this district, the building of which has been begun since January 1, 1887, the above includes all of the ovens, so far as has been reported, that were built or in course of construction December 31, 1886.

The Northern district.—In this district are included the ovens in the group of counties lying along the line of the Baltimore and Ohio railroad, near the headwaters of the Monongahela river—Preston, Taylor, Harrison, and Marion, and those of Ohio county, in the northern part of the Panhandle. The coke made at Wheeling is small in amount, and supplies a local demand, chiefly from glass works. The coke from the Monongahela district proper is used at local furnaces and is also finding a good demand outside of the State, considerable being distributed from Cincinnati, Louisville, and Chicago.

The coal used in the manufacture of coke in this district, with the exception of two works, is from the Pittsburgh bed. As mined by the Newburg-Orrel Coal Company in Preston county, this seam is from 10 to 11 feet thick. Only 9 to 9½ feet are worked, however, the rest being left to support the roof. At the Tyrconnel mines of this same company, in Taylor county, it is 9 feet; at Clarksburg, Harrison county, 8 feet 10 inches; and at Wilsonburg, in the same county, 7 feet 6 inches. The coke made from this coal is reported by Mr. Maury to be compact and handsome, but liable, in some localities, to contain an excess of sulphur. This is not true of all the cokes made in this district. The following are analyses of two of the coals of the Pittsburgh bed in this district:

Analyses of coals of the Pittsburgh bed in West Virginia.

	Marion county.	Harrison county.
	Per cent.	*Per cent.*
Fixed carbon	67.50	60.00
Volatile matter	32.50	....
Total	100.00	....
Ash	2.10	6.70
Sulphur	.95	....

The only analysis of coke obtained is the following from Preston county:

Analysis of coke from Preston county, West Virginia.

	Per cent.
Fixed carbon	89.30
Volatile matter	.54
Ash	9.30
Sulphur	.70
Moisture	.16
Total	100.00

At Austen, Preston county, the Upper Freeport seam, which is here from 5 to 5½ feet thick, is coked. Professor Lesley reports that this coal makes "a clear, even, silvery coke, sufficiently hard to bear the heaviest burden of the blast furnace." Regarding it, Mr. White says: "Since this coal is successfully worked at the Irondale furnace, on

Three Forks, as at Austen, there would seem to be good reason for believing that this great basin, 8 to 12 miles wide, stretching across Preston county from the Pennsylvania line to the Baltimore and Ohio railroad, and all underlaid by this coal, will yet furnish much valuable coking coal."

The following are analyses of this coal and coke as mined at Austen:

Analyses of Austen, West Virginia, coal and coke.

	Coal.	Coke.	
		48 hours.	72 hours.
	Per cent.	*Per cent.*	*Per cent.*
Fixed carbon	66.28	90.56	87.98
Volatile matter	31.12	....	....
Ash	2.48	9.19	11.57
Water	0.12	0.25	0.45
Total	100.00	100.00	100.00
Sulphur	0.64	0.19	0.21

The yield of coal in coke was 66 per cent.

It is evident that the coke could not have been made of the coal of which an analysis is given. Probably the coal analyzed is selected lump, the coke being from the run of the mine or slack.

The statistics of the production of coke in the Northern district of West Virginia, from 1880 to 1886, are as follows:

Statistics of the manufacture of coke in the Northern district, West Virginia, 1880 *to* 1886.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Number of establishments	8	9	11	13	13	12	12
Ovens built	145	172	222	269	281	278	275
Ovens building	0	0	0	0	100	0	104
Coal used, short tons	64,937	73,863	92,510	88,253	78,468	105,416	131,896
Coke produced, short tons	36,028	43,803	55,855	51,754	49,139	67,013	82,165
Total value of coke at ovens	$68,930	$78,014	$105,214	$90,848	$74,894	$97,505	$113,100
Value of coke at ovens, per ton	$1.91	$1.78	$1.88	$1.76	$1.52	$1.45	....
Yield of coal in coke, per cent	55	59	60	59	63	63½	62.3

From the table it will be seen that 1886 was the year of the largest production of coke in this district, exceeding by some 15,152 tons the production of 1885. This district promises to be in the near future of more importance than at present. Several of the works have increased the number of their ovens during the year, while other works have ceased to exist. Those that remain are contemplating operations on a much larger scale.

GAS COKE.

As is stated elsewhere, the word "coke" in this chapter refers to what we have termed "oven coke." A reference to gas coke may not be out of place in this connection.

There are in the United States something like 975 works producing illuminating gas. Two-thirds of these use the ordinary coal gas process; the other third, some more recent process, such as some form of the water gas, or the petroleum gas, or the natural gas process.

It is estimated that the amount of bituminous coal carbonized in the manufacture of gas in the United States in 1886 was 2,150,000 tons, and that the yield of coke per ton of coal carbonized was 1,300 pounds. This would give a total production of 1,397,500 tons of gas coke, which, at an average of $3, which is believed to be not excessive when it is considered that so much of the coke is produced in localities where fuel is expensive, would be worth $4,192,500.

COKING IN EUROPE.

The centers of coke manufacture, outside of those in the United States, are: Durham in England, Hainaut and Liège in Belgium, and Westphalia in Germany. Little coke is made outside of England, Belgium, and Germany. Portions of Austria-Hungary are amongst the oldest iron-producing districts of the world, but the small and isolated supply of coking coal and its distance from the iron ores have limited its growth. The total yearly product of Austria-Hungary does not exceed 200,000 metric tons. There is no coal in Norway. Sweden works a little coal in the Lias formation; it is non-coking. No coke is used in Swedish blast furnaces. Denmark proper has no coal beds. Russia has large coal deposits, well adapted to coke making, but the immense forests of timber in the Empire furnish excellent charcoal fuel for a limited iron product. Holland has a little coal, but makes no coke. Coal is found in Turkey and Greece, but little is mined and no coke is made. Spain has some coal basins of considerable importance, some of it adapted to coking; but Spain exports iron ore and imports coke.

British coke.—The most important of the coking districts of Great Britain is Durham. Coke is made in Yorkshire, Cumberland, and Lancashire, and in South Wales to a considerable amount, but in none of these districts is the industry so extensive nor the quality of the coke as good as in Durham. It is impossible to obtain accurate statistics of the production of coke in Great Britain. Coke is regarded as a form of coal, and its statistics are consolidated with those of coal in a most provoking manner. Mr. J. S. Jeans, the able secretary of the British Iron Trade Association, puts the total consumption of coke in iron smelting in 1882 at a minimum of 8,064,350 tons, requiring 14,120,627 tons of coal in its production. To this he adds 2,000,000 tons consumed for foundry and other purposes and the export trade, "bringing up the total production of coke to fully 10,000,000 tons in round figures. Of this quantity very nearly one-half is produced in the county of Durham, where 14,000 to 15,000 ovens, chiefly beehive, are built for its manufacture. The average yield per oven throughout the country over the whole year may be taken at about 330 tons, which would give a total of 30,300 ovens, and represents a total capital expenditure of £2,000,000 sterling."

The production of pig-iron in Great Britain in 1886 was 6,870,665 tons, or 81 per cent. of the product of 1882. On the supposition that the production of coke increases and decreases in Great Britain in about the same ratio as the production of pig-iron, on the basis of Mr. Jeans' figures for 1882 and the relative production of pig-iron for 1882 and 1886, the production of coke in Great Britain in 1886 would be but 8,100,000 tons in round numbers.

The Durham, England, coke district.—The typical coke of Great Britain, as the Connellsville is of the United States, is the Durham. It is high in carbon, low in ash, hard, firm, cellular, and capable of sustaining in the blast furnace the weight of a high column of materials.

The veins of coal in Durham are low, the thickest seam measuring but 6 feet. The miner, in mining this coal, is consequently compelled to lie on his side, working in a constrained and cramped position, never standing upright while in the face. The pits are deep and the mines fiery, with all the danger to life and health arising from these conditions. The best coal is obtained from the lower seams. The Brockwell and Busty seams, in the Brancepeth district, may be taken as fairly representing this coal. The analyses of these coals are as follows:

Analyses of Durham, England, coking coal (a).

Constituents.	Busty seam.		Brockwell seam.
	Upper part.	Lower part.	
	Per cent.	*Per cent.*	*Per cent.*
Carbon	81.22	78.46	83.40
Hydrogen	4.70	4.42	4.40
Oxygen and nitrogen	9.45	8.82	7.18
Water	0.85	0.99	0.90
Ash	3.28	6.17	3.50
Sulphur	0.81	1.83	1.00
Total	100.31	100.69	100.38

a Authority, Sir I. Lowthian Bell.

The coal of the above seams yields from 60 to 65 per cent. of its weight of coke. Its purity will be seen from the appended analyses of the coke made from the coal of the seams in the collieries named:

Analyses of Durham, England, coke.

Collieries.	Carbon.	Ash.	Sulphur.	Water.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Hamsteels	92.55	6.36	0.81	0.21
Consett	91.88	6.91	0.84	0.37
Whitworth	91.56	6.69	1.21	0.54
South Brancepeth	93.41	5.30	0.91	0.36

At the coke ovens in Durham the work differs but little from that at the ovens in Connellsville. In the Durham district the ovens average smaller in diameter and are higher, but the charges are heavier and are burned longer, 72 and 93 hour coke with charges of from 12,000 to 14,000 pounds of coal being the custom in Durham, while 48-hour coke for five days in the week, and 72-hour on Saturday and Sunday, with a charge of 7,600 pounds is customary in the Connellsville region.

In the Durham district there are three classes of coke-drawers: Class A, who draw the coke from the ovens and lay it down on the bench or wharf; class B, who draw the coke from the ovens and load it into railroad trucks or cars, and class C who draw the coke and lay it down on the bench as class A, but in addition charge the ovens from the door and build up and daub the door. The majority of Durham coke works employ drawers of class C. The drawers in the Connellsville coke region correspond with classes A and B, the only difference being that class A, instead of laying the coke on the benches, draw it from the oven in small wagons, which are then hauled to the railroad cars and loaded into them by day laborers. Class C is not employed in Connellsville. The "chargers" of the Connellsville region are termed "small runners" in Durham. These run the wagons or larries containing the charge along the over-head tramway to the charging hole, and dump the coal into the oven. The "levelers" in the two regions do practically the same work, leveling the ovens and bricking and daubing the doors. Sometimes "daubers" are employed in Durham. The levelers in Connellsville also attend to the burning of the coke. The filler at the English works is known as a "forker" in Pennsylvania, his duty being to load the coke into railroad cars. In Connellsville this is done by a common laborer.

The number of each class of employés, so far as given, is about as follows:

Number of employés in Durham, England, compared with those at Connellsville.

	Durham.	Connellsville.
Coke drawing	1,572	1,782
Small runners	233	330
Levelers	256	107
Fillers	404	759
Laborers	179	396

Average amount of work done per man in each class in Durham, England, and Connellsville.

	Durham.	Connellsville.
Coke drawers:		
A, 12-foot ovens		18 per week.
11-foot ovens	18 per week	15 to 20 per week.
10-foot 6-inch ovens	20 per week	Do.
10-foot ovens	24 per week	
B, 12-foot ovens		18 per week.
11-foot ovens	12 to 14 per week	18 to 22 per week.
10-foot 6-inch ovens	12 to 14 per week	Do.
10-foot ovens	16 to 18 per week	
C, 11-foot ovens	9 per week	
10 foot ovens	12 per week	
Chargers or small runners	12 to 14 per day	40 per day.
Levelers	12 to 14 per day	20 per day.

Fillers, daubers, and laborers work by the day.

Average rates of wages per oven or per ton in Durham, England.

	s. d.	
Drawing, 10-foot ovens ....per oven..	1 6	or $0.38
Drawing and filling .... do ..	2 3½	.55
Leveling....................................do....	4	.08
Small runner (charger)...............per ton..	3	.06

NOTE.—Above rates are subject to 5 per cent. advance.

The average earnings are as follows:

Average daily earnings of Durham, England, coke workers.

	Average earnings.		Average earnings.
A drawers	$1.108	Fillers	.926
B drawers	1.068	Levelers	.826
C drawers	1.088	Laborers..........	.704
Small runners	886		

The beehive oven is used almost exclusively, there being from 14,000 to 15,000 in Durham. The waste heat from the ovens is at many works utilized for firing the boilers at the ovens and pits' mouths. Quite a number of ovens adapted to saving the by-products of the coking process are in use in Durham.

Coking in South Wales.—Next to Durham, South Wales is the most important coking district of Great Britain. As compared with the Durham or with our Connellsville coke that from South Wales is an inferior fuel. As a rule it is not as well made as the Durham. Either from careless burning or from a want of adaptability of the coal to coke making, there is not that complete carbonization and regular physical condition characteristic of the Durham and Connellsville cokes.

The material charged into the ovens is largely slack, comparatively little lump or run of the mine being used. Sometimes this slack is crushed and washed, at other times not. Some anthracite slack in connection with bituminous slack and pitch or tar has been, if it is not at present, made into coke.

The great variety of coal found in this district and the attempts made to produce the best coke possible from it, combined with the inferior coking qualities of some of the varieties, have led to experiments and the adoption of several varieties of ovens. These are chiefly of three kinds—the ordinary beehive, and the Welsh or Drag oven, both solid wall ovens, and the Coppèe, a Belgian or flue oven.

In the ordinary beehive oven there is difficulty in getting thorough burning. The usual time of burning is 72 to 76 hours. The coke is hard and dense, but has long, deep fissures, showing a considerable amount of dark matter not well burned. At a works near Bridgend, in Glamorganshire, a new system was tried sometime ago which gave good results. The coal was first reduced to powder, carefully washed and dried before being charged into the ovens. The value of the coke made in this way was greatly increased—fully 40 per cent. When Welsh coke was worth 7*s.* 6*d.* this sold at 10*s.* 6*d.* The Coppèe oven, which is a flue or retort oven, is used to some extent in South Wales. The coke is finely divided, the ovens are small in width, and the coke is made rapidly, the charges burning but 24 hours. The coke is pushed out by a ram and cooled outside. The ovens are 30 feet long, 3 feet high, and but 16 inches wide. The emptying and refilling of the ovens require about 8 minutes. The coke made at each burning is about 2 tons. The ovens are filled six times a week. The steam for the coal washing and crushing is raised by the waste heat from the ovens.

The oven most commonly used is the Welsh oven, which is a modified beehive. It is a long oven, like a small tunnel, instead of having the peculiar shape to which the beehive owes its name. It is a solid wall oven, however. This oven varies somewhat in size. The most common size is 15 feet long, 5 feet wide at the back, and 5 feet 6 inches wide at the front; this difference in width being to facilitate the drawing of the ovens. From the floor to the highest part or crown of the arch the oven is 4 feet 10 inches, but from the bottom at the side to the point where the arch begins it is 3 feet 6 inches. These ovens are generally built back to back, with a chimney between them, and in some cases there are bottom and side flues. These ovens are sometimes charged at the door, and sometimes from the top. There are two charges a week. The first, of 4½ tons, is burned 3 days, or 72 hours; the second is 5 tons, and is burned 4 days or 96 hours. Sometimes the coke is watered in the ovens, and sometimes after it is drawn. The oven is not drawn with a hook or scraper, as is the beehive. Along the bottom of the oven from front to back, before charging, a piece of railroad iron the length of the oven is laid; this has a hook on the back end into which another piece of iron 5 feet long is laid across the end of the large piece. The charge burns upon the bar, and when it is ready to draw a chain is attached to the outer end of the long rail, and with a large crab and three or four men the charge of coke is drawn.

So great was the waste of iron by this method that some invention was sought to lessen it. A gutter large enough to admit the bar is made in the bottom of the oven and covered with sheet-iron until the oven is ready to draw. The bar is pushed into the oven and turned so as to catch onto the cross bar, which was placed in the oven when charged, and it is ready for drawing. The following is a recent estimate of a manufacturer of this district as to the cost of coke:

Cost of a ton of coke in South Wales.

Placing 3,000 pounds of coal on tipple	$1.45
Washing coal, including everything	.03
Cost of charging, drawing, and filling into cars (wagons)	.22
Total cost per ton of coke	1.70

This is the cost of manufacture when all lump is used. When only slack is coked the first item would be reduced nearly two-thirds, as nothing is paid for mining the slack, and royalty is paid only on lump. In some places the coke drawers are paid by the day, while at others they are paid by the oven. The following are the average wages:

Average wages of coke workers in South Wales.

Coke drawers, per day	\$0.73 to \$0.85
Bottom men, per day (10 to 14 hours)	.97 to 1.45
Chargers, per day	.48 to .85
Engineers or pushers on Belgian ovens, per day	.95

Selling price of coke at Cardiff, Newport, and Swansea.

Coke for Bessemer pig iron	\$3.51 to \$3.57
Ordinary brands	3.27
The freight, commission, dock charges, tipping, wharfage, &c., are	.68 to .96

Coking in Belgium.—The coal fields of Belgium, which are the most important on the Continent of Europe, have given this country an importance as an industrial center second only to Great Britain. The coal varies greatly in quality, but is on the whole good. The production of true coking coal is quite small, only about 25 to 30 per cent. of the total, and of this but a portion is coked.

The following is a statement of the production of coke in Belgium in 1885, the statistics for 1886 not yet having been published:

Statistics of the production of coke in Belgium in 1885.

Number of ovens:		
Active		3,733
Idle		2,004
		5,737
Number of workmen		2,307
Coal charged, metric tons		2,292,696
Production of coke, metric tons		1,678,475
Yield of coal in coke, per cent		73.21
Value of coke per ton, francs	13.35=	\$2.57¾

Compared with 1884, when the output of coke was 1,812,148 metric tons, the decline in production in 1885 was 133,673 tons, which is equal to 7 per cent. The total value of the product in 1884 was 26,946,640 francs, and but 22,438,444 francs in 1885; a difference of 4,508,196 francs, or 17 per cent.

The number of workmen, the total production, and the value per ton of coke produced during the past five years have been as follows:

Number of workmen, production, and value per ton of coke in Belgium, 1881 *to* 1885.

Years.	Number of workmen.	Total production.	Value per ton.
		Tons.	*Francs.*
1881	2,358	1,824,669	15.98
1882	2,519	2,066,249	17.73
1883	2,474	2,077,051	17.08
1884	2,074	1,812,148	14.87
1885	2,307	1,678,475	13.35

The oven almost universally in use is the flue or retort oven, which is often known as the Belgian. The Appolt and Coppèe are the best and most common. The size of the Coppèe oven most generally in use is, length, 9 meters; width, .40 to .45 meters; and height, 1.30 meters. The product is 2,250 kilograms of coke in twenty-four hours. A remarkable feature of coking in this country is the yield of coal in coke. It will be seen by the above table that this was as high as 73.21 per cent. in 1885. M. Wolters, in a recent pamphlet, gave the yield as from 75 to 79 per cent. In this pamphlet M. Wolters gave the following statement as the average cost of coke in Belgium in 1886:

Cost of coke in Belgium in 1886.

	Francs.
Coal	10.84
Labor	0.61
Materials	0.12
General expenses	0.15
Agency expenses	0.20
Reserve for general repairs	0.34
Total cost 1,000 kilograms coke	12.26

This is about $2.40 per ton.

Other countries.—No recent statements of production have been secured from other European countries. France has an inferior coal. It requires washing and special ovens to coke it. The yield of coke is estimated at 70 per cent. The coke production for 1880 was about 1,400,000 metric tons (2,205 pounds). The whole consumption of France is given at 2,302,511 metric tons for the year 1880.

The Westphalia coal field affords the main supply of coking coal for Germany. The coal requires washing before coking. The beehive oven is used, as well as a number of forms of the retort oven. The total output of the coke ovens of Germany is given at 5,403,392 tons in 1878.

NOVA SCOTIA.

Considerable of the coal mined in this province is suitable for coking though somewhat high in ash. In this respect, however, it is fully equal to much of the coal used in the United States for the manufacture of coke, though the coke made from it does not equal that made at Connellsville or New River. At the Spring Hill mines, in Cumberland county, a very fair coke, low in sulphur and containing about 12 per cent. of ash, is made. In Pictou county, the Albion and International coals give a coke with 14 to 15 per cent. ash. In Cape Breton there are several beds of coal that give a fair coke.

Most of the coke made is from washed slack. There is no doubt but that the best results yet obtained could be much improved by a better preparation of the coal and more careful and intelligent burning.

The production of coke in Nova Scotia in the last four years is as follows:

Production of coke in Nova Scotia in the years 1883–1886.

Years.	Short tons.
1883	49, 492
1884	44, 895
1885	33, 807
1886	35, 396

COAL CRUSHING.

No little attention has been given recently to the proper preparation of the coal for the ovens. This is a subject of more importance than is generally believed, especially in those coking districts where the coal is not of the very best quality. It is slowly forcing itself upon the belief of coke manufacturers that the old method of dumping the coal into the oven just as it comes from the mines does not by any means always, if ever, give the best results in the amount of coke that can be obtained from a given coal, nor is it the most economical. When "run of mine" is used, the varying sizes of the coal charged into the ovens do not permit of a uniform burning, and the waste in small coke is much greater than when the coal is properly prepared.

Coke manufacturers not only in districts of but little importance, where economy of production as well as the highest grade of product possible are essential, are realizing this fact; but the manufacturers of the best coke in Durham and Connellsville are carefully preparing their coal before coking. In Durham in many instances the coal is both crushed and "washed;" in Connellsville it is crushed only. One of the largest coke manufacturers in the Connellsville region advertises, "We have introduced machinery to crush all of our coal before burning, thereby avoiding the production of charred coal and spongy coke." It is also found that crushing increases the yield of large coke, decreasing in Durham from 5 to 2 per cent. the small refuse or "breeze" coke.

No form of crusher can be said to be in general use in this country; those used are mostly at plants where the coal is washed as well as crushed, and on rollers.

In Europe, Carr's disintegrator is used at a good many establishments. The disintegrator consists of two parts, one being smaller than the other, revolving in opposite directions. Each of the parts is made up of two rings of iron about three inches broad and half an inch thick, joined together by means of thin steel bars, the disintegrator itself being from four to five inches in diameter, and from thirteen to fourteen inches in width, there being an opening of from two to three feet for putting in the coal. The machine is driven at the rate of three hundred to four hundred revolutions per minute, requiring a force of about fifteen horse-power. At the Gustar Colliery, Germany, the disintegrator crushes to a fine powder about twenty-five tons of coal every hour.

COAL WASHING.

There is no little question as to what has been, on the whole, the result of washing coal for coke making in the United States. Has it been a technical and commercial success? At many works at which expensive washing plants have been erected, after careful and long-continued trials, washing has been abandoned, as it has been found that for the purpose for which the coke was made it was a better fuel with the impurities than it was after washing. This is not uniformly the case, however. There can be no doubt that some cokes are greatly improved by washing the coal prior to coking, and at quite a number of coke works in the United States, especially where only slack is used, the coal is washed with decidedly beneficial results, so far as the quality of the coke made is concerned.

It is doubtful, however, except in cases where screenings of coal are utilized or where no clean coal for coking can be obtained, if it is economical to wash coal. In the Upper Connellsville region of Pennsylvania a moderate estimate of the cost of washing would be 11 cents per ton of coke made. An acre of Connellsville coal land yields 8,000 tons of coke. The washing of the coal to produce this amount of coke would cost therefore $880. As good coal land where the coal does not require washing can be bought for $300 to $400 an acre, it is evident that if the coal land whose coke required washing were to cost nothing there would be a loss, other things being equal, of at least $400 an acre, or, on an output of 8,000 tons of coke an acre, of 5 cents a ton of coke.

It is also true that in many cases the washing carries away a portion of that constituent whose presence in the coal gives to the coke its peculiar value as a furnace fuel. So much of the hydrogenous matter which imparts to coke its desirable physical structure and gives the proper heat in the coke oven is washed away that washing has to be abandoned. Oftentimes the small excess of slate or ash in a coke is not objectionable, especially if it is aluminous, and if washing impairs the physical structure of the coke under such conditions it is better to retain the ash.

Most of the washers used in this county are some modification of the old Hartz jig, though there are some based on the trough principle. The large Bradford cylinder separator is used in the Allegheny Mountain region of Pennsylvania, operated in the dry way, removing considerable slate and pyrites quite economically.

PETROLEUM.

BY JOS. D. WEEKS. (a)

The two noticeable features of this report of the petroleum production of the United States for 1886 are, first, the increase in the production in all the oil fields of the country; and, second, the remarkable discovery of crude petroleum in enormous quantities in the Trenton rocks of northeastern Ohio. To these, possibly, should be added the remarkable development of the Washington, Pennsylvania, field in 1886.

The production of crude petroleum has increased in the whole country from 21,842,041 barrels in 1885 to 28,110,115 barrels in 1886, the increase in Pennsylvania alone being over five million barrels, or about five-sixths of the total. In this increased production all districts shared.

The remarkable discovery of oil in large quantities in the Trenton limestone, one of the most wide-spread and important of the strata of the Lower Silurian age in North America, was a complete geological surprise. Though this limestone was known to carry some petroleum, as was shown by the results of drilling in Canada and to a less extent in Kentucky and Tennessee, yet there was nothing warranting the discovery of oil in quantities in the Trenton limestone of northeastern Ohio. Petroleum had been found in this rock at the close of 1886 in seven of the counties of that portion of Ohio. The effect of this discovery upon the production of oil in Ohio is shown by the fact that the amount of oil produced in this State in 1886 exceeded by 553,747 barrels the total production of the State up to the close of 1885.

The third feature of importance in the report for the year is the remarkable increase in production in the Washington, Pennsylvania, field in 1886. At the close of 1885 there were but five wells in this district, the total production for that year amounting to but a little over 10,000 barrels. The result of the drilling during 1886 swelled the total production of this field in this year to over 3,000,000 barrels, possibly the largest amount produced in a field of this size in any one year.

LOCALITIES IN WHICH PETROLEUM IS FOUND IN THE UNITED STATES.

In nearly if not quite all of the States lying entirely or in part in the great Mississippi basin, as well as in several of the Rocky Mountain States and in California, petroleum has been found. The localities, however, in which it is produced on a commercial scale are few, in view of the great extent of territory in which petroleum has been discovered.

a. In the preparation of this report, in addition to special credit given in the body of the same, I beg to acknowledge my indebtedness to *Stowell's Petroleum Reporter* and its successor, the *American Manufacturer and Iron World* of Pittsburgh, Pennsylvania to the *Oil City Derrick*, the *Petroleum Age* of Bradford, Pennsylvania, to the writings and reports of Prof. Edward Orton, State geologist of Ohio, and to those of Professors Carll and Ashburner, of the Pennsylvania Geological Survey—J. D. W.

These producing localities are the well-known oil regions of western New York, and western Pennsylvania, Macksburg, and the recently developed northwestern or Lima field of Ohio, the Volcano and other oil districts of West Virginia, and the oil-producing portions of California.

The oil fields of Tennessee and Kentucky, where some oil was produced shortly after the great discoveries in the Pennsylvania region, as well as the Wyoming oil fields, did not produce sufficient oil in 1886 to be considered in speaking of the localities that produced oil in that year. What their possibilities may be is as yet uncertain, and can only be determined by more extensive explorations.

Several of these districts are subdivided into smaller fields, which are known by some geographical name in the field. There are also other divisions of these districts that are based upon the character of the oil, or the sand from which the oil of these districts is produced.

TOTAL PRODUCTION OF PETROLEUM IN THE UNITED STATES AND IN CANADA.

In the following table will be found consolidated the statistics of the production of petroleum in the various fields of the United States and Canada, from the beginning of operations in these fields, so far as the same could be ascertained:

Production of crude petroleum in the United States and Canada from 1859 *to* 1886 *inclusive.*

Years.	Pennsylvania and New York.	West Virginia.	Ohio.	Kentucky, Tennessee, and other States.	California.	Total United States.	Canada. (a)
	Barrels. (b)	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
1859	2,000					2,000	
1860	500,000					500,000	
1861	2,113,609					2,113,609	
1862 (c)	3,056,690					3,056,690	11,775
1863	2,611,309					2,611,309	82,814
1864	2,116,109					2,116,109	90,000
1865	2,497,700					2,497,700	110,000
1866	3,597,700					3,597,700	175,000
1867	3,347,300					3,347,300	190,000
1868	3,646,117					3,646,117	200,000
1869	4,215,000					4,215,000	220,000
1870	5,260,745					5,260,745	250,000
1871	5,205,234					5,205,234	269,397
1872	6,293,194					6,293,194	308,100
1873	9,893,786					9,893,786	365,052
1874	10,926,945					10,926,945	168,807
1875	8,787,514	(d) 3,000,000	(d) 200,000		(d) 175,000	12,162,514	220,000
1876	8,968,906	120,000	31,763		12,000	9,132,669	312,000
1877	13,135,475	172,000	29,888		13,000	13,350,363	312,000
1878	15,163,462	180,000	38,179		15,227	15,396,868	312,000
1879	19,685,176	180,000	29,112		19,858	19,914,146	575,000
1880	26,027,631	179,000	38,940		40,552	26,286,123	350,000
1881	27,376,509	151,000	33,867		99,862	27,661,238	275,000
1882	30,053,500	128,000	39,761		(e) 128,636	30,349,897	275,000
1883	23,128,389	126,000	47,632		(e) 142,857	23,444,878	250,000
1884	23,772,209	90,000	90,081		(c) 262,000	24,214,290	250,000
1885	20,776,041	91,000	650,000		325,000	21,842,041	250,000
1886	25,798,000	102,000	1,782,970	(e) 225,000	377,145	(e) 28,285,115	250,000
Total	307,956,250	4,519,000	3,012,193	225,000	1,611,137	317,323,580	6,071,945

a. There are no reliable statistics of production for Canada. Those given are the estimates of parties intimately connected with the industry.
b. All barrels in this table are of 42 gallons.
c. In addition to the above it is estimated that for want of a market some 10,000,000 barrels ran to waste in and prior to 1862 from the Pennsylvania and Canada fields; also a large amount from West Virginia and Tennessee.
d. Including all production prior to 1876.
e. This includes the 175,000 barrels produced in Kentucky and Tennessee prior to 1886.

From this table it appears that the total production of all of the oil fields of the United States since the discovery of oil in Pennsylvania in 1859 has been 317,323,580 barrels. Of this amount Pennsylvania and New York have produced 307,956,250 barrels, all of the other States together contributing less than 10,000,000 barrels, or only about 3 per cent. West Virginia produced 4,519,000 barrels, or 1.5 per cent.; Ohio, 3,012,193 barrels, or a little less than 1 per cent.; Tennessee and Kentucky, 175,000 barrels; California, 1,611,137 barrels, or .5 per cent., and other localities are credited with 50,000 barrels. The value of this oil, based on the value of the same in Pennsylvania since 1860, has ranged from 10 cents, during October, November, and December of 1861, to $19.25 in January, 1860. The lowest average in any one year was in 1861, when it was 49 cents a barrel; the highest was in 1860, when it was $9.59 a barrel. In view of the monthly and yearly average prices given elsewhere, it is believed that $1 a barrel would not exceed the average price of oil for these years, which would make the value of the crude petroleum produced in the United States $317,323,580.

TOTAL PRODUCTION AND VALUE OF PETROLEUM IN THE UNITED STATES IN 1886.

The total production of oil in the United States in 1886, arranged by States, so far as the production of the individual States could be ascertained, was as follows, the barrel being uniformly 42 gallons:

Production of petroleum in the United States in 1886.

States.	Barrels.
Pennsylvania and New York	25,798,000
Ohio	1,782,970
California	377,145
West Virginia	102,000
Elsewhere	50,000
Total	28,110,115

As compared with 1885, this shows an increase of production in the year 1886 of 6,268,074 barrels, or 29 per cent., the production of 1885 being 21,842,041 barrels. Every producing State shares in this increase. The production of the Pennsylvania and New York region increased from 20,776,041 barrels in 1885 to 25,798,000 barrels in 1886, an increase of 5,021,959 barrels, or 24 per cent.; the Ohio increase was from 650,000 barrels in 1885 to 1,782,970 barrels in 1886, an increase of 1,132,970, or 174 per cent.; the California production increased from 325,000 in 1885 to 377,145 in 1886, while the West Virginia increased from 91,000 in 1885 to 102,000 in 1886.

It is nearly impossible to arrive at the actual value of this oil. The average value of the pipe-line certificates in Pennsylvania during the year 1886 was 71¼ cents. Heavy oil, like the Franklin, of which, however, but a small quantity was produced, was worth four times this, and even some of the Pennsylvania oils, because of their superior value for making illuminating oils, were rated a certain number of cents a barrel above the average price. The Smith's Ferry oil sells higher than the average of pipe-line certificates; California oil is also worth more than the average Pennsylvania oil. On the other hand, the Lima oil at no time in 1886 sold above 40 cents, and part of the time at 35 cents. The million barrels of Lima oil which sold, say, at an average of 39 cents, or 32¼ cents below the average of pipe-line certificates, would reduce the average of both Pennsylvania and New York and Lima oil to 70 cents, which it is probable that the increased value of the lubricating oils and the California oils would restore to 71¼. So it is fair to assume that the average value of the pipe-line certificates would be the average value of all the oil produced in the United States. On the basis, then, of 71¼ cents a barrel, the value of the oil produced in the United States in 1886 would be $20,028,456.94. On the same basis—that is, the average value of pipe-line certificates for the year—the production of 1885 would be valued at $19,193,693.52. It will thus appear that, although the production of 1886 was some 6,268,074 barrels greater than in 1885, the total value of the product in 1886 was less than a million dollars greater in the latter than in the former year, owing to the higher price of the pipe-line certificates in 1885 than in 1886.

THE PENNSYLVANIA AND NEW YORK FIELDS.

As has been stated in previous reports, the intimate connection, in a commercial way, is such as to render it almost impossible to make an exact separation between the oil produced in New York and that from the wells of Pennsylvania. Latterly the oil produced in what is known as the Allegany field has been reported separately, and to this oil should be added that from the outlying districts of New York, in order to arrive at a correct statement of the production of the State. Concerning the latter amount, however, it is difficult to give even an estimate, as the returns from these wells are reported with those from Pennsylvania. If 5 per cent. of the production of the Bradford district is added to the total production of the Allegany field, it is believed that this will represent the total production of New York. The production of the Allegany field in 1886 was 1,799,305 barrels. Five per cent. of the production of the Bradford district would be 352,181 barrels, which, added to the production of the Allegany field, would make 2,151,486 barrels, the estimated production of New York in 1886.

The Pennsylvania and New York oil fields.—There are five general divisions of the Pennsylvania and New York oil field, one, the Washington, being added to the four divisions last reported. These are the Allegany, Bradford, Middle, Lower, and Washington districts.

The several Pennsylvania fields, with the exception of the Washington, have been fully described in previous reports. It may be well to say, however, that the Allegany field lies wholly in Allegany county, New

York, and is of an irregular shape, with an average length of some 20 miles. Outlying this district, in the same county, are four smaller fields, of which one, about a mile north of the town of Niles, and bearing its name, has a few small wells and produces dark oil; it is the farthest north of any of the petroleum developments of the two States of Pennsylvania and New York. The Wirt field, midway between the Niles and the Allegany fields, has a few small wells, but produces more gas than oil. The Waugh and Porter field, near the Pennsylvania State line, and lying southwestwardly from the most southerly point of the eastern limit of the Allegany field, produces an amber oil from small wells. Southeastwardly of the eastern limit of the Allegany field proper is the Harding-O'Connor territory, in which there are a few small wells.

The second district, Bradford, lies chiefly in Pennsylvania, in McKean county, but the main field extends some 5 miles into the State of New York, and an outlying basin of oil rocks, which properly belongs to the Bradford basin, is situated for the greater part in Carrollton township, in Cattaraugus county, New York. This field also includes the small outlying district of Kinzua, which lies southwestwardly from the main district, and contains large and long-lived wells, and the Windfall Run field, lying in Pennsylvania, near Eldred, which has only small wells.

The Lower field covers a large extent of territory from Sugar Run, in McKean county, just across the border from Warren county, down through Forest to Beaver county, including, in addition to Warren and Forest, all the oil-producing territory in Venango, Clarion, Butler, Lawrence, and Beaver counties, with the Pleasant Unity district in Westmoreland county.

In the Washington field are included the wells in Washington and Green counties, Shoustown, in Allegheny, and other small districts in the neighborhood.

Production in the several districts of Pennsylvania and New York.— Relative to the condition of production in the several districts at the close of 1886, it may be said that the Allegheny field is fast losing its importance as a producer. At the close of the year there were but 5 wells drilling, and but 7 new wells were brought in during the month of December, the aggregate daily production of these new wells being but 43 barrels, the average total daily production in December being but 4,723 barrels, as compared with over 14,000 barrels in December, 1882.

The Bradford field is also losing its importance as a producer, the average daily production in December, 1886, being 17,987 barrels, compared with about 39,580 barrels in December, 1882.

In the Middle field every district was on the wane at the close of the year; the Kane district was one of the surprises of the year, there being in this district at the close of 1885 but a single well, producing 96 barrels a day. The daily average production in the Kane field in 1886 was 3,520 barrels, a total in the year, when estimated by the runs, of 1,284,647 barrels. The Grand Valley district has also fallen from 2,089 barrels runs in November to 1,661 barrels in December.

In the Lower country, the Tarkill, Tipperary, and Red Valley, small pools in Venango county attracted some attention as being discovered in the oldest producing region of the country, which was long ago supposed to have been "drilled out," so far as related to new discoveries. Tarkill produced over half a million barrels in nine months, and Red Valley over 350,000. The Pontius district, in Butler county, was another white-sand pool developed in 1886, this producing in seven months over half a million barrels, while the closing month of the year shows still another field in Butler county coming into prominence, that of Reibold, southwest of the old Bald Ridge, and Thorn Creek districts.

The developments in the Washington field have been the most important of the year, and a review of petroleum for 1886 must be largely a résumé of its history. In December, 1884, the Citizens' Fuel Company, of Washington, drilled a well on the Gantz farm, near Washington, with the avowed purpose, as the name indicated, of obtaining natural gas. At a depth of 2,200 feet a small show of oil was found, and the hopes of the projectors turned from gas to oil. After two small flows, one in January, 1885, and the other in February, they were compelled to accept the fact that the well was only a "pumper." Matters remained in abeyance until August, 1885, when the advent of the Gordon gusher, drilled by the owners of the Gantz well, attracted attention once more to the field, and drilling began. The career of the field really began in March, 1886. On March 11, the Pew and Emerson "Manifold" well came in as a heavy producer, and in April the Thayer well followed with its 2,000 barrels daily, and the trade awoke to the fact that a field of gushers was found. Drilling plants began to go up and oil in large quantities was the result. The production reached 4,000 barrels daily at the close of May, and in June it had risen to 10,120 barrels. During October the maximum production, about 17,549 was reached, the price of petroleum being then on the 60-cent level, as compared with $1 at the same time in the previous year. This heavy yield was not maintained for any length of time. The decline began in spite of very energetic field operations and has continued, the output of the field at the close of 1886 being about 10,000 barrels per day. The ground has been thoroughly drilled over, and there seems to be but little doubt that the decline will continue.

Production by districts.—In the following table is given a statement of the production of crude petroleum in the Pennsylvania and New York oil fields for the year 1886, by months and districts. As is stated elsewhere, it is impossible to separate, except approximately, the New York production from Pennsylvania. All from the Allegany district is from New York; a small portion of that from Bradford is also from New York; the remainder is the production of Pennsylvania.

Total production of crude petroleum in the Pennsylvania and New York oil fields for the year 1886, by districts and months.

Months.	Allegany district.	Bradford district.	Middle district.	Lower district.	Washington district.	Total.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
January	158, 720	623, 162	233, 740	719, 944	13, 392	1, 748, 958
February	149, 688	569, 128	217, 392	650, 040	18, 600	1, 604, 848
March	181, 226	661, 106	268, 305	786, 098	31, 713	1, 928, 448
April	156, 480	620, 880	297, 450	757, 920	105, 630	1, 938, 360
May	146, 196	595, 076	291, 865	831, 916	313, 720	2, 178, 773
June	142, 380	605, 880	394, 980	896, 940	295, 200	2, 335, 380
July	147, 095	626, 076	423, 344	941, 036	282, 410	2, 418, 961
August	147, 095	547, 411	365, 844	909, 036	443, 820	2, 413, 206
September	140, 430	539, 970	368, 400	843, 270	526, 470	2, 418, 540
October	144, 832	557, 721	372, 372	869, 829	463, 357	2, 408, 111
November	138, 750	539, 610	339, 000	828, 600	376, 830	2, 222, 790
December	146, 413	557, 597	336, 505	822, 430	318, 680	2, 181, 625
Total	1, 799, 305	7, 043, 617	3,908, 197	9, 857, 059	3, 189, 822	25, 798, 000

During the past year the production of the Allegany district has declined nearly a million barrels as compared with 1885, the production being 2,658,011 in 1885 as compared with 1,799,305 in 1886. A similar statement is true of the Bradford district, the decline in production here being 1,400,000 barrels in a year. On the other hand, the Middle and Lower districts have increased—the Middle district 1,500,000 barrels and the Lower district over 2,500,000, while the new Washington appears for the first time with 3,189,828 barrels.

Total production of the Pennsylvania and New York oil fields.—In the following table will be found a statement of the total production of crude petroleum in the Pennsylvania and New York oil fields, by months, for the past five years:

Total production of crude petroleum in the Pennsylvania and New York oil fields for the years 1882 to 1886, by months.

Months.	1882.	1883.	1884.	1885.	1886.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
January	2, 353, 551	1, 948, 319	1, 825, 838	1, 652, 176	1, 748, 958
February	2, 131, 332	1, 756, 188	1, 880, 650	1, 437, 884	1, 604, 848
March	2, 482, 170	1, 830, 674	2, 052, 362	1, 638, 133	1, 928, 448
April	2, 402, 790	1, 816, 530	2, 065, 860	1, 780, 290	1, 938, 360
May	2, 486, 572	1, 962, 052	2, 381, 854	1, 771, 371	2, 178, 773
June	2, 825, 940	1, 977, 900	1, 862, 190	1, 767, 210	2, 335, 380
July	3, 258, 162	2, 020, 394	2, 059, 950	1, 775, 804	2, 418, 961
August	3, 104, 495	1, 879, 437	2, 099, 165	1, 705, 961	2, 413, 206
September	2, 620, 380	1, 913, 370	1, 948, 260	1, 712, 790	2, 418, 540
October	2, 297, 658	2, 076, 659	1, 961, 866	1, 874, 105	2, 408, 111
November	2, 192, 940	1, 958, 340	1, 811, 700	1, 761, 660	2, 222, 790
December	1, 897, 510	1, 988, 526	1, 822, 614	1, 898, 657	2, 181, 625
Total	30, 053, 500	23, 128, 389	23, 772, 209	20, 776, 041	25, 798, 000

From the above table it will be noted that the decline in production, which has been manifest every year, with one exception, since 1882, which was the year of the greatest production, has at last been stopped; the production for 1886 was over 5,000,000 barrels greater than in 1885, and over 2,000,000 barrels greater than any year since 1882. The year

1886 ranks fourth in amount of production, 1882 being the year of the largest production, followed, in order, by the years 1881, 1880, and 1886. As the great production of 1882 was reached by the phenomenal development of the Cherry Grove field, which brought the production in July, 1882, up to 105,102 barrels daily, so the increase in 1886 is due to the opening of other remarkable pools in Pennsylvania, the chief of which is the Washington field; indeed, the Washington oil field of 1886 has surpassed in production the Cherry Grove field of 1882.

Average daily production.—In the following table will be found the average daily production of all wells in the Pennsylvania and New York districts for the years 1882 to 1886:

Average daily production of crude petroleum in the Pennsylvania and New York oil fields for the years 1882 to 1886, by months.

Months.	1882.	1883.	1884.	1885.	1886.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
January	75, 921	62, 849	58, 898	53, 296	56, 418
February	76, 119	62, 721	64, 850	51, 353	57, 316
March	80, 070	59, 054	66, 202	52, 843	62, 208
April	80, 093	60, 551	68, 862	59, 343	64, 612
May	80, 212	63, 292	76, 834	59, 141	70, 283
June	94, 198	65, 930	62, 073	58, 907	77, 846
July	105, 102	65, 174	66, 450	57, 284	78, 031
August	100, 145	60, 627	67, 715	55, 031	78, 426
September	87, 346	63, 779	64, 942	57, 093	80, 618
October	74, 118	66, 989	63, 286	60, 455	77, 681
November	73, 098	65, 278	60, 390	58, 722	74, 093
December	61, 210	64, 146	58, 794	61, 247	70, 375
Yearly averages	82, 338	63, 365	65, 129	5[illegible], 921	70, 679

The yearly averages in this table were computed by dividing the total production for each year by 365.

The remark made above, under the head of total production, applies with equal force here. The average daily production of the year 1886 has been exceeded in the history of the Pensylvania and New York oil fields by but three other years, that of 1882, when the average daily production was 82,338; by 1881, when the average daily production was 75,004, and 1880, when the average production was 71,114 barrels. The production increased from an average of 56,418 barrels in January to 80,618 in September, the point of the highest production in the year, from which point it declined until December, when the average daily production was but 70,375 barrels.

Total shipments.—In the following table will be found a statement of the number of barrels of crude petroleum and of refined reduced to crude equivalent shipped out of the Pennsylvania and New York oil regions, whether by pipe or by railroad, for the years 1882 to 1886. A considerable portion of this oil is shipped as refined; this is reduced to its equivalent in crude, a barrel of refined being regarded as equal to $1\frac{1}{3}$ barrels of crude.

Shipments of crude petroleum and of refined petroleum reduced to crude equivalent out of the Pennsylvania and New York oil regions for the years 1882 *to* 1886.

Months.	1882.	1883.	1884.	1885.	1886.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
January	1,657,067	1,357,815	1,686,961	1,804,028	1,991,561
February	1,787,909	1,250,824	1,723,261	1,895,021	2,032,794
March	1,718,956	1,641,899	1,873,890	1,887,034	2,055,750
April	1,678,134	1,908,379	1,643,336	1,823,726	2,070,468
May	1,827,356	1,995,634	1,899,329	2,097,099	2,032,672
June	2,172,685	1,747,789	1,827,553	2,034,025	2,117,489
July	2,402,970	1,634,407	1,740,021	1,961,152	2,418,961
August	2,047,545	2,086,478	2,000,371	2,049,099	2,059,299
September	1,992,171	2,325,574	2,292,087	2,116,659	2,157,323
October	2,089,428	2,215,421	2,510,283	2,050,150	2,441,848
November	1,404,640	2,065,602	2,078,261	1,857,080	2,724,796
December	1,121,453	1,749,547	2,382,244	2,138,253	2,550,891
Total	21,900,314	21,979,369	23,657,597	23,713,326	26,653,852

From the above table it will be noted that the shipments out of this oil region in 1886 are the greatest in its history; they exceed the shipments of any previous year by nearly 3,000,000 barrels, and exceed the production for 1886 by nearly 1,000,000 barrels. With the exception of one year, 1880, every year's shipment since 1874 has shown an increase over the previous year, the shipments increasing from 8,821,500 barrels in 1874 to 26,653,852 in 1886. By reason of this excess of shipments, notwithstanding the great increase of production during the year, the stocks have decreased a little less than 300,000 barrels.

Total stocks.—In the following table will be found a statement of the total stocks held in the Pennsylvania and New York oil regions at the close of each month for the years 1882 to 1886. In addition to the net stocks held by the pipe lines, the term net stocks meaning the stocks after making a certain deduction for surplus and sediment, these stocks include an estimate of field oil which in the tables of *Stowell's Petroleum Reporter*, from which these tables are taken, is carried as surplus.

Total stocks of crude petroleum in the Pennsylvania and New York oil regions at the close of each month for the years 1882 *to* 1886.

Months.	1882.	1883.	1884.	1885.	1886.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
January	26,716,188	35,187,116	35,884,509	37,214,274	34,186,238
February	27,059,611	35,692,480	36,041,898	36,757,137	34,082,775
March	27,822,825	35,881,255	36,220,270	36,508,236	33,954,493
April	28,547,481	37,789,406	36,642,794	36,464,800	33,823,385
May	29,206,697	35,755,824	38,631,203	36,139,072	33,969,486
June	29,859,952	35,985,935	38,665,838	35,872,257	34,187,377
July	30,715,144	36,371,922	38,985,767	35,686,909	34,428,490
August	31,772,094	36,164,881	39,084,561	35,343,771	34,800,397
September	32,400,303	35,752,677	38,740,734	34,939,902	35,061,614
October	32,608,533	35,613,915	38,192,317	34,763,857	35,027,877
November	33,728,555	35,506,653	37,925,756	34,668,437	34,525,871
December	34,596,612	35,745,632	37,366,126	34,428,841	34,156,605
Average	30,419,500	35,953,975	37,698,481	35,732,291	34,350,467

The stocks at the close of December in 1886, it will be noted, are less than any year since 1881; the stocks at the close of 1882 were some 440,000 greater than at the close of 1886. From 1882 they increased gradually until they reached 37,366,126 barrels at the close of 1884, from which point they declined to 34,428,841 at the close of 1885, and still further declined some 272,000 barrels at the close of 1886. The largest stock at the close of any one month in 1886 was at the close of September, when there were 35,061,614 barrels. The lowest stock was at the close of April, when the amount on hand was 33,823,385 barrels.

Prices.—In the following table will be found a statement of the monthly and yearly average price of pipe-line certificates for the years 1882 to 1886:

Monthly and yearly average price of pipe-line certificates or crude petroleum at the wells for the years 1882 *to* 1886.

Months.	1882.	1883.	1884.	1885.	1886.
January	\$0.83⅛	\$0.93¾	\$1.11	\$0.70⅞	\$0.88⅜
February	.84½	1.01	1.04⅜	.72⅜	.79⅞
March	.81⅜	.97⅝	.98⅛	.80⅛	.77¼
April	.78⅜	.92⅜	.94	.78½	.74⅛
May	.71½	1.00⅛	.85⅝	.79	.70
June	.54⅜	1.16⅜	.68⅝	.82	.66⅛
July	.57 4/10	1.05⅞	.63½	.92½	.66
August	.58⅝	1.08½	81⅛	1.00¼	.62⅛
September	.72⅛	1.12½	.78	1.00¾	.63⅜
October	.93¾	1.11⅛	.71⅛	1.05½	.65⅛
November	1.14	1.14½	.72½	1.04⅜	.71⅝
December	.96	1.14¾	.74⅜	.89⅞	.70⅝
Average	.78⅞	1.05¾	.83¼	.88	.71¼

These averages, it is understood, are not true average prices, that is, averages that consider both price and quantity sold at that price, but they are the averages of prices obtained. This, under the circumstances, is the only average that can be ascertained, and does not vary greatly from the average of the prices. It is also to be understood that the oil of certain districts brings a price in excess of the average of pipe-line certificates.

The average price of pipe-line certificates for 1886 is the lowest reached since 1861. The lowest market price during the year, at Pittsburgh, was 59⅞ cents, in August, and the average that month was the lowest for any month in the year, being 62⅛ cents. The highest average during the year was 88⅜ cents in January.

Prices of refined oil.—In the following table will be found a statement of the highest and lowest prices of refined oil at New York, by months, the price being cents per gallon:

Highest and lowest prices of refined oil in New York for the year 1886.

Months.	Highest.	Lowest.
	Cents.	*Cents.*
January	$7\frac{5}{8}$	$6\frac{3}{4}$
February	$7\frac{5}{8}$	$7\frac{3}{8}$
March	$7\frac{3}{8}$	$7\frac{1}{4}$
April	$7\frac{1}{2}$	$7\frac{1}{4}$
May	$7\frac{1}{4}$	7
June	$7\frac{1}{4}$	7
July	$7\frac{1}{8}$	$6\frac{7}{8}$
August	$6\frac{7}{8}$	$6\frac{5}{8}$
September	$6\frac{3}{4}$	$6\frac{5}{8}$
October	$6\frac{3}{4}$	$6\frac{5}{8}$
November	$7\frac{1}{8}$	$6\frac{5}{8}$
December	$7\frac{1}{8}$	$6\frac{5}{8}$

Producing wells.—The number of producing wells in the Pennsylvania and New York oil fields at the close of each month for the years 1882 to 1886 has been as follows:

Number of producing wells in the Pennsylvania and New York oil fields at the close of each month for the years 1882 *to* 1886, *by years and months.*

Months.	1882.	1883.	1884.	1885.	1886.
January	18, 400	17, 600	20, 756	21, 950	23, 699
February	18, 600	17, 300	20, 930	21, 987	23, 865
March	18, 850	17, 250	21, 000	22, 042	24, 034
April	19, 150	17, 100	21, 242	22, 093	24, 269
May	19, 350	17, 100	21, 494	22, 223	24, 553
June	19, 500	17, 050	21, 658	22, 384	24, 797
July	19, 570	17, 100	21, 844	22, 524	25, 030
August	19, 600	17, 100	21, 916	22, 688	25, 120
September	19, 600	17, 300	21, 900	22, 775	25, 243
October	19, 000	19, 100	21, 859	23, 062	25, 303
November	18, 700	20, 406	21, 859	23, 295	25, 381
December	18, 000	20, 606	21, 909	23, 519	25, 443
Yearly average	19, 027	17, 918	21, 531	22, 545	24, 727

The interesting feature in this table is the gradual increase in the number of wells year by year, with the exception of the year 1883, the number of producing wells at the close of 1886 being 1,924 greater than at the close of 1885. This table, taken in connection with the tables of production given elsewhere, is a most interesting study. The average of production per well per day in 1886 was 2.80 barrels. This is a slight increase over 1885, when the average production was 2.57 barrels, but a reduction as compared with 1884, when the average daily production of each well was 3.15 barrels. Ten years ago, 1875, the average daily production per well was about 7.8, double what it was in 1884, and three times what it was in 1885, and 1886.

Wells completed.—In the following table will be found a statement of the number of wells completed in each district in the Pennsylvania and New York oil fields during each month of 1886. This table shows the total number completed, the number of those completed that produced oil, and the number of dry holes in each district, together with the totals of these several items for the entire year.

Number of wells completed during each month of the year 1886 *in the Pennsylvania and New York oil fields, by districts.*

Months.	Allegany district.			Bradford district.			Middle district.		
	Total number.	Productive.	Dry holes.	Total number.	Productive.	Dry holes.	Total number.	Productive.	Dry holes.
January	42	40	2	49	48	1	85	69	16
February	41	36	5	48	47	1	83	75	8
March	38	33	5	44	43	1	91	80	11
April	33	30	3	42	40	2	128	114	14
May	33	28	5	43	41	2	155	144	11
June	32	29	3	36	35	1	172	154	18
July	24	23	1	23	23	0	165	151	14
August	17	17	0	25	24	1	126	119	7
September	9	8	1	22	21	1	99	88	11
October	20	15	5	19	17	2	104	89	15
November	9	5	4	22	19	3	55	42	13
December	7	7	0	16	12	4	55	42	13
Total	305	271	34	389	370	19	1,318	1,167	151

Months.	Lower district.			Washington district.			Totals.		
	Total number.	Productive.	Dry holes.	Total number.	Productive.	Dry holes.	Total number.	Productive.	Dry holes.
January	94	76	18	......	......	......	270	233	37
February	108	89	19	......	......	......	280	247	33
March	118	91	27	......	......	......	291	247	44
April	125	97	28	......	......	......	328	281	47
May	98	77	21	14	8	6	343	298	45
June	92	79	13	33	15	18	365	312	53
July	125	108	17	20	12	8	357	317	40
August	113	89	24	32	22	10	313	271	42
September	91	70	21	32	30	2	253	217	36
October	91	69	22	38	25	13	272	215	57
November	83	67	16	52	47	5	221	180	41
December	74	50	24	33	24	9	185	135	50
Total	1,212	962	250	254	183	71	3,478	2,953	525

It will be noted that in this table a new district is added as compared with similar tables in previous reports, viz: the Washington district. No separate statement of the number of wells completed in this district was obtained for the first four months of the year. Prior to the May report, therefore, the number of wells completed in this district is included with the lower district.

The following table shows the total number of drilling wells completed in the Pennsylvania and New York oil fields, by months, for each of the years from 1882 to 1886. In this table are included not only those completed wells which produced oil, but also the dry holes.

Number of drilling wells completed in the Pennsylvania and New York oil fields each month from 1882 *to* 1886, *by years and months.*

Months.	1882.	1883.	1884.	1885.	1886.
January	347	125	229	64	270
February	340	126	227	62	280
March	385	142	256	82	291
April	432	209	298	116	328
May	469	231	311	213	343
June	340	228	244	242	365
July	185	261	268	217	357
August	253	309	145	283	313
September	164	321	89	356	253
October	117	321	59	397	272
November	150	302	73	384	221
December	122	272	66	345	185
Total	3, 304	2, 847	2, 265	2, 761	3, 478

Average daily production of new wells.—The average daily production of the new wells completed in the years from 1862 to 1886, by months, is shown in the following table:

Average daily production of the new wells in the Pennsylvania and New York oil fields from 1882 *to* 1886, *by years and months.*

Months.	1882.	1883.	1884.	1885.	1886.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
January	19. 5	22. 4	13. 7	40. 0	13. 5
February	19. 4	14. 9	15. 0	41. 3	13. 4
March	22. 25	22. 5	17. 0	23. 3	22. 9
April	22. 0	21. 0	12. 0	40. 0	32. 0
May	21. 3	17. 5	18. 0	23. 0	38. 6
June	36. 8	15. 0	17. 5	10. 6	25. 0
July	108. 8	15. 0	59. 3	10. 3	31. 1
August	84. 2	13. 8	22. 6	10. 6	51. 9
September	25. 75	14. 4	41. 7	13. 2	62. 4
October	15. 9	14. 2	165. 5	14. 0	28. 0
November	12. 9	13. 8	87. 4	10. 9	28. 0
December	20. 4	11. 8	92. 6	10. 9	23. 0

An inspection of this table will show at once the influence of the coming in of the prominent fields of the past five years upon production. In 1882 it will be noted that the average daily production of new wells jumped from 36.8 barrels in June to 108.8 in July, being reduced to 84.2 in August, and to 25.75 in September. This marks the rise and fall of the Cherry Grove field. From this time until July, 1884, there were no notable increases. The production jumped from 17.5 barrels in June, 1884, to 69.3 barrels in July. This was the period of the Wardwell tract. For the next two months the production was 22.6 barrels in August, and 41.7 in September, while in October the production jumped to 165.5 barrels, dropping to 87.4 barrels in November, and increasing to 92.6 barrels in December, the highest for three consecutive months in the five years covered by the table. This was the period of the Thorn Creek district. From this time to August and September, 1886, there were no notable increases. The jump from 31.1 barrels in July, 1886, to 51.9 in August, and 62.4 in September marked the coming in of the great increase in production of the Washington field.

The lowest average daily production in any one month in the years covered by this table was in July, 1885, when the average daily production was but 10.3 barrels, five months of that year showing an average daily production of new wells of less than 11 barrels. The highest average daily production of new wells in any one month was in October, 1884, the average for that month being 165.5 barrels.

Total production of crude petroleum in the Pennsylvania and New York oil fields for the years 1871–'86, by years and months.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1871	418, 407	372, 568	400, 334	385, 980	408, 797	410, 340	456, 475	462, 582	461, 940	485, 243	464, 610	477, 958	5, 205, 234
1872	583, 575	462, 985	461, 590	462, 090	537, 106	491, 130	517, 762	549, 909	500, 430	442, 432	638, 610	645, 575	6, 293, 194
1873	632, 617	608, 300	665, 291	641, 520	776, 364	793, 470	867, 473	936, 138	954, 270	942, 493	991, 470	1, 084, 380	9, 893, 786
1874	1, 167, 243	835, 492	883, 438	778, 740	895, 745	921, 750	1, 033, 447	931, 519	840, 630	919, 739	861, 060	858, 142	10, 926, 945
1875	852, 159	719, 824	789, 539	675, 060	696, 508	696, 210	788, 361	718, 766	698, 940	731, 073	700, 200	720, 874	8, 787, 514
1876	712, 225	668, 885	718, 177	701, 490	735, 351	723, 600	763, 623	782, 223	780, 600	809, 162	786, 480	787, 090	8, 968, 906
1877	842, 890	783, 216	901, 697	972, 810	1, 127, 594	1, 130, 790	1, 189, 005	1, 273, 759	1, 214, 910	1, 269, 326	1, 173, 420	1, 256, 058	13, 135, 475
1878	1, 203, 296	1, 094, 856	1, 208, 380	1, 195, 890	1, 264, 862	1, 217, 250	1, 283, 865	1, 341, 928	1, 315, 710	1, 369, 797	1, 348, 950	1, 318, 678	15, 163, 462
1879	1, 369, 921	1, 261, 935	1, 499, 315	1, 530, 450	1, 644, 922	1, 675, 650	1, 637, 767	1, 892, 302	1, 856, 700	1, 836, 378	1, 710, 480	1, 769, 356	19, 685, 176
1880	1, 904, 113	1, 870, 008	2, 015, 992	2, 015, 700	2, 228, 931	2, 158, 440	2, 248, 430	2, 341, 027	2, 346, 300	2, 385, 636	2, 274, 420	2, 238, 634	26, 027, 631
1881	2, 244, 090	1, 913, 128	2, 274, 532	2, 205, 780	2, 393, 293	2, 377, 860	2, 372, 678	2, 331, 727	2, 193, 420	2, 323, 171	2, 266, 830	2, 480, 000	27, 376, 509
1882	2, 353, 551	2, 131, 332	2, 482, 170	2, 402, 790	2, 486, 572	2, 825, 940	3, 258, 162	3, 104, 495	2, 620, 380	2, 297, 658	2, 192, 940	1, 897, 510	30, 053, 500
1883	1, 948, 319	1, 756, 188	1, 830, 674	1, 816, 530	1, 962, 052	1, 977, 900	2, 020, 394	1, 879, 437	1, 913, 370	2, 076, 659	1, 958, 340	1, 988, 526	23, 128, 389
1884	1, 825, 838	1, 880, 650	2, 052, 262	2, 065, 860	2, 381, 854	1, 862, 190	2, 059, 950	2, 099, 165	1, 948, 260	1, 961, 866	1, 811, 700	1, 822, 614	23, 772, 209
1885	1, 652, 176	1, 437, 884	1, 638, 133	1, 780, 290	1, 771, 371	1, 767, 210	1, 775, 804	1, 705, 961	1, 712, 790	1, 874, 105	1, 761, 660	1, 898, 657	20, 776, 041
1886	1, 748, 958	1, 604, 848	1, 928, 448	1, 938, 360	2, 178, 773	2, 335, 380	2, 418, 961	2, 413, 206	2, 418, 540	2, 408, 111	2, 222, 790	2, 181, 625	25, 798, 000

Shipments of crude petroleum, and refined petroleum reduced to crude equivalent, out of the Pennsylvania and New York oil fields, for the years 1871–'86, by years and months.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1871	437, 691	347, 718	383, 890	389, 147	587, 375	501, 754	541, 137	528, 134	551, 075	505, 071	480, 977	410, 822	5, 664, 791
1872	476, 966	407, 606	276, 220	428, 512	510, 417	529, 228	591, 238	621, 954	541, 607	607, 468	477, 945	430, 786	5, 899, 947
1873	573, 124	527, 440	668, 374	708, 191	768, 176	696, 414	814, 449	864, 768	952, 955	1, 010, 852	959, 589	955, 443	9, 499, 775
1874	843, 663	501, 220	518, 246	803, 409	899, 027	815, 413	940, 281	793, 865	1, 014, 570	543, 341	546, 117	602, 348	8, 821, 500
1875	453, 095	327, 776	693, 918	729, 581	681, 679	745, 986	904, 537	882, 089	1, 109, 392	871, 917	671, 066	871, 902	8, 942, 938
1876	677, 289	519, 193	623, 762	603, 037	646, 150	921, 862	1, 228, 539	1, 203, 402	1, 154, 549	524, 190	871, 496	1, 190, 983	10, 164, 452
1877	743, 461	484, 904	913, 919	903, 526	1, 234, 324	1, 391, 124	1, 096, 951	1, 425, 943	1, 563, 797	1, 268, 971	1, 205, 634	600, 019	12, 832, 573
1878	775, 791	774, 234	741, 512	846, 632	960, 894	1, 135, 119	1, 330, 454	1, 655, 651	1, 434, 225	1, 747, 390	1, 281, 410	992, 688	13, 676, 000
1879	663, 998	702, 729	973, 879	1, 136, 188	1, 331, 469	1, 369, 314	1, 625, 035	1, 808, 239	1, 627, 120	1, 662, 269	1, 453, 645	1, 532, 585	15, 886, 470
1880	1, 650, 409	1, 395, 151	1, 613, 371	842, 268	1, 095, 259	975, 083	1, 231, 611	1, 394, 129	1, 252, 635	1, 665, 933	1, 226, 030	1, 335, 613	15, 677, 492
1881	1, 061, 617	915, 028	1, 276, 746	1, 348, 398	1, 563, 436	1, 729, 697	1, 925, 532	2, 214, 877	2, 131, 950	2, 080, 467	2, 066, 906	1, 969, 581	20, 284, 235
1882	1, 657, 067	1, 787, 909	1, 718, 956	1, 678, 134	1, 827, 356	2, 172, 685	2, 402, 970	2, 047, 545	1, 992, 171	2, 089, 428	1, 404, 640	1, 121, 453	21, 900, 314
1883	1, 357, 815	1, 250, 824	1, 641, 899	1, 908, 379	1, 995, 634	1, 747, 789	1, 634, 407	2, 086, 478	2, 325, 574	2, 215, 421	2, 065, 602	1, 749, 547	21, 979, 369
1884	1, 686, 961	1, 723, 261	1, 873, 890	1, 643, 336	1, 899, 329	1, 827, 553	1, 740, 021	2, 000, 371	2, 292, 087	2, 510, 283	2, 078, 261	2, 382, 244	23, 657, 597
1885	1, 804, 028	1, 895, 021	1, 887, 034	1, 823, 726	2, 097, 099	2, 034, 025	1, 961, 152	2, 049, 099	2, 116, 659	2, 050, 150	1, 857, 080	2, 138, 253	23, 713, 326
1886	1, 991, 561	2, 032, 794	2, 055, 750	2, 070, 468	2, 032, 672	2, 117, 489	2, 418, 961	2, 059, 299	2, 157, 323	2, 441, 848	2, 724, 796	2, 550, 891	26, 653, 852

Number of drilling wells in the Pennsylvania and New York oil fields at the close of each month for the years 1871–'86, by years and months.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly averages.
1871	140	173	240	279	356	303	329	330	439	486	477	394	329
1872	363	369	313	302	386	391	359	392	301	311	354	318	347
1873	361	349	227	177	228	395	340	267	197	163	137	60	242
1874	37	55	99	213	225	210	180	128	107	82	57	54	121
1875	40	40	45	64	127	162	118	96	132	170	179	168	112
1876	142	151	230	267	307	340	353	374	511	565	618	493	363
1877	457	463	395	448	512	395	365	417	535	573	565	426	463
1878	334	326	379	409	376	266	188	185	240	282	297	218	292
1879	265	323	406	468	460	384	329	258	270	313	372	440	357
1880	540	535	577	580	460	440	452	515	491	469	475	408	495
1881	383	420	437	446	470	408	379	352	388	445	475	468	423
1882	422	438	408	405	381	226	240	194	177	184	154	138	276
1883	126	151	205	199	216	228	262	315	314	341	301	263	243
1884	270	273	260	284	244	123	123	91	79	100	86	78	168
1885	97	109	139	190	228	209	242	308	382	355	359	277	241
1886	320	337	356	318	358	403	349	290	322	272	285	238	324

Number of drilling wells completed in the Pennsylvania and New York oil fields each month for the years 1872–'86, by years and months.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1872	37	120	89	121	135	84	128	118	82	100	64	105	1,183
1873	93	94	100	105	102	130	114	120	106	101	100	98	1,263
1874	102	104	110	113	109	101	121	107	104	120	106	120	1,317
1875	190	187	195	186	172	190	200	210	201	220	217	230	2,398
1876	240	231	242	200	202	261	248	270	209	273	272	272	2,920
1877	281	241	291	269	320	403	317	255	322	467	391	382	3,939
1878	274	226	211	409	470	269	203	186	174	229	248	165	3,064
1879	136	132	238	270	402	330	327	283	210	232	227	261	3,048
1880	320	230	367	500	426	310	338	368	356	364	336	302	4,217
1881	222	220	271	316	406	374	336	332	312	322	363	406	3,880
1882	347	340	385	432	469	340	185	253	164	117	150	122	3,304
1883	125	126	142	209	231	228	261	309	321	321	302	272	2,847
1884	229	227	256	298	311	244	268	145	89	59	73	66	2,265
1885	64	62	82	116	213	242	217	283	356	397	384	345	2,761
1886	270	280	291	328	343	365	357	313	253	272	221	185	3,478

Number of producing wells in the Pennsylvania and New York oil fields at the close of each month for the years 1872–'86, by years and months.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly averages.
1872	3, 892	3, 936	3, 943	3, 967	4, 085	4, 144	4, 245	4, 423	4, 475	4, 475	4, 529	4, 553	4, 205
1873	4, 485	4, 490	4, 411	4, 265	4, 317	4, 400	4, 420	4, 163	3, 940	3, 654	3, 413	3, 358	4, 109
1874	3, 311	3, 235	3, 308	3, 301	3, 266	3, 298	3, 293	3, 287	3, 254	3, 270	3, 220	3, 270	3, 276
1875	3, 132	3, 112	3, 060	3, 052	3, 080	3, 084	3, 067	3, 088	3, 112	3, 125	3, 174	3, 078	3, 098
1876	3, 314	3, 638	3, 670	3, 772	3, 930	4. 527	4, 774	6, 047	5, 285	5, 552	5, 809	6, 000	4, 694
1877	6, 283	6, 441	6, 666	6, 846	7, 037	7, 352	7, 564	7, 684	7, 872	8, 061	8, 323	8, 458	7, 383
1878	8, 616	8, 725	8, 848	9, 071	9, 400	9, 605	9, 776	9, 884	10, 012	10, 188	10, 276	10, 337	9, 561
1879	10, 482	10, 582	10, 692	10, 782	11, 045	11, 223	11, 461	11, 585	11, 760	11, 860	11, 960	11, 960	11, 283
1880	12, 000	12, 072	12, 222	12, 572	12, 972	13, 172	13, 275	13, 500	13, 825	14, 100	14, 400	14, 700	13, 234
1881	14, 900	15, 050	15, 500	15, 769	16, 150	16, 700	17, 000	17, 250	17, 562	17, 799	18, 040	18, 300	16, 668
1882	18, 400	18, 600	18, 850	19, 150	19, 350	19, 500	19, 570	19, 600	19, 600	19, 000	18, 700	18, 000	19, 027
1883	17, 600	17, 300	17, 250	17, 100	17, 100	17, 050	17, 100	17, 100	17, 300	19, 100	20, 406	20, 606	17, 918
1884	20, 756	20, 930	21, 000	21, 242	21, 494	21, 658	21, 844	21, 916	21, 900	21, 859	21, 859	21, 909	21, 531
1885	21, 950	21, 987	22, 042	22, 093	22, 223	22, 384	22, 524	22, 688	22, 775	23, 062	23, 295	23, 519	22, 545
1886	23, 699	23, 865	24, 034	24, 269	24, 553	24, 797	25, 030	25, 120	25, 243	25, 303	25, 381	25, 443	24, 727

Average daily production of crude petroleum in the Pennsylvania and New York oil fields each month for the years 1872–'86, by years and months.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly averages.
1872	18, 825	15, 965	14, 890	15, 403	17, 326	16, 371	16, 702	17, 739	16, 681	4, 272	21, 287	20, 825	17, 194
1873	20, 407	21, 725	21, 461	21, 384	25, 044	26, 449	27, 983	30, 198	31, 809	30, 403	33, 049	34, 980	27, 106
1874	37, 653	29, 839	28, 598	25, 958	28, 895	30, 725	33, 337	30, 049	28, 021	29, 669	28, 702	27, 682	29, 937
1875	27, 489	25, 708	25, 469	22, 502	22, 468	23, 207	25, 431	23, 186	23, 298	23, 583	23, 340	23, 254	24, 075
1876	22, 975	23, 065	23, 167	23, 383	23, 721	24, 120	24, 633	25, 233	26, 020	26, 102	26, 216	25, 390	24, 505
1877	27, 190	27, 979	29, 087	32, 427	36, 374	37, 693	38, 335	41, 089	40, 497	40, 946	39, 114	40, 518	35, 988
1878	38, 816	39, 102	38, 980	39, 863	40, 802	40, 575	41, 415	43, 288	43, 857	44, 187	44, 965	42, 538	41, 544
1879	44, 191	43, 515	48, 365	51, 015	53, 062	55, 855	56, 057	61, 042	61, 890	59, 238	57, 016	57, 076	54, 206
1880	61, 423	64, 552	65, 032	67, 190	71, 901	71, 948	72, 530	75, 517	78, 210	76, 956	75, 814	72, 214	71, 114
1881	72, 390	68, 326	73, 372	73, 526	77, 203	79, 262	76, 538	75, 217	73, 114	74, 941	75, 561	80, 000	75, 004
1882	75, 921	76, 119	80, 070	80, 093	80, 212	94, 198	105, 102	100, 145	87, 346	74, 118	73, 098	61, 210	82, 338
1883	62, 849	62, 721	59, 054	60, 551	63, 292	65, 930	65, 174	60, 627	63, 779	66, 989	65, 278	64, 146	63, 365
1884	58, 898	64, 850	66, 202	68, 862	76, 834	62, 073	66, 450	67, 715	64, 942	63, 286	60, 390	58, 794	65, 129
1885	53, 296	51, 353	52, 843	59, 343	59, 141	58, 907	57, 284	55, 031	57, 093	60, 455	58, 722	61, 247	56, 921
1886	56, 418	57, 316	62, 208	64, 612	70, 283	77, 846	78, 031	78, 426	80, 618	77 681	74, 093	70, 375	70, 679

[Yearly average is total production divided by the number of days in year, *not* average of monthly averages.]

Total stocks of crude petroleum in the Pennsylvania and New York oil fields for the years 1871–'86, by years and months.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Averages.
1871	537, 751	587, 021	642, 000	771, 000	605, 000	554, 000	511, 220	530, 146	541, 300	495, 102	502, 960	532, 000	567, 458
1872	532, 971	579, 793	662, 497	877, 832	950, 803	1, 010, 302	990, 229	997, 166	951, 410	914, 423	886, 909	1, 084, 423	869, 896
1873	1, 183, 728	1, 265, 373	1, 244, 657	1, 178, 643	1, 192, 541	1, 324, 493	1, 433, 620	1, 513, 890	1, 521, 185	1, 452, 777	1, 493, 875	1, 625, 157	1, 369, 161
1874	1, 948, 919	2, 283, 032	2, 648, 210	2, 623, 534	2, 594, 286	2, 701, 625	2, 279, 479	2, 932, 444	2, 758, 504	3, 134, 902	3, 449, 845	3, 705, 639	2, 755, 035
1875	4, 011, 703	4, 546, 188	4, 592, 364	4, 537, 843	4, 552, 672	4, 502, 896	4, 386, 720	4, 223, 397	3, 812, 945	3, 672, 101	3, 701, 235	3, 550, 207	4, 174, 189
1876	3, 585, 143	3, 734, 835	3, 829, 250	3, 900, 703	3, 989, 904	3, 791, 642	3, 326, 726	3, 304, 405	2, 930, 456	3, 040, 108	2, 955, 092	2, 551, 199	3, 411, 622
1877	2, 604, 128	2, 860, 636	3, 210, 454	3, 279, 731	3, 173, 008	2, 912, 674	3, 004, 728	2, 852, 544	2, 503, 657	2 504, 012	2, 471, 798	3, 127, 837	2, 875, 434
1878	3, 555, 342	3, 875, 964	4, 342, 832	4, 692, 090	4, 996, 058	5, 078, 189	5, 031, 600	4, 717, 877	4, 599, 362	4, 221, 769	4, 289, 309	4, 615, 299	4, 501, 308
1879	5, 321, 222	5, 813, 663	6, 318, 099	6, 689, 111	6, 980, 064	7, 263, 150	7, 353, 382	7, 114, 195	7, 620, 525	7, 794, 634	8, 051, 469	8, 470, 490	7, 065, 834
1980	8, 724, 194	9, 004, 062	9, 606, 683	10, 780, 153	11, 916, 577	13, 099, 934	14, 116, 753	15, 063, 651	16, 157, 316	16, 887, 019	18, 025, 409	18, 928, 430	13, 541, 682
1881	20, 110, 903	21, 108, 003	22, 105, 789	22, 963, 171	23, 793, 028	24, 441, 191	24, 888, 337	25, 005, 187	25, 066, 657	25, 309, 361	25, 509, 285	26, 019, 704	23, 860, 051
1882	26, 716, 188	27, 059, 611	27, 822, 825	28, 547, 481	29, 206, 697	29, 859, 952	30, 715, 144	31, 772, 094	32, 400, 303	32, 608, 533	33, 728, 555	34, 596, 612	30, 419, 500
1883	35, 187, 116	35, 692, 480	35, 881, 255	37, 789, 406	35, 755, 824	35, 985, 935	36, 371, 922	36, 164, 881	35, 752, 677	35, 613, 915	35, 506, 653	35, 745, 632	35, 953, 975
1884	35, 884, 509	36, 041, 898	36, 220, 270	36, 642, 794	38, 631, 203	38, 665, 838	38, 985, 767	39, 084, 561	38, 740, 734	38, 192, 317	37, 925, 756	37, 366, 126	37, 698, 481
1885	37, 214, 274	36, 757, 137	36, 508, 236	36, 464, 800	36, 139, 072	35, 872, 257	35, 686, 909	35, 343, 771	34, 939, 902	34, 763, 857	34, 668, 437	34, 428, 841	35, 732, 291
1886	34, 186, 238	34, 082, 775	33, 954, 493	33, 823, 385	33, 969, 486	34, 187, 377	34, 428, 490	34, 800, 397	35, 061, 614	35, 027, 877	34, 525, 871	34, 156, 605	34, 350, 467

Monthly and yearly average price of pipe-line certificates or crude petroleum at well for the years 1860–'86.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Averages.
1860	\$19. 25	\$18. 00	\$12. 62½	\$11. 00	\$10. 00	\$9. 50	\$8. 62½	\$7. 50	\$6. 62½	\$5. 50	\$3. 75	\$2. 75	\$9. 59
1861	1. 00	1. 00	1. 00	. 62½	. 50	. 50	. 50	. 25	. 20	. 10	. 10	. 10	. 49
1862	. 10	. 15	. 22½	. 50	. 85	1. 00	1. 25	1. 25	1. 25	1. 75	2. 00	2. 25	1. 05
1863	2. 25	2. 50	2. 62½	2. 87½	2. 87½	3. 00	3. 25	3. 37½	3. 50	3. 75	3. 85	3. 95	3. 15
1864	4. 00	4. 37½	5. 50	6. 56	6. 87½	9. 50	12. 12½	10. 12½	8. 87½	7. 75	10. 00	11. 00	8. 06
1865	8. 25	7. 50	6. 00	6. 00	7. 37½	5. 62½	5. 12½	4. 62½	6. 75	8. 12½	7. 25	6. 50	6. 59
1860	4. 50	4. 40	3. 75	3. 95	4. 50	3. 87½	3. 00	3. 75	4. 50	3. 39	2. 10	2. 12½	3. 74
1867	1. 87½	1. 85	1. 75	2. 07½	2. 35	1. 90	2. 62½	3. 15	3. 40	3. 55	2. 50	1. 87½	2. 41
1668	1. 95	2. 00	2. 55	2. 82½	3. 75	4. 50	5. 12½	4. 57½	4. 00	4. 12½	3. 75	4. 35	3. 62½
1869	5. 75	6. 95	6. 00	5. 70	5. 35	4. 95	5. 37½	5. 57½	5. 50	5. 50	5. 80	5. 12½	5. 63¾
1870	4. 52½	4. 52½	4. 45	4. 22½	4. 40	4. 17½	3. 77½	3. 15	3. 25	3. 27½	3. 22½	3. 40	3. 86
1871	3. 82½	4. 38	4. 25	4. 01	4. 60	3. 85½	4. 79	4. 66	4. 65	4. 82½	4. 25	4. 00	4. 34
1872	4. 02½	3. 80	3. 72½	3. 52½	3. 80	3. 85	3. 80	3. 58½	3. 25	3. 15	3. 83½	3. 32½	3. 64
1873	2. 60	2. 20	2. 12½	2. 30	2. 47½	2. 22½	2. 00	1. 42½	1. 15	1. 20	1. 25	1. 00	1. 83
1874	1. 20	1. 40	1. 60	1. 90	1. 62½	1. 32½	1. 02½	. 95	. 95	. 85	. 55	. 61½	1. 17
1875	1. 03	1. 52½	1. 75	1. 36½	1. 40	1. 26½	1. 09	1. 13	1. 33	1. 32½	1. 44	1. 55	1. 35
1876	1. 80	2. 60	2. 01	2. 02½	1. 90½	2. 01¾	2. 24½	2. 71⅜	3. 81	3. 37½	3. 11	3. 73	2. 56½
1877	3. 53¼	2. 70	2. 67½	2. 58	2. 24	1. 94⅝	2. 07½	2. 51	2. 38	2. 56¾	1. 91	1. 80	2. 42
1878	1. 43	1. 65¼	1. 59	1. 37½	1. 35¼	1. 14	. 98¾	1. 01	. 86⅝	. 82½	. 89⅜	1. 16	1. 19

1879	1.03	.98	.86¼	.78½	.76	.68⅜	.69⅞	.67⅛	.69⅜	.88⅛	1.05⅝	1.18⅛	.85⅞
1880	1.10¼	1.03⅛	.88¾	.78	.80	1.00	1.06¼	.91	.96	.96⅞	.91⅞	.91⅝	.94½
1881	.95½	.90⅜	.83⅜	.86¼	.81⅞	.81¼	.76⅞	.78⅛	.97 3/16	.91¼	.85¼	.84⅜	.85⅞
1882	.83⅛	.84½	.81⅜	.78⅜	.71½	.54⅜	.57 4/10	.58⅝	.72⅛	.93¾	1.14	.96	.78⅞
1883	.93¾	1.01	.97⅝	.92⅜	1.00⅛	1.16⅜	1.05⅞	1.08½	1.12½	1.11⅛	1.14⅛	1.14¾	1.05¾
1884	1.11	1.04⅜	.98⅛	.94	.85⅝	.68⅝	.63⅛	.81⅛	.78	.71⅛	.72½	.74⅜	.83½
1885	.70⅞	.72⅜	.80⅛	.78½	.79	.82	.92½	1.00¼	1.00¾	1.05½	1.04⅜	.89⅞	.88
1886	.88⅛	.79⅞	.77¼	.74⅛	.70	.66½	.66	.62⅛	.63⅜	.65⅛	.71⅝	.70⅝	.71¼

OHIO.

The discovery that large quantities of petroleum are contained in that portion of the Trenton limestone underlying the northwestern part of Ohio, and the great increase in production consequent upon this discovery, have been among the most notable features of petroleum production in 1886. The Lima field, which is in the Trenton limestone, has been heretofore of so little importance that in the report for 1885 it was dismissed with two lines.

The two chief sources of oil in Ohio are the Trenton limestone and the Berea grit. The old and well-known fields of Mecca and Grafton, in the former of which over 2,000 wells have been drilled, none of them having a depth of more than 50 or 60 feet, derive their oil from the Berea grit, and though at Macksburg, the only important oil district at present in the eastern half of Ohio, there are four productive sand rocks, the interest centers in the Berea grit. In Athens and Morgan counties a little shallow oil is derived from the Coal Measures, while some oil is found in the Waverly Conglomerate. The chief producer of oil in Ohio at present, however, is the Trenton limestone.

The important producing fields in Ohio are the Macksburg and the Lima or northwestern, which include, in addition to the Lima field proper, the Findlay and North Baltimore. In addition to these there are several small producing districts.

The northwestern Ohio or Lima Oil fields.—Quite full descriptions of the important producing oil fields of the country, with the exception of the northwestern Ohio or Lima field, have been given in the previous volumes of "Mineral Resources of the United States." This Lima oil field is not only important by reason of its great production, but because of the contribution to economic geology which this new field has made. Before the discovery of Findlay gas and Lima oil, the Devonian system was supposed to be the lower limit of the oil-bearing strata, but with these discoveries the oil horizon descends to the Lower Silurian, the Trenton limestone in which this oil and gas is found coming very closely to the granite.

According to Professor Orton the Lima oil field constitutes a very flat-lying tract of the Trenton limestone. It is as near a level terrace as an area of this sort ever becomes. The very gentle slope that exists in it is mainly to the northward, not amounting to more than 4 feet to a mile, and at times reduced even to 1 or 2 feet. The rises in the floor, or, in other words, the knobs and bosses of the great limestone sheet, are always favorable to production, other things being equal. Indeed, the Trenton limestone shows itself wonderfully sensitive to variations in connection with its yield of oil and gas.

The limits of this northwestern Ohio oil field are not yet sufficiently determined to justify any definite statement as to its extent. The Findlay Lima and North Baltimore field proper may be regarded as extending from near Findlay, in Hancock county, northwestward to near Bowling Green, in Wood county. Oil has been found southwest of Findlay, in Mercer and Auglaize counties, and northeastwardly near the shore of Lake Erie, so that it is possible that this northwestern oil district may cross the entire northwestern portion of the State from Mercer county to Lake Erie. In the Lima field proper may be included the Findlay and North Baltimore fields. These three fields constitute the present oil centers of northwestern Ohio.

The oil is found at Lima at the depth of about 1,300 feet, it requiring about sixty days to drill a well, the cost being some $2,500. The first wells drilled in this field were none of them very large producers for new oil territory. Early in 1886 no well exceeded, if indeed it reached, 150 barrels a day, but towards the close of the year and the beginning of 1887 some very large wells were brought in, one being reported as producing 1,500 barrels a day, a number reaching the 1,000-barrel limit, and others maintaining a rate of several hundred barrels per day, week after week. At the close of 1886 the average daily production of this field was 4,374 barrels; the production of November and October, respectively, averaged 4,038 and 4,112 barrels daily. The entire production of the Lima field for 1886 is estimated at 1,064,025 barrels. As the real development of the Lima field dates from February, it will be seen that this field has assumed considerable importance. The number of wells drilled in the field in 1886 was about 250.

Lima oil and, indeed, all limestone oils differ greatly in character from the oils from the sandstones. They are dark or black, and rather heavy oils and contain sulphur compounds. In these respects the oils of northwestern Ohio resemble those of Canada and Tennessee. The oils, though they would be classed, as compared with most of the oils of western Pennsylvania, as rather heavy, differ greatly in specific gravity. In the first wells struck the oils had a gravity of 36° B. In the later wells it reaches 37° or 38° B., while in one well at least, the McCullough, it reaches 41°. There are two great drawbacks to the Lima oil, first, the presence of sulphur compounds, and secondly, the yield of illuminating oils as compared with the yield in illuminating oils of the Pennsylvania product. The sulphur compounds, which render the oil so offensive in use, are quite difficult to remove, but there is no doubt that they can be removed with care in the refining process coupled with sufficient outlay of time, labor, and money. The cost is estimated at 10 cents a barrel. Whether, however, with the enormous production of the New York and Pennsylvania oil fields, this Lima oil can be refined economically is as yet an unsettled question. The indications are that this cannot be done with the present conditions as to price and production, and that the producers of Lima oil must seek other uses for it. The second drawback is the percentage yield of illuminating oil. The testimony as to this yield is somewhat conflicting. It is claimed that tests made show a yield of completely deodorized illuminating oil of 65 per cent.

The figure most commonly given, however, is 50 per cent. These drawbacks to the use of the oil have had a marked effect on the price of the Lima product. Early in 1886 the price was 40 cents per barrel. This price was reduced, near the close of the year, to 35 cents, and since January 1, 1887, it has been further reduced to 30 cents, and again to 25 cents.

As intimated above, under present conditions as to price and production, the producers of Lima oil must look for a demand outside of that for illuminating purposes. Considerable attention is being directed to its use for fuel, and some notable results have been obtained. In this demand there would seem to be a possible relief for the Lima oil producers, provided that the production is not still more largely increased, which at the close of the year seems certain.

The Macksburg oil field.—Until the important developments in the Lima field, that is, up to the beginning of 1886, the most important of Ohio oil fields in recent years has been the Macksburg. Though oil was found here as early as 1860, the first well bored at that date producing many thousand barrels of heavy oil, it was not until the spring of 1884, when a number of successful wells were drilled, that the district assumed any importance. This is still the only important oil field in the eastern half of Ohio. As is indicated above, though there are four producing sands in this field, the important one is the Berea grit. The first oil well in the Berea grit was struck in 1878, a ten-barrel flowing well. In 1882 a hundred-barrel flowing well was attained. The attention of oil prospectors was directed to this field, and the yield in 1885 was 613,822 barrels. The following table from the *Petroleum Age* will show the runs by months, the pipe-line runs, the shipments of the West Virginia Transportation Company, etc., from the Macksburg field in 1885 and 1886:

Production of the Macksburg district for 1885–'86.

Months.	1885.			1886.		
	Macksburg pipe-line runs.	Outside shipments (estimated).	Daily average production.	Macksburg pipe-line runs.	Outside shipments (estimated).	Daily average production.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
January	11,894	1,500	432	54,806	7,000	1,994
February	20,626	1,500	790	49,694	7,000	2,025
March	27,066	1,500	922	58,795	8,973	2,186
April	40,527	1,500	1,400	64,137	7,890	2,401
May	58,258	1,500	1,605	58,596	6,630	2,104
June	64,982	1,500	2,216	65,379	2,871	2,275
July	75,737	1,500	2,492	58,410	4,080	2,016
August	74,228	1,500	2,443	57,492	2,790	1,945
September	68,110	1,500	2,320	48,918	1,240	1,672
October	63,619	7,000	2,278	46,937	3,240	1,619
November	60,926	7,000	2,264	41,359	4,090	1,515
December	61,113	7,000	2,197	40,578	3,040	1,407
Total	627,086	34,500	1,813	645,101	58,844	1,929

The number of producing wells at the close of 1886 is estimated at 450.

The Mecca field.—Near Mecca, in Trumbull county, considerable quantities of oil have been obtained in the past, though now the entire product does not exceed a few hundred barrels. More than 2,000 wells have been drilled in this field, none reaching a depth of over 50 or 60 feet. The oil has lost most of its volatile products from the light cover which caps the Berea grit in which the oil is found, its gravity being 26° to 28° B. It is a natural lubricating oil of excellent quality.

The Grafton field.—At Grafton, in Loraine county, is a field very similar to the Mecca. The Berea grit having a heavier cover than at Mecca, the oil is somewhat lighter in gravity, but is still a heavy oil. Several hundred wells have been drilled in this district, but none are producing at the present time.

WEST VIRGINIA.

There is nothing to add to the statements that have already appeared in previous volumes of "Mineral Resources of the United States" relative to the production of petroleum in West Virginia. The search for natural gas in this State has resulted in a discovery of some small amounts of petroleum, but no field of any importance has been opened, nor indeed do discoveries thus far made give any indication of future prominence in petroleum production.

KENTUCKY AND TENNESSEE.

Nothing can be added to the statements contained in previous volumes of the "Mineral Resources of the United States" relative to the petroleum fields or production of Kentucky and Tennessee. Some explorations for oil and gas have been prosecuted in these States during the past year, but the results have been of no importance commercially. The wells near Glasgow, in Kentucky, still yield a small quantity of oil, and possibly some few barrels have been produced in Tennessee, but the amount of production in either State is not of sufficient importance to justify its tabulation.

CALIFORNIA.

In the last volume of the "Mineral Resources" quite a full statement was made regarding the history and production of California oil fields and the use of petroleum in this State as a fuel. In these respects but little can be said in addition to what was there given. During the year 1886 there was considerable drilling for petroleum in this State, chiefly in what has been regarded as "oil territory." This drilling has grown out of the increased demand for oil, both for illuminating and lubricating purposes, and for fuel. In the oil regions of this State, where there are quite a number of manufactories of various kinds, coal is worth $12 a ton; oil at 5½ cents a gallon, which is the usual price at the wells, is very much cheaper than coal, and as a result, very many of the manufacturing establishments, especially in the Los Angeles field, are using petroleum. Besides this, it is used quite extensively for domestic purposes both in heating and cooking. At Los Angeles, according to the *San Francisco Call*, the following are the approximate quantities of oil used as fuel. In these establishments oil is used exclusively. Lankershim's mills (five) per month, 500 barrels; Philadelphia brewery, 500 barrels; Electric Light works, 400 to 500; Capital mills, 460; Pico Street Electric railroad, 200; Los Angeles Pressed Brick Company, 100; New York brewery, 100; Los Angeles steam laundry, 100. The smaller consumers are the *Times-Mirror* Company, Welch's fruit cannery, Barnard & Benedict, the Fruit Crystallizing Company, etc. E. M. Hamilton has been burning brick at his East Los Angeles brickyard for the last three years with oil exclusively, and claims thereby to make bricks at $1 per 1,000 as against $3 with wood as fuel. The Hotel Arcadia, Santa Monica, uses about 100 barrels of petroleum per month for fuel. Petroleum is now also used as fuel at Pasadena, Monrovia, Santa Ana, Lamanda Park, and several other towns in the county. The total consumption of petroleum for fuel in Los Angeles alone is, in round numbers, 100 barrels a day. By next winter it is expected to be double this amount.

The principal oil belt in California, so far as development and production are concerned, may be said to commence at Santa Paula, in Ventura county, and to extend thence in a southeasterly direction about 60 miles to Puente, in Los Angeles county, taking in the Sespe and other wells in Ventura county, Pico cañon, Newhall, etc.; this belt has a variable width of two or three miles, there being many oil indications and unimportant deposits on either side of it. In most if not in all of these, operations have been in progress during the past year. In the Los Angeles field, at Puente, a spouting well was struck at the depth of 675 feet, this well being No. 6. Nos. 7 and 8 were commenced about the first of the year. Other wells were bored in other districts during the year, and by the close of 1886 the production was somewhat in excess of that reached at the beginning of the year, with the prospect of a still further increase in 1887. It was estimated early in 1887 that the daily production of the several oil fields of California was as follows: Sespe, and other northermost oil fields, 700 barrels; the Newhall, 450; the Puente, about 100, and others 50; total, 1,300 barrels per day.

From the best reports obtainable, we have estimated the production of oil in California in 1886 at 377,145 barrels; this at 5½ cents a gallon, or $2.31 a barrel, would be worth $870,205.

WYOMING.

No definite statements, either as to the developments of the oil fields of Wyoming or their production, in addition to those given on page 153 and 154 of the "Mineral Resources of the United States, for 1885,' have been received. It is reported that new discoveries have been made, and that large flowing wells have been struck. Some of these reports upon investigation have proved entirely devoid of foundation, but still there is no doubt that there are indications of oil in this Territory over quite a wide extent. As yet, however, there is no production of importance.

OTHER STATES.

It is reported that a natural lubricating oil, similar to that of West Virginia, though inferior, is produced in Texas. The wells which supply it yield about 60 barrels per day. The oil is stated to be about 30° B. gravity, and, when the wells are properly drilled and the naphtha evaporated, to make a fairly good lubricant.

In Dakota some land has been leased by the Territorial government to parties who propose to develop the oil resources of the Territory.

RUSSIAN PETROLEUM.

Three petroleum fields, or districts, are known to exist in Russia—the Baku or Apsheron, the Kouban or Ilsky, and the Kertch or Crimean. Of these the latter is of but little importance at present, and requires but little description. It is near the town of Kertch in the Crimean peninsula. At a number of villages within a radius of 25 or 30 miles from Kertch, chiefly south and west of that village, oil in some quantities has been found. Near the Tartar village of Kop-Kootchigan some heavy oil is found at a depth of from 80 to 180 feet, the wells being simple holes dug in the ground without the aid of machinery. Consular Agent James C. Chambers states, in a letter to the State Department, that two years ago there were 115 of these holes, protected by barrels sunk into their tops, but that no oil had been taken from them for 12 years. A French company was induced to lease an immense tract of land, and commence prospecting for oil, the result being that a well 940 feet deep at Chingalek, 16 miles south of Kertch, produced for a short time about thirty barrels per day of crude oil, the total production of the well being some 3,500 barrels, which was also the total production of all the wells of this French company.

The other two districts, the Baku and the Kouban, are situated at the west and east extremity, respectively, of the Caucasus mountains. Of these two districts the most important, and, indeed, next to the American oil fields, the most important in the world, is the Baku.

The Baku oil fields.—Baku, from which the well known oil fields of the Caspian take their name, is a small but rapidly growing town on the Apsheron peninsula, at the eastern extremity of the Caucasus mountains. Mr. James C. Chambers, consular agent at Batoum, describes this field in No. 74 of the "Reports from the Consuls of the United States," published in February, 1887, by the State Department. As this is one of the best descriptions of this field yet published we make quite full extracts from it.

"Petroleum, or 'neft,' as the Russians call it, was known to exist in the vicinity of Baku hundreds of years ago, but the earliest records of production are from the years 1821 to 1825, in which years the Government revenue from petroleum was 131,000 roubles. In 1832 the production was about 750,000 gallons. Since 1832 a record of the annual production has been kept, which record shows a very small increase until the year 1870, when the production reached 3,500,000 gallons. The business until 1873 was a Government monopoly, held at various times by different people, the last holder being an American(*a*) named Mirzoeff, who at that time was a very wealthy man, having, it is said, made his fortune out of the monopoly. The production was also subject to an excise tax, which must have been a heavy charge upon the industry, as the amount of this tax from the year 1873 to 1877 was more than $1,000,000 on a production approximating 200,000,000 gallons. The monopoly was abolished in 1873, the business thereafter being open to all who wished to engage in it, and after September 1, 1877, the excise tax was also abolished. The commercial era of the business dates from the year 1876, when the Nobel Brothers, a trio of Swedish engineers, commenced operations. These gentlemen, by remarkable energy, enlisted an immense amount of foreign capital in this business, and to them certainly belongs the honor of building up, from a very insignificant beginning, what to-day is the greatest producing and manufacturing business in Russia.

"The great petroleum-producing district is about 8 miles north of Baku, and is called Balakhani, taking the name of the Tartar village near it. Different parts of the district are known by other names, such as Sabunchi on the south, the Garden on the east, and Shaitan Bazar in the center; and local statisticians have again subdivided the fields into groups, of which there are 17 in the Balakhani district and one at Surakhani, about 5 miles southeast of the main district. At Surakhani 23 wells have been drilled, the last one about the year 1879, but no estimate for the production of these wells has been found, and it is understood that they have produced little or no oil for several years. There is also a large refinery at Surakhani, which is supplied with crude oil by a pipe line from Balakhani.

"Between 2 and 3 miles south of Baku, on the sea shore, is another producing district, the area of which, as at present divided, is very small, called Bibi-Eibat. Twenty-two wells have been drilled here, and 14 of them were producing in July, 1886. In September one of these wells was drilled deeper, resulting in a large flow of oil. The production of this well, it was claimed, was from 30,000 to 40,000 barrels (42 gallons) per day for fifteen days, after which it ceased to flow entirely. This well was less than 700 feet deep, but it was the deepest well in the Bibi-Eibat district, and had been producing from a shallower depth for two years. There is also a large and very modern refinery at this place.

a This is possibly a misprint for Armenian. J. D. W.

"The area of what is considered sure-producing territory at Balakhani is between 3 and 4 square miles. The surface of this territory is loose sand, and the soil is the same as deep as the drill has penetrated, but is interspersed with thin strata of sandstone and solidified clay, which, when brought to the surface, are to all appearance heavy rock, but which can readily be cut with a knife. Owing to the caving of the sand and the occasional striking of hard, loose stones, which invariably causes what is called a "crooked hole," a very serious obstacle for drillers to overcome, the drilling is exceedingly difficult and expensive. The caving makes the use of iron pipe from the start to finish of the well a necessity. The wells are usually started with heavy riveted pipe (14 to 16 inches inside diameter), which is inserted by driving or with hydraulic jacks, after drilling ahead with a bit larger than the pipe. The large pipe is continued until it collapses at the bottom, or for some reason refuses to go further, when another pipe is started small enough to go inside of the first one, and is continued as long as possible, and then again reduced until the oil is found and the well finished, which is usually done with 8-inch pipe. Owing to the necessity of deeper drilling now than formerly, it is becoming necessary to start the wells with a larger pipe, and Messrs. Nobel are now preparing to commence all new wells with 24-inch pipe. Russian and German iron is used for the large riveted pipe, and the smaller sizes of pipe, from 10 inches down, which is lap-welded, is also principally German. In the past year efforts have been made to introduce American pipe and oil-well supplies, which are unquestionably the best in the world, owing to the longer experience of the American manufacturers, and which can be sold in Baku at very little advance upon the prices of other material there. Now, however, these efforts have been relaxed or entirely abandoned. The long credits absolutely necessary to buyers of exceedingly doubtful commercial integrity, and the time required for transportation from America made the business of no value to the Americans.

"All kinds of machinery and tools are used at Balakhani. A majority of the drillers use pole tools, but a few are using ropes, as in America. The progressive operators are using either American-made engines or engines made in Russia from American patterns. American machinery is, of course, very expensive, as the freight and Russian duty almost double the American price.

"The cost of a well at Balakhani varies with the depth to a certain extent. At the present time I think it impossible to drill a well from 700 to 1,000 feet for less than $10,000, and a fair average price is about $12,000. This does not include the cost of the land, which belongs generally to the operators, although some leases are held at a royalty of one-third of the production. The land belongs to different parties, but a great deal of it was originally Government land. The leases obtained from the Government were generally at a merely nominal rental or royalty, although land purchased in fee cost much more than it can be had for at present. Now, however, the Government will neither rent nor sell any more land, and it holds quite a large tract in the center of the field, which has not yet been drilled upon. The length of time required to drill a well is also uncertain, as it is from three months to three years; but I think about six to eight months the average time.

"Comparing numerous sources as to the number of wells drilled at Baku, I believe the following was nearly correct in January of this year (1886):

Number of wells at Baku up to January, 1886.

Kind of well.	Number.
Producing wells	164
Drilling wells	104
Abandoned wells	200
Total	468

"The term 'drilling wells' does not mean that work is being actively prosecuted, but that these wells are reported as in various stages of work, *i. e.*, unfinished. Since the above figures were obtained, I have seen the number of producing wells estimated at 185, but as that was in September, 1886, it is quite probable that several new wells were completed since January, 1886.

"An estimate of the production of these 164 wells, based, it was claimed, upon reports from their owners, was 58,000 barrels (of 42 gallons) daily. Considering the number of holidays in Russia, and the fact that for several months in winter, owing to a lack of transportation facilities, the river Volga being closed by ice, the wells are very irregularly pumped, this estimate is a fair one. Estimating, however, the refined oil exported at 30 per cent. of the crude, and adding the small amount of crude shipped, will not give more than 31,000 barrels per day as the average daily crude production for 1885.

"*Depth of wells.*—The depth of the wells varies from 175 to 1,030 feet, there being only one well of the latter depth, and I am not positive that it is producing profitably. The average depth of the wells is steadily increasing, and is now said to be 500 feet as against 350 feet in 1882. The average depth of new wells is, however, more than 500 feet, probably over 600 feet. By many it is claimed that the increasing depth of the drilling is proof positive of the exhaustion of the territory, and that the depth of the drilling increases 50 feet for every 500,000,000 gallons of crude taken out, but I have seen no calculations as to the depth of the lower strata of oil. Others claim that both the yield and the quality of the crude improve with deeper drilling, and that the territory will continue to produce from much greater depths. From my own observation, I am inclined to believe that the quality of the crude as an illuminant improves as the drilling gets deeper, but as to the increase in the yield I am doubtful. The following figures are given as a comparison of the yield of various parts of the territory at different depths:

Localities.	Depths of wells.	No. of wells.	Daily production of each well.
	Feet.		*Gallons.*
Balakhani	175 to 280	7	7,855
	280 to 350	7	17,000
	350 to 420	9	17,000
	420 to 490	13	17,560
	490 to 560	4	16,000
	560 to 630	2	25,000
Group V.—(A very rich section on the north of the field)	245 to 350	12	11,000
	350 to 420	6	13,300
	420 to 490	3	10,500
	490 to 560	....	No wells.
	560 to 630	2	25,000
	630 to 730	1	60,000
Sabunchi	350 to 420	8	15,435
	420 to 490	8	14,685
	490 to 560	....	No wells.
	560 to 630	2	22,500
Shaitan Bazar	175 to 280	6	8,330
	280 to 350	....	No wells.
	350 to 420	2	10,000
	420 to 490	2	15,000
	490 to 630	....	No wells.
	630 to 700	1	60,000

"This is intended to show a general increase in yield in all parts of the field from deeper drilling, but the fact that the shallow wells are all old, while the deeper ones are comparatively new, must not be overlooked, and while it does not make it perfectly clear that the deeper wells are more productive than the shallow ones, it certainly shows no exhaustion of the territory.

"When Balakhani oil wells do not flow they are pumped with what is called in the American oil fields a bailer. The pump or bailer used varies according to the size of the well-pipe, as it is made of a pipe to run freely inside of the well-pipe; but they are much larger than those commonly used in America, and hold from two to ten barrels each.

"Many of the wells flow naturally and with great force when the oil is struck. The flowing wells, or, as the Russians call them, 'fountains,' are fitted upon the top of the well-pipe with a gate or slide valve, and upon the top of this valve is an elbow of pipe the same size as the well-pipe, which directs the flow, when the valve is opened, horizontally into the trough or ditch. Many of these fountains can be opened or closed at will. If oil is required they are opened, and the oil allowed to flow until the necessary quantity is obtained, when they are again closed. This, of course, is a great advantage, the well itself answering the purpose of a tank or reservoir which is always full.

"The quantity of crude produced by some of these flowing wells is incredible to those who have never seen one of them flowing. The most productive well ever drilled at Balakhani was Nobels' No. 15. This well, while it did not flow so furiously as many others, flowed steadily the full size of the pipe (8 inches) when opened for years. It was handled just as a large tank would be, only opened when oil was required. I do not know the exact length of time it produced profitably, but its total production was over 1,800,000 barrels (42 gallons). Nobels' No. 9 was another large well. It was the largest well ever struck, for the first nine days, as it flowed that length of time steadily a solid column of oil the full size of the pipe (8-inch) to a height of two to three hundred feet. The estimated production of this well for the first nine days was 50,000 barrels per day, and its total production for the thirty-two days it flowed was over 900,000 barrels. In last June the Nobels struck a well (No. 32) which was the most difficult to control they ever had. This well was furnished with 8-inch pipe; and after it had flowed furiously for a day or two they succeeded in shutting it off by using four 8-inch gate valves on the top of the pipe. They then worked a week strengthening the derrick by using heavy timbers from the tops of the valves to the sides of the derrick and other timbers across, until they had the derrick a mass of heavy timbers. While this work was being done the valves commenced to leak, and the well was producing oil faster than it could be pumped away through two lines of pipes, one 3-inch and one 4-inch. They finally added a 6-inch line, with a large pump, to their pipe-line capacity, and then attempted to open the valves. In a very few minutes the valves and almost all of the net-work of timbers in the derrick were blown away, and the well flowed terrifically for several hours, not oil, but stones and mud. It flowed intermittently dirt and stones and oil for about fifteen days, when it quit entirely, having produced over 100,000 barrels of oil. All the large wells have stopped flowing in the same abrupt manner, and the same cause of stoppage is assigned to all of them, viz, the collapsing of the pipe at the bottom of the well. The pipe in this well (No. 32) was American, and it was hoped that it would stand the test, the first of the kind, imposed upon it, as it is certainly much superior to any of the other pipe used here; but these hopes were not realized, at least not fully; for, although it did not stand this test entirely, it stood it for fifteen days, and it was a much more severe test than any other pipe has been given. The depth of this well was 860 feet, and at that time it was the deepest producing well in the field.

"The length of the profitably producing life of Balakhani wells varies greatly, and an average is unobtainable. As I have already shown, some produce for years, while others last only a few days. They do not seem to affect each other's production, even when within a few feet of each other and producing from about the same depth. The oil contains a great deal of sand, and some of the flowing wells throw out immense quantities of sand with the oil, sufficient in several cases to completely bury the engine-house and out-houses in their vicinity. I am again indebted to Mr. Törnūdd for the following information regarding the production of the wells of Nobel Brothers.

"Nobel Brothers have drilled 74 wells in the Balakhani district, of which number 32 are now producing. Of the 74 wells, 22 have produced over 115,000 barrels (42 gallons) each, and the aggregate production of the 22 wells to September was over 7,600,000 barrels, an average of more than 345,000 barrels each. Eight other wells have produced nearly 100,000 barrels each, and almost all of the 74 wells have been profitable producers.

"Iron tanks for crude oil are but seldom used; this is also true for iron pipe for conducting the oil from wells to reservoirs. Instead of iron pipe, wooden box-troughs or dirt ditches are used for the latter purpose, and reservoirs are made by excavating the ground in the vicinity of the well, or by simply throwing up walls with the sand that has been thrown out of the wells. Of course there is a loss from the ground absorbing the crude, but the price is so low that this loss is insignificant. From the reservoirs the crude is pumped through pipes to the refineries, which are located on the sea shore, about two miles east of Baku, at Chornai-Gorod (Black Town).

"The distance from the wells to refineries is about 8 miles; and as the average elevation of the wells above the Caspian Sea is 175 feet, the piping of the crude is not at all difficult. There are now 14 pipe lines from 3 to 6 inches in diameter, and belonging to thirteen different owners. The pumps used are either of American manufacture or made in England or Russia from American patterns, with the knowledge and consent of the American manufacturers and patentees. The latter, I am informed by men of experience with both kinds, are by no means as good as those made in America, and I have heard surprise expressed at the American manufacturers allowing their machinery to be so indifferently constructed in England and Russia.

"The aggregate daily capacity of the fourteen pipe lines is about 100,000 barrels. The nominal pipeage charge is 1 kopeck per pood (about 4 cents per barrel), but the pipe lines are generally owned in connection with both wells and refineries.

"*Price of crude oil.*—The following figures, although not very complete, will give some idea of the prices for crude oil at the wells per barrel of 42 gallons in the past five years:

Prices of crude petroleum at the wells in the Baku oil fields, from 1881 *to* 1886.

Date.	Price per barrel.	Date.	Price per barrel.
	Cents.		*Cents.*
January and February, 1881	$12\frac{3}{5}$	June, 1884	$14\frac{7}{10}$
April to June, 1881	$7\frac{7}{20}$	July and August, 1884	$16\frac{4}{5}$
July, 1881	$6\frac{3}{10}$ to $10\frac{1}{2}$	September, 1884	$14\frac{7}{10}$ to $16\frac{4}{5}$
August, 1881	$6\frac{9}{20}$ to $12\frac{3}{5}$	October to December, 1884	$9\frac{9}{20}$ to $10\frac{1}{2}$
September to December, 1881	$8\frac{2}{5}$ to $12\frac{3}{5}$	January, 1885	$8\frac{2}{5}$ to $10\frac{1}{2}$
January to March, 1882	$12\frac{3}{5}$	February, 1885	$14\frac{7}{10}$
April to October, 1882	$10\frac{1}{2}$ to $12\frac{3}{5}$	March and April, 1885	$16\frac{4}{5}$
November to December, 1882	$8\frac{2}{5}$	May and June, 1885	$12\frac{3}{5}$ to $16\frac{4}{5}$
January to March, 1883	$8\frac{2}{5}$	July, 1885	$16\frac{4}{5}$
April to July, 1883	$4\frac{1}{5}$ to $8\frac{1}{2}$	September, 1885	$10\frac{1}{2}$
August to November, 1883	$2\frac{1}{10}$ to $6\frac{3}{10}$	October to December, 1885	$8\frac{2}{5}$ to $4\frac{1}{5}$
February to March, 1884	$4\frac{1}{5}$ to $7\frac{7}{20}$	January to March, 1886	$3\frac{3}{20}$ to $4\frac{1}{5}$
April and May, 1884	$7\frac{7}{20}$ to $8\frac{2}{5}$	April to June, 1886	$8\frac{2}{5}$ to $10\frac{1}{2}$

"The refineries, with the exception of three, one at Bibi-Eibat, one at Surakhani, and one in the town of Baku (the latter having been idle for some months owing to the financial difficulties of its owners), are all located at Chornai-Gorod; they are exceedingly numerous, and of every description and capacity, from the immense modern works of Nobel Brothers, capable of turning out 6,000 barrels of refined oil every twenty-four hours, down to the primitive ten-barrel still, inclosed in a little stone hut, of the Tartar refiner. The total number of refineries is generally said to be more than two hundred, but the statisticians seem to consider only about 136 as worth mentioning, as follows:

Number of refineries in the Baku oil field and their total capacity.

	No.	Stills.	Daily capacity.
			Gallons.
Large refineries	12	216	747,500
Smaller	15	115	159,050
Small	109	210	315,000
Total	136	541	1,221,550

"In the official returns for the year 1885 only 87 refineries are mentioned, as follows:

Production from the refineries of the Baku district in 1885.

[Gallons.]

	No.	Refined oil.	Lubricating.	Benzine.	Total.
Large refineries	10	123,898,430	7,337,500	205,000	131,440,930
Small	77	36,598,635	2,675,000		39,273,635
Totals		160,497,065	10,012,500	205,000	170,714,565

"The following are the official figures for the actual output of petroleum products from Baku for the last five years (in gallons):

Output of petroleum products from Baku, 1881 *to* 1885.

	1881.	1882.	1883.	1884.	1885.
Refined	58,171,425	62,898,860	59,639,400	108,609,855	131,613,925
Other products	59,467,110	99,498,910	85,541,305	154,511,855	174,637,070
Total	117,638,535	162,397,770	145,180,705	263,121,710	306,250,995

Of the above the following amounts were exported, 1883: 1,934,670 gallons; 1884: 25,284,720 gallons; 1885: 35,000,000 gallons.

"The estimate given of the capacity of the 136 refineries is no doubt reasonably correct. Owing, however, to the numerous holidays in Russia, and the impossibility of doing anything for several months in the winter, for causes already explained, the maximum annual capacity of these refineries would hardly be more than two hundred times their maximum daily capacity, as two hundred working days in the year is a fair estimate for this country. This shows an abundance of refining capacity, as the product of the refineries in 1885 was not more than half of this estimate.

"Even here in Russia there is a great difference of opinion as to the relative merits of Russian and American illuminating oil, and while it is not generally asserted that the Russian refined can be made as good an illuminant as the American, there is no doubt that it can and is made to burn quite well enough for all purposes, and emits no disagreeable odor while burning. After taking from Russian crude oil, say, 30 per cent. illuminating distillate, about 15 per cent. is taken from the residuum, which is called 'solar oil,' and which, although a nice looking white oil, is too high fire-test to burn in ordinary lamps and not sufficiently good for lubricating purposes. This is generally mixed with the 'astatki,' or crude residuum; although the last Baku congress of petroleum people 'resolved that its use should be made compulsory for the purpose of lighting public buildings, theaters, circuses, hotels, etc., that the use of kerosene (refined) should be prohibited in such buildings, and that the ordinary restrictions applied to mineral oils in transportation, storage, etc., should be taken off solar oil, and that it be placed in the same category with vegetable oils.' This is, however, only a petroleum producer's resolution, which will be understood no doubt in America. After the solar oil is taken, the lubricating-oil distillate is taken off, and varies from 20 per cent. to 25 per cent. From this distillate a very good lubricant is made, as it is affected neither by intense heat nor great cold. The lubricating oil is made in Baku, but great quantities of the distillate are also shipped to England, France, Belgium, and Germany, and there purified and made into lubricating oils. After the foregoing proportions are taken from the crude, the residuum, down to about 15 per cent. of the whole, is taken off, and generally mixed with the solar oil. This is called 'astatki,' or crude residuum, and is the fuel of southeastern Russia. As the Caspian and Volga steamers, many of the railways in eastern Russia, and the Trans-Caucasian railway use it for fuel, there is a great demand for it, and it sells at an average price of $\frac{1}{10}$ cent per gallon free on board cars or steamers at Baku. The 15 per cent. left in the still is called 'mazoot,' and, as it will not burn, is a total waste. A few years ago it was used in limited quantities to sprinkle the streets of Baku, which was a very good idea from a sanitary point of view.

"Estimated as above, the yield of Russian crude in merchantable products is about 85 per cent., as follows:

Estimated yield of Russian petroleum in merchantable products.

	Per cent.
Illuminating oil	30
Lubricating oil	20
Solar oil } Astatki (crude residuum) }	35
Waste	15
Total	100

"The specific gravity of Balakhani crude oil varies, but not sufficiently to make any difference in its value, so that it is all run together, forming a crude of about 0.865 specific gravity, or 32° Baumé. It contains no paraffin, and very little benzine is made from it, none of which is lighter than 0.700 specific gravity. As I have said before, I think it exceedingly probable that the crude will be of a less specific gravity as the drilling deepens, as I find the oil from Nobels' No. 32 about 0.850 specific gravity, or 34½° Baumé."

In this connection it is interesting to review briefly, for comparison with Russian petroleum, the chief products obtained in refining American petroleum. It would be much easier if, instead of considering "American" petroleum, the discussion were limited to "petroleum from the Bradford district" or to some other limited area. The products from crude petroleum and the percentage of each depend not only upon the character of the crude oil itself, but also upon the difference in the methods of distillation and upon the form of oil sought as the principal result of the distillation.

That there are great differences in the character of oil is well known; this is shown in the different prices paid per barrel. The Franklin crude lubricating oil is worth four times what the ordinary Western Pennsylvania crude oil brings, while the lower country oils of Pennsylvania, which are used chiefly for illuminating purposes, because of their greater yield of illuminating oil, bring considerably more per barrel than those of the ordinary upper country oils. It is also a fact that every manufacturer has his own methods and processes of distillation which he guards as valuable secrets. These methods give varying results, not, however, differing greatly when the same product is sought as the result of distillation. It is also true that the percentages of the different products vary, as one or the other of these products is the chief object of the distillation; for example, distillation, having as its chief object the production of illuminating oil, would give a larger percentage of illuminating oil than would be given at works where the chief article of manufacture was lubricating oil. Owing to these facts, therefore, the percentage of the commercial products derived from the crude petroleum vary greatly at different works from different processes of manufacture.

The three chief products of petroleum, or, better, the three products of the first process of distillation in making illuminating oil, are: naphtha, illuminating oil, and residuum. Each of these products is redistilled—the naphtha into gasoline, benzine, and the various lighter oils. The illuminating oil, if a high test is desired, has a larger portion of the lighter oils removed from it, while the residuum is broken up, by processes of redistillation, freezing, and hydraulic pressure, into paraffin wax and oil, vaseline, cosmoline, etc. After these are taken from the residuum there is a coke left which contains 90 per cent. of pure carbon from which carbon points, used in electric lighting, are manufactured.

The following may be taken as a fair average of the commercial products obtained from crude petroleum of 45° Baumé, and the oils made in a process of manufacture. It should be said that this represents good work:

Percentage yield of oils in the distillation of crude petroleum.

Product.	Per cent.
Naphtha	12
Illuminating oils	72
Residuum	10
Loss	6
Total	100

While it is generally believed that there has been such an improvement in process of distillation in the last ten years as to materially increase the yield of commercial products and decrease the loss, the fact seems to be that the improvements have rather been in the way of more careful working of old processes, thereby increasing the yield and reducing the waste. For example, the yield of naphtha is very much greater than formerly; but this increased yield is from no new process, but rather from a more careful saving of these light products. Where 8 to 9 per cent. of naphtha was formerly secured, now 10 to 12 per cent., and even in some cases 16 per cent., is saved. This is chiefly the result of closer and tighter tanks for saving the naphtha and more complete cooling. Heat is most carefully excluded, some naphtha tanks even being surrounded with brick walls, or placed under ground to shut off all heat and secure better refrigeration. As a result a larger portion of the naphtha that passes over is condensed and saved instead of passing off as gas.

From a report by Col. C. E. Stewart, published in the *Chamber of Commerce Journal*, England, we take the following statement as to the cost of refining petroleum at Baku:

"If we take the cost of 3½ poods of crude oil, which is the quantity required to produce a pood of kerosene at the wells, at 2 kopeks per pood, to be 7 kopeks; delivery of this quantity through the pipe line to the factory and other expenses at, say, 3 kopeks; cost of refining, say, 5 kopeks, we shall obtain, as the price of a pood of kerosene, 15 kopeks.

"On the other hand, we must deduct at least, as the value of the 'astatki,' or residue which remains after the distillation, 3 kopeks; leaving as the cost of production of a pood of kerosene at Baku something like 12 kopeks. The cost of transport, per pood, in tank cars by the railway, to Batoum, 16 kopeks; other charges at Batoum, including shipping, 2 kopeks; loss of quantity, &c., 1 kopek; leaving as the actual cost price of a pood of kerosene delivered on board ship at Batoum, 31 kopeks. As a pood of kerosene is about 4½ gallons, this would give less than twopence as the price of a gallon on board ship at Batoum."

In a communication from Baku to the *American Manufacturer*, of Pittsburgh, published in that paper recently, a statement relative to the cost of refining petroleum laid down at Baku is made, which differs somewhat from that given above. It is as follows:

	Cost.
	Kopeks.
One pood (5 American gallons), refined at Baku	30
Freight and expenses to Batoum	17
Packing cans and cases	45
Total	92

The production of petroleum in the Baku district in 1886.—From a translation from the *Baku Caspian*, which appeared in the *American Manufacturer*, we extract the following relative to the shipment of petroleum and petroleum products in Baku in the year 1886:

Shipments of petroleum and petroleum products from Baku in 1886.

To—	Refined kerosene.	Crude residuum.	Crude petroleum.	Lubricating oil.	Benzine.	Total.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
Russia (by sea)	90, 928, 470	171, 559, 450	14, 238, 760	3, 391, 300	186, 340	280, 304, 320
Persia (by sea)	1, 474, 225	334, 720	709, 700	185	....	2, 518, 830
Total by sea	92, 402, 695	171, 894, 170	14, 948, 460	3, 391, 485	186, 340	282, 823, 150
Batoum and intermediate by railroad	69, 661, 495	6, 002, 170	13, 417, 685	5, 101, 620	....	94, 182, 970
Total shipments	162, 064, 190	177, 896, 340	28, 366, 145	8, 493, 105	186, 340	377, 006, 120

If we compare these figures with the shipments of previous years we find that, notwithstanding the continual lamentations of the producers, the shipments have steadily increased. The total shipments of petroleum products from Baku for the last four years were as follows:

Total shipments of petroleum products from Baku from 1883 *to* 1886 *inclusive.*

	Gallons.
1883	145, 180, 705
1884	262, 621, 710
1885	300, 149, 775
1886	377, 006, 120

The shipments of refined for the same years were:

Shipments of refined oil from Baku from 1883 *to* 1886, *inclusive.*

	By sea.	By railroad.	Total.
	Gallons.	*Gallons.*	*Gallons.*
1883	58, 551, 595	13, 585, 109	72, 136, 695
1884	88, 652, 210	19, 414, 870	108, 067, 080
1885	95, 812, 860	36, 761, 240	132, 574, 100
1886	90, 928, 470	69, 661, 495	160, 589, 965
Total	333, 945, 135	139, 422, 705	473, 367, 840

Deducting from the last year's shipments the amount exported—by sea about 10,000,000 gallons and by railway 35,000,000—we find the total amount taken by the home trade was 115,000,000 gallons.

It is known that on January 1, 1886, there remained in tanks, unsold, at Tsaritzin alone, about 20,000,000 gallons refined, while the stocks at Domnino, Moscow, St. Petersburg, and Warsaw were fully as much more, making the total refined stocks in the home markets at that time about 40,000,000, which added to the shipments of 1886—115,000,000 gallons—makes the amount taken by Russia last year 155,000,000 gallons. Admitting the home consumption in 1886 was 80,000,000 gallons, the stocks in Russia the first of this year were nearly twice as large as the year before, or about 75,000,000 gallons, of which at least 25,000,000 gallons were at Tsaritzin, 20,000,000 gallons at Domnino, (*a*) and the balance at other points. This accounts for the low prices (25 kopeks per pood (*b*) and present depressed market at Tsaritzin, and this is why the Nobels (as was reported by the Volga-Don paper) were selling refined at their numerous warehouses all over Russia at Tsaritzin quotations, thus keeping buyers from Tsaritzin, for the Volga navigation will soon be open, and stocks in Russia must be disposed of at any price to make room for the new refined, which must be shipped upon the opening of navigation or the refineries remain idle. Of course it is better to sell cheap and continue working than to stop refining altogether.

The foreign export, although annually increasing, owing to the limited carrying capacity of the Trans-Caucasian railway, cannot satisfy the demand abroad for our refined. In 1885 the export to various countries from Batoum amounted to 26,865,000 gallons, and in 1886 it was 35,000,000 gallons. In the former year nine different countries were reached by our export, while in the last year we sent refined to seventeen different countries. To former consumers were added Denmark, Belgium, and even countries so far off as Algiers, Egypt, and India, the sales to which countries began in the last half of the year. Of course our refiners will not sell direct to those countries, as that trade will be taken care of by Rothschilds, to whom the refiners will sell by contract at

a Nobels' principal distributing station, near Orel.

b 2.2 cents per gallon. The average freight rate from Baku to Tsaritzin is 1.3 cents per gallon.

prices agreed upon, however, only in case no pipe line for crude is constructed to the Black Sea, for in that case the Baku refiners will lose the export markets and be confined to the home trade only, which is already oversupplied.

"The total shipments of refined last year were 160,589,965 gallons; adding to this the local consumption will give us 165,000,000 gallons as the total production of refined; calculating 3.5 gallons crude for 1 gallon refined we get a total of 575,000,000 gallons crude; adding to the home consumption of crude and the crude shipped about 50,000,000 gallons, and allowing 50,000,000 gallons for waste, loss in pumping and other causes, will give us 650,000,000 gallons crude as the total production for 1886. These figures will give a very fair idea of the extent of our producing and refining business."

A private letter from a Russian gentleman largely interested in the Russian petroleum trade to the *American Manufacturer* gives his impression of the outlook for 1887 and 1888 as follows:

"In 1887 it is quite certain that the quantities which Russian refiners can send abroad will not exceed in the aggregate 1,500,000 barrels, or 200,000 more than in 1886. There is no reason to believe that the world's consumption will not increase during this year more than this 200,000 barrels.

"For 1888 the Russian exportations are likely to attain a far higher figure. The Trans-Caucasian railway is taking steps to increase its carrying facilities, and it may be that 2,000,000 barrels of illuminating oil can be brought to the Black Sea shore in that year. But this development will also have its limits, and so long as the Russian petroleum production is practically confined to the Baku fields, this industry will scarcely be able to furnish to the world, besides the 2,000,000 to 2,500,000 barrels wanted for Russia, more than 3,000,000 barrels.

"Years must elapse before this latter figure be attained, and I confess I am rather surprised at statements made in your country about the influence exercised upon the prices for crude in America through the strong Russian competition in Europe and in India. Take away the fanciful dress in which this competition has been presented to the public and the barren facts will be found not to justify any serious alarm among American producers."

The Baku pipe line.—Considerable has been said recently relative to a project to build a pipe line from Baku to Batoum or Poti. At the close of the year, however, it had taken no definite form. Since that time the Russian Government has decided to grant a concession to build this pipe line, but it is understood that it is coupled with such conditions as to be practically prohibitive.

One of the clauses provides that the whole of the plant, comprising the pipe and accessories, reservoirs, and machinery, must be manufactured from Russian material and at Russian works. The term for which a monopoly is granted also seems exceedingly inadequate, being only for twelve years, whilst three years are allowed for construction. The pipe is to have a capacity for delivering close upon 3,000 tons of crude naphtha per working day of twenty-four hours, and the toll which the contractor may levy is limited to 11 kopecks per pood, or, at the present rate of exchange, about $3 per ton. The contractor is also required to put down a duplicate line within a period of two years, as soon as the traffic on the first line has reached 580,645 tons per annum. With this increased traffic the toll is to be reduced by about 10 per cent., and a royalty of 15 cents per ton will have to be paid to the Government. The contractor, on obtaining the concession for the work, will be required to deposit caution money with the Russian Government, the amount to be determined by the minister of public domains and finances at St. Petersburg.

The Kouban oil field.—The second in importance of the Russia oil fields, and the only one, with the exception of the Baku, that gives any promise of producing petroleum in commercial quantities, is the Kouban, situated at the western extremity of the Caucasus mountains. This district is on the northwestern slope of Mount Oshten, the most western peak of the Caucasus. Operations were begun here in 1864; the first wells being sunk near the Black Sea coast. No wells were put down at Ilsky until 1873; in that and the two following years nine wells were sunk, the deepest to the depth of 527 feet; but though some oil was found, one well pumping 2,100 gallons a day and another 1,900 gallons, the venture was an unprofitable one, and after the death of the gentleman owning the concession, Colonel Novosilvsoff, his lease was granted to Mr. Tweedle, who ultimately conveyed his rights to the "Standard Russe Petroleum Company," of Marseilles. The wells of this company, of which in 1866 some 69 had been bored, are near Ilsky, some 47 miles in a nearly direct line from Novo Rassisk, the refining and shipping point of this oil—this town being a port on the Black Sea, and the oil being conveyed from Ilsky by a pipe line, 47 miles long, the only one of any length in Russia. It crosses quite a range of hills to Novo Rassisk, and there is considerable difficulty in operating the line in winter owing to the freezing of water, of which the oil carries considerable. Five pumps are maintained along the line; three of them are used generally, the other two being used as auxiliaries in winter.

Early in 1886 there were some 15 wells producing, the total output being some 1,500,000 poods. New wells were at that time being bored with the expectation of a larger production in the last half of 1886. Both heavy and light oils are produced; generally the latter oil resembles the Baku oil in appearance, but is said to produce a larger proportion of illuminating oil than the Baku, the yield of the latter being some 28 per cent. and of the Ilsky 33 per cent. The wells in this district are drilled in a similar manner to those of Baku, and differ greatly from the methods employed in the United States, as a reference to the statement concerning Baku petroleum will show. At Ilsky, however, although for a certain depth the tubes, made of rolled plate iron 3-16 inch in thickness, riveted together, are used as at Baku, yet at greater depths these are replaced by tubing 10 inches inches in diameter.

EGYPTIAN PETROLEUM.

The petroleum deposits of the western shore of the Red Sea have attracted no little attention recently, especially since 1884, when Nubar Pasha employed M Debay, a Belgian, to examine the district with a view to working the deposits. So great is the confidence of the Egyptian Government in the ultimate success of the explorations now in progress, which will be detailed below, that the sum of £30,000 sterling has been appropriated in the budget for 1887 for continuing and bringing to an early termination the preliminary operations now in progress at Jebel Zeit, and Jemsah, on the Red Sea littoral.

Mr. Edgar Vincent, the financial adviser to the Government of the Khedive, however, does not believe that this sum will be necessary to test the territory, and states that should oil not be found in remunerative quantity by April, the borings will probably be abandoned and the material sold. It is evident, however, that there is little prospect of a supply being discovered sufficient to cause any uneasiness among American producers.

The existence of petroleum in small quantities on the western shore of the Red Sea at the mouth of the Gulf of Suez has been known by reason of surface indications for centuries. Prominence has been given to this fact by the name given the mountain that carries the shore at this point—Mons Petroleus of the Russians and the Jebel Zeit (also spelled Djebel Zeyt) of the Arabs having the same meaning, "oil mountain." There is evidence that the petroleum from this region was used by the early gold diggers and porphyry quarriers in the mountains inland from Kossier and Berenice, and possibly it was employed by the ancient Egyptians in their embalming and in other ways.

Petroleum is found and borings are in progress at two points—at Jebel Zeit, and in the peninsula of Jemsah. From an article by Colonel Ardagh, in the proceedings of the Royal Geographical Society, it appears that the formation at Jebel Zeit is recent, coral extending both above and below sea level. This is underlaid with fucoid and shelly limestone, and that with porphyry. The limestone, which is compact and semi-crystalline, of the Tertiary or even possibly an earlier period, has been upheaved by a ridge of igneous rock, and the pale buff colored masses can be seen 600 to 800 feet above the sea. Upon the top of this limestone the usual recent coral formation has gone on, with occasional upheavals sufficient to raise the modern coral rock above the level of the sea, and form a foreshore mingled with the débris of the older formations, comprising amongst them layers of marl and a breccia or conglomerate, formed of fragments of porphyry, granite, syenite, hornblende, and other igneous rocks embedded in limestone.

Digging anywhere along the foreshore of the oil region at 50 or 100 yards from the sea, as soon as the level of the water is reached the strata, which are usually of a soft character—whether coral, gypsum, marl, or sand—are found to be black and oily, and after a time such an excavation fills with salt water having a film of greater or less thickness on the surface composed of petroleum of the heavier kind from which all the volatile components have evaporated by long contact with dry heated air.

The oil found in the surface holes at Jebel Zeit was dark brown and thick. It could not be ignited by itself, but burned well with a wick of any sort. When heated to its own boiling point it became inflammable. No doubt all the lighter components in the original oil which oozed up to the surface very soon evaporated, leaving nothing but this dense residue. Colonel Ardagh is of the opinion that the main deposit of oil at Jebel Zeit will be found between 20 and 100 meters from the surface.

Jemsah is a peninsula some 13 miles in a straight line from Jebel Zeit. Petroleum was discovered here by the Marquis de Barsano; it occurred in a gypsum deposit. The discovery was considered of but little importance, and, after sulphur mining was abandoned, nothing was done until 1884, when, as noted above, Nubar Pasha employed M. Debay to explore for petroleum. M. Debay's report being favorable, it was determined to procure suitable machinery and commence proper borings in lieu of the insignificant holes and galleries hitherto made. He was intrusted with £3,000 for the work. The boring plant and a quantity of tools, machines, and engines were procured in Belgium in the course of 1885, and in November of that year M. Debay, with a party of 24 borers, mechanics, and skilled workmen, proceeded to Jemsah and began boring 30 yards from the sea. The drill penetrated successively through gypsum containing veins or nests of sulphur, shale, green and blue clay, limestone and sandstone, from whence oozed a small supply of crude petroleum, and on February 25, 1886, at a depth of 32 meters, the drill dropped, and an oil spring was reached which produced a very small quantity of petroleum. A second boring, 60 meters from the first, struck oil on April 5 at 41 meters, and a copious flow immediately rushed up the tube and poured into the gallery. No accurate measurement was taken of the quantity, but it was roughly estimated that about 500 cubic meters of liquid were delivered in twenty-four hours, two-thirds being water and one-third petroleum. As the means at hand for storing this abundant supply were relatively infinitessimal, the pipe was closed as soon as possible and steps taken to procure reservoirs and tanks.

Further drillings were undertaken; parties versed in petroleum explorations were engaged to superintend the work, and American machinery and workmen were engaged. The latest advices however, are not favorable to finding oil in paying quantities. Wells have been bored 500 feet, but no more oil is found, indeed not so much as at the shallower depths. The latest returns are, however, conflicting. One is to the effect that very small amounts of oil have been obtained at one of the Jemsah wells and none at the others. At 125 feet below the surface oil was found in No. 1 well at Jemsah; the drilling has been continued to 500 feet, but, though some light gases have been found, no more oil has been reached. In this well "oil wax" or "ozocerite," was found between 265 and 270 feet. In No. 2 and No. 3 wells at Jemsah no oil has been found. At latest reports (January 4, 1887) the Jebel Zeit well was down 350 feet, with no oil. On the whole, therefore, present advices do not give promise that petroleum in any considerable quantities will be found along the Red Sea littoral, though the final decision of this question has not yet been reached. It seems as if surface indications of petroleum have been taken as giving assurance that large deposits of petroleum were to be found, when, as a rule, they prove just the opposite. When there are surface indications it will be found in most cases that the conditions necessary to the storage of oil in large quantities are wanting, and that therefore, though at one time oil might have existed in large quantities or the conditions for its production been present, the oil stored or produced has been lost.

BURMESE PETROLEUM.

The recent occupation of Burmah by the British, and with it the removal of the restrictions that have heretofore been imposed upon industry and commerce, has directed the attention of consumers of petroleum to the character and possibilities of the Burmah oil fields. The two best sources of information relative to these fields are (1) a British Blue Book "British Burmah Administration Report, 1883–'84," and (2) a letter in the London Times from a Rangoon correspondent. From these two sources the following statement is compiled.

There are two distinct oil fields in Burmah—one on the Arakan coast, in the neighborhood of Akyab, and the other in Upper Burmah, at a place called Yenanchaung. But there are many other places where petroleum oozes out of the soil and where it may exist in quantity. Wells have been dug at Thayetmayo, the old frontier town. At Mimbu petroleum is noticed in small quantities in the neighborhood of the mud volcanoes. Also, it has been stated by those who went on the recent expedition to the Yaw country to the west of the Chindwin that petroleum was observed.

There is a great difference in the method of working these two fields. In the Arakan there have been two British companies at work for some years, sinking deep wells by boring till the strata yielding the oil are reached. At Yenanchaung, the natives dig wells into which the oil oozes through the soil. In the one case a boring of 7 or 8 inches has been carried down to the very source of the oil. In the other there is a well of several feet in section, and carried down not nearly so deep. And thus the first, as it reaches the source, brings forth the oil as it exists and as it was formed and sealed up in the rocks ages ago; while the second only gives an oil that has filtered through the surface soil and may have lost a large proportion of the volatile oils in percolation. There is also a difference between the oil obtained from the Arakan field and that from the Yenanchaung. The former yields a light limpid oil, while the latter gives the viscid, almost solid, substance known as "Rangoon oil." And of the Yenanchaung oil it may be said that it is hardly refined for illuminating oils, but for lubricating oils and for paraffin.

In Akyab the wells have been worked and the oil refined for several years past, but the result has been disheartening. The companies formed have either been unsuccessful or have merely kept going without making any profit on their labors. At the commencement of the operations, about ten years ago, as much as 250 gallons a day was obtained from one well. Thus encouraged, the work was prosecuted on a larger scale. Four years ago there were 24 wells, ranging from 500 to 1,200 feet in depth, from one of which, for a time, 1,000 gallons a day were pumped. The company which was then working raised 234,300 gallons in a year, and refined 65,450 gallons, selling the rest in a crude state. As the price of refined oil was very low, there was a loss on the operations, and the works, as above said, have almost, if not entirely, been stopped. So long as prices are low and the production costly, little progress can be expected in the Arakan oil industry.

The wells in the Upper Yenanchaung oil field were royal monopolies during the reign of King Thebaw and his father. There were 200 royal wells at Yenanchaung, and about as many in private hands. Many of these are not working. At present about 200 are working. They produce about 30 tons per day, or about 7,500 gallons. This would give an average of 37 gallons per day per well. In the 200 referred to are included about 60 situated at Bema, in the neighborhood of Yenanchaung. Besides those already named, there are 2 or 3 wells at Thayetmayo. Opposite Pagan there is another, and in the Yaw country there are 2 or 3 shallow wells, as noticed above. The large proportion of the oil is sent down in barrels or in bulk in native boats to Rangoon. There is one refinery here, which has therefore a monopoly of the whole oil produced in Burmah. The natives in the neighborhood of the wells use a little crude oil, but the quantity bears a small proportion to the total yield.

The Blue Book before referred to states that the "earth oil" industry, as it terms it, in the Kyaukpyu district, has not made much progress during the year 1883–'84. The Boronga Company has invested in the business more largely than any one else. It has steam machinery for sinking wells and pumping oil, and a large refinery capable of refining and tinning many thousands of gallons per week. They have a staff of 8 or 10 English and Canadian artificers besides Indian and Chinese laborers.

During the past year this company sank 8 new wells, ranging from 500 to 610 feet in depth. They have now 24 wells, of which the deepest is over 1,200 feet deep. At present they pump 9 wells at a time, but with additional gear they could pump many more with the same engine. In May and June, 1883, one of the company's new wells was yeilding largely, and there seemed hope of financial success for the undertaking, but the yield of the well soon fell, and the amount of crude oil pumped during the whole year by the company from 10 wells did not exceed 234,300 gallons. Of this the company refined 65,450 gallons, and sold the rest in the crude state. The gross yield of the company's sales was about £6,000. Their markets were Calcutta, Rangoon, Akyab, and Moulmein. The company's refined oil sold at 9*s.* per case in Kyaukpyu at the same time that a case of Devoe's American oil was quoted in Calcutta at 10*s.* 6*d.* per case. The price of crude oil at Kyaukpyu ranged during the year from 1*s.* to 8*s.* per "maund" of 11 gallons. The lowest prices of 1*s.* to 4*s.* ruled while the wells were being pumped, and the price was 8*s.* when most of the wells were idle.

Another company, named the Arakan Company, started during the year with steam machinery. It sunk seven wells, the deepest of which was 400 feet. Five of these wells have been pumped, yielding a total output of 167,800 gallons, all of which was sold on the spot in the crude state. This company has a staff of three Canadians besides Indians. A smaller company, called the "Petrolia Company," obtained a protecting license and sank ten wells, some of them to a depth of 450 and 500 feet. Unfortunately all those holes have turned out dry and have yielded no oil. The example and the processes of Canadian experts have had an effect on the native oil winners. These people hold rights in old wells which have been worked fitfully for many years past. They do not use steam apparatus, but with windlasses, shears, and locally-made boring tools they have put down holes of 250 and 350 feet deep. The deepest hole sunk by a native was 350 feet and turned out dry. One Arkanese worker obtained a total output of 24,090 gallons at an outlay of £76 for the year; another produced 20,075 gallons at a total outlay of £34 for the year, of which £10 were spent in boring an old well down to 165 feet without striking oil. The Arkanese workers put down their wells and manage their proceedings much more economically than the English companies. The total output of the whole field, including the Boronga Company's wells, was 404,325 gallons. The unhealthiness of the site of the refinery is a great drawback to the Boranga Company's work. As yet no one in the Kyaukpyu field has discovered oil-bearing strata of the type of the good American or of the Caspian fields, and so far the business of oil winning on a large scale has not been a success.

The imports of crude oil from Upper Burmah during the year were 968,210 gallons. Most of this was taken by the Rangoon refinery, which produced 640,000 gallons of refined oil during the year. The Upper

Burmah oil is much thicker and darker colored than the Arakan oils. The chief oil sources in Upper Burmah are at Yenanchaung. This place was visited by the Government Chemical Examiner in May last, who reported:

"The oil wells of Yenanchaung are situated on the banks of the creek that flows into the Irrawaddy at that place. There are two groups, the smaller about 2 miles east of the town, the other about 3 miles northeast. The country is table-land intersected by ravines, the beds of torrents flowing into the creek. The surface is covered with gravel and blocks of fossil wood. Below is a great thickness of a friable sandstone; below this, again, a blue shale alternating with beds of sand. It is in the sand that the oil is found. The wells are sunk indifferently on the sides of the ravines and on the tops of the hills. The strata appear to dip generally towards the west, with many folds and contortions, and the ravines run in a westerly direction. Hence, a well at the head of a ravine, on the top of the hill, may reach the oil-bearing stratum as soon as one at the bottom. We saw a well being dug at the top of the hill. They had reached a depth of 135 feet. They were cutting through a hard blue shale full of cracks filled up with sand. The sand was wet with oil, but not enough to drain out. Another well, about 50 yards off in the ravine, was 225 feet deep. It was forty years old. Oil had been reached at 160 feet, and it had been gradually deepened to its present depth as the stratum of shale had been exhausted of oil. We saw some fragments of rock that had just been brought up. It was this same hard blue shale with cracks filled up with sand that we had seen at the other well. Going down the ravine I found a stratum of this oil-bearing rock cropping up, but apparently higher than that into which the wells were sunk. This was the only well we saw at work; the others were stopped for the day. It gave 60 gallons daily, and might give more were there means of carrying away the oil. The oil is raised in earthen pots shaped like gourds, and holding about 4 gallons. From these it is decanted into larger pots of the same shape, holding about 6 gallons. The work of raising the oil was performed by a laborer and his wife, who were paid 1*s.* per diem, 6*d.* each. They work in connection with a carter, who is paid 2*s.* for himself and pair of bullocks, making one trip a day to the river shore, whence the oil is carried in bulk in boats to the steamers. The capacity of the boats is said to be about 25 tons of oil. The method of raising the oil is very rude. Two forked branches set upright carry a horizontal beam bearing a roller over which passes the rope. The laborer takes the end of the rope and runs down hill with it and holds it while his companion runs down with another length, and so on. While the last length of the rope is drawn out, one of the men is waiting at the mouth of the pit to exchange the full pot for an empty one. It is impossible to say what the real maximum yield may be. Many of the wells are not worked; some of them are exhausted. We found that there were 130 cart-loads brought from the great wells, and this represented the accumulation of five days; Dr. Oldham, thirty years ago, was told that the yield was 150 carts daily. If the wells are worked to their utmost now, unless Dr. Oldham was misinformed, the product has greatly fallen off.

"We were told that two wells had been sunk at a point to the southwest of the smaller wells on the other side of the water-shed; that oil had been obtained, but it was mixed with water, and the wells had been abandoned. I think it very probable that oil-bearing strata may be found all over that strange barren table-land of which Yenanchaung is the center. There is a smaller district farther up the river on the west bank opposite Pagan, but the oil is light like the Arakan oil. This is also the case with the oil found at Yaw in the Chindwin district. It is obtained there from surface springs but cannot be exported for want of roads. The rock formation seems to be much more recent than that in which we find the petroleum of Yenanchaung in the Myanaung district and the coal of Okpo.

"The imports of kerosene oil from America fell from 2,530,534 gallons in 1882-'83 to 1,205,160 gallons in the year 1883-'84. The reduction was probably due partly to oversupply in the previous year and partly to the stringency of the new Petroleum Act, rather than to the output of local oils. The Petroleum Act is now less stringently enforced, and imports of American petroleum are more active again."

THE SHALE OR PARAFFIN OIL OF SCOTLAND.

It was not until 1850 that what is now known as the paraffin or shale industry of Scotland assumed any commercial importance. In this year James Young and his associates, Messrs. Binney and Meldrum, established the extensive refining works at Bathgate, from the success of which has followed the Scotch paraffin and mineral-oil industry.

The sources of the oil in this industry are the bituminous, or, as they are sometimes called, the mineral shales which are found in the coal measures. These are distilled, not only for their oil, but also for other products, as scale or wax, sulphate of ammonia, etc.

The distillation of shale is mainly confined in Scotland to the counties of Midlothian and Linlithgow. Shales, however, are found in other districts, both in England and Scotland, but with the exception of the seam worked by the Burntisland Company, in Fifeshire, there are few if any which at present will pay the expense of mining and retorting.

During the last few years and especially during the last three years the production of shale oil has greatly increased in Scotland. This is largely due to the fact that the trade has been an exceedingly profitable one. The business of mining and refining requires large outlays of capital; it has been in the hands of limited liability companies, and the large dividends paid by some of them has led to the investment of capital in this industry, greatly increasing production and reducing the price of the product. In 1878 it was estimated that the production was some 24,000,000 gallons; the last year it was double this.

The total quantity of shale raised and distilled daily, each working day, in 1886, was about 6,500 tons. Taking the average yield of crude oil at 30 gallons per ton, this would give a yearly output for 300 working days of 48,500,000 gallons.

The following table, published in a recent issue of the *American Manufacturer and Iron World*, gives approximately the quantities and values of the oil and other products of the distillation of shale in Scotland:

19,400,000	gallons burning oil, at 10 cents	$1,940,000
6,305,000	" scale or wax, at 32 cents	2,017,600
4,850,000	" lubricating oil, at 10 cents	485,000
3,395,000	" gas and other oils, at 6 cents	203,700
33,950,000		
14,550,000	gallons tar, &c., consumed at works	....
48,500,000		
17,429	tons sulphate of ammonia, at $57.50	1,002,167
		$5,648,467

From this statement it will appear that the importance of this industry is much greater than the figures of the production of burning oil would indicate. The illuminating and other burning oils produced from the distillation of the nearly 2,000,000 tons of shale was only 19,400,000 gallons, or a little less than 10 gallons to a ton of shale, its value being but $1,940,000, while the total value of the products, including this oil, was $5,648,467, the products other than burning oil being worth $3,708,467, or, to state it roughly, the value of the oil was but two-fifths of the value of all the products of the distillation, not counting in this the value of the tar consumed at the works.

The source of the great profit of the Scotch companies above referred to has been chiefly the sulphate of ammonia and scale. The high prices obtained for these in past years has enabled those engaged in the Scotch paraffin-oil trade to view with indifference the heavy importations of petroleum from the United States.

During the past year, however, the reduction in the price, not only of burning oil but of scale and sulphate of ammonia, has been very great, and has seriously affected all the Scotch companies. This is seen in the dividends recently declared. The Broxburn Company, which for eight consecutive years has paid 25 per cent., has been able to declare only 15 per cent., and the Burntisland Company, which has hitherto paid 20 per cent., is now only able to pay 7 per cent.

This reduction in dividends has followed the pressure of competition above referred to. Two other important results have followed this competition. First, decrease in cost of manufacture; and, second, improvement in the quality of all products. If the prices current a few years ago could now be obtained the Scotch companies would be able to pay from 25 to 50 per cent.

The cheapening of paraffin candles has practically driven all competitors out of the market and has enormously increased the demand. Contracts are now being made for delivery during the coming season at prices far below anything known before. Good white candles of about 120° melting point (British test) are offered at from 6 cents to 6.5 cents per pound—a price which a year or two ago was obtained for crude scale. This reduction in the value of the most important article produced from shale has had an injurious effect upon the value of oil property.

Regarding the importation of petroleum and lubricating oils in Scotland and the possibility of the Scotch manufacturer competing successfully in price with the oils so imported, the article in the *American Manufacturer* above referred to states:

"With the large importations of petroleum and lubricating oils and the low prices at which these are sold at all the ports, little can be done to effect sales at paying prices. It is believed, however, that for the home demand higher prices are obtainable. Taking 10 cents per gallon as the c. i. f. price at an English port, it would be impossible for an importer to deliver oil in small quantities, to allow discount and two or three months' credit to petty dealers, and to buy back barrels at $1 each, all for a less price than 15 or 16 cents per gallon. All these things are done by the Scotch manufacturer, and the price throughout does not exceed 10 to 10.5 cents. Were an understanding arrived at, it would be easy to secure an additional 2 cents on each gallon, which would be equal to a dividend of 5 per cent. on the paid-up capital of the oil companies. But it is to an improvement in scale that the Scotch makers naturally look for help in the present juncture. It is estimated that two-thirds of the candles made in Britain are composed of Scotch wax, and an increase of 2 cents per pound on this article is equal to a dividend of 10 to 15 per cent. To accomplish this it may be necessary to reduce the output, but it is felt to be better to do this, even if costs are fractionally raised, than to manufacture at a loss. An important factor is the possible quantity which can be imported from America. It is not believed that any sensible increase can be effected at present. Whether this is the case or not, it is probable that an attempt will be made to raise values by the restriction of output, and it might be for the benefit of American refiners if they were to assist their Scotch rivals in carrying it into effect."

VENEZUELA.

The occurrence of petroleum in Venezuela has been known for many years. It is stated that as early as 1824 specimens of a liquid known as "oil of Columbia," from the locality in which it was found, and which was undoubtedly petroleum, were sent to England, France, and the United States. At this time, however, the method of refining was not in use, and the oil was regarded chiefly as a curiosity, of which specimens were also found in Pennsylvania and West Virginia. This oil was collected from shallow pits or wells, by absorption in cloth, like the so-called "Seneca oil" (petroleum) of western Pennsylvania. In Pennsylvania woolens were used; in Venezuela, cottons. When the cloth was saturated the oil was pressed or wrung out and used for fuel and light.

From a report of United States Commercial Agent E. H. Plumacher, the petroleum accumulations of Venezuela would appear to be found along the slopes and at the base of the two spurs of the Cordilleras, forming the basin in which Lake Maracaibo is situated.

For some years these localities have been worked to a small extent. One of the chief of these is near Belijoque in the State of Los Andes, at which point a small refinery is located. It is reported that the owner of the concession for the exclusive right of refining petroleum in the section of Venezuela in which Belijoque is situated, has sold his right to the Rothschilds, and that they will at once undertake energetic development. Venezuela papers of recent date express the hope not only that the demands of the country may be supplied from its own "mines," but that its petroleum may "enter into competition with other exporting countries."

NATURAL GAS.

By Jos. D. Weeks.

The excitement following the remarkable discoveries of natural gas in western Pennsylvania and Ohio, in 1885, and the knowledge of its value and economical applications as a fuel, and the ease with which existing plants could be adapted to its use, have led to a most extensive search for gas in nearly every State of the Union. Wells have been drilled from the Hudson river on the east to the Pacific coast on the west, and from Michigan on the north nearly to the Gulf coast on the south. It is probable that in every State and Territory, with possibly the exception of the New England States, and the four Southern Atlantic States, wells have been drilled or explorations made for the purpose of ascertaining whether natural gas could be found in paying quantities. In many cases these explorations have taken the form of sinking wells; sometimes springs or old water wells, from which gas has been known to issue, have been reopened and endeavors made to secure a larger flow. When these explorations have been upon any extended scale requiring the drilling of deep wells, local companies, composed usually of the citizens of the neighborhood in which the well was to be sunk, and who would be benefited if gas were found, have been formed to make the explorations. In this way the expenses of making the test have been divided through the community to be benefited, and the tax upon each has been slight, while the benefit has been general.

Time covered by the report.—It has been usual to close these reports with the close of the calendar year, and this rule will be followed in this report so far as relates to statistics. In view, however, of the explorations that were in progress in many of the fields at the close of the year, the results of which had not been ascertained, indeed, had not been reached at that time, it has been thought best to deviate slightly from this rule, and whenever the drilling has revealed the presence of quantities of gas in certain localities to report them in this chapter, even though these discoveries were made early in 1887.

LOCALITIES IN WHICH GAS IS FOUND.

As the result of these explorations, gas, in greater or less quantities, has been found in all of the States mentioned. In general, the results of these explorations have been to indicate:

First: That along the Atlantic coast, east of the Appalachian chain, including in this term the Green mountains, no gas is found, or if found at all, in such small quantities as to indicate that it is of comparatively recent origin. It is also found in such horizons, and under such conditions as to give but little evidence that it is in such storage reservoirs as to promise any considerable supply.

Second: That the chief sources of the supply of natural gas in this country are to be found in the Mississippi valley, and so far as present explorations show, in that portion of it east of the Mississippi river.

The chief localities that had assumed any prominence as gas centers at the close of 1886, were in southwestern New York, western Pennsylvania, northwestern Ohio, and central eastern Indiana; to these may be added a locality in Michigan and one in eastern Kansas. These are the important fields. Others of less importance, but which explorations in progress may show to have great value, will be named in discussing the localities under the several States. In the localities named the chief fields are Murrysville, Grapeville, Washington, and the other districts in the neighborhood of Pittsburgh; the Wirt district in New York; the Findlay, North Baltimore, and Bowling Green districts, in Hancock and Wood counties, in northwestern Ohio; and the Kokomo, Muncie, Portland, and Noblesville fields in Indiana.

THE GEOLOGICAL DISTRIBUTION OF NATURAL GAS.

While it is true that natural gas has been found from the Drift to the Potsdam, it has been chiefly in the Trenton limestones of Ohio and the Paleozoic strata of the Upper Coal Measures of Pennsylvania that the great deposits of natural gas have been struck. The highest stratum in which any considerable quantity of gas has been found in Pennsylvania is the Homewood sandstone, the highest of the three recognized members of the Pottsville Conglomerate. The lowest are the Kane sand and the sand of the Roy and Archer gas pool, of Elk county. According to Mr. Carll, the geological position of the latter sand is 1,800 feet below the horizon of the Murrysville gas sand. As the question of the geological distribution of natural gas will be discussed in other publications of the Geological Survey, as well as to some extent in this report, in connection with the several gas fields, it is not necessary to enter into a complete discussion of the subject here.

TOTAL CONSUMPTION OF NATURAL GAS IN THE UNITED STATES.

It is simply impossible to ascertain the total production, or even the consumption, of natural gas in the United States. While a great many wells have been accurately measured within the past year, these measurements only give the rate of production for the moment when the observations were taken. The rate changes not only from day to day, but from hour to hour and from moment to moment. It is usually greater at certain times of the day, as in the morning, than at others; it varies with the weather and with the state of the barometer. It will thus appear that, while for the wells that have been measured an estimate of their yearly production could be made, it is evident that even this would be only a rough approximation, while for those wells that have not been measured only the wildest guess could be made, and since the tendency is to very much over estimate the production, such estimates would have but little value. Nor is it possible to arrive at the consumption of gas in cubic feet. It might be possible to ascertain in a given locality, for example, how many mills, how many furnaces, how many boilers, how many grates were using natural gas, but the rate of consumption in furnaces, boilers, and grates varies greatly. Pittsburgh measurements show that while some furnaces use but 13,000 cubic feet of gas to produce a ton of iron, others use 35,000 cubic feet, and still others as much as 65,000 cubic feet.

The best basis of calculation, therefore, is that which has been given in previous volumes of "Mineral Resources of the United States," viz: The coal displaced by gas. Where coal is not used in a locality, or where it furnishes only a portion of the fuel, the value of wood or other fuel used is regarded as the value of coal displaced, and an estimate of the tonnage of coal that would be displaced is made, based on the selling price of coal in that locality.

The total displacement of coal by gas in 1886, and its value, are as follows:

Amount of coal displaced by natural gas in 1886, and its value.

Locality.	Coal displaced.	Value.
Pennsylvania:	*Short tons.*	
Allegheny county	4,000,000	$5,000,000
Balance Pittsburgh district	1,000,000	1,500,000
Western Pennsylvania, outside Pittsburgh district	1,000,000	2,500,000
New York	60,000	210,000
Ohio	200,000	400,000
West Virginia	30,000	60,000
Indiana	150,000	300,000
Illinois	2,000	4,000
Kansas	2,000	6,000
Michigan	4,000	12,000
Elsewhere	5,000	20,000
Total	6,453,000	10,012,000

A similar statement for 1885 is as follows:

Amount of coal displaced by natural gas in 1885, and its value.

Locality.	Coal displaced.	Value.
Pennsylvania:	*Short tons.*	
Allegheny county	2,000,000	$2,500,000
Balance Pittsburgh district	500,000	750,000
Western Pennsylvania, outside Pittsburgh district	500,000	1,250,000
New York	56,000	196,000
Ohio	50,000	100,000
West Virginia	20,000	40,000
Illinois	600	1,200
Elsewhere	5,000	20,000
Total	3,131,600	4,857,200

From these two tables it will appear that the consumption of natural gas, estimated by the coal displacement in 1886 as compared with 1885, was a little more than double. In Pennsylvania it is estimated that the consumption just doubled; in New York there was a slight increase; while in Ohio the amount of coal displaced by natural gas was increased fourfold. In West Virginia there was a slight increase; in Illinois the increase was three times, though still the amount of coal displaced by gas in this State is quite small. Kansas and Michigan, which were reported in 1885 under the general term "elsewhere," now have separate amounts given them, while the consumption of gas in the States other than the eight mentioned, remains the same as last year, equivalent to 5,000 tons.

The total consumption of natural gas in the United States in 1886, estimated by coal displacement, was equivalent to 6,453,000 short tons, as compared with 3,131,600 tons in 1885. The value of this coal in the different States is taken at the same rate as in 1885, and is $10,012,000, or a little over $1.55 a ton.

The method adopted in reaching these results is given in the report on natural gas in the last volume of "Mineral Resources of the United States."

THE PRESSURE AND PRODUCTION OF GAS WELLS.

It has been ascertained, as the result of the measurement of a large number of wells, that there is a pressure that is normal to each district, and that all wells in the same district ultimately show the same closed pressure; that is, the pressure measured when the well is closed and gas is not escaping. Wells are sometimes measured by their flowing pressure, that is, the pressure shown on a gauge attached to the pipe through which the well is discharging gas into the air or into the mains, through which it is transported for delivery to consumers. Oftentimes when a well is first struck, owing to local causes, the pressure and production will be greater than the normal pressure of the district, but this is ultimately reduced to the average pressure of the district. It is not to be inferred from this, however, that all wells of the same bore and with the same ultimate pressure, and located in the same district, have the same production; quite the contrary. In some wells the normal pressure, say 500 pounds, will be reached within one minute after the wells are closed for ascertaining the pressure, in others the normal pressure of the district will not be reached for days. It is evident that the well which reaches the normal pressure in a minute will be a greater producer than the one requiring hours to reach this pressure. All the wells in the neighborhood of Pittsburgh have about the same normal closed pressure, about 500 pounds, but the wells of the several subdistricts in that vicinity show a great difference in the time required to reach this pressure, and, secondly, show great difference as producers of gas. Taking the production of the wells in the Murrysville district, near Pittsburgh, as practically the same, and their rate of production as the unit rate, the production in the Hickory district in some wells is as low as one-tenth, and varies from this to unity. That is, some of the Hickory wells produce as much gas in a given time as the Murrysville well, others produce but one-tenth as much. The wells in the Cannonsburg district vary from three-tenths to 1 in producing power, compared with Murrysville wells. The Tarentum wells would be but one-tenth in producing power.

On November 1, 1886, the six companies piping gas to Pittsburgh had a total of 107 wells, 58 of which were in the Murrysville district, 11 in the Tarentum district, 21 in the Hickory district, and 17 in the Cannonsburg. Reducing the producing power of these 107 wells to the unit of the Murrysville well, they were equal in producing power to 82.9 Murrysville wells.

THE PRODUCTION OF WELLS.

As was stated in the last volume of "Mineral Resources of the United States," the published figures of pressure and production of wells had been largely estimates, based on no correct information, and the statements were of but little value. Shortly before the publication of that volume, however, some more accurate and scientific methods had been adopted, and since that time very careful measurements of the production of wells have been made. Two methods have been adopted—the anemometer for small wells yielding 1,000,000 cubic feet or less a day, and a modification of Pitot's tubes for larger wells. The use of the anemometer for this purpose was first suggested, so far as is known, by Mr. E. McMillin, of the Columbus, Ohio, Gas-Light Company, and was first used in measuring the Adams well at Findlay, in June, 1885. The measurements obtained have been compared with those obtained by other methods, and their reliability established.

The use of the modified form of Pitot's tubes was devised and worked out by Prof. S. W. Robinson, of the Ohio State University. A complete statement regarding this use will be found in *Van Nostrand's Magazine* for August, 1886.

It is not necessary to give in detail the measurements of the wells made by these methods. It may be said in general that the production of the Murrysville, Pennsylvania, wells is about 15,000,000 cubic feet a day on the average; that of the Tarentum wells about 1,500,000. This represents the two extremes of the production of the gas wells of Pennsylvania, the wells in the different districts varying with the rapidity with which the wells reach their normal pressure.

In the Findlay field the wells produce from 1,150,000 to 12,080,000 cubic feet a day, the low-pressure wells in this State producing from 10,000 cubic feet up. In Indiana the wells of high-pressure gas produce from 1,000,000 cubic feet a day upwards, while the wells in Illinois, Michigan, Kansas, and other States are all low-pressure wells.

CAPITAL INVESTED IN NATURAL GAS.

As to the amount invested in the production and transportation of the gas, and not that invested in preparing material and appliances to be used in the business, such as tubes, etc., there are no data for giving an estimate, even an approximate one. The capital of the Philadelphia Company, of Pittsburgh, is $7,500,000. As a guess, it might be said that this is probably equal to that of all the other companies supplying Pittsburgh, which would make the capital of the companies coming into this city $15,000,000. We presume that the capital invested in the production and transportation of gas in western New York and West Virginia, outside of the companies supplying Pittsburgh, would be at a low estimate equal to this amount, and might possibly run up to double this, making the total capital invested in the production and transportation of natural gas in western Pennsylvania, western New York, West Virginia, and those parts of eastern Ohio that are supplied from western Pennsylvania, from $30,000,000 to $45,000,000. Including the amounts invested in Ohio—besides eastern Ohio, supplied from western Pennsylvania—Indiana, Illinois, Michigan, Kansas, and other States, the amount would probably reach $50,000,000; it may possibly exceed this.

THE TRANSPORTATION OF NATURAL GAS.

In but few instances are gas wells so situated, relative to the manufactories in which they are to be used, as to permit the taking of the gas directly from the well to the point of consumption; this is especially true where the gas is used in manufactories already established. Works that have been erected since the discovery of gas have, in some instances, been placed at the wells, and it is also true that the earliest establishments using natural gas in manufacturing, the salt works of the Kanawha Valley and the iron works at Leechburg, Pennsylvania, were in close proximity to the wells. As a rule, however, the gas has to be conveyed a considerable distance from the wells to the point of consumption.

The conduits used are iron pipes, wrought iron for up to 16 inches in diameter, and cast iron for larger diameters. The great pressure of the gas has complicated the question of its transportation, making it much more difficult to prevent leakage, while, at the same time, it has made it possible to transport the gas to greater distances than could be done if the pressure had been lower; gas, in some instances, has been conveyed more than 60 miles from the wells.

In view of the danger from leakage, especially in the cities, great precautions have been taken in laying the pipes to provide, first, against leakage as far as possible, and, secondly, to provide means for removing gas, that may escape, before it shall accumulate in sufficient quantities to become dangerous. More attention has been paid to these two points in Pittsburgh than elsewhere, and probably the system of the Philadelphia company, of that city, which is the invention of Mr. George Westinghouse, jr., is the best yet adopted. In the systems of laying the pipes, adopted by the Philadelphia company, each joint of the pipe, which, it is assumed, will sooner or later leak more or less, is surrounded by a conical pile of broken stone, inclosed in a covering of thick tarred paper, through which rises a vertical trumpet-mouthed pipe intended to gather the gas which may leak from the joint into the interstices between the broken stones and to convey it away by the small pipe, which extends horizontally over the main pipe, which carries the main volume of the gas. This leakage-pipe, or escape-pipe, as it is called, is led off at intervals (usually of about 300 feet) to a lamp-post in the sidewalk, where the gas may escape harmlessly into the open air; or, as is frequently the case, may be lighted for the purposes of illumination.

This free mode of escape, provided for the gas which may leak from the joints, is found to be sufficient for the protection of adjoining cellars and vaults from the gas which may escape from the joints of a screwed line; but for sizes of pipe larger than 8 inches in diameter, it is found best to use either wrought-iron pipe, with cast-iron sleeve joints, or cast iron pipe. Up to 16 inches in diameter, the wrought-iron pipe with sleeve joints is preferred; but the making of satisfactory wrought-iron pipe of larger diameter than 16 inches has not yet been accomplished; therefore, for pipes larger than 16 inches in diameter cast iron is used. In laying this, exterior to the ordinary bowl and socket joint there is provided a casing extending around the pipe and around the exterior or socket; and this casing forms a chamber surrounding the joint, into which any gas which may leak from the joint is received. Into this casing is screwed a vertical pipe, communicating with the chamber formed by the casing, which rises to a 2-inch horizontal escape-pipe, which receives in the same manner the leakage from all the joints, over a determined section (usually about 300 feet long); this leakage gas is carried to a lamp-post in the sidewalk.

The vertical pipe from the chamber formed by the casings extends upward to within a few inches of the surface of the roadway, where it is surmounted by a screwed cap. In case a considerable leakage is discovered, it is easy to determine at which joint it occurs, by digging down to this screwed cap, and by removing it to discover whether the leak is from that joint or from some other. If from the joint examined, the leak may generally be repressed, or entirely arrested, by filling the chamber, formed by the casing, through this vertical pipe, with a fluid, as asphaltum or varnish, under pressure; this will penetrate all the imperfections of the interior joint, and solidify there. When a sufficient time has elapsed, the joint can be pumped out, removing the surplus material from the chamber and restoring the cap to the pipe. The pavement may then be replaced, and the whole repair completed with very little disturbance in the roadway, and at a very small expenditure for the examination and repair of the joint.

As there is liability to leakage at very low pressure from the joints of the casing, which forms the chamber surrounding the bell joint, the joints of this exterior casing are covered with a conical heap of broken stone, which is in turn covered with tarred paper. From this rises the trumpet-mouth pipe, as in the smaller lines, to the 3 inch escape pipe, parallel with the main, from which a pipe leads to the lamp-post in the sidewalk, as before.

TOTAL MILEAGE OF PIPES USED IN THE UNITED STATES.

From returns received it is estimated that at the close of 1886 there were over 2,300 miles of pipe in the mains used for transporting the gas from the wells to the consumers, not including in this the amount of small pipes used in the houses of manufacturers for distributing the gas from the mains to the points of consumption. Of this, over 500 miles were used in supplying the city of Pittsburgh, some 232.4 miles having been laid in the city of Pittsburgh up to November, 1, 1886. In the following table is given the total number of feet of each size of pipe laid in the city of Pittsburgh by each natural-gas company on the date mentioned above, November 1, 1886:

Total number of feet of each size of pipe laid in Pittsburgh by each natural-gas company.

Companies.	Feet of pipe.	Size.
		In.
Philadelphia	11, 389	30
	65, 899	24
	43, 377	20
	3, 500	16
	17, 306	12
	10, 533	10
	308, 150	8
	211, 855	6
	152, 989	5⅝
	4, 091	4½
	130, 684	4
	10, 230	3
Total	970, 003	
Chartiers	32, 985	20
	15, 356	16
	3, 035	12
	12, 800	8
	52, 800	6
Total	116, 976	
Peoples	47, 425	8
	17, 365	6
	2, 490	4
Total	67, 280	
Pennsylvania	7, 900	16
	8, 080	10
	1, 405	8
	11, 125	6
	5, 680	4
	385	3
Total	34, 575	
Manufacturers	22, 750	12
	3, 780	8
Total	26, 530	
Washington	5, 150	6
	5, 150	8
Total	10, 300	
	1, 225, 664	

Total number of feet of natural-gas pipe of each size laid in Pittsburgh.

Size of pipe.	Pipe laid.	Size of pipe.	Pipe laid.
30 inches	11,589 feet.	8 inches	378,710 feet.
24 inches	66,899 feet.	6 inches	298,295 feet.
20 inches	76,362 feet.	5⅝ inches	152,989 feet.
16 inches	26,756 feet.	4¼ inches	4,091 feet.
12 inches	43,091 feet.	4 inches	138,854 feet.
10 inches	18,613 feet.	3 inches	10,615 feet.

In addition to this it may be stated that the total area of the cross sections of the pipes leading from the wells supplying Pittsburgh, the measurement being made at the wells, was 1,346,608 square inches. The total area of these pipes at the city line had increased to 2,337,083 square inches.

CHARGES TO CONSUMERS FOR GAS.

As stated in the last report, the charges to consumers vary greatly in different localities, depending usually, in the absence of ruinous competition, upon the cost of other fuel for doing the same work. For example, in fixing the rates to be charged a rolling-mill or a glass works an attempt will be made to ascertain what the cost of the coal used as a fuel in this works had been per ton, or per pot, and this would be taken as the basis of the charges for gas. In the presence of competition, however, no consideration is given to the value of the gas as a fuel or to the value of the other fuel it displaces. Prices are made without the least reference to cost or value. In one instance, in the presence of competition in a locality where coal is worth, say, $5 a ton, a company offered to supply gas for cooking and heating stoves at 50 cents a month each. In other cases gas companies have put the fittings into houses and agreed to supply gas for one year free. Such competition is not only ruinous but absurd. It is also true that in many localities where gas has been found, as an inducement for manufacturers to locate at that point, gas is furnished free; and in addition other inducements are offered to lead parties to erect manufacturing establishments in these localities.

It will be unnecessary to give the charges in various sections of the country, as they differ so greatly. The open rates of the Philadelphia Company, at Pittsburgh, which may be taken as fairly representing the ruling rates in that city, are sufficient.

Rates for furnishing natural gas.

Iron and steel:			
Puddling	long ton		$1.00
Heating (each heat)	do	$0.40 to	0.60
Boilers	per month	50.00 to	100.00
Total cost of gas per ton of iron, single heated	long ton	1.80 to	2.10
Sheet iron or steel	do	2.25 to	2.60
Hoop iron or steel	do	2.25 to	2.60
Open-hearth melting	do		.70
Crucible steel melting	do		.50
Hammer furnaces	per day	1.00 to	1.60

Glass:		
Flint, each 10-pot furnace	per month	$160.00
each large glory hole	do	30.00
each small glory hole	do	$15.00 to 20.00
each lear	do	25.00
each steam-boiler	do	35.00 to 50.00
Average cost of gas about $28 per pot per month.		
Window glass.—Average $33.33 per pot per month, blowing furnaces, flattening ovens, sand furnaces, and boilers included.		
Green bottle glass same as window glass.		
Boilers in general works range from $20 to $150 per month.		
Oil stills	per month	35.00 to 100.00
Brick kilns and drying floors	per thousand	1.00
Fire brick	do	1.00 to 1.40
Domestic use.—This is based on the number of square feet heated, the basis being $10 a year for 15 square feet. The charge for heating stoves is $2.50 a month; for open grates, $2.		

It will be noted that the charges are not per thousand cubic feet, but per unit of product, or some unit other than cubic feet. For example, in iron making, the charge is per ton of iron puddled, heated, or rolled; in glass works, per pot of glass melted; in brick making, per thousand burned; for steam, per boiler, varying with the size.

This method of disposing of gas has led to an enormous waste and in view of the fact that the natural-gas supply in certain sections is being comparatively rapidly exhausted, and that in all probability what is burned is not replaced in the reservoirs from which it is drawn, this waste has led to an earnest consideration of the question whether natural gas should not be sold by the thousand cubic feet, in order that those who are willing to practice economy in its use should pay a less rate for the product than those using it wastefully.

In connection with this discussion another has arisen, viz., the importance of burning the gas at a much lower pressure in order to get the best results. Mr. William Metcalf, of Pittsburgh, long ago pointed out that gas must be burned at a low pressure in order to get its full fuel value; that driving the gas through the furnace at such a rate as is generally practiced in Pittsburgh was wasteful to the extent that the pressure exceeded the very low tension at which it had been the custom to burn producer gas. It is estimated that in the past four years Pittsburgh has consumed and wasted enough gas, in one way and another, to have lasted ten times as long if it had been judiciously produced and burned.

ECONOMIES IN THE USE OF NATURAL GAS.

On page 159 of the report on natural gas in "Mineral Resources of the United States, 1885," a statement was given as to the economies in the use of gas at a flint-glass works. This showed that at a furnace using coal for fuel, during a forty-five weeks' run in 1883, the average cost per week for coal, coke, and benzine and the labor not needed with gas amounted to $175.17. The cost per week in 1885, when natural gas was used as a fuel at the same works, was $94.96, or 46 per cent. less than when working with coal. To this might have been added the saving in wear and tear of the furnace, the better quality of glass produced and other items which would have materially increased this saving.

It is also true that as a result of the use of gas, the window-glass and plate-glass works in the neighborhood of Pittsburgh have been enabled to produce a very much better quality of glass, the quality being improved chiefly in the flattening at the window-glass works, and in the quality of the "metal" (the melted glass) at both the plate and window glass works. This has enabled the gas-made glass to compete on much more favorable terms than the glass made with coal, and has led quite a number of establishments that are not situated in the gas district either to move their works to the gas district or establish other factories at points where gas can be secured.

Relative to the economies in the use of natural gas in the manufacture of wrought iron, it is very difficult to obtain exact figures. It is evident that those using it do not care to give exact statements as such statements may result in an advance in the price of gas. The statements given below, however, are approximately correct. It is fair to say that the mills from which they were obtained use coal as economically, if not more so, than the average of the mills in Pittsburgh, so that this showing is less favorable for gas than if the comparison had been made from the results in the average mill.

As is stated elsewhere, the amount of gas used as fuel for a ton of iron varies greatly, being from 13,000 cubic feet in the very best furnaces (the Siemens) to an average of 35,000 cubic feet in the ordinary type, and to as high as 65,000 cubic feet in furnaces that are badly constructed. The gas, however, is not sold by measure, but at so much per ton of iron puddled, heated, etc. Some of these rates are as follows, taken from the report, "Mineral Resources of the United States, 1885," since which time the open rate has not varied. It must be understood, however, that these rates are shaded. Many mills have contracts by which they secure their fuel at rates very much below these.

Rates for furnishing natural gas to iron and steel works.

Puddling	gross ton..	$1.00
Heating (each heat)	do.....	$0.40 to .60
Boilers	per month..	50.00 to 100.00
Total cost of gas per ton of iron, single heated	gross ton...	1.80 to 2.10
Sheet iron or steel	do.....	2.25 to 2.60
Hoop iron or steel	do.....	2.25 to 2.60
Open-hearth melting	do.....	.70
Crucible steel melting	do.....	.50
Hammer furnaces	per day..	1.00 to 1.60

The methods of using the gas are very wasteful. Old works, fitted to use coal, have been altered in the crudest manner to use gas. There was a fear at first that the gas might give out, necessitating a return to coal at a moment's warning; indeed, some of the mills that did not exercise the best judgment in selecting the company from which they secured their gas have been compelled to do this through a failure in the gas supply. If a new factory were to be built and piped expressly for the use of gas, the cost of the furnaces needed would be only a small proportion of the amount expended in preparing the great combustion chambers necessary for the use of coal. There is no doubt that the present consumption of fuel is more than twice, perhaps more than four times, what it would be if the gas were sold by measure, and the manufacturer found it necessary to be economical in its use. The gas ought not to be burned at a pressure of more than one-half an ounce to an ounce per square inch; and the pipes should be large enough to admit of a sufficient delivery at these pressures, whereas now it is delivered at the furnace at something like a hundred times this pressure.

The direct saving to iron mills in using natural gas instead of coal is from four sources: (1) reduced fuel cost; (2) reduced labor cost; (3) reduced waste of iron; (4) reduced cost of repairs.

It will be readily understood that these items vary at the different mills, and even at different times at the same works. It will also be evident that a mill that used coal economically would not show as great a saving as one that used it wastefully. The figures given below may be regarded as a fair average.

(1) *Reduced fuel cost.*—To puddle and heat a ton of iron at Pittsburgh and to raise the steam necessary to squeeze, shear, and roll the same, requires 50 bushels, of 70 pounds each, of lump coal, worth at the time when most works ceased to use coal 6 cents a bushel, and 12 bushels of slack, worth 3 cents a bushel.

The consumption is divided as follows:

Puddling, 36 bushels, at 6 cents	$2 16
Heating, 14 bushels, at 6 cents	84
Steam, 12 bushels slack, at 3 cents	36
	$3. 36

The ruling rates for gas are as follows, though some mills are getting it at less:

Puddling, gross ton	$1. 00
Heating	80
Steam	20
	$2. 00

This shows an actual saving in fuel by the use of gas amounting to $1.36. Some mills, it is reported, get gas for $1 per ton of finished product. This would make the saving $2.36 for fuel. These figures are not used, however; the above rate being preferred.

(2) *Reduced labor cost.*—The labor of making a ton of iron is very much less when using gas than when using coal. There is no wheeling of coal to the furnace nor of ashes from it; no "stoking" by helpers, no cleaning of grate bars. The saving of labor to puddlers, heaters, and helpers, however, results in no reduction of wages, these employés being tonnage men. But no coal wheelers and ash wheelers are needed, and the boilers can be run with less firemen, so that there is a saving of labor on these classes of workmen. At a mill making 16,650 tons a

year, this saving was about $2,000, say 12 cents a ton. Actual saving in labor per ton, 12 cents.

(3) *Reduced waste of iron.*—This varies greatly. There is a small saving in the puddling furnace, with proper care. In the heating furnace the piles are heated uniformly throughout their length, thereby avoiding the waste at one point which is common in a coal furnace. The waste so frequent, when coal is used, from the iron having to be held in the furnace after it is ready for the rolls, though the rolls may not be ready for it, is entirely avoided, as the gas can be so regulated as to provide for contingencies of this kind and to maintain the piles at their proper heat without loss. A 4-per-cent. saving on the entire output of the mill by reason of these two items is very low, and is less than one-half the amount at which it is frequently estimated. This saving, regarding the iron as worth $36 a ton, would be $1.44.

(4) *Reduced cost of repairs.*—It is within bounds to say that a furnace running double time using gas lasts twice as long as one using coal. The cost per ton of repairs at a puddling furnace, including rebuilding, clay, brick, etc., at a Pittsburgh mill, when using coal, was 60 cents; with gas, 47 to 53 cents; say 50 cents average, saving 10 cents.

The repairs to a heating furnace cost 7½ cents with coal, 4¾ cents with gas, making total saving as follows:

Saving in cost of repairs in heating and puddling furnaces using natural gas.

	Cents.
Puddling	10
Heating	2¾
	12¾

Recapitulation.

(1) Reduced cost of fuel	$1 36
(2) Reduced cost of labor	.12
(3) Reduced waste of iron	1.44
(4) Reduced cost of repairs	.12
Saving on one ton of bar iron	3.04

These figures are very conservative and very much below the saving at many works. They are based on the actual results of a year's work at a mill that was equal to the best, when coal was used, in its economical methods and appliances for handling and consuming the coal. At many works the saving will be much greater.

On the average it will be fair to estimate that 4 cents spent for gas give the equivalent of 100 pounds of coal or of 1.31 bushels, which at 6 cents a bushel would be 7.86 cents; that is, the cost with gas as a fuel is a little more than one-half what it would be with coal as a fuel, if all lump is used. The use of slack for making steam would make this relative difference a little less.

As stated above, the use of gas has not changed rates of wages, but has reduced labor cost by doing away with certain employés, as ash and coal wheelers, a portion of the firemen, etc. Though the labor of the puddler and his helper and of the heater and his helper is much less, the rates for boiling and heating per ton have not decreased.

There is a number of items both of direct and indirect advantage in the use of gas, for which no equivalent can be given in dollars and cents. The saving in fire boxes and of grate bars at the boiler furnaces is no inconsiderable item. The saving of the space required when coal is used, for standing cars and for the storage of the coal is an important item in a location where land is as high as it is in Pittsburgh.

Below is the statement from another mill:

Coal, per ton of muck bar, 30 bushels, at 5 cents	$1.50
Coal, per ton in heating bar, 16 bushels, at 5 cents	80
Slack and labor in making steam, per ton of finished bar	35
Labor in removing ashes, per ton	17
	2.82

The saving in brick and clay is about one-third the amount with gas. The cost of gas in the mill is from $2.25 to $2.75 per ton of finished iron. This price includes gas for making steam.

The Maumee Rolling Mill Company of Toledo, Ohio, which has an output of 50 tons of iron per day, gives the following comparative estimates of the cost of coal and gas for making fuel: The cost of coal was $200 a day, to which had to be added the wages of men who handled the coal hauled away the cinders, etc., and the cost of grate bars and fire brick, The total cost of coal fuel was summed up to $5.25 per ton of iron produced, while the cost with gas is but $1.90, a saving of $3.35 per ton, or $167.50 a day. The difference in favor of natural gas is $50,000 a year, or 10 per cent. of the amount of the capital invested.

NATURAL-GAS COKE.

For many years the product of the imperfect combustion of natural gas, which forms a sort of lampblack, and is in some cases pure carbon, and in others imperfectly decomposed hydrocarbons, has been collected and used for various purposes, for which lampblack and ivory black have been employed. A great deal of printer's ink is made from this natural-gas carbon, and large quantities of it are used for paints. Quite recently it has begun to be employed for the manufacture of carbons for electric lights. All carbons made from woody fiber, though they may vary in percentages, contain more or less of earthy salts. These interfere with the steadiness of the light and diminish the life of the carbon. It is evident, however, that a perfectly pure carbon can be produced from natural gas, and that a carbon so produced will answer admirably for the points of the electric light.

The coke or the gas carbon is a most beautiful, solid material, looking more like coal than coke, the processes of manufacturing giving it a banding that still further increases its resemblance to coal. It has the metallic ring of coke to a much greater extent than coke itself, the gas carbon, when struck, having a sound somewhat like a solid, hard-burned red brick, only a little more metallic. In its natural state it breaks into large pieces quite readily, though it resists attempts to chip it with considerable obstinacy.

Experiments already made show that the life of the electric light carbons made from natural-gas carbon, as compared with those made from ordinary material, is as 13 to 8, and it is expected that improvements that have been adopted in the process of manufacture will prolong the life of these gas carbons still more, making their relative value still greater. It is also found that these carbons excel others in brilliancy of light and noiselessness. There is an absence of that spitting sound that is so disagreeable.

NATURAL GAS IN PENNSYLVANIA.

The localities in which natural gas is found in Pennsylvania were set forth in detail in the volumes of "Mineral Resources of the United States" for 1883-'84 and for 1885. These statements practically cover all the territory in this State in which gas had been found up to the close of 1886. During the past year large producing wells have been struck in towns, and possibly in counties, not included in the previous volumes, but these could hardly be regarded as opening new fields. They are more properly extensions of old ones. In general, therefore, the districts named in the previous volumes may be regarded as including all the wells that were in existence at the close of 1886.

The gas wells of western Pennsylvania may be broadly divided into two great divisions, first, the Pittsburgh gas district, and, second, the oil district, and these are again subdivided into many minor fields or districts.

The chief subdistricts in the Pittsburgh field are the Murrysville, Grapeville, Cannonsburg, Hickory, Sheffield, Baden, Bull Creek or Tarentum, and the Pine Run. Most of these districts are included within a radius of 20 miles from Pittsburgh, the Sheffield, Hickory, and Grapeville being just beyond the 20-mile limit. From all of the wells within this 20-mile circle gas is piped to Pittsburgh or Allegheny. The Grapeville wells at present send no gas to Pittsburgh, their production going chiefly east and south. From the Washington district a great deal of gas is sent to West Virginia, while the Sheffield district supplies Phillipsburg, Beaver Falls, and New Brighton.

The gas wells of the oil district may be subdivided into three great divisions, the same that are made in the petroleum business. These are, first, the Bradford district, the most northerly one, which includes the gas fields of McKean and Elk counties and such pools as the Wilcox, Sergeant, Kane, Wetmore, and Ludlow, and the gas associated with oil in McKean county, and Johnsonburg, Roy, and Archer, and Ridgeway in Elk. The second great division is the middle field, including the wells in Warren, Forest, and Crawford counties; and, third, the Lower fields, including all the territory usually grouped together as the lower or southern oil fields of Pennsylvania. This may be regarded as including all the gas territory in Venango, Clarion, Jefferson, Indiana, Armstrong, and Butler counties.

The consumption of the gas produced in each district or subdistrict is generally for domestic purposes and for manufacturing in the large towns and cities in the immediate vicinity of the wells. Of course, where large wells are struck and a large volume of gas is found, more distant consumers are sought than where the amount is small. A great deal of the gas found in the oil district is in small quantities and associated with petroleum, and is used chiefly at the wells and in drilling and pumping, and where there is an amount in excess of the requirements for such purposes, it is used in the small manufactories and in the stores, offices, and dwellings near the wells.

A great deal of the Pennsylvania gas, however, is piped to other States. From the wells of northern Pennsylvania gas is piped 60 miles to Buffalo. The gas from northwestern Butler county is piped not only to the large manufacturing towns of Lawrence and Mercer counties, Pennsylvania, but also to Youngstown, Ohio, while the gas of the Baden and New Sheffield districts is sent to the small manufacturing towns in Ohio, from Wellsville to East Liverpool, and the gas from Washington county is piped to Wheeling, in West Virginia, and Bellaire, Bridgeport, Martin's Ferry, and Steubenville, in Ohio.

It is impossible to arrive at any correct statement of the number of wells or their aggregate production in millions of cubic feet in western Pennsylvania. The same is true of any district. As is stated elsewhere, there is the utmost difficulty in arriving at the production of even a single well, and even the measurements that have been made most accurately are open to question. On November 1, 1886, the number of wells in the Murrysville, Tarentum, Hickory, and Cannonsburg districts sending gas to Pittsburgh, with the names of the owners, was as follows:

Gas wells of the Pittsburgh district supplying Pittsburgh, November 1, 1886.

Company.	Murrysville.	Tarentum.	Hickory.	Cannonsburg.	Total.
Philadelphia	48	10	....	....	58
Chartiers	7	....	16	....	23
Manufacturers'	....	....	....	10	10
Pennsylvania	....	1	....	7	8
Washington	....	....	5	....	5
People's	3	....	....	....	3
Total	58	11	21	17	107

The Philadelphia company, which probably produced and supplied half of all the gas that was sent to Pittsburgh, estimates its production for 1886 at 60,000,000,000 cubic feet. Estimating 1,000 cubic feet of gas as equivalent to 81$\frac{32}{49}$ pounds of coal, this enormous amount of gas would be equivalent in heat units to 2,500,000 tons of coal. Owing to the wasteful methods of gas consumption, however, the actual work done by this gas was only a small proportion of what would have been done by this amount of coal.

It has been estimated that the production of the Philadelphia company is about one-fourth of the entire production of western Pennsylvania that is used for domestic purposes and in the arts. On this basis the production of gas in western Pennsylvania would reach the enormous amount of 240,000,000,000 cubic feet, the fuel value of which, measured in heat units, would be equivalent to 10,000,000 tons of coal. It will be noted, however, in the statement showing the amount of coal displaced in western Pennsylvania, that we have estimated it at only 6,000,000 tons, the value of which is $9,000,000.

NATURAL GAS IN WEST VIRGINIA.

While gas, in some quantities, has been found in this State from the time Washington secured possession of the "burning springs" in the Kanawha valley, by far the largest amount consumed in the State at the present time is piped from Washington county, Pennsylvania. For the history of natural gas in this State, and a statement regarding the wells drilled, the reader is referred to the previous volumes of Mineral Resources of the United States.

There are two companies supplying Wheeling with gas from the Washington, Pennsylvania, field—the Natural Gas Company of West Virginia and the Wheeling Natural Gas Company. These companies supply, in addition to Wheeling, the group of towns in the immediate vicinity, which make up what is known as the "Wheeling manufacturing district," viz., Benwood, in West Virginia, Martin's Ferry, Bridgeport, and Bellaire, in Ohio. These two companies had, on December 31, 1886, 15 wells, all in Washington county, Pennsylvania. The depth of the wells was from 2,200 to 2,500 feet, and the flowing pressure from 200 to 250 pounds at the well, the closed pressure averaging 400 pounds. These companies had a total of 925,145 feet of pipe, ranging from 4 to 12 inches. At this date they were supplying 1,200 houses, 9 iron works, 20 glass works, besides breweries, potteries, paper and flour mills, and other industrial establishments with light, heat, and power. As it was late in the summer before the lines of these companies were laid, the consumption of gas in 1886 was but moderate, and very small as compared with what it will be in 1887.

NATURAL GAS IN OHIO.

As the geology of natural gas in Ohio is to be discussed at length by Professor Orton, State geologist, in another of the publications of the United States Geological Survey, it will be only necessary to refer to it here in the briefest way possible.

There are in Ohio three geological horizons from which gas is produced, viz, the Berea grit, the Ohio shales, and the Trenton limestone. Geographically, the territory of the high-pressure gas from the Berea grit is in the southeastern and middle eastern part of the State, bordering on West Virginia and Pennsylvania. Roughly its extent is from the border line of these two States to a line drawn northwardly and southwardly through Lancaster and just east of Mount Vernon, striking the Ohio river at Sciotoville, and bending eastwardly near New London and Wellington, leaving a narrow strip between its upper northern border and the lake. The eastern border of the territory of low-pressure gas from Ohio shale skirts the western border of the territory of high-pressure gas from the Berea grit. The western border of the shale gas district, extending from the southeast corner of Adams county, on the Ohio, northwardly through Greenfield, Columbus, Delaware, and Bucyrus counties to the lake, which it strikes near Sandusky. All the territory west of this shale gas territory, except the extreme northwestern corner of the State, and an isolated patch near Fremont, belongs to the territory of high-pressure gas from the Trenton limestone. As suggested by Professor Orton, in making these divisions it is not to be understood that gas will be found at all points in the territory marked out as being the limits of each of these three great divisions. It merely indicates that gas has been found in the geological horizon named in the territory, and indicates the geological possibilities of the counties, but this only from one standpoint, viz., the stratigraphical elements that enter into the section.

Treating first of the territory of low-pressure gas from the Ohio shale, though counting from the eastern border of the State, it is really the second area geographically. This shale enters the State from Pennsylvania at its northeastern border, as explained above. It was the gas from this horizon which was the earliest utilized in the United States. The gas used at Fredonia, New York, as early as 1821, and that burned at the light-house at Barcelona, near Westfield, had its source in these shales. At a much later date, but still a score of years ago, Erie, Pennsylvania, began to use natural gas in a small way, all the supply being derived from the shales that make the underlying rocks of this region. The lake-shore towns of Ohio were not far behind in following the example of Erie. Painesville and Cleveland, in particular, made a trial of the shales as a source of gas, and secured a small but useful supply sixteen or seventeen years ago. Many wells were drilled along the shale belt in the oil excitement of 1860–1865, but none of these were in any reasonable degree successful, except in disclosing the presence of gas within the formation. The gas from this shale is essentially marsh gas with small percentages of the more complex hydrocarbons, and is usually free from sulphur, differing in this respect from the gas from the limestone field. It is low pressure, its closed pressure probably never exceeding 100 pounds. Shale-gas wells are small producers, the maximum production never passing 100,000 cubic feet a day, very few of them reaching 20,000, and many giving no more than 10,000, and some being as low as 1,500. Professor Orton points out the admirable adaptation of this gas to household use. Regarding its use for this purpose, he says, in an article published in the *American Manufacturer and Iron World:*

"This is its proper field, and for this purpose it will be more highly esteemed, as fuel becomes scarcer in the country. Tracts of land in which shale gas is available for use will certainly be valued on this account as much as if they contained other forms of stored power, namely, forests upon the surface, or peat or coal bedded beneath the surface. The capabilities of a hundred acre farm in this production will be found to be very great. A shale gas well does not exhaust a large territory around it, like a reservoir well, and the drilling of these wells is very simple and inexpensive. They require little or no casing; and after the house is piped for the use of gas it will be but a small burden to renew the supply by drilling a new well a few rods from the old one."

The territory of high-pressure gas from the Berea grit, described above, includes in whole or in part 33 counties of southeastern Ohio. Professor Orton points out that while the drill develops this gas as stored in the Berea grit, its source is unquestionably the great Ohio shale that underlies the entire territory with a thickness never less than 600 feet, and which, for much of this area, is three to five times this measure. Over this territory, rarely, if ever, are the conditions for production and storage of gas and oil wanting. There is the source in the great Ohio shales, the reservoir in the Berea grit, and the cover never wanting in the black Berea shale, and the blue Cuyahoga shale, the cover being from 200 to 500 feet in thickness. Structure, the fourth of Professor Orton's general conditions, which includes the dip of the strata and all folds or arches that occur in them, is, however, doubtful. The normal structure of the Berea grit is fatal to gas or oil accumulation. Professor Orton states that there are not a half dozen bold, well marked, and fairly persistent anticlinals known in southeastern Ohio, and that this is why the search for gas is so poorly rewarded in eastern Ohio. Trials have been made in 27 of the 33 counties included in the territory of high-pressure gas from the Berea grit, but the record is not encouraging, the drill having shown that gas does not exist in paying quantities, at least in the localities that have been tested, with a very few exceptions, these exceptions being Washington and Jefferson counties. The only localities in this district where gas is produced in any quantity are at East Liverpool, where it is used for fuel and light, and at the Neff wells on the Kokosing river, on the east side of Knox county, the gas of which is used in the manufacture of lamp-black.

The most important natural-gas horizon in Ohio, and the only one from which gas has been produced in sufficient quantities to be used on a large scale in manufacturing, is the Trenton limestone. The discovery of gas at Findlay, in this horizon, in 1885, was of great importance geologically and commercially. It disclosed the fact, before unsuspected, that the limestone of the Lower Silurian age and at the bottom of this great division of geological time contained immense stores of gas; commercially it has resulted in bringing into the section of Ohio in which it has been found a vast amount of capital for investments in manufacturing industries, and in stimulating the search for gas in Indiana, which has resulted in the discoveries at Kokomo, Muncie, and elsewhere. The first discovery of gas in Findlay in recent times was made in October, 1836, in digging a well. In 1838 gas from another water well was conducted by wooden tubes into the fireplace in one of the living rooms of the house of Daniel Foster, and burned from an old gun barrel. The fire thus kindled has burned almost uninterruptedly until the present time. It was not until 1884, following the great gas discoveries in Pennsylvania, that the Findlay Natural Gas Company, the pioneer company in the search for gas in this region, began to drill. In November of that year gas was struck in the limestone rock at a depth of 1,100 feet.

In the Bowling Green field, in Wood county, due north from Findlay, drilling began in February, 1885, which resulted in the development of an important gas field. These two towns, which are 24 miles apart, may be regarded as marking the northern and southern extremities of what may be termed the Findlay-Bowling-Green gas field, though gas has been found in this Trenton limestone territory at Oak Harbor, in one township in Wyandot county, one in Auglaize, and one in Mercer.

Though, as stated above, the Findlay gas field was developed by drilling the first well in November, 1884, and by the wells of 1885, it was not until the "drilling in" of the great Karg well, on January 20, 1886, that the possibilities of the field were made evident, and it was shown that this territory could produce wells of the first class even when judged by the standard of the great Pennsylvania wells. The excitement following the striking of this well can hardly be conceived. Its immense production; the force with which the gas escaped and its velocity; and the light of the blazing gas which could be seen at night 40 miles distant, all conspired to lead to that vigorous search for gas which immediately followed, and to stimulate that which had already begun. Though quite a number of wells have been bored in this neighborhood, but one has surpassed the Karg, viz., the Van Buren well drilled in, in August, 1886.

The most important field in the State next to the Findlay is the Bowling Green, which already possesses a number of very important wells. The first important well in this field was struck in March, 1886. At the time of the publication of this report enough drilling has not been done in the vicinity of Bowling Green to show fully its possibilities, but it is beyond doubt a gas field of importance.

At Bloomville and Bairdstown, wells yielding a fairly good amount of gas were struck in the summer of 1886, and these were followed later by the wonderful Simmons well, north of Bairdstown. A good well has also been obtained in Range township, Wyandot county, a short distance from Cory.

The production of the three great wells of Ohio—the Van Buren, the Karg, and the Simmons—measured by the Robinson method is, according to Professor Orton, as follows:

	Yield from casing.	Yield from 4-in. pipe.
Van Buren well	15,000,000	12,614,400
Karg well	....	12,080,000
Simmons well	12,422,000	....

Among other wells that have been measured by the same system the following may be named: the Cory, the Briggs, and the Jones wells, of Findlay; the Dwyer, or St. Henry well, Fort Recovery well, and the Axe well, of Saint Mary's. Their daily production is as follows:

	Cubic feet.
Cory well	3,318,000
Briggs well	2,565,000
Jones well	1,159,200
St. Henry's well, No. 1	2,635,200
Fort Recovery well	1,814,400
Axe well	2,042,864

As the result of the discovery of this high-pressure gas in northwestern Ohio, there has been a great influx both of population and of manufactories. Some of the towns have doubled in population in a year, while others are increasing rapidly; industries before unknown in this section of the country, owing to the absence of cheap fuel, are now flocking to the gas territory. Glass works, potteries, straw-board manufactories have been established in this Findlay-Bowling Green field, and the promise is that in 1887 the number will be very largely increased.

The consumption of natural gas in Ohio, in 1886, is estimated as equivalent to the displacement of 200,000 tons of coal. The production of the wells represented an amount of gas very much in excess of what would be the equivalent of this amount of coal, but at the close of 1886 but a small portion was utilized. This consumption will be multiplied many times in the year 1887.

NATURAL GAS IN INDIANA.

It was not until the fall of 1886 that the natural-gas fields of Indiana assumed any importance. In this State, as in the others of the Ohio Valley, gas was discovered years before, and usually in the same manner—that is, in digging water wells or in drilling for petroleum. In 1876 a well bored for oil at Eaton struck a small vein of gas, and there are records of other similar finds. It was not, however, until the excitement following the discovery of gas in northwestern Ohio started the drill in Indiana again, and not until after well No. 1, at Kokomo, with its daily production of 2,000,000 cubic feet, was sunk, that the gas fields of Indiana began to be developed earnestly. At the close of 1886 these fields had not attained the importance, nor was their extent defined nor their capacity tested as they have been by developments made in 1887. It does not, however, fall within the scope of this report to more than refer to developments made after December 31, 1886.

The principal gas wells in Indiana are located at Portland, Jay county; Muncie, Delaware county; Marion, Grant county; Kokomo, Howard county; Winchester, Randolph county, and Noblesville, Hamilton county. These points all lie south of the Wabash river. If a line were drawn though the center of the State, east and west, and bisected by one running north and south through the center, this territory would be in the lower part of the northeastern quarter thus formed. Noblesville, Tipton, and Kokomo are north of Indianapolis; Marion east, a little north of Kokomo; Portland east, a little south of Marion; Winchester south of Portland, and Muncie west of Winchester, between it and Tipton.

The first well put down in Indiana for natural gas was drilled in 1885 at Union City, Randolph county. It was abandoned when the drill was in the Potsdam sandstone at a depth of 1,900 feet, as no gas was found. On September 16, 1886, drilling began at well No. 1 at Kokomo, and on October 6, at a depth of 904 feet, a small supply of gas was obtained from the Trenton limestone. Four feet below this, or at a depth of 908 feet, a large vein was tapped, the daily production of which is now estimated at 2,000,000 cubic feet per day. From the boring of this well dates the natural-gas industry of Indiana. Two other wells were drilled in rapid succession in the same fall, gas being reached in well No. 2 on November 31, at a depth of 916½ feet, with a pressure of 400 pounds and a daily flow of 6,000,000 cubic feet, and at No. 3, on December 28, at a depth of 912 feet, the pressure being still stronger, and the flow 7,000,000 cubic feet per day.

The following table shows the succession and thickness of the strata encountered in boring the several wells at Kokomo, and also the depth at which gas was found, compared with sea level:

Strata encountered in boring the Kokomo gas wells, Indiana.

	No. 1.	No. 2.	No. 3.
Drift	....	....	5
Niagara limestone	285	284	280
Clinton limestone	20	20	20
Hudson River group	525	530	530
Utica shale	50	40	50
Trenton limestone	40	42½	27
Total	920	916½	912
Below sea level	95	91½	62
Top of Trenton limestone below sea level	55	49	35

Wells Nos. 1 and 2 were continued to depths considerably greater than that given in the tables, without increasing the flow of gas or showing evidences of petroleum. In both at the depth of about 946 feet, strong flows of salt water were obtained.

The discovery of gas at Kokomo created an unparalleled degree of excitement in the State, exceeding that aroused by the discoveries at Findlay, and in northwestern Ohio. Companies were organized in the surrounding towns, until at the close of 1886 there was hardly a place of any importance at which there was even the remotest possibility of obtaining gas, that had not effected an organization for prospecting for gas or oil. These companies are organized upon a "mutual plan," or a plan of local subscription, stock being sold in shares of from $5 to $25, thus enabling all who care to invest to share the expenses, and the profits of the enterprise, too, if there be any. The most important discoveries of gas made in connection with this drilling have been at Muncie, in Delaware county; Portland, in Jay county; Noblesville, in Hamilton county; and Marion, in Grant county.

Next to the Kokomo field the Muncie is probably the most important. No failures have yet been reported in efforts to develop gas either at Kokomo or Muncie, and the prevailing opinion is that these fields are likely to prove among the very best in the country. There are three gas wells near Muncie. Mains have been laid through the city, and gas is used quite universally for heating and lighting purposes. The pressure of well No. 1 is 325 pounds to the square inch, the aggregate daily production of the three wells being from 12,000 to 15,000 feet. The strata passed through in boring well No. 1 at Muncie are shown as follows:

Strata penetrated in drilling well No. 1 at Muncie, Indiana.

	Feet.
Niagara limestone and shales	246
Clinton limestone	19
Hudson River limestone	571
Utica shales	40
Trenton limestone	22
Total	898

The first well bored at Portland was in July, 1886, but the supply obtained was very small. The bore in this well was continued to the depth of 1,440 feet, passing entirely through the Trenton limestone, and terminating in the Potsdam sandstone. Not discouraged by a practical failure in the first instance, the company at once put their drill to work in another place, and in this attempt they were eminently successful, securing a flow that upon accurate test has a pressure of 298 pounds per square inch. The strata passed through were as follows;

Strata penetrated in obtaining natural gas at Portland, Indiana.

	Feet.
Drift	58
Niagara limestone	175
Clinton limestone	17
Hudson River rocks	700
Utica shale	40
Total	990

The gas was found just at the top of the Trenton rocks.

Gas has recently been found in quantities at Noblesville, Hamilton county, 20 miles north of Indianapolis. The flow was obtained in the Trenton limestone at a depth of about 950 feet; but full particulars regarding this well have not yet been received. The estimated flow of gas is 4,000,000 cubic feet per day.

The first gas well of large capacity in the State was bored at Eaton, in the northern part of Delaware county. It was bored to the depth of 600 feet in 1876, with a view to obtaining oil. There were no indications of oil, but a flow of gas was obtained. Not producing oil, the well was abandoned. With the finding of gas in northwestern Ohio a company was formed, which sunk a well, striking gas in the Trenton limestone, at a depth of 922 feet. The limestone was reached at 5 feet above sea level. The pressure is estimated at upwards of 100 pounds per square inch, and the flow of gas at near 1,000,000 cubic feet per day. No accurate tests have yet been made of the capacity of this well. Gas was struck at Marion, Grant county, in January, 1887, in the Trenton limestone, at a depth of 885 feet. The well was shot with the expectation of increasing the flow of gas, and the hope of securing a flow of petroleum. No evidence of petroleum was produced by the explosion, but the flow of gas was about trebled. The daily flow of gas is estimated at 1,000,000 cubic feet.

Efforts to develop natural-gas wells in the southern part of the State have so far proved almost wholly futile, from an economic standpoint. Gas, it is true, has been found in nearly every county in the State, but with the exception of two or three wells in Harrison and Crawford counties, near the Ohio river, the quantity obtained has not been sufficient to remunerate the explorers. In the two counties mentioned, two or three wells have been bored, from which were obtained flows of gas amounting to from 20 to 40 pounds' pressure per square inch.

NATURAL GAS IN ILLINOIS.

But little can be added to the statement contained on pages 167 and 168 of the volume of "Mineral Resources of the United States for 1885" relative to the occurrence of natural gas in Illinois. No deposit of commercial importance other than those named in that statement has been opened. Prof. Theodore B. Comstock, of the University of Illinois, in discussing the subject of oil and gas in Illinois, reaches the conclusion that this State possesses in its measures a fair supply of natural gas. Regardless of actual discoveries, but from geological considerations alone, he hazards the opinion that the counties in this State in which the conditions are specially favorable for finding a supply of oil and gas are Champaign, Ford, Livingston, Edgar, Vermillion (west edge), Clark, Douglas, McLean, Woodford, Marshall, Piatt, DeWitt, Coles, Shelby, Montgomery, and Madison, with probably other adjoining counties which can be included when their geology has been thoroughly worked up.

For the localities in which gas has actually been discovered in this State reference should be made to the previous volumes of this series. The wells at Urbana and at Champaign all lie along the La Salle-Terre Haute axis of Professor Comstock. The pressure in these wells is very small, and the amount of gas produced inconsiderable.

The most important gas locality yet discovered in Illinois is near Litchfield, in Montgomery county. These wells were described on page 167 of Mineral Resources of the United States for 1885. There are four wells in this locality owned by the Litchfield Gas, Oil and Fuel Company. They are located 2½ miles southeast of the city. The depth of the wells is 640 to 670 feet, the best gas being discovered at a depth of 666 feet. This company has about seven miles of pipe, ranging from 3 to 8 inches in diameter, and supplies some 500 stoves; the gas is used chiefly for domestic purposes—heating, cooking, and lighting.

The rates made by this company for the use of gas are as detailed as any that have been secured, and the rules are interesting. They are as follows:

Rates for stoves are based on the use of gas with meter burners as per size indicated, with each rate.

The meter burners, being the property of the company, are loaned, not sold, and must not be interfered with.

Special rates will be made with any one wanting gas for heating during the months of May, June, July, August, and September.

These rules and all the laws of the State of Illinois now in force or that may come in force, applicable to gas companies, shall form part of the contract with each consumer.

Two meters or more will be required in all steam heaters and furnaces. Whenever more than two heating burners are used a reduced rate will be given on the burners over two.

One-half rates will be charged for burners in grates where apartments are heated by steam or furnace, provided the flues of such grates are properly stopped.

One-half rates will be charged for laundry stoves where a cook stove is also furnished.

Special rates will be made for public buildings, hotels, halls, etc.

A damper is required in all stove-pipes.

Rates per month for furnishing natural gas at Litchfield, Illinois.

	Charges.	Discount.	Net charges.
Heating stoves and grates for dwellings:			
First, 1-8 meter burner	$3.30	$0.30	$3.00
Second, 1-8 meter burner	2.75	.25	2.50
Third, 1-8 meter burner	2.20	.20	2.00
Fourth, 1-8 meter burner	1.65	.15	1.50
Fifth, 1-8 meter burner	1.10	.10	1.00
First, 5-32 meter burner	4.40	.40	4.00
Second, 5-32 meter burner	3.85	.35	3.50
Store-rooms, saloons, etc.:			
500 feet surface, 1-8 meter burner	3.30	.30	3.00
800 feet surface, 5-32 meter burner	4.40	.40	4.00
1,200 feet surface, 1, 1-8 and 1, 5-32 meter burner	5.50	.50	5.00
1,800 feet surface, 2, 5-32 meter burners	6.60	.60	6.00
2,500 feet surface, 2, 5-32 meter burners	7.70	.70	7.00
Cook stoves, private families:			
Cook stoves, 1-8 meter burner	2.50	.25	2.25
Cook stoves, 5-32 meter burner	3.30	.30	3.00
Hotels and restaurants:			
Cook stoves, 1, 5-32 meter burner	3.96	.36	3.60
Cook stoves, 1, 1-8 and 1, 5-32 meter burner	5.50	.50	5.00
Cook stoves, 2, 5-32 meter burner	6.60	.60	6.00
Gasoline stoves, per burner	.60	.10	.50
Nursery burners, each	.60	.10	.50
LIGHTS.			
Fifteen-feet Lungren lamps:			
First lamp	2.75	.25	2.50
Second lamp	2.20	.20	2.00
Third lamp	1.65	.15	1.50
Where lamps are furnished by the company:			
First lamp	3.85	.35	3.50
Second lamp	2.75	.25	2.50
Third lamp	2.20	.20	2.00
Argand lamp, single light	.50	.10	.40
Saloons, club and billiard rooms, each burner	.50	.10	.40
Stores, offices, etc.:			
10 lights or less, each	.40	.05	.35
Over 10 lights, each	.35	.05	.30
Private houses:			
4 lights or less, each	.35	.05	.30
Over 4 lights, each	.30	.05	.25

NATURAL GAS IN MICHIGAN.

Gas has been found at one or two localities in Michigan, but not in sufficient quantities at the close of the year 1886 to give the occurrence much commercial importance. The wells at Port Huron are some 500 feet deep, and it is reported that the gas exhibits a closed pressure of 180 pounds. It is used chiefly for domestic purposes and in the manufacture of salt. Gas, however, has not been wholly unknown in this region, it having frequently been found at depths varying from 80 to 150 feet, but not, until recently, in large quantities.

NATURAL GAS IN IOWA.

Gas in considerable quantities has been found in the town of Hearndon, Guthrie county, Iowa, some 55 miles northwest from Des Moines. The first well was struck in October, and still yields large quantities of gas. The gas was struck at the depth of 145 feet. Since this time four other wells have been put down, all of which have found the gas at about the same depth. One well has been sunk 228 feet, the gas being struck at about 145 feet, and in three other places, as the drill descended. In another well the gas was struck at 208 feet. But little information has been received as to the character of the strata through which the drill penetrated. The covering of the gas reservoir seems to be clay. Near the surface there are about 15 feet of yellow clay, and below this some 64 feet of blue clay.

NATURAL GAS IN KANSAS.

The only district in Kansas in which, as yet, gas has been found in sufficient quantities to justify its use, is in the counties along the eastern border of the State, in Miami, Linn, Bourbon, and possibly others. Gas has also been found in Washington and Marshall counties on the Nebraska border, and it is possible that it may be found in the shales and sandstones of the western part of the State. It is in the eastern tier of counties, say, from Atchison to Cherokee, and especially in the three counties above named, that we are to look for commercial supplies of gas.

The surface outcrop on the eastern border of Kansas has two lines of demarkation, forming three distinct geological divisions. The first line occurs near the extreme southeastern corner of the State, where the outcrop of the sub-Carboniferous strata is bounded by a line drawn from northeast to southwest, parallel with the Ozark range of mountains. To the north and west of this line the Lower Coal Measures form the surface rocks and extend north until near the east center of Miami county, where another line of demarkation occurs between the Lower and Upper series of Coal Measures, which trends southwest parallel to the former; thence the Upper Coal Measures extend to the north line of the State, and west to the Big Blue river. The dip of the rocks in all this region trends about due northwest, or in the direction of a line drawn at a right angle with the Ozark uplift, and amounts to about 6 feet per mile, when following the true direction of the dip.

Though gas had been found in prospecting for oil, and had been noticed escaping from springs as early as 1864, and again in 1874, it was not until 1882 that what could be termed a gas well was struck at Paola, in Miami county. In 1865 the Saint Louis or Ernstein Oil Company bored two wells for oil some 10 miles east of Paola. The tools were lost at 700 feet, the wells showing some oil. In 1882 a well was bored on the Westfall place, near Paola, which gave gas in considerable quantity. Quite a number of wells have since been bored near the town, but three wells on the Westfall place are the sources which are now supplying the gas to Paola, some 7 miles distant. The Paola Gas Company, which owns these wells, was supplying, on December 31, 1886, 87 stores, offices, and private dwellings from their six wells. They had, at this time, 42,240 feet of pipe laid; the charges to consumers were from $2 to $9 per month for heating stoves, the latter being for house furnaces; $2 to $3.50 per month for cooking stoves, and 25 to

40 cents per month each for lights, the charge for lights depending upon the number used.

No. 1, well exclusive of the surface deposits of drift and alluvium, penetrates an aggregate thickness of 31 feet of limestone, 58 feet of sandstone, 206 feet of colored shales, and 10 feet into the gas rock, which the drill showed to be 35 feet thick in well No. 2. This gas rock is of a light-gray color, quite porous and composed of very minute particles of sand, with no more calcareous matter than sufficient to cause a very slight adhesion of the particles. Well No. 7 of the Paola Gas Company, like all its predecessors, is situated on the Westfall farm, which contains 160 acres, but unlike the others is on a different level, being on a ridge about 75 feet, and as it pierces the gas rock to the depth of 20 feet, it shows that at this point the gas rock has about 25 feet higher elevation than the others, indicating that this well tapped the rock at or near the crown of an anticlinal fold. This is a thoroughly dry well and largely excels all others previously sunk in this vicinity in the amount of gas it furnishes, generating a pressure of 110 pounds per square inch in 4 minutes and 50 seconds, when the casing head, which was imperfectly adjusted, gave way. The closed pressure of these wells varies from 40 to 60 pounds, this pressure being obtained not at the wells, but after the passage of the gas through 7 miles of 3½ inch pipe. This company has bored one well, No. 8, 1½ miles east of the city limits of Paola, which showed, as stated above, a pressure of 110 pounds per square inch. It is the intention of this company, in view of the belief that they can secure gas in greater quantities, to bore a well to the depth of 2,000 feet. At Wyandotte, in this county, there are two or three small wells, the gas from which is being used under boilers.

Southwest of Fort Scott, in Bourbon county, on the banks of the Marmaton river, gas has been escaping for many years. The Fort Scott Economy Fuel Company has drilled four wells, three of which are yielding a supply of gas. The three productive wells form the apices of a triangle nearly equilateral, whose sides are just under 700 feet in length. The distance from town is slight, as the farm abuts on the city boundaries. Mains have been laid, and the gas is now in use in Fort Scott hotels, private houses, etc. The chief gas horizon at Fort Scott is sandstone from 275 feet to 295 feet in depth.

Gas is also found at various other points in the State, as at La Cygne, in Linn county; at Mound City, in the same county; at Iola, in Allen county; at Girard, in Crawford county; at Mound Valley, in Labette county; and at Ottawa, in Franklin county; but these deposits had assumed no commercial importance at the close of the year 1886.

NATURAL GAS IN UTAH.

The report that natural gas had been discovered in quantities at Salt Lake City seems to have been without any foundation, except the fact that slight amounts of gas came up along with, or alternately with, water in some one or two of the driven wells in the lower part of the city. The gas rises at short, intermittent intervals to the amount of not over 2 or 3 cubic feet to each well in five minutes, and then stops for an interval.

At Lake Shore, the old Utah Central bathing resort, it is stated that natural gas is being used in the manufacture of salt. Four large jets of natural gas are burned under a vat 5 by 12 feet, and 14 inches deep. The gas was struck when drilling for water. At Ogden City are two wells, bored for water to the depth of 178 feet, from which a small amount of gas is produced. The wells were sunk for supplying water for irrigation, and when they were completed it was discovered that considerable gas came up with the water. Two gasometers were constructed and the gas used in lighting the residence of the owner of the well, the gas being sufficient to supply some twenty lights from burners using 2 to 5 feet per hour.

STRUCTURAL MATERIALS.

BY WM. C. DAY.

THE BUILDING INDUSTRY IN GENERAL.(a)

The year 1886 opened with encouraging prospects for the building industry generally throughout the country, but scarcely were active operations fairly under way when the widely-spread labor disturbances which have made the year memorable began, making themselves felt in a number of the largest cities, both in the east and west. As soon as the labor troubles were inaugurated, many building enterprises were abandoned, and many more were postponed until the differences between labor and capital should be smoothed over. The building operations which were carried on during the period of disturbance were in most cases attended by small margins of profit to all concerned, and in some instances by disaster to contractors and to those who supplied material. Business was dull for all branches of trade connected with the building industry; demand for material was low and irregular, and values fell off quite considerably.

This period of general depression was, however, followed by one of the greatest activity, and while it is true that many building enterprises contemplated at the beginning of the year were abandoned and not taken up again during 1886, still the fact remains that at the close of the year the showing made by the principal cities of the country was a large increase in the amount of building done, as compared with 1885.

The kind of buildings most extensively erected during this period of activity consisted of residences, the demand for which, in view of our rapidly increasing population, is naturally at all times imperative.

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a In the preparation of this report the sources drawn upon for information have included a large number of quarrymen, producers of all kinds of structural materials, dealers, architects, contractors and builders, building inspectors and commissioners, trade journals, statistical publications from various States, etc. Sincere thanks are due to the large number of correspondents whose replies to inquiries addressed them were so courteously and conscientiously given, and to whom the value of the report is largely due. Information in regard to the Rocky Mountain division was furnished, as in former reports, by Mr. F. F. Chisolm, and that for the Pacific coast by Mr. C. G. Yale. Especial acknowledgments are hereby tendered to Mr. Robert H. Dalby and also to Mr. L. E. Schlauch, both of Slatington, Pennsylvania, for valuable information in regard to slate; to Mr. S. L. Merchant, of New York, for aid in preparing the report on cement; to Dr. J. M. Safford, State geologist of Tennessee; Prof. Thomas B. Bancroft, chief inspector of mines in Ohio; Mr. O. C. S. Carter, of Philadelphia, and to Mr. Henry J. Biddle, of Philadelphia.

Only a few cities show positive evidence to the effect that building operations for the entire year were curtailed owing to the influence of labor troubles, although, of course, the frequently-propounded question, "What would have been the amount and value of building done in 1886 had there been no serious interruption?" is one which no one can satisfactorily answer.

The following table has been constructed on the basis of statistics furnished by the building inspectors and commissioners of the various cities considered. The figures represent in general the number of permits issued during the year and the estimated values of the buildings for which permits were given. Although all the buildings for which permits are issued are not completed during the same year, still this fact does not diminish the value of the figures as showing the comparative condition of the industry in different years:

Number and value of the buildings for which permits were issued in twenty cities during the years 1884, 1885, and 1886.

Cities.	Frame buildings.		Brick buildings.		Total for year.	
	Number.	Value.	Number.	Value.	All buildings.	Value.
1884.						
Portland, Maine	56	....	25	....	81	$210,000
Boston, Massachusetts (a)	1,123	$3,078,145	(b) 312	$5,400,775	1,435	8,478,920
Fall River, Massachusetts	416	....	7	....	423	866,450
Providence, Rhode Island	393	1,145,840	16	239,400	409	1,385,240
Bridgeport, Connecticut	240	360,000	20	100,000	260	460,000
Brooklyn, New York	1,304	....	1,435	....	2,739	12,672,334
New York City, New York	....	....	....	....	2,897	41,461,208
Wilmington, Delaware	....	....	326	730,225	....	....
Washington, Dist. Columbia	151	94,784	1,042	3,293,070	1,193	3,387,854
Richmond, Virginia	186	154,200	226	733,200	412	887,400
Saint Paul, Minnesota (c)	2,075	1,667,035	269	2,387,490	2,344	4,054,525
Saint Louis, Missouri	620	371,136	1,989	6,393,655	2,609	6,764,791
Topeka, Kansas	603	....	68	....	671	406,671
1885.						
Portland, Maine	67	....	14	....	81	250,000
Boston, Massachusetts (a)	1,372	4,552,538	(b) 348	6,218,800	1,720	10,771,338
Fall River, Massachusetts	200	....	10	....	(d) 212	330,975
Providence, Rhode Island	452	1,273,745	13	364,700	465	1,638,445
Bridgeport, Connecticut	280	420,000	25	125,000	305	545,000
Brooklyn, New York	1,261	....	1,377	....	2,638	11,465,795
New York City, New York	....	....	....	....	3,368	45,374,013
Wilmington, Delaware	....	....	280	668,590	....	....
Philadelphia, Pennsylvania	....	....	....	....	6,326	....
Pittsburgh, Pennsylvania	795	....	647	....	1,442	3,030,429
Baltimore, Maryland	....	....	....	....	2,970	3,500,000
Washington, Dist. Columbia	325	195,255	1,333	3,297,252	1,658	3,492,507
Richmond, Virginia	244	124,900	238	873,400	(e) 483	(f) 1,021,300
Galveston, Texas	116	177,630	7	123,500	123	301,130
Detroit, Michigan	1,328	1,437,819	563	2,040,500	1,891	3,478,319
Chicago, Illinois	....	....	....	....	4,638	24,530,125
Saint Paul, Minnesota (c)	2,964	2,238,026	385	1,921,182	3,349	4,159,208
Saint Louis, Missouri	510	456,825	2,160	6,400,779	2,670	6,857,604
Omaha, Nebraska	600	957,318	60	1,788,145	(d) 662	(g) 2,865,463
Topeka, Kansas	696	....	75	....	771	494,291

a Values estimated for completed buildings.
b Number of brick, stone, and iron buildings for which permits were issued.
c The total values for Saint Paul include "additions, alterations, and repairs."
d Includes 2 stone buildings.
e Includes 1 stone building.
f Includes value of 1 stone building, $23,000.
g Includes value of 2 stone buildings, $120,000.

Number and value of the buildings for which permits were issued, &c.—Continued.

Cities.	Frame buildings.		Brick buildings.		Total for year.	
	Number.	Value.	Number.	Value.	All buildings.	Value.
1886.						
Portland, Maine	91	....	32	....	123	$300,000
Boston, Massachusetts (a)	1,353	$3,992,792	(b) 346	$8,813,100	1,699	12,805,892
Fall River, Massachusetts	205	....	22	....	(c) 230	666,750
Providence, Rhode Island	407	1,194,607	12	168,750	419	1,363,357
Bridgeport, Connecticut	350	630,000	34	170,000	384	800,000
Brooklyn, New York	1,774	....	2,215	....	(d) 3,990	20,318,485
New York City, New York	....	....	....	....	4,095	58,750,733
Wilmington, Delaware	....	....	192	622,983	....	....
Philadelphia, Pennsylvania	....	....	....	....	7,561	....
Pittsburgh, Pennsylvania	847	....	568	....	1,415	2,401,809
Baltimore, Maryland	....	....	....	....	2,632	3,100,500
Washington, Dist. Columbia	392	295,689	1,802	4,412,240	2,194	4,707,929
Richmond, Virginia	137	125,000	204	528,600	341	653,600
Galveston, Texas	181	394,400	5	104,000	(e) 187	(f) 623,400
Detroit, Michigan	1,533	1,561,864	520	2,335,350	2,053	3,897,214
Chicago, Illinois	....	....	....	....	4,664	26,868,375
Saint Paul, Minnesota (c)	3,017	2,488,271	553	3,567,571	3,570	6,055,842
Saint Louis, Missouri	491	405,892	1,732	5,916,978	2,223	6,322,870
Omaha, Nebraska	1,150	2,224,390	145	2,950,750	1,295	5,175,140
Topeka, Kansas	576	....	69	....	645	621,596

a Values estimated for completed buildings.
b Number of brick, stone, and iron buildings for which permits were issued.
c Includes 3 stone buildings.
d Includes 1 iron building.
e Includes 1 stone buildings.
f Includes value of 1 stone building, $125,000.

Adding together the figures for the values of "all buildings" for all cities except Wilmington and Philadelphia, data for which are wanting, the total $124,105,942 is the result for 1885, while for 1886 the corresponding total is $155,433,492. An increase during 1886 of $31,327,550, or 25.2 per cent., over 1885 is evident. Omitting New York city from the calculation, the totals are $78,731,929 for 1885, and $96,682,759 for 1886, an increase for the latter year of $17,950,830, or 22.8 per cent.

In order to convey a general idea of the condition of the building industry in the United States during 1886, the following information relative to a number of the more or less important cities and towns in the country is presented.

MAINE.

Bangor.—This city is the center of a large lumber-producing district, and this product is naturally much more extensively used than brick, stone, or other building materials. Comparatively few of the finer or more expensive buildings are erected. During 1886, dwellings of moderate cost formed the class of structures most largely built. There being a number of slate quarries near the city, slate for roofing purposes is cheap and is freely used. Ornamental building materials find little favor and it does not seem likely that there will be any great demand for them in the near future.

Portland.—The following table shows the progress made in building during the last three years:

Number and value of buildings erected in Portland, Maine, 1884 *to* 1886.

Kinds of buildings.	1884.		1885.		1886.	
	Number.	Value.	Number.	Value.	Number.	Value.
Frame buildings	56	....	67	....	91	....
Brick buildings	25	....	14	....	32	....
Total	81	$210,000	81	$250,000	123	$300,000

The building stone used in Portland consists chiefly of red and buff sandstone quarried at Long Meadow, Massachusetts, and granite taken from quarries at Biddeford, Red Beach, and Hallowell, Maine, and Conway, New Hampshire. For roofing purposes slate is quite freely used, and the demand for it is increasing; tiles are not much employed, the climate being unfavorable to their adoption.

As shown in the foregoing table, frame structures formed the large majority of buildings erected during 1886; brick is manufactured from local clay deposits; the use of ornamental brick and tile is gradually increasing.

VERMONT.

Burlington.—Stone for foundations is quarried within the city limits. Buildings of the better class are of brick, trimmed with brown stone. During the past year dwellings of an average cost of $3,000 formed the class most largely constructed.

Slate, on account of its cheapness, is the roofing material commonly used even on unpretentious structures; demand for it is increasing. For flat roofs tin is employed; roofing tiles are not known. The use of ornamental brick is not increasing, stone trimmings being preferred in the best buildings.

NEW HAMPSHIRE.

Manchester.—For the better class of buildings in this city, red brick, with granite trimmings for exterior work, is generally used. The stone in common use is granite, quarried locally and at Concord, New Hampshire. During 1886 dwellings formed the class of buildings most largely erected. Slate for steep roofs is freely used, with increasing demand; tin and asphalt composition on flat roofs.

MASSACHUSETTS.

Boston.—The following table shows the comparative condition of the building industry in this city for the past five years:

Number of wooden, brick, stone, and iron buildings for which permits were issued.

Kinds of buildings.	1882.	1883.	1884.	1885.	1886.
Wooden buildings	841	1,005	1,123	1,372	1,353
Stone and iron buildings	235	236	312	348	346
Total	1,076	1,241	1,435	1,720	1,699

Estimated cost of completed buildings.

Kinds of buildings.	1882.	1883.	1884.	1885.	1886.
Wooden and frame buildings	$2,379,278	$1,670,806	$3,078,145	$4,552,538	$3,992,792
Completed brick buildings	4,932,640	5,864,577	5,400,775	6,218,800	8,813,100
Total	7,311,918	7,535,383	8,478,920	10,771,338	12,805,892

From this table it is evident that while there has been a decrease in the number of buildings erected in 1886 as compared with 1885, the total value is over $2,000,000 greater for 1886 than for 1885, showing, of course, a decidedly higher average value for the buildings of 1886.

The foundations of buildings are usually granite; for superstructures and for ornamental trimmings in brick buildings, etc., sandstones from Nova Scotia, Long Meadow, Massachusetts, and from Ohio are quite extensively employed. For roofing purposes, slate, tin, composition of tar and gravel, and, recently, copper are used.

No increase over the present consumption of ornamental brick and tile is anticipated since the present tendency is towards the use of stone for ornamental work, and toward greater simplicity in construction.

Fall River.—The following table gives an idea of the progress made in building during the past three years:

Kinds of buildings.	1884.		1885.		1886.	
	Number erected.	Value.	Number erected.	Value.	Number erected.	Value.
Frame buildings	416	....	200	....	205	....
Brick buildings	7	....	10	....	22	....
Stone buildings	....	....	2	....	3	....
Total	423	$866,450	212	$330,975	230	$666,750

A considerable falling off for 1885 and 1886, as compared with 1884, is evident, although a marked gain for 1886 over 1885 is also apparent.

CONNECTICUT.

Bridgeport.—The following table gives a statement of the building industry for the past three years:

Kinds of buildings.	1884.		1885.		1886	
	Number erected.	Value.	Number erected.	Value.	Number erected.	Value.
Frame buildings	240	$360,000	280	$420,000	350	$630,000
Brick buildings	20	100,000	25	125,000	34	170,000
Total	260	460,000	305	545,000	384	800,000

As is evident from this table, frame buildings formed a large majority of the buildings erected during 1886. The building stone consumed consists of gneissoid rock of good quality quarried locally, Connecticut River brownstone, and also brown sandstone from quarries at Springfield, Massachusetts, and Portland, Connecticut.

Dwelling houses were in greatest demand during 1886, although some factories were erected. Slate is the favorite roofing material for large buildings, and the demand for it is always good, although it cannot be said to increase rapidly; that from Bangor, Pennsylvania, seems to be preferred, although some from Vermont is also used. The use of ornamental brick and tile has increased markedly during the past few years.

Hartford.—For buildings of the better class, brick with brownstone trimmings is largely used. Brown sandstone from Portland, Connecticut, is very popular for trimmings and ornamental stonework; granite from various places on the coast of Connecticut, Massachusetts, and Rhode Island is employed to some extent. For roofing purposes, slate, the demand for which is gradually increasing, is in common use for the better class of buildings; tin and gravel and tar composition are used for flat roofs. The use of ornamental brick and tile is reported as increasing.

New Haven.—In this city, for all ordinary brick work, brick manufactured at North Haven, Connecticut, is extensively employed, while in the best brick buildings pressed brick from Philadelphia and Trenton is liberally made use of for facings; black mortar in brick work is frequently used. Terra cotta has as yet been but sparingly introduced, but ornamental brick is quite popular. The stone employed consists of brown sandstone from Portland, Connecticut, bluestone from the North River quarries, and granite from quarries in Maine, New Hampshire, and Rhode Island. During 1886 small private dwellings and flats took the lead among the various classes of buildings erected. Slate is the favorite roofing material, that from Pennsylvania being preferred; tile is not used; no shingles are allowed on roofs within the city.

RHODE ISLAND.

Providence.—The state of the building industry is indicated by the following table:

Kinds of buildings.	1884.		1885.		1886.	
	Number erected.	Value.	Number erected.	Value.	Number erected.	Value.
Frame buildings	393	$1,145,840	452	$1,273,745	407	$1,194,607
Brick buildings	16	239,400	13	364,700	12	168,750
Total	409	1,385,240	465	1,638,445	419	1,363,357

Quite a marked falling off both in number and value of buildings for 1886 is evident. This is ascribed by local authorities to the influence of strikes and other labor troubles occurring between May and the early part of July.

For buildings of the better class, brick, with brown-stone trimmings, is generally employed, while granite from Westerly, Rhode Island, and Oneco, Connecticut, is used to some extent. The popular roofing materials are slate and tin, with increasing demand for slate. Ornamental brick is favorably regarded, but tile is not so freely used.

NEW YORK.

Albany.—Brick, with pressed brick and Long Meadow sandstone trimmings and facings, is the favorite building material for the finer structures in this city.

Besides the Long Meadow stone, bluestone, from Schenectady, New York, sandstone from Connecticut and New Jersey, and granite from Maine are used.

The class of buildings in greatest demand seems to have been, during 1886, flats for no more than three families, and two-story basement houses for single families.

Slate and tin are the favorite roofing materials. The demand for slate is decidedly increasing, as is also that for ornamental brick and tile.

Brooklyn.—The following table shows the progress in building for the past three years:

Kinds of buildings.	1884.		1885.		1886.	
	Number erected.	Value.	Number erected.	Value.	Number erected.	Value.
Frame buildings	1,304	....	1,261	....	1,774	....
Brick buildings	1,435	....	1,377	....	(*a*)2,216	....
Total	2,739	$12,672,334	2,638	$11,465,795	3,990	$20,318,485

a Includes one iron building.

A heavy gain over 1885, both in number of buildings and in value, is apparent from this table.

The stone used in combination with brick is chiefly brownstone from quarries in Connecticut, Wyoming Valley bluestone, and granite from Quincy. Tenement flats and small dwellings were most largely erected during the year. Slate and tin are the chief roofing materials, but tile is said to be in considerable demand. The use of ornamental brick, tile, and terra cotta is said to have increased very largely.

New York.—The following table will serve to show the extent and the kind of building done in New York during 1886:

Plans and specifications for new buildings filed and acted upon in New York during the year ending December 31, 1886.

Kinds of buildings.	Number.	Estimated cost.
Dwelling houses:		
Estimated cost over $50,000	5	$395, 000
Estimated cost between $20,000 and $50,000	163	3, 816, 500
Estimated cost less than $20,000	1, 144	13, 089, 700
Flats, estimated cost over $15,000	1, 174	23, 481, 400
Tenement houses, estimated cost less than $15,000	448	5, 415, 900
Hotels and boarding houses	5	523, 900
Stores:		
Estimated cost over $30,000	28	2, 066, 000
Estimated cost between $15,000 and $30,000	18	402, 000
Estimated cost less than $15,000	90	280, 848
Office buildings	26	1, 389, 100
Manufactories and workshops	160	2, 608, 400
School houses	8	705, 000
Churches	19	804, 950
Public buildings:		
Municipal	14	1, 009, 500
Places of amusement	12	593, 000
Stables	131	663, 800
Frame buildings in twenty-third and twenty-fourth wards	557	1, 353, 480
Other frame structures	93	152, 255
Total	4, 095	$58, 750, 733

In 1886, 3,750 buildings were commenced, and 3,250 were completed; 2,677 were in progress on January 1, 1887.

Number and estimated cost of proposed new buildings in New York from 1875 *to December* 31, 1886.

Years.	Number.	Estimated cost.
1875	1, 406	$18, 226, 870
1876	1, 379	15, 903, 880
1877	1, 432	13, 365, 114
1878	1, 672	15, 219, 680
1879	2, 065	22, 567, 322
1880	2, 252	29, 115, 335
1881	2, 682	43, 391, 300
1882	2, 577	44, 793, 186
1883	2, 623	44, 304, 638
1884	2, 897	41, 461, 208
1885	3, 368	45, 374, 013
1886	4, 095	58, 750, 733
Total	28, 448	$392, 473, 279

The large increase of 1886 over 1885 and all previous years is very striking, and, moreover, the average value ($14,346) of the buildings for 1886 is greater than that ($13,472) of the buildings for 1885.

Among the building materials used brick is, of course, the important material constructionally. Granite is extensively employed in public buildings and large business houses. The Connecticut brown sandstone, which has been so popular for many years, is still extensively employed, also a red sandstone quarried at Belleville, New Jersey. Other brownstones are used to a moderate degree. Among these may be mentioned that quarried in the Potomac range in the District of Columbia, and also stone of fine quality from North and South Carolina. Among the sandstones of recent adoption in New York may be mentioned the stone imported from Scotland, including two varieties, one known as the "Corsehill freestone," and the other the "Gatelaw bridge sandstone;" both are of a brownish-red color; the former is fine and the latter coarse grained. The "Dorchester freestone" from New Brunswick, and Ohio sandstone, from Berea, have been popular for some years.

The study for strong and effective contrasts indulged in for some ten years past has resulted in the introduction of a considerable variety of stones, chiefly quarried in the South and West. Among these may be mentioned the oolitic limestone from Bedford, Indiana, as well as from Kentucky, Tennessee, and Georgia. Marble from Vermont and Georgia is used to a liberal extent.

A very great variety of roofing materials is employed. Slate and tile are abundantly used, but tin is perhaps most commonly preferred.

Large quantities of ornamental brick and tile are used, but can hardly be said to increase at present in the best class of buildings, for which carved work in stone (largely marble) is becoming popular.

NEW JERSEY.

Elizabeth.—For foundations of buildings, trap rock, from Schooley's mountain, New Jersey, is generally used. The first story of private dwellings is frequently built of brick or stone; the upper stories of wood covered with shingles. Brownstone, from Belleville, New Jersey, is used for trimmings and ornamental work. During 1886 the buildings erected in greatest number consisted of private residences, costing from $5,000 to $10,000.

Shingles, as roofing material, are generally preferred, while slate is used to some extent, with no perceptible increase in demand at present. The use of ornamental brick and tile, while not very extensive, is steadily growing.

Hoboken.—Brick, with brownstone trimmings, is the material most generally employed for the better class of buildings. For foundations, trap rock, quarried on the Palisades immediately west of Hoboken, is the material customarily used.

During 1886 tenement houses, large flats, and small and inexpensive dwellings for one family formed the great majority of buildings erected.

For roofing purposes tin was the material by far most freely employed. Comparatively little slate was used, and the demand for it is not very great, nor is it perceptibly increasing.

Ornamental brick and tile are employed, but for the finest buildings erected there is a growing preference for carved work in stone.

Newark.—New Jersey common brick is the material used for walls and behind the facings in buildings of the better class; North River and Hackensack brick is used for the facing of rear walls, and Trenton brick for facing on street fronts; for trimmings, Trenton and Philadelphia molded brick, Perth Amboy terra cotta, and Belleville and Newark, New Jersey, brown sandstone. Small private dwellings were in greatest demand in 1886, but a number of large factories were in course of erection; a number of handsome private residences were completed. Slate is used on high-pitched roofs of buildings of the better class, shingles on cottages; tin is generally employed for flat roofs. The increase in use of ornamental brick and tile is said to have been quite marked.

Paterson.—The buildings of the better class erected during 1886 consisted of frame structures in greatest number and combinations of brick and stone. The stone used is brown sandstone quarried at Paterson, Belleville, and Little Falls, New Jersey.

Shingle, slate, and, to a very limited extent, tiles were used for roofing purposes. The demand for slate is increasing. Ornamental brick and tile are gradually coming into use.

DELAWARE.

Wilmington.—The state of the building industry for the past three years is indicated by the following table:

Kinds of buildings.	1884.		1885.		1886.	
	Number erected.	Value.	Number erected.	Value.	Number erected.	Value.
Brick buildings	326	$730,225	280	$668,590	192	$622,983
Stone buildings	1					

PENNSYLVANIA.

Philadelphia.—The following table gives the number and kind of buildings erected in 1885 and 1886:

	Stories.	1885.	1886.
Dwelling houses	2	4,113	4,850
	3	1,286	1,669
	4	7	6
Stores and dwellings	2	105	128
	3	157	203
	4	2	1
	5	....	3
	6	....	3
Stores	2	17	29
	3	13	7
	4	12	6
	5	5	10
	6	1	4
	7	....	1
Banking buildings	....	2	3
Churches and chapels	....	26	24
College buildings	....	....	1
Factories and foundries	....	71	79
Home buildings	....	3	4
School-houses	....	10	15
Other miscellaneous buildings	....	496	515
Total	....	6,326	7,561
Alterations and additions	....	1,638	1,639

No data as to the value of the buildings erected could be obtained, but judging from the much greater number of buildings erected in 1886 and also from their more pretentious character in many cases, it is plain that the value for 1886 must have markedly exceeded that for 1885.

For foundations of buildings Conshohocken limestone is in common use; for superstructures brick is of course the standard material. Among the stones most abundantly used for superstructures and in combination with brick for ornamental purposes may be mentioned, brown sandstone from Hummelstown, Pennsylvania, and from various quarries in New Jersey, Connecticut, and Ohio. Indiana limestone is quite extensively used. Ohio limestone is also used, but to a less extent; granite from Quincy and Cape Ann is frequently employed.

For roofing purposes tin is the material most in demand, as the majority of the roofs are flat; for steep roofs Pennsylvania slate is liberally employed and the demand for it is increasing, while tile for exterior work seems to be losing ground, although largely used for interior ornamentation. Ornamental work in general is not so freely indulged in as formerly, and better taste is displayed.

Pittsburgh.—The state of the building industry for the past two years is indicated by the following table:

Kinds of buildings.	1885.		1886.	
	Number.	Value.	Number.	Value.
Frame buildings	795	....	847	....
Brick buildings	647	....	568	....
Total	1,442	$3,030,429	1,415	$2,401,809

Dwellings and manufacturing establishments have taken the lead among the buildings erected in 1886. A new court house was begun in 1885 and was nearly completed in 1886. It is built of granite from Worcester, Massachusetts, and its cost is $1,850,000. A new jail of the same material was completed in 1886 at a cost of $400,000. A new post-office is in course of erection.

Among the building stones in common use in Pittsburgh may be mentioned the following: Sandstone from Beaver county, Pennsylvania, and from Cleveland, Ohio.

Slate is the leading material for all steep roofs. Brick and tile, for exterior ornamentation, are being superseded, to some extent, by stone-work. Considerable injury to the building industry was sustained from strikes during the year.

MARYLAND.

Baltimore.—In 1885 permits were issued for the erection of 2,970 and in 1886 for 2,632 buildings. No figures for the detailed value of these buildings could be obtained; from the returns of the assessors it appears that about 70 per cent. of the buildings for which permits were issued were completed during the year; $3,500,000 per year is believed to cover the value of the completed buildings, but for 1886 the actual amount was probably less than this figure.

Most of the buildings erected are of brick. The finer residences are frequently faced with white Maryland marble or brown sandstones, from various localities. Pressed brick of fine quality is used in very large quantity, and ornamental brick and tile are continually increasing in favor. Tin is very largely used as roofing material, as also is slate for steep roofs. Tile is employed to a limited degree.

DISTRICT OF COLUMBIA.

Washington.—The following table shows the state of the building industry for the past three years:

Kinds of buildings.	1884.		1885.		1886.	
	Number.	Value.	Number.	Value.	Number.	Value.
Frame buildings	151	$94, 784	325	$195, 255	392	$295, 689
Brick buildings	1, 042	3, 293, 070	1, 333	3, 297, 252	1, 802	4, 412, 240
Total	1, 193	3, 387, 854	1, 658	3, 492, 507	2, 194	4, 707, 929

The building stones used consist largely of Potomac red sandstone quarried near Washington and brown sandstone from Hummelstown, Pennsylvania. Brick of very fine quality and appearance is used for street facings. Slate is extensively used, and the demand for it is increasing. No increase in use of ornamental brick and tile in the better class of buildings is likely, although both are at present quite liberally used.

VIRGINIA.

Richmond.—The state of building in Richmond is shown by the following table:

Kinds of buildings.	1884.		1885.		1886.	
	Number.	Value.	Number.	Value.	Number.	Value.
Frame buildings	186	$154, 200	244	$124, 900	137	$125, 000
Brick buildings	226	733, 200	238	873, 400	204	528, 600
Stone buildings	....	....	1	23, 000	....	....
Total	412	887, 400	483	1, 021, 300	341	653, 600

Granite from quarries near Richmond and from other parts of the State is in use, also brown sandstone from Pennsylvania. Slate quarried in the State is the favorite material for steep roofs; very little tile is used; tin is the common material for flat roofs.

GEORGIA.

Atlanta.—The building stones most used are: granite taken from quarries 16 miles from the city; limestone from Indiana, Bowling Green, Kentucky, and Dickson, Alabama; brown sandstone from North Carolina, and marble from the vicinity of Marietta, Georgia. Frame buildings are mostly in demand. Tile roofing is in use on but one house in the city. Georgia and Virginia slate is used to a limited extent on steep roofs. Within the past five years the use of ornamental brick and tile has been increasing.

Savannah.—The stone now used for building purposes is chiefly Alabama limestone; Connecticut brown stone and Georgia granite have been driven out of use almost entirely.

Small frame residences are the buildings most in demand. Tin is almost exclusively used for roofing; no slate is employed. Very little ornamental material is in use.

TENNESSEE.

Memphis.—The building stone chiefly used includes limestone from Dickson, Alabama, sandstone from Mount Sterling, Kentucky, granite from quarries near Little Rock, Arkansas. The best and finest buildings now erected are mainly of brick, and a comparatively recent increase in the use of brick has been attended with a greater indulgence in ornamental brick, tile, and terra cotta. Tin is more largely used than anything else for roofing purposes; but slate, which thirty years ago was used more than at present, is again coming into use, and the demand for it is increasing, though not rapidly.

TEXAS.

Austin.—In this city frame buildings are much more extensively erected than any other class, but stone in combination with brick is used in the finest buildings. The stone most used is magnesian limestone, quarried locally. Granite is quarried in Burnet county and is used to some extent. The bricks in use are of a yellowish color, but of good quality. Tin is most freely used as roofing material, but slate is also employed, while copper is an experiment and has been used in the new capitol building. There is a steady increase in the use of ornamental brick and tile.

Galveston.—The following table shows quite a marked increase in building during 1886:

Kinds of buildings.	1885.		1886.	
	Number.	Value.	Number.	Value.
Frame buildings	116	$177,630	181	$394,400
Brick buildings	7	123,500	5	104,000
Stone buildings	....	....	1	125,000
Total	123	$301,130	187	$623,400

The stone residence included in the above table is not yet completed; it is the only stone building in the city; the stone used in it is a hard and close grained sandstone from quarries in Brown county, central Texas. The trimmings used consist of granite from Burnet county, the same stone as that used in the new capitol.

As the nearest stone suitable for building purposes is more than 200 miles from the city, and freight rates are high, it is not probable that the use of stone will rapidly increase.

A large portion of the residence part of the city was destroyed by fire in November, 1885, and the owners of small houses almost immediately rebuilt structures of the same kind as those destroyed; hence the low average value, $1,530, of the buildings erected in 1885. During 1886 a much better class was put up, and the prospects are good for further improvement in quality as well as in number during the present year.

ARKANSAS.

Little Rock.—In this city limestone from Dickson, Alabama, and oolitic limestone from Kentucky are used chiefly; granite from quarries near the city is also employed, but not to a great extent, owing to cost of cutting. Brick is used for stores and for the best residences. Frame buildings have been in greatest demand.

Tin is used for all flat roofs, but slate quarried near the city will probably be more and more freely used for steep roofs. Ornamental brick and tile have been used only within the past two years; their use is increasing continually, though the quantity now used is not great.

KENTUCKY.

Louisville.—Among the various kinds of stone used in Louisville may be mentioned the following: Oolitic limestone from Bedford, Indiana, also from Salem and Bowling Green, Kentucky. Buena Vista, Ohio, Lake Superior, and Long Meadow sandstones are used to a limited degree. Brick with stone facings or with ornamental brick and tile trimmings is largely used in buildings of the better class. Tin and slate are the favorite roofing materials. It cannot be said that there is a marked increase in the use of slate.

OHIO.

Cincinnati.—For all ordinary works in this city the local limestone is used. For ornamental purposes Buena Vista, Berea, Amherst, and Cleveland sandstones are liberally employed; also Dayton, Ohio, and Bedford, Indiana, limestone. Granite, chiefly from Maine and Missouri, is used to some extent. For roofing purposes the usual varieties of materials used in large cities are employed here. The slate used is taken largely from the Virginia quarries. The use of ornamental brick and tile is extensive and increasing.

Cleveland.—The stone used for building in this city includes a number of the Ohio sandstones, particularly that from Amherst and Berea; also sandstone from the Lake Superior region, and to a small extent from Pennsylvania and Massachusetts. For roofing purposes slate, tin, tar and gravel, and copper are used. Tile for roofing is unpopular. Ornamental brick and tile have not been very largely employed and no marked increase is perceptible.

MICHIGAN.

Detroit.—The following table gives an idea of the state of building in this city for the past two years:

Kinds of buildings.	1885.		1886.	
	Number.	Value.	Number.	Value.
Frame buildings	1,328	$1,437,819	1,533	$1,561,864
Brick buildings	563	2,040,500	520	2,335,350
Total	1,891	3,478,319	2,053	3,897,214

An increase in the total number of buildings erected and in total value is evident, and also a higher average value for the brick buildings, which were not so numerous in 1886 as in 1885.

For the best buildings erected, ordinary brick, with pressed brick fronts in combination with stone trimmings, is generally employed. Kelly Island (Lake Erie) limestone is employed for foundations, while for facings and trimmings Ohio, Lake Superior, and Ionia, Michigan, sandstones are popular.

For roofing, tin, slate, and asphalt composition are the common materials; tile is only sparingly used. Ornamental brick and tile are being introduced and will probably become quite popular. Terra cotta has been considerably used, but is said to be giving way to stone work.

ILLINOIS.

Chicago.—The following table shows the increase in building in Chicago:

Years.	Number of buildings.	Frontage.		Cost.
		Feet.	Miles.	
1885	4,638	108,850	20.3250	$24,530,125
1886	4,664	112,302	21.1422	26,868,375

For foundations and ordinary work Joliet and Lemont, Illinois, limestone is used; for ornamental work the following are used: Brown sandstone from Connecticut; red sandstone from Long Meadow, Massachusetts; sandstones of all kinds from different sources in Ohio, the Lake Superior region, and, to a less degree and quite recently, from Colorado. Bedford, Indiana, limestone is quite popular. Georgia marble is being introduced with great satisfaction, particularly the pinkish-gray variety. Granite from Maine, Missouri, and Minnesota is largely used.

Brick of all kinds is used in enormous quantities; ornamental materials in general are extensively indulged in.

A great variety of roofing materials is employed, particularly for flat roofs; for steep roofs, slate and tile are liberally used, with, however, considerable opposition to tile from architects.

MINNESOTA.

Minneapolis.—The favorite building-stones used in this city include red sandstone from Lake Superior, brown sandstone from Bayfield, Wisconsin, and a drab variety from Cleveland, Ohio. A considerable quantity of pink granite from Saint Cloud, Minnesota, is used. Some of the best buildings of recent erection have been faced with Rasota stone from Le Sueur county, Minnesota.

The pressed brick in use comes chiefly from Chicago and Saint Louis, though a fair grade from Menominee, Wisconsin, is now being employed to a slight extent.

Business houses are said to have been in active demand during the past year. For roofing materials, composition of tar, gravel, etc., is common on flat roofs. Slate does not enjoy great popularity at present, although its use is becoming more general. Tile is in good repute, but to be efficient in such a cold climate must be laid with extreme care, and thus the cost is made so heavy that extensive use of it, as in many other cities, is not probable.

Saint Paul.—As will appear from a consideration of the following table the building industry in Saint Paul has been quite active during the past three years:

Kinds of buildings.	1884.		1885.		1886.	
	Number.	Value.	Number.	Value.	Number.	Value.
Frame buildings	2,075	$1,667,035	2,964	$2,238,026	3,017	$2,488,271
Brick buildings	269	2,387,490	385	1,921,182	553	3,567,571
Total	2,344	4,054,525	3,349	4,159,208	3,570	6,055,842

The values in this table include "alterations, additions, and repairs," besides the value of the buildings newly erected.

The stone used for ornamental work, trimmings, etc., includes brown sandstone from Bayfield, Wisconsin, and also from various localities in Ohio. Rasota and Kette River sandstones are also popular at present. Brick, with pressed brick facing, is a very popular material for the best buildings. For roofing, tin and composition are used for flat roofs and slate for steep roofs. The demand for slate is decidedly increasing. Ornamental brick and tile, particularly the latter, for interior work are coming more and more into use.

MISSOURI.

Saint Louis.—The following table shows a falling off in the amount of building done in this city during 1886 as compared with 1884 and 1885:

Kinds of buildings.	1884.		1885.		1886.	
	Number.	Value.	Number.	Value.	Number.	Value.
Frame buildings	620	$371,136	510	$456,825	491	$405,892
Brick buildings	1,989	6,393,655	2,160	6,400,779	1,732	5,916,978
Total	2,609	6,764,791	2,670	6,857,604	2,223	6,322,870

It is claimed by local authorities that disastrous strikes reduced the amount of building 35 per cent.

The building stone in use consists of local limestone; sandstone from Warrensburg, Missouri; Lake Superior brown sandstone, and granite from Iron Mountain, Missouri, and from Maine.

Fine bricks, including ordinary, pressed, and ornamental, are manufactured quite extensively in Saint Louis, and are very largely used. Slate, for which there is an increasing demand, is used for roofing purposes to a considerable extent, but tile does not seem to be at all popular.

NEBRASKA.

Omaha.—A liberal increase in the amount of building done in Omaha is shown by the following table:

Kinds of buildings.	1885.		1886.	
	Number.	Value.	Number.	Value.
Frame buildings	600	$957, 318	1, 150	$2, 224, 390
Brick buildings	60	1, 788, 145	145	2, 950, 750
Stone buildings	2	120, 000	....	....
Total	662	2, 865, 463	1, 295	$5, 175, 140

The buildings erected during these two years were as follows:

Designation of buildings.	1885.	1886.
Schools and churches	$92, 600	$214, 900
Manufactories	342, 750	504, 000
Hotels	120, 000	190, 000
Stores and warehouses	701, 000	1, 325, 000
Residences	1, 609, 063	2, 890, 490
Total	2, 865, 413	5, 124, 390

KANSAS.

Topeka.—The following is a statement of the building done in the last three years:

Kinds of buildings.	1884.		1885.		1886.	
	Number.	Value.	Number.	Value.	Number.	Value.
Frame buildings	603	....	696	....	576	....
Brick buildings	68	....	75	....	69	....
Total	671	$406, 671	771	$494, 291	645	$621, 596

IOWA.

Des Moines.—For the finest buildings in this city, brick, with pressed brick fronts and stone trimmings, is chiefly used.

Brick is obtained mainly from Saint Louis ard Chicago, although there is some local manufacture.

For foundations limestone and brick are used. The former is from Earlham, Madison county, Iowa. For trimmings there are in use the following: Sandstones from Carroll county, Missouri, and Cleveland, Ohio; a comparatively small amount of quartzite from Sioux Falls, Dakota, and artificial stone locally manufactured. During the past year frame dwellings have comprised the bulk of the buildings erected, and little artistic work has been done. For the finest residences slate is used for roofing; shingles, of course, for cheap frame buildings. Business buildings are about equally divided between gravel-and-tar composition and tin. Tile is not used for roofing. Ornamental brick and tile are coming more and more into use.

WISCONSIN.

Milwaukee.—The materials most used for buildings of the better class are buff brick and limestone, both produced locally. This limestone is quarried 5 miles west of the city and is, for the most part, of the usual drab color, but a pink variety occasionally found is more highly prized, as its effect in buildings is very agreeable. To some extent sandstones from the Lake Superior region, and to a greater extent from Ohio, are used for facings and trimmings. Joliet limestone is used for large flagging and steps. Red brick and terra cotta are increasing in demand, but none are of local manufacture, owing to absence of the proper clay.

For flat roofs, gravel composition ranging from the cheapest coal tar to the best asphaltum is chiefly used; tin is used to a less extent but still quite extensively. For the best buildings having high pitched roofs, slate, which comes chiefly from Maine and Pennsylvania, but also a fine quality from Michigan is used; for the cheap buildings, shingles are of course employed.

Ornamental brick is new, but its use is increasing.

The amount of building done in 1885 has been estimated at $4,000,000, while that done in 1886 is believed to have been less than that amount. The falling off is ascribed to labor troubles.

COLORADO.

Denver.—The building stone used in Denver consists of lava from Castle Rock and Coal Creek sandstone, both quarried near Denver; sandstone from Armago, New Mexico; red sandstone from Morrison, near Denver, and granite from Platte Cañon and Georgetown, Colorado.

During 1886 there was a marked demand for residences. Tile is not used for roofing purposes. Slate has been used only within the past year and the demand for it is not likely to increase greatly, owing to the expense of shipping from the East, which has thus far been the source of supply. Buildings of the better class have used Philadelphia pressed brick to some extent. Quite recently ornamental tile has been introduced.

CALIFORNIA.

Sacramento.—Buildings of the better class consist of frame structures for dwelling houses, but for a few of these and for the best business houses, brick is used, with pressed brick fronts and granite trimmings.

The stone most used is granite, quarried at the Folsom State prison and at Penryn, Placer county.

For roofing purposes tin is chiefly used on business houses; red-wood shingles are used outside the fire limits; they are very durable and seem to be much liked. Slate is very little used, and tile practically not at all. Ornamental brick is very slightly employed, but terra cotta is used to a considerable extent; it is manufactured at Lincoln, in Placer county.

Los Angeles.—Among the better class of buildings frame structures for dwellings and brick for business houses are erected, with adobe structures for the poorer classes. Until the past year granite has been the stone most used for trimmings, etc., but the demand for a cheaper stone has resulted in the development of several quarries of sandstone of a variety of colors in the foothills and cañons near the city.

The buildings erected during the past year consist chiefly of dwelling houses, small hotels, and lodging houses. For roofing purposes red-wood shingles are principally used for dwellings and tin for business houses. Slate is practically unknown. No ornamental brick or tile is used.

BUILDING STONE.

Production.—The value of the building stone quarried in the United States during the past five years is estimated in the following table:

Value of building stone produced in the United States, 1882 *to* 1886.

Years.	Value.
1882	$21,000,000
1883	20,000,000
1884	19,000,000
1885	19,000,000
1886	19,000,000

As was shown in the report for 1882, the estimate for that year was based upon the census returns of 1880. For the years since 1882 the estimates have been based upon comparisons of the general condition of the industry in the preceding years. The estimate for 1886 was determined as the result of extensive correspondence with quarrymen, architects, builders, dealers, etc., in all parts of the country, and the comparative state of the industry in 1886 and 1885 was thus revealed. While it is true that the total amount of stone quarried was greater in 1886 than in 1885, it is also true that prices in general were lower. The reduction in price was due to a variety of causes, such as naturally increasing competition, efforts to introduce new kinds of stone, or to extend the market to new localities, etc. Another cause was the temporary falling off in demands produced by the labor disturbances from May to July. Prices fell, and did not in all cases recover when active building operations were resumed in the latter part of the summer. Furthermore, it is probable that many building enterprises involving the use of stone for ornamental purposes were postponed until the season of 1887, in the hope of fewer indications of labor troubles. There are, however, many notable exceptions to the foregoing statements implying reduction in demand and in prices, a number of long established and important quarry regions having held their own in regard to price with a good increase in production over 1885.

GRANITE AND ALLIED ROCKS.

Production.—The depressing influences which have been felt during a part of 1886 by the quarrying industry as a whole have naturally produced their effects upon the production of granite, and although the total output is unquestionably greater than that of 1885, still it has by no means come up to what appeared to be expected at the beginning of the year. Granite is steadily increasing in popularity as a stone for ornamental and decorative purposes. This statement applies particularly to those varieties which admit of a high polish. A statue of granite is now said to cost very little more that one of marble, notwithstanding the much greater hardness of the former. This, however, may be accounted for in part at least by the fact that much less detail is brought out in granite than in marble sculpture. Granite is produced in eighteen different States; the most important of these are in the order named, as follows: Massachusetts, Maine, Rhode Island, Connecticut, Virginia, and New Hampshire. While it is probable that half of the counties in California contain more or less granite, the only localities where the stone is quarried to an extent greater than is required for local use are Penryn, Pino, and Rocklin, in Placer county, and Folsom, in Sacramento county. The quantity quarried and shipped from these several points in 1886 was about as follows: From Penryn, 10,000 tons; from Pino and Rocklin, 5,000 tons; and from Folsom, 7,000 tons.

More than half of this production finds a market in San Francisco, the balance being mostly used by the United States Government in the construction of fortifications, light-houses, and the dry-docks at Mare Island. Between 2,000 and 3,000 tons of granite were quarried at other points in the State during the year. The demand for the stone is quite variable from year to year.

New discoveries and developments.—Late in 1886 three new companies were organized for the purpose of quarrying syenite found in Warwick township, Chester county, Pennsylvania, on the line of the Saint Peter's branch of the Wilmington and Northern railroad, about 40 miles from Philadelphia.

Two or three varieties of fine granite were discovered at the new town of Hinsdale, Minnesota, on the Iron Range railroad. The Hinsdale Granite Company has already begun the shipment of granite to Chicago, in fulfillment of a contract for about 600 car loads.

The Southern Granite Company, of Atlanta, Georgia, has recently made preparations for increased production of granite from its quarries on Stone mountain, near the city, by exploding large quantities of giant powder, with which three shafts of a depth of 60 to 65 feet were charged. One of these shafts was charged with 2,000, the second with 5,000, and the third with 8,000 pounds of the explosive.

Quarries of granite at Henderson, Vance county, North Carolina, have been developed during the past year, but the exact extent of operations has not been reported. There are indications that granite will be quarried at quite a number of localities in the South during 1887. Virginia is the only southern State reported as having produced granite during the last Census year.

In Colorado the production of granite is still largely prospective, but active efforts are being made by those interested in developing the resources of the State to introduce the stone into western markets. Two quarries owned by the Union Pacific Railroad Company are said to yield granite of the very best quality. The stone from one of the quarries is pink in color, while that from the other is gray.

The following table gives the results of tests made by the commissioners appointed to select suitable stone for the Colorado State capitol:

Results of tests of stone for the Colorado State capitol.

Locality.	Color.	Position.	Size of specimens.	Strength of the specimen.	Strength of 1 square inch.	Specific gravity.	Weight of 1 cubic foot.	Ratio of absorption in twenty-four hours.
			Inches.	*Pounds*	*Pounds.*		*Pounds.*	
Grape creek	Pinkish gray (a)	Bed	2.03 × 2.04	60,000	14,492	2.603	162.375	.048
		Edge	2.05 × 2.07	73,750	17,352			
Brownsville	Mottled gray	Bed	2.02 × 2.03	62,500	15,244	2.700	168.426	.004
		Edge	2.02 × 2.03	85,000	20,731			
Do	do	Bed	2.07 × 2.08	67,500	15,625	2.713	169.236	.004
		Edge	2.08 × 2.09	90,000	20,694			
Lawson	Light gray	Bed	2.00 × 2.07	72,500	17,512	2.629	163.997	.006
		Edge	1.97 × 2.06	74,000	18,226			
Platte cañon	Pink	Bed	1.97 × 2.08	65,000	14,585	2.625	163.747	.006
		Edge	2.04 × 2.00	60,000	14,634			
Cotopaxi	Mottled gray	Bed	1.99 × 2.00	74,250	18,654	2.667	166.367	.003
		Edge	1.99 × 1.98	92,500	23,358			
Monarch	Dark mottled gray	Bed	2.03 × 2.03	62,500	15,170	2.760	172.168	.012
		Edge	2.00 × 2.02	71,500	17,698			
Gunnison	do	Bed	2.04 × 2.06	52,500	12,976	2.715	169.361	.006
		Edge	2.02 × 2.04	64,250	15,594			

(a) Gneiss; the other samples are all granite.

LIMESTONE AND MARBLE.

Production.—The limestone and marble industry may be regarded as in a very satisfactory condition when its present magnitude is compared with that revealed by the census of 1880. There are many good and quite obvious reasons why in times of reasonable prosperity the production both of ordinary, uncrystallized limestone and of the more or less completely metamorphosed variety, marble, should steadily increase from year to year. In the first place, ordinary limestone is very largely used for foundations in the construction of all kinds of buildings, while the better grades are, in many localities, extensively used as the material of superstructures. Furthermore, vast quantities are of course burned for lime and used as a flux in blast furnaces.

Owing to the rapidity with which marble and limestone in general undergo discoloration and disintegration from climatic and local atmospheric conditions, it does not seem improbable that the out-of-door use of these materials in many of our important cities may be considerably reduced in the not distant future. Still, even if this be so, the demand for all the varieties of white and variegated marbles for purposes of interior decoration is becoming sufficient to counterbalance a considerable falling off in the consumption of these materials for external ornamentation.

The returns of the Tenth Census place the product of 615 limestone and marble quarries in the United States at 65,373,965 cubic feet, valued at $6,846,681. The value of the limestone and marble quarried in 1886 is estimated at $8,500,000. This figure would, in all probability, have been somewhat exceeded but for the reduced demand caused by the interruption in building in the early part of the summer.

As compared with 1885, there has been a falling off in many quarry districts in the production of common limestone, and prices generally have been somewhat lower, although from a few quarry regions slight gains, both in production and price, are reported.

Very few strikes on the part of workmen in the quarries of important districts have been reported as occurring during 1886, but a number of the largest quarry regions of Ohio, Indiana, Missouri, Illinois, and Wisconsin experienced considerable loss in trade owing to the strikes in Saint Louis, Cincinnati, Chicago, and Milwaukee.

Considering the discouraging and depressing effect of labor troubles upon the building industry during part of the year, it is somewhat surprising that so few quarries were entirely abandoned, although quite a number suspended or reduced operations during the period of general disturbance. This fact reflects quite favorably upon the general stability of the industry.

The following table, compiled by Mr. Thomas B. Bancroft, chief inspector of mines in Ohio, gives the production of all grades of limestone in that State for 1886:

Production of limestone in the State of Ohio in 1886.

Counties.	Weeks worked.	Men employed.	Burned for lime.	Used for fluxing.	Dimension stone.	Ordinary building stone.	For piers and protection purposes.	Flagging.	Paving.	Curbing.	For ballast and macadam.
			Short tons.	*Short tons.*	*Cubic feet.*	*Cubic yards.*	*Cubic yards.*	*Square feet.*	*Square feet.*	*Linear feet,*	*Cubic yards.*
Allen	24	67	7,969			10,857	310	17,000		3,775	9,831
Adams	9	6	587								
Butler	22	42				7,307	730	4,850		8,870	
Belmont		4	2,450								1,055
Clinton	16	24	1,160		13,000	1,553	280				370
Crawford	28	14	936			1,329		8,640			
Clarke	37	126	19,591	23	22,632	17,912	480	2,845		12,788	2,375
Clermont	10	13				2,237					551
Delaware	30	35	23,949		1,600	1,642		2,000			500
Darke	27	9	1,460								
Erie	38	101	30,350	28,430		21,095	2,505	200	78,336		1,720
Franklin	37	76	5,516	35,094	17,425	27,759	698			4,588	650
Greene	25	61	18,768		23,077	3,354	740	5,250		100	1,389
Hardin	22	52	315			1,193	140	60			10,762
Holmes	14	14	75			140	24				611
Highland	30	66	11,192		51,583	4,352		21,811	7,200	5,000	61
Hamilton	33	452	11,006			63,972			54,000		25,605
Hancock	32	41	3,406			11,928	926	125			2,453
Jackson				15,879							
Lucas	29	39	1,051		12,900	3,843	4,700	426	10,800		2,346
Logan	36	21				5,427	2,000				
Lawrence				67,669							
Mahoning				30,823							
Muskingum	30	51	3,265	14,344	10,475	1,892	37			1,250	1,116
Montgomery	37	141	4,683		149,100	19,709	2,596	47,496		3,000	392
Marion	44	133	56,400	45,489	4,550	16,866	2,981	14,200			25,742
Miami	35	152	5,813		158,846	34,315	6,232	39,647	300	18,079	5,825
Ottawa	38	269	189,310	34,113	8,417	10,882	32,551	300		2,700	28,736
Perry	5	20		2,022							
Preble	22	64	8,342		7,750	5,308	4,267	19,750			1,411
Putnam	4	17				502					
Paulding		2				355					
Seneca	30	67	14,036		71,808	5,243	182	3,300	4,000		32,618
Stark	23	12	3,530								
Sandusky	35	65	28,450		4,950	1,203	70			500	3,749
Shelby	28	10	4,620								
Scioto				52,544							
Tuscarawas				1,650							
Van Wert	26	9	4,310			2,313	277				1,040
Wood	31	86	47,415		7,334	10,586	306				23,351
Wyandot	22	22	7,315		1,250	157	18				2,551
Total		2,383	517,270	328,080	566,697	295,231	63,050	187,900	154,636	60,650	186,810

According to the census returns for 1880 Ohio produced 11,098,583 cubic feet of limestone. Reducing the product of 1886 to cubic feet, a figure something more than 15,000,000 cubic feet is the result, thus showing a large gain in production since the census year.

As Ohio stood second in production of limestone in 1880, Illinois taking first place with a production of 13,013,139 cubic feet, a correspondingly large gain may be inferred for other States producing similar material.

The product of the Joliet (Illinois) quarry district for 1886, including 18 quarries, is estimated to be, in round numbers, 5,340,000 cubic feet, while that of the Lemont quarry region reaches 1,200,000. In view of the fact that labor disturbances very seriously affected these regions these figures are probably decidedly below what might justly be expected for the coming year, although this production is believed to be very slightly, if at all, in advance of that of 1885, when local labor trouble is said to have curtailed the output. The value of the product of the Joliet and Lemont regions is estimated to be $800,000.

The production of limestone in Missouri during the census year was 4,419,300 cubic feet, valued at $421,211. Of the 27 quarries at that time operated in the entire State 20 were in the vicinity of Saint Louis. The product of the Saint Louis region for 1886 is estimated at 2,500,000 cubic feet, valued at $150,000. The product of this region is devoted almost entirely to local consumption, and the effect of strikes in Saint Louis is said to have been very severely felt, one authority claiming that the output of 1886 was about one-half that of 1885, and that labor troubles were largely responsible for this considerable falling off. Three quarries in this region were abandoned during the year.

The limestones of Indiana are becoming yearly more and more popular, particularly the oolitic stone of the sub-Carboniferous age. Statistics from this State are too meager to admit of a reliable estimate of production, but it is certain that large quantities are shipped out of the State to many of the larger cities, both east and west, Chicago, Cincinnati, and Philadelphia being among the most important markets.

Production of marble.—As has already been indicated the marble industry as a whole is in a thrifty condition. Although the labor troubles of the year have had their depressing effect upon this as well as upon other quarrying industries, still the effect has been far less marked and, as will be shown later in detail, a number of new and important discoveries and developments have been made.

The following table gives for the census year the value of the marble quarried in the States which at that time were the only ones producing fine marble in any considerable quantity. This table has lately been compiled by Mr. George P. Merrill from the original data on limestone, furnished for the Tenth Census.

Value, by States, of marble quarried in 1880.

States.	Value.
Vermont	$1, 340, 000
New York	224, 500
Massachusetts	238, 125
Maryland	65, 000
Tennessee	173, 600
Total	2, 041, 225

The value of the marble produced in Vermont during 1886 is estimated at $1,500,000. Accurate returns from Tennessee give 269,486 as the number of cubic feet of all kinds of marble shipped from the

State during 1886. This is valued at $1.50 per cubic foot, giving $404,229 as the total value of the year's production.

The marble quarries of Georgia yielded an output of 100,000 cubic feet, valued at $100,000.

The total value of the marble produced in the United States during 1886 is probably very nearly $2,400,000.

New discoveries and developments of common limestone.—The limestone of the Joliet (Illinois) quarry region has until the last year been recognized as being in general unfit for use as a flux in blast furnaces. The discovery in this region, during 1886, of a bed of quite pure limestone well suited for use as a flux, is therefore of particular interest. The location of this newly discovered bed is at Gravel Bank about 10 miles below Joliet. The following analysis shows the composition of the stone.

Analysis of limestone from Gravel Bank, near Joliet, Illinois.

	Per cent.
Calcium carbonate	92.14
Magnesium carbonate	1.75
Alumina	2.50
Silica	3.70
Total	100.09

The use of this stone as a flux in this region is said to be interfering decidedly with the shipment of limestone to this locality from Indiana.

In the various important limestone-producing States the opening of quite a number of new quarries has been reported, but as such developments are, in the majority of cases, mere additional operations of beds already worked by existing companies, they are not of especial interest.

New discoveries and developments of marble quarries.—The active quarrying of marble in Georgia was commenced only within the last few years, the census report making no mention of any limestone production whatever in this State during 1880.

The Georgian Marble Company, of Atlanta, is operating extensive marble quarries near Tate Station, Pickens county, Georgia. The deposit is of great thickness, very free from joints, and of uniform quality. The marble consists chiefly of the following descriptions: The most of it is white, with a few gray streaks. Light gray and white mottled, dark gray and white mottled, and flesh color with occasional greenish streaks, are also found. Diamond drills and channelers are in use, and the quarries are supplied throughout with the best machinery for quarrying and handling the product.

Considering the recent appearance of the Georgia marble upon the market, the demand for it is exceedingly good and is quite rapidly increasing, particularly in Chicago, Cincinnati, and other western cities.

It is not so well known in the East, although used in New York and Philadelphia to some extent. The coarsely crystalline character of this marble is somewhat against it for the finest kinds of decoration, but its attractive colors will secure for it an increasing popularity.

Alabama.—Toward the close of 1886, a company known as the Alabama Marble Company, with a capital stock of $100,000, was organized to develop and operate a quarry situated 16 miles from Florence and 1 mile from the Nashville and Florence railroad, in Lauderdale county. The officers of this company are W. J. Kernachan, president; C. B. Eldred, vice-president; J. B. White, secretary and treasurer.

Tennessee.—The already celebrated marbles of this State are rapidly increasing in popularity, and unquestionably they are at present the finest in the country for general decorative work.

The building of the South Atlantic and Ohio railroad, now in progress, from Bristol, Tennessee, to the Kentucky State line, is having the effect of stimulating the investigation and development of marble beds known to exist along its line. The next volume of this series will probably record encouraging results.

The Grayson Marble Company was organized in November, 1886, for the operation of quarries to be opened in a tract of about 70 acres of marble land owned by the company and situated in Monroe county.

In the early part of the present year a company known as the "Middle Tennessee Marble and Manufacturing Company," with a capital stock of $200,000, was organized for the purpose of operating a marble quarry in the vicinity of Kelso, on the Nashville and Chattanooga railroad, in Lincoln county. The marble has been tested and is said to be of fine quality, while the quantity is large. The officers of the company are R. L. Bright, president; Dr. W. C. Bright, vice-president; H. R. Shepard, secretary and general manager; Hugh Francis, treasurer.

There is some prospect of the development during the present year of a quarry near Athens, McMinn county.

The Crescent Marble Company, of Knoxville, is making preparations for doubling the output of 1886 during 1887. The following is a statement of the results of an analysis of the marbles quarried by this company:

Analysis of marble from Knoxville, Tennessee.

	Per cent.
Moisture	0.13
Silica	0.125
Sesquioxide of iron	0.26
Alumina	trace.
Lime	55.32
Magnesia	0.02
Carbonic acid	43.51
Sulphur	0.005
Organic matter and loss	0.63
Total	100.00

The analysis was made at the Columbia College School of Mines, New York. This marble broke under a crushing strain of 12,340 pounds to the square inch.

The Knoxville Marble Company reports a more flourishing condition of its business during the past year than in any previous year. The following are results of tests applied to the marble products from the quarries of this company. A cube $3\frac{1}{8}$ by $3\frac{3}{16}$, by $3\frac{3}{16}$ inches broke under a pressure of 12,550 pounds to the square inch. A slab of this marble, 2 feet $5\frac{1}{2}$ inches wide and 3 inches thick, on supports 4 feet $8\frac{1}{2}$ inches apart, was loaded at the center until it broke; the breaking load was 4,638 pounds. These tests were made by Henry Flad & Co., civil engineers, of Saint Louis.

Some four or five new quarries are said to have been opened near Concord, Knox county, but no particulars in regard to these developments were received.

Altogether the condition of the marble industry in Tennessee is most encouraging, and, in view of the enterprising spirit which is rapidly developing, some interesting results of the current year's progress may be expected in the next report. Improvement in transportation facilities is much needed in nearly all the quarry regions, of this State.

Virginia.—The Virginia Marble Company was reorganized late in 1886 by ex-Mayor Grace, Joseph S. Spenny, J. B. Hill, of New York city, and a number of Virginia gentlemen, for the purpose of operating a quarry near Mountsville, in Loudoun county. The capital stock of the company is $500,000.

Colorado.—The establishment by the Union Pacific Railroad Company of a "stone department," for the purpose of quarrying and transporting to consumers all kinds of building stone found in the "Great Hog Back" elevations of Colorado, and the liberal policy pursued by the company toward private quarry enterprises, have done a great deal, particularly during the past year, toward putting the building stone industry of the State in a promising condition. The following statements serve to indicate that the production of marble in Colorado may be looked for in the near future:

The Midland Railroad Company has made surveys of its marble deposits, and has located a railroad running directly to the beds. The Osgood Company has made investigations of the thickness of its marble deposits with a view to subsequent development.

The beds at Marble Glen, 10 miles northwest of Fort Collins, are said to consist of very fine material and to be of vast extent. Governor Routt has made preparations for opening up these deposits.

Some of the Colorado marbles are said to be fully equal in quality to those of Vermont and Tennessee. Inasmuch as investigations thus far have been of a preliminary character, definite statements in regard to both quality and quantity must be left for a future report.

PACIFIC COAST.

California.—The recent discoveries of marble in California have been the subject of considerable comment during the past year.

In September, 1885, Mr. Israel Luce, now superintendent of the Inyo Marble Company, at the request of members of the Carson and Colorado Railroad Company, visited the marble deposits known to exist in Owen's valley, 1½ miles from Owen's lake, 5 miles north of Keeler, and ½ mile from the Carson and Colorado railroad. At that time a company was organized for the purpose of developing the beds, but in May, 1886, it abandoned the project and sold out all equipments, etc., to the present owners, the Inyo Marble Company, which since that time has been developing the ledge and putting up a mill for sawing; sand suitable for this purpose being found in the neighborhood. The first car-load of sawed marble was shipped early in the present year.

The stone is said to be pure dolomite and the greater part of it is white, but a great variety of colored products is also found, including the variety known as moss agate. According to the reports of all experts who have examined this marble it is of very superior quality, being adapted not only for structural purposes, but also for the finest kinds of work.

The stone appears to exist in three layers; the upper one is from 15 to 20 feet thick, is considerably shattered and strained, and its present position is believed to have been the result of a slide from the mountain above.

The second layer is 3½ to 4 feet thick, apparently, in its original bed, but is also somewhat strained. The third layer has not been disturbed from its original position; its thickness is not yet known, but it has been penetrated to a depth of 6 feet. This stone is the only California marble that has proved acceptable to local cutters and dealers. The officers of the Inyo Marble Company are J. M. Keeler, president; H. B. Keesing, vice-president; O. F. von Rhein, secretary, and Israel Luce, superintendent.

In Antelope valley, Mono county, another marble deposit was discovered. This bed is said to be extensive, and to include all colors, from white to black; some of it has a strong resemblance to onyx. It takes a fine polish and is believed to be of great value. Blocks of any required size can be quarried, some weighing as much as 25 tons having been taken out. Shipments to the owners' works in Reno have already been made.

In the autumn of 1886 a deposit of marble, represented as covering an area of 600 acres, was discovered in the Mojave desert, San Bernardino county, 3 miles from Victor station, on the California Southern railroad. Nothing is yet known in regard to the depth of the bed. As both stone and lumber fit for building purposes are scarce in southern California, this discovery is likely to prove a valuable one for Los Angeles, where it is calculated the stone can be laid down for $1 per cubic foot. At present, adobe, or unburnt brick, and lumber, are almost the only building materials extensively used in the town. The railroad company expects to build a track connecting the marble beds with Victor station.

The variety of marble known as onyx has been found in quantity at two places on the Pacific coast, one being the Kesseler quarry, in San Luis Obispo county, and the other near Suisun City, Solano county. A considerable quantity of stone has been taken from the former during the last three or four years; it has been manufactured into mantels, table tops, pedestals, vases, and other articles, which are readily sold at high prices, the mantels selling for $300 to $400 each. The onyx from the Kesseler quarry is indeed a magnificent stone, and has been very enthusiastically described by those familiar with it.

About 200 tons of the Suisun stone were shipped to Eastern markets last year; being situated near a railroad, a larger quantity is shipped from the Suisun than from the Kesseler quarry, the latter being at a considerable distance from the railroad.

Idaho.—A recent discovery of marble is reported in Cassia county, near the place at which the old stage road crosses the summit of the Goose Creek mountains. The deposit is said to be large, covering the mountain side over an area of 1 mile in width and 4 miles in length. Being 30 miles from a railroad, there is not much likelihood that the stone will be utilized in the near future.

Utah.—Several marble deposits are known to occur in Utah, but no very valuable stone has been quarried; this may, perhaps, be due to the fact that most of the marble investigated has been taken from near the surface, while that which is to be found at a greater depth may turn out to be of finer quality.

Marble has been found on Snake creek, east of Park City, Summit county, near Spanish Fork, and near Frisco.

SANDSTONE.

Production.—The output and the price of sandstone for 1886 were quite noticeably affected by the strikes of the early part of the year. The total falling off was, however, much less than was expected at the time of the general labor disturbances. This was due to the quite rapid and vigorous revival of building enterprises which took place toward the end of the year.

According to the last census report, the total production of sandstone for the entire country amounted to 24,776,930 cubic feet; of this quantity Ohio produced 8,574,726 cubic feet, or more than one-third; Pennsylvania came next with a yield of 6,229,110 cubic feet; New York and

New Jersey followed in the order named with productions of 2,980,353 and 2,384,791 cubic feet, respectively.

Ohio still stands at the head of the list of sandstone-producing States and its lead appears to be continually increasing.

Owing to insufficient data it is impossible to give an estimate of the total output for the year, but it is probable that the output was but little greater in 1886 than in 1885. Of all the different quarry regions in the eastern division from which information was received, a majority reported production as "about the same" as in 1885; a smaller number reported a curtailment, owing chiefly to strikes; while a still smaller number report an increase of business, although in no case is this very considerable.

In the Rocky Mountain division, and particularly in Colorado, the general condition of the quarrying industry has been good. This prosperity is largely due to the efforts of the Union Pacific Railway Company to develop the quarries which abound along the Great Hog Back in Colorado, and to create a demand for the stone in the important cities of the Missouri valley. No separate figures for sandstone production alone have been furnished, but the amounts of stone of all kinds quarried and shipped by the Union Pacific Company during 1886 have already been given.

The composition of the most popular sandstones of this region are shown by the following analyses:

Analyses of sandstone.

	Stout quarry.	Buckhorn quarry.
	Per cent.	*Per cent.*
Silica	95.50	96.45
Iron and alumina	0.78	1.90
Calcium oxide	0.88	1.06
Magnesia	1.45	0.64
Carbonic acid and water	1.18	....
Total	99.79	100.05

When engaged in making a selection of the stone to be used in building the Colorado State capitol the board of commissioners having the matter in charge made tests of quite a number of different kinds of stone chiefly from Colorado, but also from other States.

The following table gives the results for sandstone:

Results of tests of sandstone for the State Capitol, Colorado.

Number of specimen.	Locality.	Color.	Position.	Size.	Strength of the specimens.	Strength of one square inch.	Specific gravity.	Weight of one cubic foot.	Ratio of absorption in 10 minutes.	Ratio of absorption in 24 hours.
				Inches.	*Lbs.*	*Lbs.*		*Lbs.*		
50	Buck Horn.....	Grayish white....	Bed... Edge..	2.05 × 2.07 2.04 × 2.06	78,750 72,500	18,573 17,261	2.379	168.402	.011	.040
51	Thistle, Utah...	Dark reddish brown.	Bed... Edge..	2.06 × 2.06 2.02 × 2.04	35,000 38,750	8,254 9,405	2.407	150.211	.024	.063
52	Trinidad	Drab	Bed... Edge..	2.01 × 2.03 1.94 × 2.00	41,250 37,500	10,110 9,665	2.339	145.906	.009	.069
53	Manitou (Snider)	White	Bed... Edge..	2.01 × 2.05 2.06 × 2.07	53,750 48,750	13,046 11,442	2.207	137.672	.071	.094
54	Ralston	Red	Bed... Edge..	2.04 × 2.04 1.99 × 2.02	46,250 39,000	11,118 9,701	2.245	140.043	.062	.080
55	Left Hand......	Pink	Bed... Edge..	1.98 × 2.00 2.03 × 2.03	45,000 56,250	11,278 13,653	2.240	139.731	.023	.042
56	Saint Vrains ...	Light red	Bed... Edge..	2.00 × 2.01 2.00 × 2.04	46,250 71,500	11,505 17,187	2.393	149.275	.012	.061
57	Douglas county	Red	Bed... Edge..	2.04 × 2.01 2.02 × 2.02	14,250 14,250	3,544 3,492	2.191	136.674	.088	.134
58	Fort Collins....	Gray	Bed... Edge..	2.03 × 2.05 2.00 × 2.04	48,750 44,000	11,707 10,784	2.252	40.679	.013	.072
59	....do..........	Light red	Bed... Edge..	2.00 × 2.01 1.99 × 1.99	51,250 69,250	12,740 17,487	2.432	151.648	.011	.051
60	Stout..........	Dark gray	Bed... Edge..	2.07 × 2.07 2.08 × 2.10	45,000 55,000	10,514 12,585	2.263	141.165	.040	.066
61	Coal Creek	Greenish gray....	Bed... Edge..	2.02 × 2.02 1.96 × 2.01	11,750 9,500	2,879 2,411	2.033	126.818	.053	.167
62	Oak Creek	Yellowish gray ..	Bed... Edge..	2.03 × 2.04 2.02 × 2.03	11,000 10,000	2,657 2,475	1.953	121.828	.076	.193
63	Coal Creek	Greenish gray....	Bed... Edge..	2.05 × 2.05 2.03 × 2.04	15,000 14,000	3,570 3,381	2.067	128.939	.055	.158
64	Gunnison	Brownish gray, speckled.	Bed... Edge..	2.02 × 2.02 2.00 × 2.01	25,000 21,000	6,127 5,224	2.066	128.877	.128	.146
70	Cañon City.....	Cloudy blue......	Bed... Edge..	1.99 × 2.00 1.95 × 1.91	22,750 14,250	5,716 3,820	2.301	143.536	.061	.100
71	Manitou (Emerins).	White	Bed... Edge..	1.97 × 2.03 2.01 × 1.96	37,000 40,000	9,250 10,152	2.233	139.294	.077	.120
72	Gunnison	....do...........	Bed... Edge..	1.98 × 2.02 2.02 × 1.96	21,000 21,750	5,250 5,492	2.204	137.485	.087	.090
73	La Porte, Colorado.	Pink	Bed... Edge..	2.03 × 2.04 2.03 × 2.00	43,750 35,000	10,567 8,620	2.235	145.033	.031	.079
74	Brandford......	Greenish gray ...	Bed... Edge..	2.01 × 2.02 2.02 × 2.01	13,500 11,750	3,308 2,894	2.004	125.009	.071	.189
75	Wyoming	Gray	Bed... Edge..	2.06 × 2.02 2.01 × 2.03	45,500 38,750	10,833 9,544	2.021	126.069	.102	.217
76	Left Hand......	Cream gray	Bed... Edge..	1.99 × 2.04 2.04 × 1.95	50,000 52,000	11,848 13,056	2.394	149.237	.011	.049
77	....do..........	Light pink	Bed... Edge..	2.02 × 1.97 2.01 × 2.04	54,000 36,250	13,300 8,841	2.290	142.850	.026	.054

Although granite, slate, jasper, marble, limestone, as well as sandstone, are found in Dakota, the last-mentioned stone is the only one as yet quarried. During 1886 about 5,000 perches were shipped from Buffalo Gap to O'Neal City, Norfolk, Fremont, and Omaha, Nebraska; 12,000 perches were used in 1886 for building purposes in Rapid City.

The Dakota sandstone is from 250 to 400 feet in thickness and forms the foot hills which completely encircle the Black Hills. It is generally to be found in good seams varying in thickness from a few inches to several feet; its hardness is quite variable, as also are its colors, which include brown, white, pink, yellow, brick-red, and variegated; the last is much admired locally, and is in common use for window sills, keystones, etc.

New discoveries and developments.—Under this heading there is comparatively little to be said for the Eastern division, owing to the unfavorable conditions which prevailed during the early part of the year.

In November of 1886 steps were taken to open a new sandstone quarry at the mouth of the Salmon Trout river near Marquette, Michigan. The stone lies in three distinct beds; the first one, consisting of a variegated stone similar to that of the Marquette quarries, is about 6 feet thick. The second bed is 7 feet thick and resembles the Portage Entry stone, though darker in color, more compact, and of finer grain. The third bed is the most valuable; it is about 5 feet thick, and its color is about the same as that of the Marquette brownstone; its quality is said to be very fine and great popularity is predicted for it. It will be known as the Newport and Lake Superior quarry, and from present indications the output during 1887 will be abundantly sufficient to demonstrate satisfactorily the quality and extent of the deposit. Considerable activity in developing other quarries of Lake Superior sandstone is being manifested and encouraging results may be anticipated for the current year.

Quarries of red sandstone at Wadesboro', Anson county, North Carolina, are being actively worked, but no full account of operations thus far conducted at this point have been received.

About the end of the year a new quarry of sandstone was opened 2 miles east of Warrensburgh, Johnson county, Missouri.

A marked increase in activity in the quarrying of sandstone near Thistle Station, on the Denver and Rio Grande Western railroad, in Utah, has been revealed during the past year, and this point is becoming quite noted locally for the extensive shipments made.

Near Buffalo Gap, Custer county, Dakota, a large bed of rock, which promises to be of considerable value for use as whetstones and hones, was discovered in July, 1886.

SLATE.

Production.—The year 1886 opened with quite encouraging prospects for the slate industry, prices being maintained at nearly the same figures as for the early part of the preceding year, while the outlook for a brisk demand was fairly good. Hardly had the season fairly opened, however, when the labor troubles made themselves immediately felt by curtailing demand in a number of districts which had previously been reliable markets. Large enterprises, which would have been carried out forthwith, were either abandoned entirely or indefinitely postponed until the times should present fewer elements of doubt and uncertainty. Furthermore, a number of the prominent slate regions were burdened with the overproduction of two or three years previous, it having been the policy of large producers to continue operations undiminished in spite of slack demand rather than, by reducing output, to throw out of employment the peculiarly skilled laborers whose places it might afterwards be difficult to fill.

In view of the above facts, the production of slate in 1886, although falling considerably behind expectations, and also, for the principal districts, slightly behind the production of 1885, may be regarded as by no means unsatisfactory.

Production of roofing slate in all sections during the years 1884, 1885, *and* 1886.

[Squares of 100 square feet each.]

Sections.	1884.	1885.	1886.
Bangor and Pen Argyl region, Pennsylvania	195, 505	196, 832	215, 341
Slatington section, Pennsylvania	104, 000	108, 000	109, 000
Vermont	85, 000	130, 000	111, 385
Maine	41, 000	34, 000	36, 000
Chapman's	29, 499	26, 328	24, 464
Peach Bottom	10, 000	14, 500	12, 000
Virginia	9, 000	17, 300	16, 600
Michigan	7, 000	10, 000	12, 000
Total	481, 004	536, 960	536, 790

Total yearly production of roofing slate from 1879 *to* 1886 *inclusive.*

Years.	Number of squares.	Average price per square, delivered on cars.	Value.
1879	367, 857		
1880	382, 867		
1881	454, 070		
1882	501, 000		
1883	506, 200		
1884	481, 004	$3. 85	$1, 851, 865
1885	536, 960	3. 07	1, 648, 467
1886	536, 790	3. 00	1, 610, 370

Prices.—The prices of slate in New York for different times are shown in the following table:

Comparative prices of roofing slate at New York, January 1.

	1885.	1886.	1887.
Purple	$6. 00 to $7. 00	$6. 00 to $7. 00	$5. 00 to $6. 00
Green	6. 00 7. 00	6. 00 7. 00	5. 00 6. 00
Red	15. 00	15. 00	10. 00
Black	4. 50 5. 00	4. 50 5. 00	3. 50 4. 00

Quite a marked falling off is apparent for the early part of the present year; according to some slate producers this decline may be, in part at least, accounted for by the lack of harmony between operators and the failure of a number to adhere rigidly to the scale of prices agreed upon. There is no reliable evidence to show that the use of roofing slate is at all falling into disrepute; but on the contrary, home demand, particularly in the West, has increased during the past year, and the indications for still further increase during the present year are decidedly good.

In so far as information has been received, there have been no serious disturbances between employers and workmen at any of the quarrying centers during 1886. The following is the scale of wages paid at the Slatington section:

	Cents per hour.
Splitters	15 to 18
Blockmakers	15 18
Laborers	10 13

This differs from the scale of last year only in being less for splitters, who were at that time paid 18 to 20 cents per hour.

The following is the scale of prices for roofing slate on board cars, adopted February 8, 1887, by the Slatington Slate Exchange:

Prices of roofing slate at Slatington, Pennsylvania.

	Per square.
24's and 22's	$3.75
20's, 18's, and 16's	4.00
14's	3.75

Exports.—The exports of roofing slate from New York City during 1886 show a decided falling off. As the following table shows, no roofing slate was shipped from New York to European ports, as was the case some years ago, when several cargoes of slate were shipped direct to Welsh ports.

Exports of roofing slate from New York for 1886.

	Pieces.	Value.
British West Indies	30, 100	$1, 330
British Australia	2, 577, 576	71, 671
New Zealand and Tasmania	217, 570	6, 063
Total	2, 825, 246	79, 064

Exports of roofing slate from the port of New York from 1876 *to* 1886 *inclusive.*

Years.	Tons.	Pieces.	Value.
1876	19, 475	646, 985	$377, 233
1877	25, 565	2, 895, 428	646, 272
1878	12, 320	1, 834, 225	308, 852
1879	4, 792	3, 085, 124	166, 220
1880	11, 267	1, 698, 522	220, 292
1881	2, 927	3, 522, 527	138, 904
1882	864	4, 337, 801	153, 318
1883	187	1, 488, 226	54, 063
1884	50	2, 776, 236	90, 262
1885	....	4, 113, 204	115, 206
1886	....	2, 825, 246	79, 064

The export trade to Australia increased quite rapidly during 1885, with the ultimate effect, however, of overstocking the market there to such an extent that it is said that some lots were sold in Australia for less than it cost to put them on board ship here. Welsh producers have been shipping considerable quantities to the same Australian ports, and since they undoubtedly have the advantage of American producers in matters of cost and transportation facilities, successful competition with them can no longer at present be maintained.

The use of slate for other purposes than as a roofing material appears to be increasing. During 1886 business has been fully as good as in previous years for some of these slate products, such as mantels, blackboards, flagging, etc.; prices were quite well sustained during the year. The following table for the Slatington section will serve to give some idea of the comparative condition of trade in these products for 1885 and 1886:

Comparative table of the annual sales in the Slatington section.

Articles.		1885.	1886.
Roofing squares		108,000	109,000
School slates	cases	38,872	42,388
Flagging	pieces	31,849	58,713
	cases	1,429	1,673
	cars	27	21½
Blackboards	cases	5,882	6,791
Mantels	pieces	8	....
	cases	24	21
Hearth slate	do	2	1
Rough, sawed, and shaved	do	46¾	32

The exports of manufactured slate still consist almost entirely of school slates. The following tables give the shipments from New York; the figures represent a large proportion of the entire exports for the year:

Exports of manufactured slate from the port of New York 1876 *to* 1886 *inclusive.*

Years.	Cases.	Value.	Years.	Cases.	Value.
1876	10,612	$87,500	1881	14,414	$62,109
1877	8,675	68,437	1882	14,625	68,150
1878	13,274	88,215	1883	8,943	40,674
1879	17,505	74,251	1884	12,189	53,021
1880	15,674	76,709	1885	10,573	49,965
			1886	9,498	40,804

Exports of all kinds of slate from the port of New York, 1876 *to* 1886 *inclusive.*

Years.	Value.	Years.	Value.
1876	$464,733	1881	$201,013
1877	714,709	1882	221,468
1878	397,067	1883	94,737
1879	240,471	1884	143,283
1880	297,001	1885	165,171
		1886	119,868

New discoveries and developments.—In the latter part of 1886 a large bed of slate was discovered on Abram's creek, 1½ miles from the Little Tennessee river, in Blount county, Tennessee. Some very encouraging statements in regard to both the quality and the extent of the rock have been made, and inasmuch as a company known as the Abram's Creek Roofing Slate Company, capital stock $125,000, was organized early in 1887 for the purpose of quarrying and manufacturing the slate, interesting items in regard to developments may be looked for in the next volume of this series.

A new company, known as the Washington Red Slate Company, with a capital stock of $30,000, was recently incorporated at Middle Granville, New York, for the purpose of operating slate quarries in that region.

Slate of a quality sufficiently good for roofing purposes is reported by Mr. F. F. Chisolm as occurring on Pennington and Slate creeks, Dakota.

In the latter part of 1886 operations for the purposes of developing a slate quarry 8 miles southwest of Little Rock, Arkansas, were instituted. The slate as indicated by samples submitted is of good quality, and exists in apparently unlimited quantity. None seems to have been quarried during 1886 at this place, but there are indications of a liberal production during 1887. The quarry is owned by Mr. Alonzo Hull, of Little Rock, Arkansas.

Utilization of slate débris.—In view of the rapid accumulation of slate refuse in the neighborhood of all actively-worked quarries, the question of its disposal has always been one of considerable interest to slate producers. The following facts, abstracted from the London *Machinery Market*, seem to indicate that the disposal of this refuse may become a source of profit. In 1878 Thomas Evans took out a patent for the manufacture of slate refuse into bricks. He had demonstrated that, by subjecting a mixture of the finely-powdered slate débris and water to sufficient pressure in molds, the consistence of the mixture being about that of mortar, the product was a superior quality of brick.

The patent was purchased by Messrs. Coley, Bromfield, and Davis, who subsequently sold it to a company known as the Patent Slate Brick and Sanitary Tube Company, limited. This company erected an expensive plant and commenced manufacturing the new product. The cost of manufacture has been found to be 1*s.* 1*d.* per 1,000 bricks. The bricks thus made are said to resist extremes of temperature well, and to withstand crushing force up to the limit 1,056 tons to the square foot. Owing to the fact that sewage acids have no deleterious effect upon this material, it is well adapted to the manufacture of sanitary tubes, which have already been made up to 3 and 4 feet in diameter.

An investigation of this subject might well repay slate producers in this country, where so many thousands of tons of slate are constantly being thrown aside as waste.

Imports and exports of building stone.—The following tables show the extent of the foreign commerce of the United States in marble and other stone:

Marble imported and entered for consumption in the United States, 1867 *to* 1883 *inclusive.*

Fiscal years ending June 30—	Sawed, dressed, etc., not over 2 inches in thickness.	Sawed, dressed, etc., over 2 and not over 3 inches in thickness.	Sawed, dressed, etc., over 3 and not over 4 inches in thickness.	Sawed, dressed, etc., over 4 and not over 5 inches in thickness.	Sawed, dressed, etc., over 5 and not over 6 inches in thickness.	Veined and all other in blocks, etc.	White, statuary, Brocatella, etc.	Not otherwise specified.	Total.
1867						$192, 514	$2, 540	$51, 978	$247, 032
1868						309, 750	4, 403	85, 783	399, 936
1869						359, 881	3, 898	101, 309	465, 088
1870						332, 839	3, 713	142, 785	479, 337
1871	$5, 973	$168	$77	$44	$28	400, 158	1, 134	118, 016	525, 598
1872	3, 499	1, 081	452		318	475, 718	4, 017	54, 539	539, 624
1873	3, 124	21				396, 671	4, 148	69, 991	473, 955
1874	1, 837					474, 680	2, 863	51, 699	531, 079
1875	1, 456	427	96			527, 628	1, 623	72, 389	603, 619
1876	595	126	204	87		529, 126	1, 151	60, 596	591, 885
1877	2, 124					349, 590	1, 404	77, 293	430, 411
1878	198	11	8			376, 936	592	43, 915	421, 660
1879	184					329, 155	427	54, 857	384, 623
1880						531, 908	7, 239	62, 715	601, 862
1881	339					470, 047	1, 468	82, 046	553, 900
1882	655					486, 331	3, 582	84, 577	575, 145
1883	619					533, 096	2, 011	71, 905	607, 631

During the last three fiscal years the classification has been as follows:

Classification.	1884.	1885.	1886.
Marble:			
In blocks, rough or squared, of all kinds	$511, 287	$429, 186	$410, 843
Veined marble, sawed, dressed, or otherwise, including marble slabs and marble paving tiles	12, 941	43, 923	81, 497
All manufactures of, not specially enumerated	67, 829	54, 772	34, 546
Total	592, 057	527, 881	526, 886

Building stone (exclusive of marble), paving stone, and stone ballast imported and entered for consumption in the United States, 1867 to 1886 inclusive.

Fiscal years ending June 30—	Building stone, dressed.	Building stone, rough.		Sandstone.	Slate chimney pieces, mantels, etc.	Roofing slate.	Limestone.	Paving stones.	Ballast.	Total value.
		Quantity.	Value.							
		Long tons.								
1867	....	....	....	....	$37, 510	$85, 204	....	....	....	....
1868	$59, 081	....	....	....	16, 045	118, 776	....	$5, 718	....	....
1869	61, 408	....	$8, 237	$4, 171	19, 602	85, 364	....	467	$3, 987	....
1870	150, 619	....	....	3, 201	19, 870	107, 521	....	2, 034	10, 518	....
1871	145, 759	1, 455	16, 982	3, 660	21, 381	117, 484	....	....	34, 703	....
1872	162, 614	10, 723	39, 515	7, 680	25, 925	107 192	$2, 459	5, 529	11, 303	$362, 217
1873	218, 236	20, 226	73, 889	6, 160	26, 643	91, 503	1, 486	3, 788	17, 143	438, 848
1874	238, 680	19, 658	81, 645	8, 534	27, 519	80, 519	1, 639	7, 246	21, 882	467, 664
1875	275, 633	15, 748	67, 357	10, 986	42, 022	16, 342	2, 023	2, 017	9, 025	425, 405
1876	316, 404	8, 199	34, 124	7, 174	44, 266	2, 051	1, 938	1, 005	9, 350	416, 312
1877	201, 034	7, 584	25, 571	5, 492	34, 479	4	1, 705	485	6, 272	275, 042
1878	153, 693	10, 197	37, 878	7, 136	39, 935	275	2, 614	1, 950	6, 989	250, 470
1879	125, 493	6, 845	24, 531	13, 956	46, 260	620	1, 456	2, 943	2, 365	217, 624
1880	75, 501	11, 035	43, 997	10, 220	51, 165	72	2, 560	2, 383	7, 572	193, 470
1881	76, 741	15, 867	65, 950	15, 115	46, 862	2	1, 990	3, 799	5, 401	215, 860
1882	104, 296	16, 778	75, 369	....	45, 774	154	2, 710	16, 599	8. 792	253, 694
1883	127, 476	14, 324	64, 767	....	44, 375	2, 813	1, 841	2, 629	5, 745	249, 646
1884	122, 463	12, 198	50, 860	....	34, 640	16, 099	143	2, 576	2, 551	229, 332
1885	145, 344	13, 183	64, 680	....	56, 913	5, 196	....	....	4, 056	276, 189
1886	171, 840	13, 084	65, 459	....	60, 512	4, 366	....	....	3, 759	305, 936

Marble and stone of domestic production exported from the United States.

Fiscal years ending September 30, until 1842, and June 30 since.	Rough.	Manufactured.	Total.	Fiscal years ending June 30—	Rough.	Manufactured.	Total.
1826	....	$13, 303	$13, 303	1857	....	$111, 403	$111, 403
1827	....	3, 505	3, 505	1858	....	138, 590	138, 590
1828	....	3, 122	3, 122	1859	....	112, 214	112, 214
1829	....	2, 647	2, 647	1860	....	176, 239	176, 239
1830	....	4, 655	4, 655	1861	....	185, 267	185, 267
1831	....	3, 588	3, 588	1862	....	195, 442	195, 442
1832	....	3, 455	3, 455	1863	....	138, 428	138, 428
1833	....	5, 087	5, 087	1864	$57, 715	144, 647	202, 362
1834	....	7, 359	7, 359	1865	74, 261	183, 782	258, 043
1835	....	8, 687	8, 687	1866	89, 703	112, 830	202, 533
1836	....	4, 414	4, 414	1867	53, 983	138, 558	192, 541
1837	....	5, 374	5, 374	1868	60, 399	105, 046	165, 445
1838	....	5, 199	5, 199	1869	62, 266	87, 135	149, 401
1839	....	7, 661	7, 661	1870	42, 227	138, 046	180, 273
1840	....	35, 794	35, 794	1871	135, 672	137, 613	273, 285
1841	....	33, 546	33, 546	1872	156, 976	165, 311	322, 287
1842	....	18, 921	18, 921	1873	96, 735	189, 795	286, 530
1843 (nine months)	....	8, 545	8, 545	1874	126, 669	168, 977	295, 646
1844	....	19, 135	19, 135	1875	125, 968	254, 356	380, 324
1845	....	17, 626	17, 626	1876	95, 480	236, 255	331, 735
1846	....	14, 234	14, 234	1877	131, 716	917, 937	1, 049, 653
1847	....	11, 220	11, 220	1878	142, 661	597, 356	740, 017
1848	....	22, 466	22, 466	1879	143, 457	430, 848	574, 305
1849	....	20, 282	20, 282	1880	199, 051	453, 912	652, 963
1850	....	34, 510	34, 510	1881	220, 362	409, 433	629, 795
1851	....	41, 449	41, 449	1882	180, 774	433, 656	614, 430
1852	....	57, 240	57, 240	1883	152, 182	389, 371	541, 553
1853	....	47, 628	47, 628	1884	188, 245	415, 015	603, 260
1854	....	88, 327	88, 327	1885	182, 719	(a)330, 786	513, 505
1855	....	168, 546	168, 546	1886	159, 553	(a)445, 708	605, 261
1856	....	162, 376	162, 376				

a Includes roofing slate.

Marble and stone, and manufactures of marble and stone, of foreign production exported from the United States, 1872 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Value.	Fiscal years ending June 30—	Value.
1872	$1,229	1880	$6,816
1873	4,571	1881	709
1874	1,928	1882	4,848
1875	3,428	1883	490
1876	13,371	1884	8,420
1877	8,475	1885	14,406
1878	3,448	1886	4,617
1879	6,364		

Summarizing the foregoing statistics, the movement during the fiscal years 1882 to 1886 may be stated thus:

Palance of trade in marble and stone.

Fiscal years ending June 30—	Imports.	Exports.			Excess of imports over exports.
		Of domestic production.	Re-exports of foreign production.	Total exports.	
1882	$828,839	$614,430	$4,848	$619,278	$209,561
1883	1,475,658	541,553	490	542,043	933,615
1884	821,389	603,260	8,420	611,680	209,709
1885	804,070	513,505	14,406	527,911	276,159
1886	832,822	605,261	4,617	609,878	222,944

CEMENT.

Production.—The following table shows the production of the natural rock cements in the leading districts during 1886:

Production of cement in the leading districts in 1886.

	Barrels of 300 pounds.
Rosendale district, Ulster county, New York	2,050,856
Buffalo and Akron districts, New York	550,000
Williamsville, Erie county, New York	20,000
Louisville, Kentucky	925,210
Utica, Illinois	226,000
Mankato, Minnesota	114,086
Milwaukee, Wisconsin	300,000
Total	4,186,152

The total production for 1886 of all kinds of cement, including the artificial Portland cement, is estimated to have been 4,500,000 barrels, valued at $3,990,000.

The total amount of cement manufactured from natural rock during 1886 is estimated at 4,350,000 barrels, estimated at $3,697,500.

The total amount of American Portland cement manufactured during 1886 is estimated at a maximum of 150,000 barrels, valued at $292,500.

The following tables show the production in the past five years:

Production of cement made from natural rock in the United States from 1882 *to* 1886.

Years.	Barrels of 300 pounds.	Average price per barrel.	Total value.
1882	3,165,000	$1.10	$3,481,500
1883	4,100,000	1.00	4,100,000
1884	3,900,000	.90	3,510,000
1885	4,000,000	.80	3,200,000
1886	4,350,000	.85	3,697,500

Estimated production of American Portland cement from 1882 *to* 1886.

Years.	Barrels of 400 pounds.	Average price per barrel.	Total value.
1882	85,000	$2.25	$191,250
1883	90,000	2.15	193,500
1884	100,000	2.10	210,000
1885	150,000	1.95	292,500
1886	150,000	1.95	292,500

The total production of all kinds of cement during the past five years was about as follows:

Total production of all kinds of cement in the United States from 1882 *to* 1886.

Years.	Barrels.	Value.
1882	3,250,000	$3,672,750
1883	4,190,000	4,293,500
1884	4,000,000	3,720,000
1885	4,150,000	3,492,500
1886	4,500,000	3,990,000

As the foregoing tables show, the production of cement in the United States has increased quite markedly over that of 1885, prices generally have been steadier, and from the first of June until the close of the season producers have been kept busy to supply a good demand. The average cost of production has been higher than in 1885; greater care has been taken in selecting the natural rock and in manufacture, and, generally speaking, an excellent product has been the result. The margin of profit to producers has been small, but the volume of business has in a measure compensated for this.

The production of American Portland cement, while it has thus far been comparatively small, is increasing, and particularly within the past few years considerable interest has been shown in improving methods of manufacture and machinery, so that competition with foreign producers is becoming more and more favorable to the American manufacturers.

Most of the cost of producing Portland cement being that of labor, when the processes of manufacture are the same, the foreign producers have of course a great advantage in cheap labor, but there are indications that this advantage will be offset in this country by signal improvements in methods, whereby workmen are replaced by machinery, which is expected to effect a great saving of time, space, and interest on capital. Judging from all present indications the manufacture of American Portland cement, now in its initial stages, will increase with rapid strides during the next few years.

The demand for the best mortar to be used in buildings rapidly erected is becoming more and more pronounced. Lime mortar, requiring external influences in the setting process, does not contract uniformly on both sides of walls, one of which is freely exposed to the atmosphere and the other more or less protected from it. Cement, on the other hand, containing within itself all the elements necessary to the setting process, is not open to the above objection, and can be used without danger of settling and sliding due to unequal hardness in different parts of the walls even when the superimposed weight is rapidly added without allowing time for chemical or physical changes in mortar.

The scientific investigation of cements of all kinds is at present claiming considerable attention, and its results are to some extent becoming manifest in the care shown by manufacturers to maintain and, if possible to improve, the quality of their products.

The subject of properly testing and comparing the different kinds of cement in use is, however, one to which more attention might well be given by competent and unprejudiced authorities.

Imports.—The following table gives the imports of cement at New York since 1877. The statement for New York was taken from the *Record and Guide:*

Imports of cement at New York, in casks of 400 *pounds.*

Years.	From Great Britain.	From European continent.	Total casks.	Cost on pier per cask.	Total value.
1877	47,632	10,818	58,450	....	....
1878	51,477	19,040	70,517	....	....
1879	80,834	25,212	106,046	....	....
1880	120,833	45,080	165,913	....	....
1881	149,486	73,186	222,672	....	....
1882	171,202	190,924	362,126	$2.60	$941,528
1883	158,602	143,363	301,965	2.70	815,306
1884	155,477	201,085	356,562	2.50	891,405
1885	187,955	250,860	438,815	2.05	899,571
1886	261,464	301,887	563,351	....	....

The total imports (classed as "Roman" cement at the custom-houses) into the United States since 1868 have been:

Roman cement imported and entered for consumption in the United States, 1868 to 1886 inclusive.

Fiscal years ending June 30—	Quantity.	Value.	Fiscal years ending June 30—	Quantity.	Value.
				Barrels.	
1868	....	$10,168	1878	....	$184,086
1869	....	9,855	1879	....	212,719
1870	....	18,057	1880	....	373,264
1871	....	52,103	1881	....	441,512
1872	....	172,339	1882	370,406	683,684
1873	....	209,097	1883	456,418	802,294
1874	....	286,429	1884	(a)585,768	825,095
1875	....	261,741	1885	554,396	874,070
1876	....	247,200	1886	650,032	733,297
1877	....	201,074			

a Classed simply as cement; kind not specified since 1883.

Imports of cement at San Francisco.

Years.	Barrels.	Years.	Barrels.
1864	13,322	1876	66,988
1865	26,270	1877	45,469
1866	34,360	1878	57,258
1867	31,666	1879	15,668
1868	31,954	1880	62,417
1869	54,697	1881	65,695
1870	42,377	1882	99,208
1871	32,602	1883	151,807
1872	54,746	1884	152,500
1873	61,911	1885	167,000
1874	79,435	1886	159,000
1875	73,814		

It is evident from the table for total imports that while the quantity imported in 1886 is decidedly greater than in 1885, its value is less.

Comparative prices per barrel of cement in New York January 1, 1884 to 1887.

	1884.	1885.	1886.	1887.
Rosendale	$1.10 to $1.20	$1.00	$1.10 to $1.25	$1.20 to $1.25
Portland	2.40 2.75	$2.50 to 3.00	2.25 2.50	2.00 2.25
Roman	2.75 3.50	2.75 3.50	2.75 3.25	2.65 2.85
Keene's common	5.00 6.00	5.00 6.00	4.50 6.00	4.50 5.50
Keene's fine	9.25 9.75	9.50 10.00	9.00 10.00	7.50 8.50

From this table it is plain that while the domestic (Rosendale) has risen the imported Portland has fallen in price. A reaction for the better has taken place since the latter part of 1886 in the cement trade of England and Germany.

As compared with the imported Portland cement, the American Portland may be said to be far superior to a large number of imported brands; but it is also true that a considerable number of the imported articles are in turn superior to the American.

The works at South Bend, Indiana, manufacturing Portland cement, have been obliged to add to their facilities in order to supply the increased demand for their product, which seems to have steadily maintained its good standard of quality.

A considerable variation existing at present in the modes of testing cements is unfortunate, and makes it very difficult to arrive at a correct conclusion in all cases as to the comparative merits of different articles.

The following description of the process of manufacture used by the American Improved Cement Company at their works at Egypt, Pennsylvania, is taken from a paper by Mr. R. W. Lesley, and read before the Engineers' Club, at Philadelphia:

"The material used in the manufacture is a hydraulic limestone or cement rock containing the proper chemical ingredients. The process is briefly as follows: The raw rock is crushed and ground dry. The powder thus formed is run into a mixer, when a small proportion of pitch and water is added. The moistened powder is then passed through a pair of heavy rolls, having matched egg-shaped cavities, which mold it into small eggs and deliver these latter in front of the kilns, avoiding all handling. These eggs can be used the same day in the kilns if necessary, whereas under the old process the same stage of manufacture required weeks, a manifest advantage, to say nothing of the immense saving in labor, land, and interest. The form of the material, its uniformity in density, porosity, and size make it more easily burned, handled, crushed, and ground, and make it a saving at every stage of the process; while the addition of the pitch aids the uniform burning, and, moreover, by forming pores, through which the moisture in the eggs escapes, prevents them from falling away in the kiln, which they would otherwise do, owing to the generation of steam within them and the formation of a crust on their outer surfaces. This is the point which in the old processes prevented placing the wet paste in the kilns promptly, and which is here overcome by the use of a combustible. By this process the foreign brands are fairly met in point of price, and repeated tests by leading authorities here and in Europe show that the quality of the cement made is equal to the foreign Portland."

An article by R. J. Friswell, in the London *Engineer*, March 4, 1887, gives an an account of "Ransome's improvements in the manufacture of Portland cement." After describing the old process of manufacture and pointing out its lack of economy and various other disadvantages and defects, the author says:

"It will be seen from the above that the processes of burning and grinding the cement are by far the most costly of all the operations involved in its manufacture, and that they are beset with defects, both scientific and practical, of a very serious nature. It is evident that if any great improvement is to be effected in the manufacture, the most serious attention must be directed to those portions of the process. It is, therefore, to this part of the work that Mr. Ransome has directed his attention. Taking as his guiding principles economy of fuel, space, and labor, he has devised the following process:

"The 'slurry,' prepared by any one of the methods now in use, is dried on a floor heated as usual, or by waste gas from subsequent processes. The soft, friable, and easily crushed blocks are now reduced to coarse powder, and are then ready for burning. The old kiln is totally abolished, and in its place a cylinder of boiler plate is used. This is lined with good refractory fire-brick set in fire-clay, and about every fourth row the bricks are set up on end, thus producing a number of parallel longitudinal feathers or ridges extending completely through the cylinder from end to end. The outside of the cylinder is provided with two smooth rings or rails of iron. In the center a third rail is wrought into teeth, in which a worm is rotated at a slow speed. The two rails rest on friction rollers, and the whole cylinder being set at an angle with the horizon, is caused to rotate slowly. This construction, though appearing somewhat formidable, is in practice extremely simple, and similar machines, known as 'black-ash revolvers' or 'revolving black-ash furnaces,' have long been and are now in daily use in alkali works. The cylinder is mounted on the top of a brick-work chamber divided by interior walls of bricks. The two outer chambers are filled with bricks piled in loosely, chequerwise, so as to present a large surface. Supposing a cylinder to be started, the operations will be described. A gas-producer being in working order and delivering its gas at a regular rate, it is lighted and the flame passes through the cylinder, which, in the course of a few hours, attains a white heat. The waste heat from the revolver has also passed through and heated the right-hand division of the generator to a bright cherry red. A shunt valve is now opened, causing the waste gases to pass through the left-hand regenerator, while the gas from the producer is caused to flow through the heated right-hand chamber, and thus arrives at the mouth of the revolver already intensely heated. The result of this is that an immediate economy of fuel is produced, and to avoid overheat it will be necessary to reduce the gas supply. During the whole operation the air necessary for combustion is also heated by passing down a separate division of the regenerator, where it receives heat from the walls of the outer compartments. As soon as the right-hand chamber begins to cool, the furnace-man reverses his shunt valve, and the fresh gas is turned through the hot regenerator, while the waste combustion products are heating that which has cooled down. The effect of this method of working is to return into the furnace the heat which in ordinary methods of work goes up the chimney. No startling innovation occurs save in the application of the method to cement making. Regenerative furnaces are in use all over the world, and an intelligent furnace man will learn how to manage one in a few hours.

"We have now to turn our attention to the cement, which, taken from the drying floor, we described as crushed to a coarse powder. The powder is lifted by any convenient mechanical arrangement to a hopper, placed at the upper end of the revolver; from this it falls in a steady shower *through the flame* to the lower side of the cylinder, and lodges between the feathers. As the advancing side of the cylinder rises it is lifted until the feather attains such an inclination as to shoot it off again through the flame to the bottom once more, but, owing to the incline, several inches nearer to the lower end. As the revolver moves on, this operation continues again and again, the powder is constantly lifted and shot through the flame in showers, gradually getting nearer and nearer to the lower and hotter end of the cylinder, until at last it falls out into a receptacle at the lower end. In practice it is found desirable to rotate the cylinder at such a rate that any given particle of cement takes about thirty minutes to travel from one end to the other, during which time it has been lifted and shot through the flame about fifty times.

"The powder has now arrived at the outside of the furnace, and having been delivered onto a floor to cool, is at once ready for grinding; that is, it is in the same state as the clinker after being seven days in the kiln. Unlike cement clinker, however, it does not consist of lumps weighing from 14 pounds downward, and as hard as granite, but of a coarse sand. Nor does it consist of an overburnt skin, a properly burnt inner portion, and a possibly underburnt center; but if the operation has been properly carried out, each fragment has been heated to exactly the proper degree. Again, the fuel used is gaseous; consequently no mixture of coke ash has taken place, and the cement is really what it professes to be.

"The next question to be considered is the economy of fuel effected by the use of gas-producers. Instead of consuming coke, these require only to be fed with slack, coal dust, or anything that will burn, fed in at intervals through a hopper. A two-cylinder works would require for its daily service probably one gas-producer capable of converting about 6 hundredweight of slack per hour into gas.

"These producers are chambers of brick-work in which a portion of the fuel burning converts the rest into gas, a small jet of steam being blown in.

"The results derived from this plan of gas firing are: (1) Possibility of working with regenerative furnaces, thus saving all heat passing from the revolver; (2) use of about 3 hundredweight of cheap slack per ton of cement instead of 7 hundred weight of coke; (3) complete combustion of all fuel, the steam injected being decomposed by the red-hot cinders, and producing carbonic oxide and hydrogen; (4) the cement is kept entirely free from fuel ash. .

"In addition the revolver gives us the following advantages:

"(1) Economy of space, two revolvers with their appurtenances, and one in reserve covering 900 square feet, turning out the same weight of cement as eleven kilns covering 4,400 square feet;

"(2) Continuous working day and night;

"(3) Economy of repairs which are simple and cheap;

"(4) Less frequent need of repairs, as the continuous heat involves no racking like the alternate heating and cooling;

"(5) Economy in first cost;

"(6) Economy in grinding, a granular sand being produced instead of lumps of clinker, whereby crushers are quite abolished, and the wear and tear of the millstones greatly reduced;

"(7) Economy of hand labor. Revolver cement can be handled on the American elevator system;

"(8) Improved quality from (*a*) non-mixture with fuel ash; (*b*) neither over burning nor under burning;

"(9) Increased control over the quality of cement, it being possible to stop, increase, or diminish the flow of crushed slurry and to vary its quality at any time;

(10) Fewer losses by accident. The ordinary kiln once charged and fired must burn out, whether charged wrongly or rightly, while, as before stated, any error in material can be rectified in a revolver as soon as discovered.

"(11) Perfect control of temperature;

"And, lastly, power of varying the temperature according to the nature of the material.

"In addition to the method of burning just described, Mr. Ransome has introduced another improvement, which, however, is available only in certain districts. This is the introduction of a new material in cement-making in the form of blast-furnace slag."

Mr. Ransome's experimental furnace is at Grays, Essex, England.

A new cement, known by the name "Cement de Paris," has been introduced in France, the inventor and manufacturer of which is M. Vallin, the director of a French cement works, the Gypsine de la Gare. M. Vallin, instead of crushing the material after burning, does so before placing it in the kiln. A crushing mill breaks it into small pieces, which are automatically conveyed to a vertical-cylinder mill, whence they issue ground to powder. This is in turn again automatically placed on sieves, which sift it into pans or kilns heated by gas. A series of inclined plates, having a gyrating motion, agitate the powder in each of the pans, and thus render every particle of it amenable to the action of heat. Finally a mechanical arrangement conveys it to sacks, which a man fills as the powder arrives. The whole operation is thus continuous and automatic, which of itself is a great advantage. But still more important is the fact that all the particles of the cement are thoroughly burnt.

Rocky Mountain division.—Hydraulic cement of fair quality is made in Denver, Colorado, from materials obtained in the Great Hog Back, near Morrison. The Denver company sells all its product to the Denver and Rio Grande and Denver, Texas and Gulf railways where its use is perfectly satisfactory.

The capacity of the works was enlarged during 1886, and the sale of the cement will be extended as much as possible. Cement has also been manufactured to a small extent at Cañon City.

Pacific coast.—No cement was made in 1886 in the Pacific coast division, the small production in California having ceased altogether. The imports at San Francisco for the year were 159,000 barrels, having been the largest in the history of the trade. The consumption of this article on the Pacific coast, confined mostly to the city of San Francisco and vicinity, has largely increased of late, owing to the construction there of numerous cable railroads. Prices in San Francisco at the beginning of 1887 ruled as follows:

Prices of cement in San Francisco January 1, 1887.

	Per barrel.
Rosendale	$2.00 to $2.25
Portland	3.00 to 3.75
Dyckerhoff Portland	3.60
German	3.25

The imports of cement at San Francisco have been as follows:

Imports of cement at San Francisco.

Years.	Barrels.	Years.	Barrels.
1864	13,322	1876	66,988
1865	26,270	1877	45,469
1866	34,360	1878	57,258
1867	31,666	1879	15,668
1868	31,954	1880	62,417
1869	54,697	1881	65,695
1870	42,377	1882	99,208
1871	32,602	1883	151,807
1872	54,746	1884	152,500
1873	61,911	1885	167,000
1874	79,435	1886	159,000
1875	73,814		

New developments.—Most of the well-established cement works have been preparing for an increased output during the present year by enlarging to a greater or less extent their facilities for production. New works have been established at Erin, Tennessee, for the manufacture of natural rock cement, and at Birmingham, Alabama, $100,000 have been invested in a project for the manufacture of cement from blast-furnace slag.

LIME.

The production of lime in the United States during 1886 is estimated at 42,500,000 barrels, valued at $21,250,000.

For comparison with the production of previous years the following table is presented:

Estimated production of lime in the United States from 1882 *to* 1886.

Years.	Barrels of 200 pounds.	Average value at kiln.	Total value.
1882	31,000,000	$0.70	$21,700,000
1883	32,000,000	.60	19,200,000
1884	37,000,000	.50	18,500,000
1885	40,000,000	.50	20,000,000
1886	42,500,000	.50	21,250,000

The *Record and Guide* states that "according to estimates made by some of the principal receivers, the arrivals of Rockland lime at New York were, in round numbers, about 900,000 barrels in 1886, against 800,000 barrels in 1885 and 700,000 barrels in 1884. The imports from St. John, New Brunswick, were in 1886 about 40,000 barrels, against 15,500 barrels in 1885, showing quite an important increase."

Comparative prices per barrel of eastern lime at New York on January 1, 1878 to 1887.

Years.	Common.	Fine.	Years.	Common.	Fine.
1878	$0.80	$1.00	1883	$1.10	$1.40
1879	.80	.90	1884	1.00	1.20
1880	.85	1.00	1885	1.00	1.20
1881	.90	1.00	1886	1.00	1.20
1882	1.25	1.40	1887	1.00	1.20

Particularly in the last few years the attention of architects and builders has been turning more and more to the use of cement instead of lime mortar in the erection of high buildings as well as of buildings of the better class generally. Although of course the amount of lime mortar thus displaced by cement is very insignificant at the present time, and although it may be many years before a perceptible inroad upon the consumption of lime mortar may be expected, still it is interesting to note a tendency, however slight, toward such a change, which, in so far as the quality of buildings is concerned, would be a great improvement.

In the States and Territories west of the Rocky mountains lime sufficient for the demand continues to be made. The quantity of lime burned in California last year amounted to 230,000 barrels, the receipt at San Francisco being 152,006 barrels. Receipts for the past ten years in this city have been as follows:

Receipts of lime in San Francisco from 1877 *to* 1886.

Years.	Barrels.	Years.	Barrels.
1877	155,113	1882	133,309
1878	144,072	1883	158,036
1879	104,405	1884	150,526
1880	133,007	1885	154,375
1881	123,779	1886	152,006

The price of lime in San Francisco at the beginning of 1887 ranged from $1.50 to $1.75 per barrel.

Lime imported and entered for consumption in the United States.

Fiscal years ending June 30—	Quantity.	Value.	Fiscal years ending June 30—	Quantity.	Value.
	Barrels.			*Barrels.*	
1869		$10,800	1878		$14,344
1870		9,063	1879		13,196
1871		11,315	1880		15,852
1872		11,014	1881		24,968
1873		8,260	1882	73,093	36,879
1874		10,964	1883	76,889	41,224
1875		7,328	1884	53,505	26,370
1876		7,367	1885	54,676	28,270
1877		12,823	1886	82,855	41,307

Lime and cement of domestic production exported from the United States, 1864 *to* 1886.

Fiscal years ending June 30—	Quantity.	Value.	Fiscal years ending June 30—	Quantity.	Value.
	Barrels.			*Barrels.*	
1864		$86,386	1878	82,507	$98,334
1865		94,606	1879	60,657	74,097
1870	31,175	61,490	1880	41,989	52,584
1871	21,575	51,585	1881	57,555	83,598
1872	39,686	69,218	1882	67,030	100,169
1873	27,873	52,848	1883	74,687	120,156
1874	41,349	69,080	1884	65,768	108,437
1875	64,087	98,630	1885	79,627	127,523
1876	53,827	77,568	1886	81,465	123,103
1877	78,341	97,923			

BRICK.

Production.—The year 1886 has been an active one for the brick industry generally. The total production of bricks in the United States for 1886 is estimated at 5,135,000,000, valued at $27,500,000—*i. e.*, an increase of 12 per cent. in number and 10 per cent. in value over 1885.

The increase in production was most marked towards the close of the season and was due not only to greater activity on the part of brick yards in existence prior to 1886, but also, and to no inconsiderable extent, to the product of yards newly established within the year. These additions to old facilities were most numerous in the west and south, and in the latter section especially much greater advances may be confidently expected during the year 1887.

The use of machinery for brick manufacture is extending quite rapidly and from all indications will increase markedly more in 1887 than it has done in 1886.

Strong competition in brick manufacture and an increasing tendency on the part of consumers to investigate, test, and compare the various products in general use act as keen stimuli to manufacturers in putting forth their best efforts to maintain and to improve if possible the quality of the articles put upon the market. It is gratifying for those interested in this industry to note the progress made not only in the improvement of processes of manufacture, but in the increased knowledge of crude materials which is rapidly being gained, and in the care taken in selecting and handling these materials so as to secure the best results.

The use of ornamental brick and tile is generally on the increase, but in a few building centers there is a tendency toward the substitution of carved work in stone for a free use of manufactured clay products. The latter statement applies of course only to the finest edifices in the erection of which expense is not a controlling factor.

The percentage increase in the production of pressed brick is about the same as that of common brick, and the production for 1886 is estimated at 258,000,000. The sources for the best products remain as heretofore reported, but in a number of localities south and west there are indications that the production of pressed brick of very fair quality may be expected during 1887.

Philadelphia and Trenton pressed brick are sold all over the country and their popularity seems to be markedly on the increase. The products of Baltimore and Washington are extensively used in the principal cities of the east; their great hardness and beautiful cherry-red color securing for them an unfailing demand at prices so high as to admit of their use only in the finest buildings.

For the finest grades of ornamental or molded and enameled brick, Ohio is in the lead, the principal center of production being, as heretofore, Zanesville. At this point a great variety of forms of molded brick, some of them quite intricate, are produced and shipped to all parts of the country west of Pittsburgh. Enameled brick of various shades are produced and their general use is extending rapidly. A new yard for the manufacture of red pressed brick was established in Zanesville during the year, and the production for 1887 is expected to be double that of 1886.

The following information in regard to the production of a number of brick manufacturing localities, while quite incomplete, may nevertheless be found of interest inasmuch as it gives some idea of the brick industry in 1886, as compared with 1885, besides indicating to some extent what may be expected for the current year.

Résumé of brick production in 1886.

	Estimated production during 1886.	Increase over 1885.
		Per cent.
New York	962,000,000	13
According to the *Record and Guide* the production of brick at points from which the New York market draws its supply was 962,000,000. The area included in this estimate covered the Hudson River district, Long Island, Staten Island, and New Jersey, including Hackensack.		
Galveston, Texas	8,000,000	....
New Orleans	25,000,000	....
The production in this city in 1886 did not exceed that of 1885 by any considerable amount, but the outlook for 1887 is unquestionably encouraging.		
Columbus, Georgia	5,000,000	
The brick produced in this city are used locally to the extent of about two-thirds of the entire amount, the balance being shipped to various points. The production was very little in advance of 1885.		
Macon, Georgia	20,000,000	....
The production of this city is chiefly shipped to Florida.		
Atlanta, Georgia	40,000,000	....
About two-thirds of the entire production is used in Georgia, the balance being shipped to Florida chiefly, but also to a less degree to Alabama and Tennessee.		
Birmingham, Alabama	10,000,000	....
The production of brick in this city largely exceeded that of 1885, having been estimated by some authorities as double the amount produced in the previous year. Preparations for a still larger output during 1887 were active during the latter part of 1886.		
Montgomery, Alabama	11,500,000	....
A fair proportion of this product was shipped to Florida. One new yard was established during the year.		
Selma, Alabama	2,500,000	50
Lexington, Kentucky	5,500,000	10
Chicago, Illinois	400,000,000	11
During 1886, 9 new yards were established and the outlook for 1887 is most encouraging.		
Urbana, Illinois	3,000,000	12.5
In addition to the brick produced during 1886 must be added 10,000,000 tiles.		
Joliet, Illinois	3,000,000	....
2,500,000 tiles were also produced during 1886.		
Vincennes, Indiana	4,000,000	....
150,000 tiles were also produced.		
Aurora, Indiana	8,500,000	....
The brick produced here are used chiefly in Cincinnati.		
Elkhart, Indiana	4,000,000	....
The product here is for the most part locally used.		
Cincinnati, Ohio	90,000,000	....
The strikes which occurred during the year are said to have seriously curtailed the output for the year. Two new yards were established.		
Zanesville, Ohio	12,000,000	....
A variety of brick is manufactured here, including common brick as well as the very fine pressed ornamental and enameled brick, discussed in another place in this report. One new yard for the manufacture of red pressed brick was established during the year, and the output for 1887 will be much larger.		
Omaha, Nebraska	75,000,000	33
The brick industry has been very active during 1886, and a large business is anticipated for 1887. The brick is used locally. Three new yards were started during 1886.		
Lincoln, Nebraska	10,000,000	33
The product is used locally.		
Menominee, Wisconsin	15,000,000	100
The manufacture of brick has been in a flourishing condition during the year, the amount produced being about double that of 1885. Three new yards were established during the year. The principal markets are Saint Paul and Minneapolis, and in these cities the demand for Menominee pressed brick is decidedly increasing.		
Milwaukee, Wisconsin	35,000,000	....

Firebrick.—The demand for firebrick during 1886 has been generally better than during 1885. To meet this increased demand many of the larger producing establishments have been obliged to force old facilities and in some cases to enlarge them. Furthermore a considerable number of entirely new plants has been erected.

The activity in the erection of iron furnaces at a number of places in the South is doubtless one of the causes for the increase in demand for firebrick, and this cause will probably be felt more in 1887 than it has been during the past year.

Estimated production of firebrick for 1883, 1884, 1885, *and* 1886.

	1883.	1884.	1885.	1886.
Ohio	23,000,000	25,000,000	25,000,000	25,000,000
Pennsylvania	55,000,000	50,000,000	50,000,000	52,000,000
New Jersey	21,000,000	20,000,000	20,000,000	22,000,000
Scattering	7,000,000	8,000,000	10,000,000	11,000,000
Total	106,000,000	103,000,000	105,000,000	110,000,000

Production of fireclay in Ohio in 1886.

Counties.	Number of weeks worked.	Number of miners.	Number employed in manufacture.	Production—short tons.
Columbiana	40	51	499	56,233
Hocking	40	7	50	13,802
Jackson	47	20	92	12,218
Jefferson	49	60	469	115,024
Lawrence	46	20	76	17,150
Muskingum	....	3	....	751
Mahoning	27	1	4	600
Stark	29	8	12	17,250
Scioto	35	19	132	23,075
Tuscarawas	37	33	98	10,606
Totals and average	39	222	1,432	266,709

The increase in importations in 1886 was not so great as in 1885. The imports for the years in question are as follows: In 1884, 1,524,000 bricks; in 1885, 3,401,449; in 1886, 3,463,002.

The following table shows the relative prices of fire-brick in New York on January 1 for the past four years, including January 1, 1887:

Prices of firebrick in the New York market per thousand.

Kinds.	1884.		1885.		1886.		1887.	
Welsh	$30.00 to	$35.00	$25.00 to	$30.00	$24.50 to	$30.00	$21.50 to	$24.00
English	25.00	30.00	25.00	30.00	22.00	30.00	22.00	24.00
American No. 1	33.00	35.00	30.00	35.00	30.00	35.00	30.00	33.00
American No. 2	25.00	30.00	25.00	30.00	25.00	30.00	23.00	28.00

A general falling away in price has evidently taken place since 1884 and during the past year manufacturers have had to accept a small margin of profit.

New discoveries of fireclay.—There is at present no great incentive toward activity in the discovery of new deposits of fireclay, as the beds now extensively worked are in most cases ample to supply the demand, and numerous deposits not worked are known to exist. However, the following account of a bed discovered at Socorro, New Mexico, is interesting on account of its situation and the ease with which the clay, which is of very fine quality, is taken out.

This deposit is about 5 miles east of Socorro. A road of easy down grade leads from the bed to the town and also to the main line of the Atchison, Topeka and Santa Fé railroad.

The deposit is in the form of a uniform vein from 7 to 15 feet in thickness inclosed between walls of hard siliceous rock in places. It crops out in section for about 1,000 feet of surface. Its main inclination, as exhibited by a sectional view of the outcrop from the highest to the lowest point of the same on the surface of the ground, consists of about 1 foot in 20. It is now being developed by a tunnel starting from the lowest point on the vein and running on an up grade into the hill. The product is run out onto the dump by gravity, requiring therefore no hoisting power. Direct entry can be made into the body of the vein at any or all points along the outcrop. The vein could hardly have been formed by nature more advantageously for economical development and mining. The clay is semi-plastic, refractory, and very similar to the celebrated Stourbridge clay of England. It contains no free silica, and is remarkably free from the impurities usually found in the purest and best fireclays. Aside from a small percentage of organic matter and moisture, it is virtually pure silicate of alumina. It is claimed to be good compared to other American fireclays for extreme refractoriness to the action of the metals and their oxides under high temperatures.

When first mined it is soft, waxy, and of a black color, but after weathering a few days it becomes bluish gray in color and can then be reduced to an impalpable powder readily and cheaply in almost any grinding mill, and as it contains nothing of a gritty character it effects little or no wear of the grinding parts.

Colorado.—During the year 1886 the manufacture and sale of fireclay and its products did not very materially increase. The clay produced near Denver is of the most satisfactory character, and is generally used in preference to foreign manufactures. As stated in previous volumes of this series, the clay is mined near Golden, 14 miles west of Denver. The quantity is practically inexhaustible, and as it is as good, if not better, than any clay found elsewhere in the Rocky mountains, there is little prospect of opening other beds.

The principal manufacturers of fireclay products are the Denver Fireclay Company and the Denver Firebrick Company. These companies report the following production in 1886:

Production of fireclay in Denver, Colorado, in 1886.

	Quantity.
Denver Fireclay Company:	*Short tons.*
Total tonnage	2, 600
Firebrick	1, 950
Ground clay	520
Assay and furnace goods	130
Denver Firebrick Company	*Pounds.*
Firebrick	837, 000
Tiles	1, 386, 000
Retorts (number, 85)	160, 000
Muffles	1, 185
Glass-house pots, 30	30, 000
	Short tons.
Ground clay	540
Calcined firebrick	160
Total tons of clay mined	3, 685
Plastic clay mined	473

The amount of fireclay mined from 1880 to 1885 was about as follows:

Fireclay used by the Colorado works.

Works.	Location.	1880.	1881.	1882.	1883.	1884.	1885.
		Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
Cambria Brick and Tile Company	Golden	....	2, 000	3, 000	3, 000	500	....
G. A. Duncan and Company	....do	4, 000	6, 000	9, 000	10, 000	12, 000	15, 000
Golden Brick and Coal Company	....do	5, 000	4, 500	960	750	1, 200	800
Denver Fireclay Company	Denver	1, 200	1, 200	1, 500	1, 200	3, 200	4, 500
Denver Firebrick Company	....do	....	....	4, 000	1, 600	....	....
Total		10, 200	13, 700	18, 460	16, 550	16, 900	20, 300

Fireclay of good quality is found between the Dakota sandstone and the rocks of the Jurassic period. No works have been established to utilize it in manufacture, although it has been thoroughly tested and found first class.

Pottery.—The representatives of the pottery industry in the United States have been steadily gaining ground in their active competition with foreign producers; this statement is made not only with reference to the plainer wares, but also to the fine decorated articles of England and the French or German china.

The following is a statement of the imports of earthenware and china entered for consumption in the United States during the fiscal year ending June 30, 1886:

Value of imports of earthenware and china in the fiscal year 1886.

Brown earthen and common stone ware	$39, 154
China and porcelain not decorated	807, 645
China and porcelain decorated	2, 967, 058
Other earthen stone or crockery, glazed, etc	1, 024, 235
Total	4, 838, 092

From the above table it is evident that the total value of the staple white goods imported is $1,024,235; for the same period the value of the same class of goods manufactured in this country was, in round numbers, $5,000,000; the value of the decorated ware produced amounted to $3,000,000.

A comparison of the figures for production in this country with those representing total consumption shows that about 80 per cent. of the total consumption of staple white goods is supplied by the American producers, while a little more than 40 per cent. of the total consumption of china and porcelain, decorated and not decorated, is the result of home production.

The following table gives the imports of pottery products since 1880:

Earthenware and china imported and entered for consumption in the United States, 1880 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Brown earthen and common stone-ware.	China and porcelain not decorated.	China and decorated porcelain.	Other earthen stone, or crockery, glazed, etc.	Total.
1880	$31, 504	$334, 371	$1, 188, 847	$3, 945, 666	$5, 500, 388
1881	27, 586	321, 259	1, 621, 112	4, 413, 369	6, 383, 326
1882	36, 023	316, 811	2, 075, 708	4, 438, 237	6, 866, 779
1883	43, 864	368, 943	2, 587, 545	5, 685, 709	8, 686, 061
1884	50, 172	982, 499	2, 664, 231	666, 595	4, 363, 497
1885	44, 701	823, 334	2, 834, 718	963, 422	4, 666, 175
1886	39, 154	807, 645	2, 967, 058	1, 024, 235	4, 838, 092

An examination of this table shows that while the figures for china and porcelain, decorated and not decorated, have decidedly increased since 1880, the figures for "other earthen stone," etc., *i. e.*, staple white goods, show a falling off since that time, the decline being most marked in 1884. In other words, the bulk of the ware imported up to 1880 consisted of plain goods, while at the present time about three-fourths of the imports are French or German china and English decorated ware.

These facts indicate not only an advance on the part of the American producers, but also markedly improved taste on the part of consumers in the United States. This disposition to use the finer grades of pottery ware dates back to 1876, and is believed to be a result of the Centennial Exposition. English manufacturers, discovering that there was little profit in competition with American potters in the production of plain white ware for consumption in the United States, made special efforts to create a demand for the various grades of fine decorated pottery. The American producers are now endeavoring to keep pace with the new departure, and their efforts are becoming more and more successful.

No serious labor troubles in the pottery industry have occurred during the year, and workmen have been kept in most instances fully employed, producing an output probably exceeding that of average years.

In improvements of machinery, a little has been done during the year, but it has not been one of marked advances in this branch of the industry.

Kaolin.—The amount of kaolin produced in the United States during 1886 was 23,900 long tons, valued, after washing at the mines, at an average of $14 per ton, or in all $334,600. Crude kaolin, as it occurs in the natural deposits, is a mixture, consisting chiefly of quartz sand and china clay or pure kaolin. The latter is separated by washing. There is no demand for the crude mixture above described.

During the fiscal year ending June 30, 1886, the amount of kaolin imported was 14,183 tons, a gain of 3,557 tons over 1885.

New discoveries.—At Lima, Delaware county, Pennsylvania, a bed of kaolin was discovered in October, 1886. The deposit is reached after removing about 10 feet of material above it, and extends, according to examinations thus far made, to a depth greater than 31 feet from the surface of the ground; the exact depth is not known. The investigations of this deposit which have been made are not sufficient to justify any definite statements as to quality or extent, but during the summer of 1887 thorough tests are to be made.

About 1½ miles south of Bodie, California, there is a bed of what is called kaolin, but whether it is sufficiently pure for pottery use, tests thus far made do not show. The deposit was discovered in 1884, but nothing was done towards testing or utilizing it until 1886, and even as yet the tests made are insufficient to admit of any very promising statements in regard to it, although it would probably well repay thorough investigation.

At Leakey, Edwards county, Texas, a company was formed for the development of kaolin deposits in that region.

The Allen kaolin mines at Valley Head, Alabama, were recently sold to a new company, which proposes to erect a mill for washing the product. The exact character of the clay at this point has not been reported.

"*Porous earthenwares.*"—The products included under the name porous earthenwares are severally as follows: Terra cotta lumber, brick wood, cellular pottery, and holtzstein.

They are the products obtained by mixing with water, pressing, drying, and firing different combinations of earthy matters with vegetable materials. The nature of the ingredients used and the methods of treating their mixture secure products of exceedingly porous character, and which possess in general the properties of both brick and wood.

Terra cotta lumber was the first in order of discovery, and is manufactured by mixing together fictile clays with resinous sawdust, and ultimately burning the mixture. The resulting product is susceptible of treatment with carpenters' tools, and may be sawed, planed, and nailed with facility.

The expense connected with firing such refractory clays as those used in terra cotta lumber is quite considerable, and, moreover, they are not sufficiently widely distributed for extensive use. These facts led to further experiment and investigation for a cheaper material, and one that is as widely distributed as possible. The product "brick-wood" resulting from these experiments is made from surface clays, with or without grit, mixed homogenously with sawdust of any kind, and fired in the up-draft kiln of the brickmaker. The expensive heavy-power grinding mills and costly down-draft kilns, necessary to the working of fictile clays, are done away with in this product. It was found that the vegetable matters contained in the dried, pressed material were adequate as a fuel, after ignition, to bake the clay residue. This product was put upon the market in Saint Paul in 1884.

The substitution for sawdust of straw or hay, cut into short lengths, gave rise to a third product, known as "cellular pottery." It is claimed that in this material the lengths of straw used arrange themselves parallel with each other, and in the direction of motion of the plastic mass through the dies while under the action of the press. The effect of this arrangement of the straw was to produce a fibrous character in the manufactured article, and to render possible the production of pieces in the shape of slabs, joists, and scantlings 10 or 12 feet in length.

The fourth product, "holtzstein," is the result of bringing together, with proper subsequent treatment and firing, clay, sawdust, and cut straw; and therefore it includes within itself the materials and the properties of "brick-wood" and "cellular pottery."

The valuable properties and the advantages claimed for porous earthenwares are their incombustibility, their non-conducting power as regards heat and sound, resistance to chemical agencies and indifference to sudden changes of temperature, light weight with ample strength, susceptibility to the action of edged tools, etc.

Factories for the manufacture of these materials are in operation in several cities and their number is increasing. Reports from some of these individual factories indicate marked demand for these products chiefly as fireproofing material in large buildings. One report showed an increase of the original manufacturing plant, to three times the capacity at first provided for.

The use of these materials in dwelling houses is at present very slight indeed, and comparatively little is known of them by architects whose practice consists mainly of residence construction. Most architects who have any knowledge of "porous earthenwares" speak favorably of them, and predict an extensive use for them in buildings of all kinds.

Roofing tiles.—The use of tiles for roofing purposes is not very extensive, and while many architects denounce them strongly as being unsatisfactory, many others are favorable to their use, if very carefully and skillfully applied to roofs, which must be abundantly strong enough to sustain their considerable weight. The proper use of tile in roofing involves, therefore, a number of items of expense, in addition to the cost of the material itself, which do not so necessarily present themselves with other roofing materials.

In quite a number of cities where tiles have been tried for roofing the climate has been found too severe to admit of their successful use, but their expense and the skill and care required in applying them are probably the causes which are most powerful in restricting demands, and the consequent production, which for 1886 has probably been little greater than for 1885.

The value of the roofing and paving tiles imported during 1885 was $99,258; for 1886, $80,420; *i. e.*, a decline of $18,838. Unfortunately no distinction between roofing and paving tiles is made in the valuation.

Terra cotta.—The production of terra cotta is increasing, both on account of increase in consumption in cities where its use is comparatively old and well established, and because of a rapidly increasing area in which it is comparatively new but is rapidly gaining in popularity. In the West, particularly, many new establishments have been erected during 1886, and still greater activity in the industry may be expected during 1887 At a number of cities in the South, particularly in Alabama and Tennessee, new establishments were either actually started during 1886 or were contemplated for the early part of 1887. Clay products generally in the South are receiving much more attention at present than has been devoted to them for thirty years past.

Drain tile.—Increase in the production of drain tile in a number of the Western States, particularly Ohio, Indiana, Illinois, and Michigan, is steady and quite rapid. During the past year a considerable number of new factories has been added to those already existing, and, moreover, the tendency to establish yards intended to supply strictly local demands extending over small areas is increasing. Manufacturers are now sending out perfected brick and tile machines, with directions and instructions for use so explicit and definite, that persons previously unskilled in such manufacture may in a comparatively short time become able to produce articles good enough to answer their own purposes and those of their neighbors. As was remarked in the last report, it happens that in many regions requiring drain tile the clay suitable for its manufacture is also found, and this fact, of course, explains the tendency to manufacture for local use only. In some single counties in the States above mentioned there are as many as twenty tile factories, most of them engaged in supplying local demand. The increase in value of lands supplied with a good system of underground drainage in the States mentioned is such, that property owners can ill afford to ignore such improvements when they are at all called for.

Production of drain tile in Indiana.

Years.	Number of establishments.	Capital employed.	Value of product.	Hands employed.
1879	297	$456,489	$623,720	948
1880 (*a*)	486	700,000	900,000	2,187
1882	261	491,130	764,345	1,086
1883	387	759,562	1,133,515	1,517
1884	513	958,920	1,659,820	1,880

a Estimated; evidently too high.

Sewer pipe.—The annual product of Ohio has been valued at $3,000,000, that of New York at $1,500,000, while the product of New Jersey amounts to about $400,000. It is probable that the value of sewer pipe produced in 1886 is not far from $5,000,000, although this estimate must be regarded as only approximative, owing to a lack of returns full enough to justify a positive and definite statement.

IMPORTS AND EXPORTS.

As will be seen from the following tables, there is a considerable importation of clay and its products, especially china, porcelain, etc., and a small export trade:

Clay imported and entered for consumption in the United States, 1867 *to* 1883 *inclusive.*

Fiscal years ending June 30—	Fuller's earth.		Kaolin.		Unwrought pipeclay and fireclay.		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Long tons.		*Long tons.*		*Long tons.*		
1867	280.25	$3,113	....	....	6,383.75	$72,204	$75,317
1868	211.00	2,522	....	....	8,384.75	66,958	69,480
1869	324.10	3,587	....	....	12,963.75	84,645	88,232
1870	239.40	2,619	....	....	8,014.15	76,057	78,676
1871	290.20	3,383	....	....	10,900.48	103,144	106,527
1872	274.00	3,358	....	....	13,081.20	128,130	131,488
1873	251.18	2,978	1,378.30	$13,091	12,883.82	141,927	157,996
1874	277.20	3,440	89.21	1,378	12,909.14	147,782	152,600
1875	300.06	3,694	130.47	1,977	10,374.65	116,307	121,978
1876	246.73	3,097	142.00	2,152	11,799.12	126,738	131,987
1877	400.00	4,460	204.26	3,009	11,680.14	129,016	136,485
1878	335.07	4,095	3,499.30	38,899	9,406.74	95,877	138,871
1879	361.21	4,269	4,774.60	45,272	8,477.80	87,948	137,489
1880	578.00	6,925	7,823.66	67,740	11,899.80	117,350	192,015
1881	267.55	3,207	6,887.37	66,654	12,444.28	123,545	193,406
1882	908.27	11,444	13,954.85	135,448	12,181.39	119,620	266,512
1883	1,241.27	14,309	12,870.60	115,492	7,841.32	74.673	204,474

Classified imports of clay during the fiscal years 1884, 1885, *and* 1886.

Kinds.	1884.		1885.		1886.	
	Long tons.	Value.	Long tons.	Value.	Long tons.	Value.
China clay or kaolin	16,112	$131,063	10,626	$83,722	14,183	$110,452
All other:						
Unwrought	11,021	85,990	9,736	76,899	11,807	89,626
Wrought	2,149	16,158	3,554	29,839	3,908	34,129
Total	29,282	233,211	23,916	190,460	29,898	234,207

Building brick imported and entered for consumption in the United States, 1868 *to* 1886.

Fiscal years ending June 30—	Quantity.	Value.	Fiscal years ending June 30—	Quantity.	Value.
1868	....	$44,453	1878	25,170	$166
1869	....	59,359	1879	918,840	4,534
1870	....	46,892	1880	349,000	1,662
1871	....	52,997	1881	539,600	3,002
1872	....	5,275	1882	711,150	9,168
1873	963,500	6,982	1883	764,700	7,958
1874	594,330	4,929	1884 (*a*)	531,820	9,985
1875	495,500	3,278	1885	1,220,000	12,905
1876	411,550	3,147	1886	6,219,441	19,461
1877	129,970	897			

a Classed as "brick other than firebrick."

Bathbrick and firebrick imported and entered for consumption in the United States, 1868 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Value.	Fiscal years ending June 30—	Value.
1868	$8,763	1878	$36,670
1869	86	1879	44,681
1870	19,112	1880	60,589
1871	18,215	1881	82,581
1872	47,502	1882	69,575
1873	60,442	1883	124,948
1874	66,428	1884	(*a*)103,309
1875	50,325	1885	35,616
1876	69,063	1886	43,371
1877	43,548		

a Firebrick only, since 1883.

Firebrick imported since 1877.

Fiscal years ending June 30—	Imports.	Fiscal years ending June 30—	Imports.
	Number.		*Number.*
1877	303,870	1882	2,831,033
1878	244,614	1883	1,250,135
1879	690,954	1884	1,524,000
1880	1,504,462	1885	3,401,449
1881	1,968,230	1886	3,463,002

Earthenware and china imported and entered for consumption in the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Brown earthen and common stone ware.	China and porcelain not decorated.	China and decorated porcelain.	Other earthen, stone, or crockery, glazed, etc.	Total.
1867	$48,618	$418,493	$439,824	$4,280,924	$5,187,859
1868	47,208	309,960	403,555	3,244,989	4,005,712
1869	34,260	400,894	555,425	3,468,970	4,459,549
1870	47,457	420,442	530,805	3,461,524	4,460,228
1871	96,695	391,374	571,032	3,573,254	4,632,355
1872	127,346	470,749	814,134	3,896,664	5,308,893
1873	115,253	479,617	867,206	4,289,868	5,751,944
1874	70,544	397,730	676,656	3,686,794	4,831,724
1875	68,501	436,883	654,965	3,280,867	4,441,216
1876	36,744	409,539	718,156	2,948,517	4,112,956
1877	30,403	326,956	668,514	2,746,186	3,772,059
1878	18,714	289,133	657,485	3,031,393	3,996,725
1879	19,868	296,591	813,850	2,914,567	4,044,876
1880	31,504	334,371	1,188,847	3,945,666	5,500,388
1881	27,586	321,259	1,621,112	4,413,369	6,383,326
1882	36,023	316,811	2,075,708	4,438,237	6,866,779
1883	43,864	368,943	2,587,545	5,685,709	8,686,061
1884	50,172	982,499	2,664,231	666,595	4,363,497
1885	44,701	823,334	2,834,718	963,422	4,666,175
1886	39,154	807,645	2,967,058	1,024,235	4,838,092

Value of tiles imported for consumption in the United States, 1868 to 1886 inclusive.

Fiscal years ending June 30—	Encaustic.	Roofing and paving.	Total.
1868	$11,423	....	$11,423
1869	7,599	$1,443	9,042
1870	8,549	875	9,424
1871	4,771	884	5,655
1872	8,083	31,453	39,536
1873	18,717	51,772	70,489
1874	14,193	51,010	65,203
1875	15,401	45,360	60,761
1876	15,267	29,903	45,170
1877	16,787	42,143	58,930
1878	13,112	41,032	54,144
1879	17,355	31,177	48,532
1880	16,896	34,063	50,959
1881	21,106	43,717	64,823
1882	27,729	46,562	74,291
1883	16,459	83,777	100,236
1884	16,011	115,770	131,781
1885	10,312	99,258	109,570
1886	7,719	80,420	88,139

Value of clay exported from the United States, 1865 to 1886 inclusive.

Fiscal years ending June 30—	Value.	Fiscal years ending June 30—	Value.
1865	$29,975	1878	$8,384
1869	5,065	1879	6,314
1870	2,354	1880	8,355
1871	10,904	1881	8,762
1872	5,275	1882	17,458
1873	4,970	1883	17,790
1874	8,146	1884	7,725
1875	13,933	.885	8,225
1876	4,325	1886	9,978
1877	5,493		

Value of brick, etc., of domestic production exported from the United States.

Fiscal years ending September 30, until 1842, and June 30 since.	Brick and lime.	Brick, lime, and cement.	Firebrick and firetile.	Brick, other than fire.	Total.
1826	$6,075				$6,075
1827	3,365				3,365
1828	4,573				4,573
1829	3,717				3,717
1830	2,482				2,482
1831	4,412				4,412
1832	3,502				3,502
1833	3,866				3,866
1834	4,294				4,294
1835	4,133				4,133
1836	6,829				6,829
1837	29,626				29,626
1838	31,322				31,322
1839	16,298				16,298
1840	16,949				16,949
1841	14,064				14,064
1842	5,728				5,728
1843 (nine months)	3,883				3,883
1844	12,833				12,833
1845	8,701				8,701
1846	12,578				12,578
1847	17,623				17,623
1848	24,174				24,174
1849	8,671				8,671
1850	16,348				16,348
1851	22,045				22,045
1852	13,539				13,539
1853	32,625				32,625
1854	33,194				33,194

Value of brick, etc., of domestic production exported from the United States—Continued.

Fiscal years ending September 30, until 1842, and June 30 since.	Brick and lime.	Brick, lime, and cement.	Firebrick and firetile.	Brick, other than fire.	Total.
1855		$57,393			$57,393
1856		64,297			64,297
1857		68,002			68,002
1858		103,821			103,821
1859		160,611			160,611
1860		154,045			154,045
1861		93,292			93,292
1862		83,385			83,385
1863		99,313			99,313
1864		49,106			49,106
1865		64,105			64,105
1866		146,874			146,874
1867		102,324			102,324
1868		140,338			140,338
1869		83,229			83,229
1870			$4,483	$25,091	29,574
1871			18,471	9,279	27,750
1872			10,233	14,305	24,538
1873			14,651	10,632	25,283
1874			22,365	11,290	33,655
1875			14,476	12,120	26,596
1876			20,348	18,035	38,383
1877			9,892	25,571	35,463
1878			13,900	254,446	268,346
1879			11,096	51,714	62,810
1880			12,027	36,299	48,326
1881			12,290	27,989	40,279
1882			30,649	50,870	81,519
1883			47,120	56,227	103,347
1884			41,012	60,702	101,714
1885			31,058	41,181	72,239
1886			41,343	35,579	76,922

During the years given there were exported from the port of New York the following numbers of brick:

Building brick and firebrick exported from New York.

Calendar years.	Building brick.		Firebrick.	
	Number.	Value.	Number.	Value.
1877	13,603,475	$70,629	45,000	$2,185
1878	4,471,980	29,457	118,994	3,148
1879	1,381,775	9,371	94,976	6,867
1880	921,654	7,486	80,000	3,208
1881	971,500	8,663	181,359	8,361
1882	778,000	7,026	269,810	9,843
1883	2,642,625	21,737	358,616	11,039
1884	1,702,850	14,148	300,100	9,042
1885	973,000	8,894	....	12,059
1886	977,500	9,075	223,010	7,838

Value of earthenware and stoneware of domestic manufacture exported from the United States.

Fiscal years ending September 30, until 1842, and June 30, since.	Value.	Fiscal years ending June 30—	Value.	Fiscal years ending June 30—	Value.
1790	$1,990	1845	$7,393	1866	$31,616
1791	1,984	1846	6,521	1867	29,308
1826	1,958	1847	4,758	1868	29,528
1827	6,492	1848	8,512	1869	19,213
1828	5,595	1849	10,632	1870	42,120
1829	5,592	1850	15,644	1871	37,383
1830	2,773	1851	23,096	1872	48,941
1831	7,378	1852	18,310	1873	53,909
1832	6,333	1853	53,685	1874	59,494
1833	12,159	1854	33,867	1875	92,253
1834	12,745	1855	32,119	1876	73,846
1835	16,427	1856	66,696	1877	87,355
1836	13,391	1857	34,256	1878	98,035
1837	14,219	1858	36,783	1879	80,898
1838	12,019	1859	47,261	1880	106,724
1839	11,645	1860	65,086	1881	123,177
1840	10,959	1861	40,524	1882	180,773
1841	6,737	1862	32,108	1883	227,547
1842	7,618	1863	88,244	1884	236,247
1843 (nine months)	2,907	1864	67,591	1885	135,385
1844	4,884	1865	93,258	1886	150,272

ABRASIVE MATERIALS.

BUHRSTONES.

By William A. Raborg.

Granular masses of flint and quartz suitable for making millstones are found more or less in all the range of the Alleghany mountains. In New York these masses are called "Esopus stone," in Pennsylvania "Cocalico stone," and in North Carolina "North Carolina grit."

The value of the output at the above localities for the years 1883 to 1886 is estimated as follows:

Estimated value of the buhrstones produced in the United States from 1883 *to* 1886.

Year.	Esopus.	Cocalico.	North Carolina grit.	Total value.
1883	$120,000	$30,000	....	$150,000
1884	110,000	40,000	....	150,000
1885	90,000	10,000	....	100,000
1886	100,000	10,000	(a)$30,000	140,000

a for 300 complete sets.

Foreign buhrstones.—The reasons for the small development of the buhrstone industry in the United States are, first, it is not a growing one, being reduced by the substitution of the roller process of grinding grain; again, the foreign supply is well established and capable of supplying the best known quality of stone at satisfactory rates. The best buhrstone is found in France, in the mineral basin of Paris and in a few adjoining districts, where it occurs in great masses. The stone has a straight fracture, and is not so brittle as flint, though its hardness is nearly the same. It has a white, gray, yellow, or bluish color, and varies in texture from the most open and porous to the closest quality possible. The stone sometimes appears to be filled with fresh water shells or land shells, and vegetable matter of inland growth. Some of the stone contains no organic forms at all. The stone is quarried in the open air and sold in solid stones, blocks, quarters, panels, and half panels, and is usually imported in this condition, to be finished in this country.

German buhrstone comes from a district on the Rhine, near Cologne. It is a basaltic lava, and is found near the old craters of extinct volcanoes, at a depth of from 100 to 150 feet under ground. A shaft is sunk and the stone quarried out so as to leave natural columns to support the earth above. The stones increase in size with the depth. The structure is very uniform and of a dark blue color. It is too soft for grinding wheat.

These foreign buhrstones, principally French, are shipped to the United States in all sizes from 16 up to 54 inches, and weighing from 500 to 5,000 pounds per pair. The average weight is 3,500 pounds per pair. The average price is $60 for the unfinished and $125 for the finished stones per pair.

Buhrstones and millstones imported and entered for consumption in the United States, 1868 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Rough.	Made into millstones.	Total.	Fiscal years ending June 30—	Rough.	Made into millstones.	Total.
1868	$74, 224	....	$74, 224	1878	$87, 679	$1, 928	$89, 607
1869	57, 942	$2, 419	60, 361	1879	101, 484	5, 088	106, 572
1870	58, 601	2, 297	60, 898	1880	120, 441	4, 631	125, 072
1871	35, 406	3, 698	39, 104	1881	100, 417	3, 495	103, 912
1872	69, 062	5, 967	75, 029	1882	103, 287	747	104, 034
1873	60, 463	8, 115	68, 578	1883	73, 413	272	73, 685
1874	36, 540	43, 170	79, 710	1884	45, 837	263	46, 100
1875	48, 068	66, 991	115, 059	1885	35, 022	455	35, 477
1876	37, 759	46, 328	84, 087	1886	40, 722	676	41, 398
1877	60, 857	23, 068	83, 925				

GRINDSTONES.

BY WILLIAM A. RABORG.

The sandstone deposits of this country from which grindstones are obtained are found along the shores of Lake Erie, and extending for a considerable distance east and west of Cleveland, Ohio, and inland as far as Marietta, on the Ohio river. They are also found on the shores of Lake Huron, above Detroit, Michigan.

The total value of the domestic grindstones produced in 1886 may be put at, roundly, $250,000.

The most important feature in the grindstone industry of the United States during 1886 was the consolidation of the following firms into the Cleveland Stone Company, which produces nearly all the grindstones used in the United States: The McDermott and Berea Stone Company, Worthington & Sons, James Nicholl, the J. McDermott Company, the Clough Stone Company, the Berea and Huron Stone Company, the Clough, Haldeman and Atlantic Stone Company, the Atlantic Stone Company, L. Haldeman & Son, the Berea Stone Company, the Ohio Grindstone Company, the Nickel Plate Stone Company, and the Columbia Stone Company.

Almost all the Ohio grindstones are made by machinery driven by steam power. The blocks of stone being loosened from the quarry bed, are roughly hewn out with a square hole in the center; they are then placed on a heavy square iron shaft furnished with a 9-inch collar, against which the stone is securely fastened by means of another collar keyed against the stone. The shaft and stone being driven by steam power, two men on opposite sides of the stone turn it off perfectly true by means of soft iron bars 6 feet long and 2 inches by one-half inch thick, which are drawn out to a thin edge which is curved upward. This was formerly a very unhealthy operation, owing to the dust being inhaled by the work man, but this difficulty is now obviated by means of blowers.

The following analyses represent the general composition of the Ohio grindstones:

Analyses of Amherst and Berea grindstones.

BUFF AMHERST STONE.(a)

	Per cent.
Silica	97.00
Lime	1.15
Alkalies	.64
Sesqui-oxide of iron	1.00
Moisture	.17
Loss	.04
Total	100.00

BEREA STONE.(b)

	Per cent.
Silica	96.90
Carbonate of iron	1.68
Carbonate of calcium	.55
Alkalies	.55
Water	.30
Loss	.02
Total	100.00

Specific gravity 2.335. Weight per cubic foot (dry) 140 pounds.

a Prof. J. H. Salesbury, State Geologist, analyst.
b John Eisenmann, Professor of Civil Engineering Case School of Applied Science, Analyst.

Uses.—There are specialties in the mechanic arts which are the results of many years of practice, and in nothing more than in the varied and important uses to which grindstones are applied. Formerly their operations were confined to sharpening tools only, but this is now only a small part of the uses to which they are put, as it has been found by experience that almost every kind of steel, iron, and brass work used in finished machines can be ground better and cheaper than by filing. Almost every part of the locomotive engine is now finished on the grindstone, which leaves the metal in the best possible condition to receive the polish or paint in finishing.

The Ohio, English, and Nova Scotia grindstones are the principal kinds in use, but each of these sorts is subdivided into an endless variety of sizes and "grits." The following table will serve to show the different qualities of the various stones, and the principal uses to which they are put:

Table showing the various kinds of sandstones made into grindstones and the special purposes for which they are used.

Name.	Color.	Structure.	Special purposes for which used.
UNITED STATES.			
Ohio.			
Berea	White	Fine and sharp grit	For sharpening edge tools generally.
Amherst	Brownish-white	Soft loose grit	For edge tools, and the very soft ones for saws.
Independence	Grayish-white	Coarse sharp grit	For grinding springs and files, and for dry grinding of castings.
Massillon	Yellowish-white	do	For edge tools, springs, files, and nail cutter's face stones, and for dry grinding of castings.
Michigan.			
Huron	Blue	Fine sharp grit	For sharpening tools when a very fine edge is required.
ENGLISH.			
Newcastle	Yellow	Sharp grit	The fine soft ones for grinding saws and the coarse and the harder ones for sad irons and springs, pulleys, and shafting (instead of turning), and for bead and face stones in nail works, and for castings (dry grinding).
Wickersly	Grayish-yellow		For grinding saws, squares, bevels and cutter's work generally. A very soft grit to avoid taking out the temper.
Liverpool	Red	Very sharp grit	For saws and edge tools generally. An excellent grit for sharpening axes in ship-yards.
Nova Scotia	Blue or yellowish-gray.	All grits from the finest and hardest to the coarsest and softest.	The large ones for grinding sad irons and hinges, springs, and edge tools. The medium and small sizes for machine shops, and for sharpening edge tools generally.
Bay Chaleur, New Brunswick.	Blue	Soft sharp grit.	For manufacturing table cutlery, and for machinists' tools, and for sharpening edge tools generally, when a fine edge is required.

Foreign sources.—The sandstones overlying the coal beds of England furnish the grindstones of that country, the principal quarries being located at Newcastle-on-Tyne and at Wickersly. The quarries are worked by hand, and all the grindstones are made with mallet and chisel; they have been imported into this country for over one hundred years. The grindstones from the provinces of Nova Scotia and New Brunswick are, also, the overlying sandstones of the coal district and border on the Bay of Fundy; extending across the province to the Gulf of Saint Lawrence. These immense deposits contain a great variety of grits, and are generally worked by the French people, known as Acadians. The tides of the Bay of Fundy rise and fall from 60 to 70 feet every twelve hours, and these people avail themselves of this power to work the quarries, which extend from a high bluff on the mainland down to low-water mark in the bay. At low water a huge mass of stone is loosened from its bed and a heavy chain is passed under it and over a large boat which is placed alongside. As the tide rises the stone attached to the bottom of the boat is floated into a sand cove at high water, and made into grindstones after the tide recedes. This is done with mallet and chisel, the rough parts being first chopped off with a heavy axe. The introduction of machinery has enabled them to turn the small grindstones in a lathe by steam power.

Grindstones imported and entered for consumption in the United States, 1868 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Finished.		Unfinished or rough.		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Long tons.		*Long tons.*		
1868		$25, 640		$35, 215	$60, 855
1869		15, 878		99, 715	115, 593
1870		29, 161		96, 444	125, 605
1871	385	43, 781	3, 957. 15	60, 935	104, 716
1872	1, 202	13, 453	10, 774. 80	100, 494	113, 947
1873	1, 437	17, 033	8, 376. 84	94, 900	111, 933
1874	1, 443	18, 485	7, 721. 44	87, 525	106, 010
1875	1, 373	17, 642	7, 656. 17	90, 172	107, 814
1876	1, 681	20, 262	6, 079. 34	69, 927	90, 189
1877	1, 245	18, 546	4, 979. 75	58, 575	77, 121
1878	1, 463	21, 688	3, 669. 41	46, 441	68, 129
1879	1, 603	24, 904	4. 584. 16	52, 343	77, 247
1880	1, 573	24, 375	4, 578. 59	51, 899	76, 274
1881	2, 064	30, 288	5, 044. 71	56, 840	87, 128
1882	1, 705	30, 286	5, 945. 61	66, 939	97, 225
1883	1, 755	28, 055	6, 945. 63	77, 797	105, 852
1884					86, 286
1885					50, 579
1886					(*a*) 45, 713

a Classed as finished or unfinished.

CORUNDUM.

BY WILLIAM. A. RABORG.

The Laurel Creek mine, situated in the northwestern part of Rabun county, Georgia, and the Corundum Hill mine, which is about 8 miles southeast of the town of Franklin, Macon county, North Carolina, are the principal localities from which American corundum is obtained. The mines at both localities are owned by the Hampden Emery Company, of Chester, Massachusetts, and are operated under the direction of Dr. H. S. Lucas. A detailed description of the deposits is given in the 1883-'84 report of this series. The following table shows the output for the year 1886:

Production of corundum during 1886.

	Short tons.	Value.
Corundum hill	290	$52, 200
Laurel creek	355	63, 990
Total	645	116, 190

The Laurel Creek mine is located about 20 miles from the nearest railroad station, Walhalla, South Carolina, on a branch of the Richmond and Danville railroad. The corundum is packed in bags and hauled to the station in wagons, the price of hauling being 35 cents per hundredweight.

The corundum from the Cullasagee or Corundum Hill mine, after being packed in bags, is hauled 30 miles to Sylva station, on the Western North Carolina railroad, at 40 cents per hundredweight. The entire product of both mines is shipped to Chester, Massachusetts. At present, works are being erected near the mine to crush and grade the corundum, so as to ship it from the mine in marketable form.

In addition to the localities mentioned, corundum has been found at numerous points in western North Carolina, and indeed it has been mined at some other localities to a slight extent. No mines are known to have been regularly operated in 1886 except the two mentioned. A small quantity of impure corundum was taken from a mine near Webster, Jackson county, North Carolina, but was found not suitable for shipment. The Burch Creek mine, in Clay county, North Carolina, has passed into new hands, and will probably be operated during the present year. Mining operations have been commenced near Democrat, in Buncombe county, North Carolina, and a small quantity of corundum (about 20 tons) was taken out during the present year.

Emery imported and entered for consumption in the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Grains.		Ore or rock.		Pulverized or ground.		Powdered.	Total.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.		
	Pounds.		*Tons.*		*Pounds.*			
1867	....	....	428	$14,373	924,431	$38,131	....	$52,504
1868	....	....	85	4,531	834,286	33,549	....	38,080
1869	....	....	964	35,205	924,161	42,711	....	77,916
1870	....	....	742	25,335	644,080	29,531	....	54,866
1771	....	....	615	15,870	613,624	28,941	....	44,811
1872	....	....	1,641	41,321	804,977	36,103	....	77,424
1873	610,117	$29,706	755	26,065	343,828	15,041	107	70,919
1874	331,580	16,216	1,281	43,886	69,890	2,167	97	62,366
1875	487,725	23,345	961	31,972	85,853	2,990	20	58,327
1876	385,246	18,999	1,395	40,027	77,382	2,533	94	61,653
1877	343,697	16,615	852	21,964	96,351	3,603	....	42,182
1878	334,291	16,359	1,475	38,454	65,068	1,754	34	56,601
1879	496,633	24,456	2,478	58,065	133,556	4,985	......	87,506
1880	411,340	20,066	3,400	76,481	223,855	9,202	145	105,894
1881	454,790	22,101	2,884	67,781	177,174	7,497	53	97,432
1882	520,214	25,314	2,765	69,432	117,008	3,708	241	98,695
1883	474,105	22,767	2,447	59,282	93,010	3,172	269	85,490
1884	143,267	5,802	4,145	121,719	513,161	21,181	(a)....	148,702
1885	228,329	9,886	2,445	55,368	194,314	8,789	(a)....	74,043
1886	184,366	7,751	3,430	83,868	335,161	14,877	....	106,496

a Not specified.

Exports of manufactured emery.

Fiscal years ending June 30—	Value.	Fiscal years ending June 30—	Value.
1878	$813	1883	1,857
1779	$1,608	1884	3,565
1880	1,265	1885	99,232
1881	1,312	1886	38,820
1882	1,242		

INFUSORIAL EARTH.

The deposits of infusorial earth on the Patuxent river, near Dunkirk, Calvert county, Maryland, continued to be worked with satisfactory results during 1886. The production for the year amounted to 1,200 short tons, with a spot value of $6,000. The shipments were made principally to New York city, Philadelphia, and Chester, Pennsylvania.

The above deposit is the only one in the United States which produces infusorial earth to an extent worth mentioning. The well-known deposit near Richmond, Virginia, is not worked even for local use.

New Jersey.—The following statement is made by Mr. J. W. McKelvey, regarding the occurrence of infusorial earth near Drakesville, New Jersey. In a small basin on the farm of Mr. D. Judson Cook, which is located near Drakesville, Morris county, New Jersey, there is a deposit of infusorial earth that covers about 3 acres. The first stratum, which begins at the surface, is peaty to a depth of about 1 foot. The next is infusorial earth to a depth of 3 feet, and then come 7 feet of a white, sandy clay. At the bottom of this there is a deposit of gravel and cobblestone drift. The white clay seems to be a mixture of clay and infusorial earth. Near the edge of the bed it grows thin, and the upper 15 inches of the 3-foot layer are more porous than the rest.

This infusorial earth is of a grayish-white color, and on igniting becomes perfectly white. It contains small fragments of leaves and twigs. The specific gravity of the sample was 1.11. On analysis it gave:

Analysis of infusorial earth from Morris county, New Jersey.

	Per cent.
Silica	80.66
Alumina	3.84
Lime	.58
Loss on ignition	14.01
Total	99.09

New Mexico.—Regarding the deposit of infusorial earth near Socorro, New Mexico, the following statement is made by Mr. George H. Thwaites:

A uniform horizontal deposit of infusorial earth, known locally as tripolite, occurs in Socorro county, New Mexico, within 12 miles of the city of Socorro. It crops out in section for about 1,500 feet in length, at an elevation of about 20 feet above the sloping plain below it. The deposit is about 6 feet thick. Its composition is uniform and homogeneous, containing no mechanical mixture of any impurity. It is infusorial earth of a very high grade, of grayish-white color, soft but compact, and apparently composed solely of diatoms impacted by simple pressure of a superincumbent layer of natural cement also about 6 feet thick. Its specific gravity is very low, and it appears to bé an excellent absorbent. Blocks cut out of the face of the vein with a common hand-saw make perfect filter stones. The powdered tripolite is obtained by rubbing two blocks together; it is washed in water, poured off in suspension, settled, and dried in the sun. This makes a polishing powder said to be equal, if not superior, to the best commercial article. The layer of cement referred to above is also soft and compact, composed of carbonate of lime, silica, and alumina, the three essential elements of hydraulic cement.

Underneath the strata of tripolite there is a layer a few inches in thickness of soft unctuous clay, and beneath this is a deposit of unknown depth of coarse, light brown inferior tripolite, harder than the one above, and from which experimental scouring bricks have been made with satisfactory results.

Pacific Coast States.—The following facts concerning the occurrence of infusorial earth in the Pacific States have been ascertained from the explorations of Mr. J. S. Diller, of the U. S. Geological Survey:

"Perhaps the most extensive deposits of infusorial earth yet discovered in any country occur in our Pacific States. During a very recent geologic epoch numerous lakes of considerable size existed in California, Oregon, Washington Territory, Nevada, and Idaho and furnished especially favorable conditions for the development of infusorial forms of life. Many of the lake beds, consisting in large part of infusorial earth, are yet covered, but in other cases where modern streams have carved cañons through them they are well exposed and easily accessible. One of the most important deposits of this sort occurs along Pitt river, California, between Great Bend and Fall River mills. The deposit has a length of about 16 miles and is a mile or more in width, with a thickness at some places of over 300 feet. The best exposures occur near the Pitt river free bridge, north of Burney valley, Shasta county, where it appears to be composed wholly of infusorial remains. On Winter's toll road, near the California State fish station, there are good exposures, but the deposit does not appear to be so purely infusorial. In both localities the exposures are near good wagon roads and about 75 miles from the nearest railroad station (Redding, in the Sacramento valley).

"A similar deposit occurs along the Klamath river on the stage road from Yreka, California, to Linkville, Oregon. At this locality the deposit is much less extensive than on Pitt river and perhaps on the whole of an inferior quality. It is only about 12 miles from the railroad, which can be reached by a good road for wagons."

NOVACULITE.

By George M. Turner.

According to its present use, the term novaculite is applied to a class of siliceous rocks valuable as whetstones because of their grit or sharpening qualities. This peculiar sharpening quality is due in some cases to crystalline silica; in others, according to a German writer, to minute crystals of garnet or rutile. In order that a whetstone may be efficient, it should combine with the hardness of its particles the property of not glazing. Stones having these two properties in the highest degree serve best the purpose of a whetstone.

Occurrence.—Quarries of novaculite are at present worked in Hot Springs and Garland counties, Arkansas; in Orleans and Orange counties, Vermont; in Grafton county, New Hampshire; in Onondaga county, New York, and in Orange county, Indiana.

Arkansas.—Arkansas produces two varieties of whetstone known as the "Washita" and "Arkansas." Both are composed of nearly pure silica in the form of minute crystals interpenetrating each other. These two varieties differ from each other only in the minuteness of the crystals and correspondingly compact arrangement. The large number of edges exposed, together with the number of very small cavities, gives to the rock its power as a whetstone. Both kinds of rock are to be found in the same quarry. Quarries are located in Montgomery, Saline, Hot Springs, and Garland counties, although the best stone comes from Garland county. The quality of the rock varies greatly in different parts of the same quarry. All gradations are to be found between the perfect whetstone, of even grit and uniform crystallization, and worthless rock of glassy and vitreous structure. The Washita, which in appearance is a white opaque stone, is found and quarried in much larger quantities than the Arkansas stone. The quality of the stone taken from the quarries during 1886 was about the same as that taken out in 1885. No new quarries were opened during the year, but several which had been lying idle for some years were reopened.

About 650,000 pounds—150,000 pounds more than in 1885—of the rough Washita stone were placed on the market in 1886. The Arkansas stone, which is white and very finely grained, is quite translucent in comparatively thin pieces. This rock, which occurs only at intervals in the quarry, is found in a similar manner to the pockets of minerals in mines. These sections, which are rarely over 100 feet in length, contain the rock much broken up by natural forces. As a result this rock is never found in very large pieces. The market prices are about the same as those in 1885. The increased demand for the Washita in 1886 was chiefly in New York and Chicago. The call was for the low-grade stones; that is, whetstones containing more or less vitreous quartz. The prices for 1886, as quoted by George Chase, of New York;

J. J. Sutton, Hot Springs, Arkansas, and the A. F. Pike Manufacturing Company, of Pike Station, New Hampshire, are as follows:

Dimensions and cost of Washita and Arkansas stones.

Grade and dimensions.	Per pound.
Washita oil stones:	
No. 1 (extra), 8 by 2 by 1⅛ inches	$0.25
No. 1, 8 by 2 by 1⅛ inches	.20
No. 2, 8 by 2 by 1⅛ inches	.12
Washita slips:	
Round edge (extra)	.50
Round edge (No. 1)	.40
Wheels, per inch	.40
Arkansas oil stone:	
No. 1, 4 to 6 inches long	1.25
No. 1, 6 to 9 inches long	1.50
No. 1, 8 to 12 inches long	2.50
No. 2	.70
Round-edge slips	1.30
Powder	.20
Wheels, 2 to 4 inches and ½ inch thick, per inch	1.00

New Hampshire.—Schists capable of being used as whetstones are to be found at Piermont, Lisbon, and Littleton, Grafton county; Tamworth, Carroll county; and Connecticut Lake, Coos county. The deposits of Grafton county are the only ones worked to any extent. The stone from these quarries is placed on the market under the names of the "Indian Pond," "chocolate," and "White Mountain." These three varieties are all argillitic mica schists, with varying color and hardness.

The chocolate is a very compact finely-grained form and is of a dark gray color. Its value as a whetstone lies in the small crystals of garnet and rutile which are to be found in its structure as well as the little quartz crystals that lie with their axes parallel to each other.

The Indian Pond stone is of a light gray color. It is somewhat softer and more schistose than the other two. It serves well the purpose of cutting an edge rapidly, and hence answers as a forerunner of the chocolate. This stone has been quarried for about fifty years. Not until quite recently, however, have the quarries of Grafton county been worked to any considerable extent.

The White Mountain stone bears a close relation to the Indian Pond. It is, however, somewhat lighter in color and more massive than the Indian Pond variety.

Vermont.—Just over the State line from Grafton county, New Hampshire, into Orleans county, Vermont, is found the so-called Lamoille stone. This schist is quite similar to the forms found in New Hampshire. It has about the same relation to the chocolate that the White Mountain bears to the Indian Pond. This stone is not as finely grained as the chocolate, but it is more massive and resembles it in color.

All the principal quarries from which these four varieties come are controlled by the A. F. Pike Manufacturing Company, of Pike Station, New Hampshire. Their estimates and prices are given below, The chocolate and White Mountain stones find their market principally in this country. In 1886 about 80,000 pounds of the chocolate and 40,000 pounds of the White Mountain rock were taken from the quarries.

Prices for Chocolate stone.

	Per pound.
Scythe stone:	
No. 1	$0.16
No. 2	.10
Axe stone:	
No. 1	.12
No. 2	.08
Penknife stone	.25
Carpenter's bench stone:	
No. 1	.25
No. 2	.15

Prices for White Mountain oil and water stones.

	Per pound.
Joiner's, 8 by 2 by 1⅛ inches	$0.12½
Axe, 3 by 2 by ¾ inches	.12½
Slips	.25
Penknife pieces	.25

During the year 1886 between 2,000,000 and 3,000,000 pounds of rough Indian Pond stone were taken from the quarries. Nearly all this stone was made up into scythe stones according to the following prices·

P ices for Indian Pond stone.

	Per gross.
Extra	$3.75
No. 1	3.50
No. 2	2.50

The Lamoille is also cut chiefly into scythe stones which sell for about $5.50 per gross.

New York.—But little accurate information could be obtained concerning the so-called Labrador oil stone of this State. The stone, which is a fine-grained sandstone having very sharp angular grains of quartz and a few of feldspar cemented by argillaceous matter, is of a light slate color, with a hardness, according to Mohr's scale, between 3 and 4. The quarries of the stone are located in Cortland county. The demand for it is not great, since only about 5,000 pounds of finished stone find a market annually.

The stone is quoted as follows:

Prices for Labrador oil stone.

	Per pound.
Size 8 by 2 by 1½ inches	$0.12
Axe stone	.10
Slips	.24

Indiana.—About forty-five years ago a bluish white whetstone, which now bears the nar "Hindostan," was first placed on the market. It came from a town of the same name in Martin county, Indiana. The town, which was situated near the White river, has since passed out of existence. A stone similar in structure to the Hindostan, but differing in color and hardness, is also to be found in Indiana. It is called "Orange stone;" it is of a light buff shade. The fact that it bears the name of the county in which it occurs most abundantly may account for its title. At present nearly all the Hindostan and Orange whetstones come from Orange county. Quarries are to be found at French Lick Mineral Springs, between 2 and 3 miles from West Baden, in French Lick township, and in Northwest township, about 8 miles from the French Lick quarries. Both these varieties of whetstone are in some places found in the same quarry, but occur in different ledges. The rock is decidedly stratified and splits with great readiness into large sheets.

At times the whole ledge, from 10 to 20 inches in thickness, is raised by means of steel bars and wedges. More frequently sheets from 5 to 6 inches in thickness are cleared off. These sheets are again split to the desired thickness. Some pieces of rock can readily be severed into layers not having a thickness of over ¼ inch. After the stone has been brought to the proper thickness it is marked off into pieces of the requisite length and width by means of a straight edge and scribing awl. The stone is so soft that the awl will penetrate it sufficiently for it to be readily broken. The stone is now worth one-half of its price when finished. Finishing on iron wheels with sand, and boxing complete the cost of manufacture. Between the ledges of good stone is generally found from 6 to 10 inches of soft shale. The whetstone varies in hardness. That at the surface is usually much softer than the rock underneath. The harder variety makes the best stone for use. At fissures in the rock is found what the quarrymen call ironstone. This contains, as its name indicates, a large quantity of iron, sometimes in the form of limonite, but more frequently as brown hematite. The presence of the iron ore prevents the rock from crumbling as readily as it does in the ordinary Hindostan and Orange stones, and hence makes a very fair finishing stone. It is, however, apt to become glazed after some use.

In French Lick township, about 7 miles south of the Hindostan and Orange quarries, are found sandstones which are quarried for dry whetstones. These stones are sold principally to shoemakers.

During the year 1886 about 400,000 pounds of Hindostan and Orange stones were quarried. The prices for the Hindostan stones, according to J. A. Chaillaux, of Orangeville, and William F. Osborn and T. N. Braxton & Sons, of Paoli, Indiana, are as follows:

Prices for Hindostan oil and water stones.

	Per pound.
No. 1, Washita finish, 8 by 2 by 1½ inches	$0.03½
Axe, small, 3 by 2 by 1 inches	.04
Slips:	
Plain	.04½
Beveled	.06

About the same amount (400,000 pounds) of the sandstones as of the Hindostan and Orange was placed on the market during 1886. Nearly one-quarter of this quantity went to Europe. As the cost of the preparation is not great, this stone can be sold for 4 cents a pound.

Exports.—It is exceedingly difficult to obtain any accurate information as to the total amount of whetstones exported annually from this country, as official data are combined with those of marble and other stone.

The chocolate whetstone (finished) is shipped in small quantities to Canada and England. Of the Indian Pond stone in 1886 about 500,000 pounds went to Germany. A large quantity was also shipped to England, Canada, and Australia. But little of the White Mountain stone passes out of this country. About 40,000 pounds of the Lamoille rock were exported during the past year. It is estimated that 100,000 pounds of the Hindostan and Orange stones find a market in Europe each year. Nearly the same amount of the sandstone from French Lick township is annually taken out of this country. The Arkansas and Washita stones also find quite a market abroad.

Imports.—The value of hones and whetstones imported into the United States during the year 1886 was $18,160.72. This includes both the entries for immediate consumption and withdrawals from the warehouse. The value of the imports by custom districts were:

Value of imported whetstones, by customs districts, during the fiscal year ending June 30, 1886.

Customs districts.	Value.
Boston and Charlestown, Massachusetts	$483.00
Chicago, Illinois	839.00
New Orleans, Louisiana	1.00
New York, New York	14,434.00
Philadelphia, Pennsylvania	621.00
San Francisco, California	150.00
Saint Louis, Missouri	215.00
All other customs districts and ports	6.00
Total	16,749.00

The difference between the amount imported for immediate consumption, including the withdrawals from warehouse ($18,160.72), and the value of imports by customs districts ($16,749) is due to the fact that whetstones to the value of $1,411.72, which were already in stock from the previous year, were withdrawn for consumption.

The value of imports by way of New York for the separate countries was as follows:

Value of imports of whetstones into New York during the fiscal year ending June 30, 1886.

Whence imported.	Value.
Germany	$4,608
Belgium	3,915
Scotland	3,646
England	2,630
Italy	348
Chili	176
Australia	175
Japan	134
Mexico	19
Netherlands	12
Total	15,663

The above figures give the value of whetstones removed for consumption rather than the mere import for the year. Quite a large amount of foreign stone is shipped to this country in the rough and prepared for market by our own manufacturers. As it is brought over as ballast the expense of transportation becomes very light. During last year about 100,000 pounds of Turkey oil stone was finished for market in this country. German and Belgian hones found quite a ready market at the following prices:

Prices of German razor hones.

	Per dozen.
With rubber stone:	
6-inch	$2.00
7-inch	3.00
8-inch	4.00
9-inch	5.00
10-inch	6.00

Prices of Belgian razor hones.

	Per dozen.
5-inch, common	$1.25
5-inch, fine	1.50
6-inch, superfine	4.00
8-inch, superfine	10.00

Stones imported from Scotland bearing the name Scotch Water of Ayr are also sold in this country. These stones are not only used as whetstones but for burnishing purposes and as lithographic stones. A few of the so-called Norway Rugg, from Norway, and a few Welsh stones, find a market in the United States. Probably $100 will cover the value of the annual import of the two stones last mentioned.

PRECIOUS STONES.

By George F. Kunz.

Mining during 1886.—As stated in the previous reports of this series, the search for precious stones in the United States is extremely irregular and is generally a side issue in mining other substances. Still, at Stony Point, North Carolina, and at Mount Mica, Paris, Maine, operations involving systematic mining are carried on for obtaining precious stones. At the former locality, which is controlled by the Emerald and Hiddenite Mining Company, nine emeralds were found which were valued at over $2,000. The large crystals, weighing 8¾ ounces, as well as the fine large lithia emerald, are now in the cabinet of Mr. Clarence S. Bement. The total production during 1886 amounted to perhaps $4,000. Particulars concerning this locality were given on page 437 of the last report of this series.

After three months of unsuccessful mining at Mount Mica, Paris, Maine, several pockets were found; one found in October contained cookite, decomposed feldspar, crystals of quartz, and, at the bottom, tourmalines either loose or embedded in the floor of the cavity. Over 100 crystals were obtained, which will furnish more than 200 gems. The entire find was estimated to yield cut tourmalines to the value of about $5,000, and crystals, specimens, and associated minerals to the value of another $1,000. Two of the gems cut from these crystals weighed 34¼ and 27½ carats, respectively. They were of a brilliant, rich grass-green color. Another gem of a deep blue-green color, and weighing 8 carats, one green chrysoberyl of 7½ carats, several yellow and a variety of blue gems, but no red or pink stones, were obtained. Messrs. N. H. Perry and E. M. Bailey found good specimens of tourmaline, but they were of little gem value. Messrs. T. F. Lamb and G. C. Hatch mined for a time at the Mount Apatite locality, near Auburn, Maine, and found tourmaline gems and minerals to the value of $500. This locality will be further worked. Quite a large number of the yellow, green, and white beryls, found in Litchfield county, Connecticut, have been nicely cut and extensively sold. The cut gems sold during the past year are valued at $5,000, but a large part of this sum probably represents the cutting and other necessary expenses.

In connection with mining for substances, other than precious stones, many very considerable contributions have been made to the total output of gems. For example, at the mine of the Marion Bullion Company, Marion, North Carolina, Colonel Deming has obtained some very good garnets in sufficient quantity to offer them to the trade; also, one fine amethyst of a magnificent purple color and over one inch across, fine aquamarines 1 to 6 carats in weight, and some beautiful chloritic inclusions in quartz, which, when polished, show very fine landscape effects. Among the finds which may be classed in general as accidental are the following:

Garnet.—Of the large garnets from Salida, Colorado, previously referred to, over a ton has been sold during the past year. Quantities of almandite garnet are said to have been found in the gravel of the placer mines near Lewiston, Idaho, in rolled and pitted grains from $\frac{1}{16}$ to $\frac{1}{2}$ inch across. They would cut into gems and jewels for watches.

Quartz.—The large masses of clear quartz referred to in the last report as having been found near Abingdon, Virginia, were in reality found in the mountains of Ashe and Mitchell counties, North Carolina. In addition to these, one large crystal weighing 190 pounds and two smaller ones, weighing 60 and 22 pounds respectively, have been found. Mr. D. A. Jones states that all these masses were found within a distance of 5 miles—the one weighing 22 pounds on the land of Saint Leger Brooks, and the others on the farm of Dr. L. C. Gentry. There was also reported a finding of transparent crystals of quartz, one weighing 642 pounds, another 340 pounds. When these reached New York, however, they proved not to be crystals, but veins of translucent quartzite with crystalline markings of a group rather than of a single crystal, and the clear spaces which were only observed on these crystalline sides would not afford a crystal ball more than one inch in diameter. The larger part was almost white with flaws. Mr. P. A. Hubbard reports finding specimens of rock crystal and rutilated quartz on or near the surface; one mass of the former weighed over 10 pounds and was quite clear, though fractured by frosts. Mr. J. P. M. Butler, of Trinidad, Colorado, reports finding large quantities of crystalline quartz with small doubly terminated crystals of quartz, resembling those from Herkimer county, New York. These may be of value to the dealers selling to Western tourists.

Topaz.—In Bulletin No. 27, United States Geological Survey, Prof. F. W. Clark describes topaz, and its alterations, from Stoneham, Maine, and also publishes an analysis of it. A topaz crystal weighing 18$\frac{1}{4}$ ounces (587 grams) was found at Cheyenne Mountain, Colorado, about 7 miles southwest of Colorado Springs. It is very perfect, but of little gem value.

Amethyst.—Among some amethysts found at Deer Hill, Stow, Maine, during the last year, was one remarkable mass which furnished a gem weighing 25 carats, and of the deep purple color of the Siberian amethyst. Very fair amethysts have also been found at Burrville, Rhode Island.

Jasperized wood.—Very little was done during the year 1886 in the development of the jasperized wood deposits of Arizona, but the base of the New York *World* memorial presented to the eminent sculptor, Bartholdi, was made of it. Preparations have been made to polish this material at Sioux Falls, Dakota, water power and other facilities being found there, and during the present year (1887) important developments are expected in the form of table tops 2 feet across made from a single section.

Hydrophane.—An opaque white hydrophane of great interest has been found in Colorado and the finder has named it "magic stone," because, as usual with this mineral, it possesses the property of becoming absolutely transparent if water is dropped slowly on it from one to three minutes. It is so porous that it will absorb its own weight of water; it quickly recovers its opacity. The finder suggests that the stone be used for seals, rings, and scarf pins, as by reason of its opacity it would completely conceal portraits, mottoes, or mementoes which could be brought to view when desired by the application of a little water. This is the finest hydrophane known.

Chalcedony.—Near Cisco, Utah, a pink chalcedony has been found which admits of a high polish, but which has not yet been introduced in any quantity.

Agate.—The beautiful little agate pebbles from the Pescadero beach, in California, are sold in large quanties and in different forms, polished, and unpolished, and loose, or in vials of water. Occasionally some of them are found inclosing a pebble moving in liquid, like the hydrolites from Uruguay and the chalcedony from Tampa Bay, Florida. They vary in diameter from $\frac{1}{10}$ to $\frac{1}{4}$, rarely 1 inch.

Obsidian.—Mr. J. P. Iddings has contributed a paper to the Seventh Annual Report of the United States Geological Survey, describing the obsidian cliff in the Yellowstone Park, Wyoming, stating that it presents the partial section of a flow of obsidian; the dense glass which forms the lower portion is from 75 to 100 feet thick. A remarkable feature about it is the development of prismatic columns which form its southern extremity, rising 50 or 60 feet, and being only 2 to 4 feet in diameter. The color of the material is for the most part jet black, but some of it is mottled and streaked with bright brownish red and various shades of brown (mountain mahogany), passing into dark or light yellow, purple, and yellowish green. The great quantity and beauty of the material invite attention to its use in the arts.

Azurite and Malachite.—Mr. T. A. Heistand obtained masses of azurite, and malachite resulting from the alteration of azurite, which, being botryoidal in form and showing the two minerals in distinct layers, formed a most beautiful ornamental stone when cut across the tops of the mamillary masses (1 to 3 inches across) and carefully polished. There are from two to four alternate and concentric rings of each color, which produce a very novel and pleasing effect. If this were found in sufficient quantity it would make a very valuable ornamental stone.

As it is, there is barely enough of it to supply the cabinets. The stone is well worthy of attention. Mr. W. A. Woodcock communicates that malachite, which is evidently of value in the arts, has been sent to him from the Yukon country, Alaska.

Amber.—Mr. J. B. Livezey sent the writer a specimen piece of amber found on the southwest branch of Mantua creek, near the town of Sewall, which is 13 miles below Camden, New Jersey. This specimen was taken from the lower marl bed, while the one from Harrisonville, described in a previous report, was from the middle marl bed. Information was also obtained that several other pieces had been found at the former locality, but they have been lost.

Chrysoberyl.—Among some small rolled quartz pebbles sent to Messrs. Tiffany & Co., for examination, a transparent yellow chrysoberyl was observed which would afford a ¼ carat stone.

Diamond.—In the summer of 1886 a diamond was found in the spring on the Alfred Bright farm at Dysortville, McDowell county, North Carolina. While Mr. Grayson Christie's son was drawing a bucket of water, his attention was attracted by the brightness of the stone. It was thought to be a diamond and sent to Messrs. Tiffany & Co., and was so proved to be by the writer. The stone is a distorted hexoctahedron with partial twinning; its length is 10 millimeters and its width 7 millimeters. It is quite perfect and transparent, but having a grayish-yellow tint. Its specific gravity is 3.549+. This stone being more than an average find, the writer thought it would be of interest to visit the locality, and while there, in June, 1887, he fully authenticated all the facts of the finding. No trace of garnet, peridotite, or any of the associations of the diamond was found near the spot. The sediment at the bed of the spring was taken out and carefully examined, as also were the small hollows on the adjacent hillside. This diamond must therefore have been transported in decomposing soil from distant higher ground in the vicinity during a heavy freshet. Its value as a gem, not counting any value its American origin may attach to it, would be from about one hundred to one hundred and fifty dollars. A number of small stones, exhibited as diamonds, have been found at Brackettstown, near by. They are identical with the supposed fine diamonds found by Capt. J. C. Mills at his mine at Brindletown; that is, transparent zircon or smoky-colored quartz, the former of which has a luster that is readily mistaken for the diamond's by an inexperienced person. A number of pieces of bort (rough diamond) exhibited as from the same section, I am informed on good authority, are of South African, and not North Carolina, origin. It is to be hoped that the few legitimate finds which have actually occurred at this locality will not lead to any deceptions, which would greatly retard any natural development.

The stone, 3½ ounces, and said to be a diamond, and which was found by J. S. Keyser in digging for coal near Ponca, Nebraska, proved not to be such, although the excitement it caused was certainly genuine.

Diamond cutting, though now carried on here much more extensively than ever before, has not always proved a profitable industry. The price for rough diamonds in the London market is so close, and they are disposed of so soon after their arrival, that unless purchases are made with the greatest possible judgment, the competition of the foreign cutters, who are convenient to the market, cannot be successfully met. For this reason the trade has in many cases been given up here, yet the standard of merit has been so raised that to-day the finest cutting is done in the United States. A large part of the work done here consists in improving and recutting old stones that have been cut in the East for weight only, or in more modern work that can be improved upon, and these branches are generally profitable. But even with a 10 per cent. duty on cut gems as a protection, it is not likely that we shall soon rival the great foreign cutting centers. Sards, bloodstones, and other cheap agates are often cut to a uniform size for mounting, because it is cheaper to fit the stone to the mounting than the mounting to the stone, and such stones as are from time to time found here are generally cut in this country.

At the time of the publication of the last report the writer had not heard of the occurrence of the shale in the Elliott county peridotite, hence the statement then made in regard to it; but important investigations have since been made in that locality. In his remarks on the "Genesis of the Diamond" (Science, Vol. VIII, p. 345), Prof. Carvill Lewis alluded to the peridotite of Elliott county, Kentucky, and suggested that it is well worth while to examine carefully all localities whose geological composition and history are analogous to those of the South African diamond fields. Mr. J. S. Diller, in the *American Journal of Science*, August, 1886, refers to Prof. A. R. Crandall's having discovered two dikes of eruptive rock in eastern Kentucky, about 7 miles southwest of Willard. Mr. Diller states that he found by microscopic examination that this rock belongs to the peridotites, and occurred in conjunction with a carbonaceous shale; although the exact contact of the two rocks was not exposed, hardened shale was found near the peridotite under such circumstances that the induration is certainly attributable to the influence of the eruptive mass. But this, he thinks, is not the strongest evidence that the peridotite is eruptive, for the peridotite itself includes many fragments of shale which were picked up on its way to the surface. The contact metamorphism has resulted generally in the development of a micaceous mineral, and the production from the shale of a rock such as has been designated spilosite. And in some notes on the trap dikes of Elliott county by A. R. Crandall and J. S. Diller, published in the report on the geology of Elliott county by the Kentucky Geological Survey, Frankfort, Kentucky, 1887—also in *Science*, October 29, 1886—it is stated that although there were few exposures and the excavations made were inconsiderable, nevertheless he reached the conclusion that the shales had been distinctly metamorphosed by the peridotite, a fact which was most patent in the enveloped fragments of shale, which in one locality were quite numerous. He says that both forms of peridotite described by Professor Lewis occur in Kentucky, but the brecciated form has not yet been found to contain diamonds. In the advanced stages of metamorphosis little spheroidal bodies were found, pale yellowish to colorless translucent to transparent and remarkably uniform in size. These generally appeared in a form very suggestive of the diamond, resembling a hexoctahedron with curved faces. Notwithstanding that some of their properties favored the view that they were diamonds more or less perfectly crystallized, their solubility in concentrated hydrochloric acid rendered such a view untenable and even if they were diamonds their value would be comparatively insignificant because of their small size. In concluding, he says: "The dark shale, which is frequently enveloped by the peridotite, is somewhat carbonaceous, but contains a small proportion of carbon as compared with that of the South African diamond field. H. Carvill Lewis (Science, viii, p. 346) remarks concerning the South African mines, that "recent excavations have shown that large quantities of this shale surround the mines, and that they are so highly carbonaceous as to be combustible, smouldering for long periods when accidentally fired." In the chemical laboratory of the United States Geological Survey Mr. J. Edward Whitfield determined 37.521 per cent. of carbon in the shale from near the Kimberley mine, while the blackest shale adjoining the peridotite near Charles Isom's in Kentucky, he found to contain only 0.681 per cent. of carbon. For this reason it appears to me rather improbable that diamonds will be discovered at the locality in question." Nevertheless, upon the invitation of Prof. J. R. Proctor, State Geologist of Kentucky, Mr. J. S. Diller and the writer were sent by the United States Geological Survey to examine the locality, viz: Isom's creek, Elliott county, Kentucky. The plan was to search by sifting and carefully panning the stream beds receiving the drainage directly from the surface of the peridotite.

The peridotite alters and disintegrates readily; but, from the fact that the declivity of the surface is considerable, the transportation of material almost keeps pace with disintegration, and there is no great accumulation of residuary deposits upon the narrow divides and hillsides. The specific gravity and durability of the gems found in connection with peridotite are generally greater than those of serpentine and other products of its alteration. On this account the gems accumulate upon the surface and in favorable positions along adjacent lines of drainage. We enlisted the services of the people in the neighborhood to scrutinize the steep slopes, where gems weathered out of the peridotite might be exposed. Particular attention was directed also to the examination of the solid rock and residuary deposits, which so closely resemble the material of the South African mines.

During a careful search over a small area for nearly two days, no diamonds were found; but this by no means demonstrates that diamonds may not yet be discovered.

The best time to search for gems in that locality is immediately after a heavy rain, when they are most likely to be well exposed upon the surface. It is proposed by those most interested to keep up the search economically, by furnishing to responsible individuals in the vicinity a number of rough diamonds mounted in rings, for comparison, that they may know what to look for under the most favorable circumstances.

Besides pyrope garnets, a few of which are good enough for cutting, several fairly good specimens of a green pyroxene were found. They resemble the same transparent mineral from Arizona. The South African specimens of this mineral are a little more opaque, but of a richer green color.

Artificial rubies.—The subject of artificial gems is at the present moment of considerable interest. Early this summer the Syndicate des diaments et pierres précieuses was informed that certain stones which had been sold as rubies from a new locality were suspected to be of artificial origin. They were put upon the market by a Geneva firm; and it was surmised that they were obtained by the fusion of large numbers of small rubies, worth at the most a few dollars per carat, into one fine gem worth from $1,000 to $2,500 per carat.

Some of these artificial stones were kindly procured by Messrs. Tiffany & Co. I was not, however, permitted to break them for analysis, to observe the cleavage, or to have them cut so as to observe the optical axes more correctly. It is possible, however, to detect the artificial nature of this production with a mere pocket-lens, as the whole structure is that peculiar to fused masses. Examination elicited the following facts: The principal distinguishing characteristics between these and the genuine stones is the presence in them of large numbers of spherical bubbles, rarely pear-shaped, sometimes containing stringy portions showing how the bubbles had moved. These bubbles all have rounded ends, and present the same appearance as those seen in glass or in other fused mixtures. They are nearly always in wavy groups or cloudy masses. When examined individually they always seem to be filled with gas or air, and often form part of a cloud, the rest having the waviness of a fused mixture. Some few were observed inclosing inner bubbles, apparently a double cavity, but empty. In natural rubies the cavities are always angular or crystalline in outline, and are usually filled with some liquid, or, if they form part of a "feather," as it is called by the jewelers, they are often arranged with the lines of growth. Hence the difference in appearance between the cavities in the natural gem and those in the fused gem is very great, and can readily be detected by the pocket-lens. I have failed to find in any of the artificial stones even a trace of anything like a crystalline or angular cavity. Another distinguishing characteristic is that in many genuine rubies we find a silky structure (called "silk" by the jewelers), which, if examined under the microscope, or under a $\frac{4}{10}$ to $\frac{8}{10}$ inch objective, we find to be a series of cuneiform or acicular crystals, often iridescent, and arranged parallel with the hexagonal layers of the crystal. When in sufficient number, these acicular and arrow-shaped crystals produce the asteria or star-effect, if the gem is cut *en cabochon* form with the center of the hexagonal prism on the top of the cabochon. I have failed to find any of them in the stones under consideration, or even any of the markings of the hexagonal crystal which can often be seen when a gem is held in a good light, and the light allowed to strike obliquely across the hexagonal prism. Dr. Isaac Léa has suggested (*a*) that these acicular crystals are rutile, and interesting facts and illustrations have been published by him. From my own observations on many specimens, I believe there is little doubt of the truth of this hypothesis. My explanation is that they were deposited from a solution, either heated or cold, while the corundum was crystallizing, and I doubt very much whether they will ever be found in any substance formed by fusion. The hardness of these stones was found to be about the same as that of the true ruby, 8.8, or a trifle less than 9, the only difference being that the artificial stones were a trifle more brittle. The testing-point used was a Siamese green sapphire, and the scratch made by it was a little broader, but no deeper than on a true ruby, as is usually the case with a brittle material. After several trials it was faintly scratched with chrysoberyl, which will also slightly mark the true ruby.

The specific gravity of these stones was found to be 3.93 and 3.95. The true ruby ranging from 3.93 to 4.01, it will be seen that the difference is very slight and due doubtless to the presence of the included bubbles in the artificial stones, which would slightly decrease the density. As a test, this is too delicate for jewelers' use; for if a true ruby were not entirely clean, or a few of the bubbles that sometimes settle on gems in taking specific gravities were allowed to remain undisturbed, it would have about the same specific gravity as one of these artificial stones.

I found on examination by the dichroscope that the ordinary image was cardinal red, and the extraordinary image a salmon red, as in the true ruby of the same color. Under the polariscope, what I believe to be annular rings were observed. With the spectroscope the red ruby line, somewhat similar to that in the true gem, is distinguishable, although perhaps a little nearer the dark end of the spectrum. The color of all the stones examined was good, but not one was so brilliant as a very fine ruby. The cabochons were all duller than fine, true stones, though better than poor ones. They did not differ much in color, however, and were evidently made by one exact process or at one time. Their dull appearance is evidently due in part to the bubbles. The

a Proc. Philad. Acad. Sc., Feb. 16, 1869, and May, 1876.

optical properties of these stones are such that they are evidently individual or parts of individual crystals, and not agglomerations of crystals or groups fused by heating. In my opinion these artificial rubies were produced by a process similar to that described by Fremy and Feil (*Comptes Rendus*, 1877, p. 1029), by fusing an aluminate of lead in connection with silica in a siliceous crucible, the silica uniting with the lead to form a lead glass and liberating the alumina which crystallizes out in the form of corundum in hexagonal plates, with a specific gravity of 4.0 to 4.1, and the hardness and color of the natural ruby, the latter being produced by the addition of some chromium salt. By this method rubies were formed, which, like the true gem, were decolorized temporarily by heating.

It is not probable that these stones were formed by Gaudin's method (*Comptes Rendus*, XIX., p. 1342), by exposing amorphous alumina to the flame of the oxyhydrogen blowpipe, and thus fusing it to a limpid fluid, which, when cooled, had the hardness of corundum, but only the specific gravity 3.45, much below that of these stones. Nor is it at all likely that they were produced by fusing a large number of natural rubies or corundum of small size, because by this process the specific gravity is lowered to that of Gaudin's product. The same also holds good of quartz, beryl, etc.

The French syndicate referred the matter to M. Friedel, of the Ecole des Mines, Paris, supplying him with samples of the stones for examination. He reported the presence of the round and pear-shaped bubbles, and determined the hardness and specific gravity to be about the same as of the true ruby. On analysis he found them to consist of alumina, with a trace of chromium for the coloring matter. The cleavage was not in all cases distinct, and the rough pieces given to him as examples of the gem in its native state had all been worked, so that nothing could be learned of their crystalline structure. When properly cut according to axes, they showed the annular rings. The extinction by parallel light was not always perfect, which he believed to be due to the presence of the bubbles. He states that he himself has obtained small red globules with these inclusions by fusing alumina by oxyhydrogen light; and, although having no positive evidence, he believes these stones to be artificially obtained by fusion.

On the receipt of M. Friedel's report the syndicate decided that all cabochon or cut stones of this kind shall be sold as *artificial*, and not precious gems. Unless consignments are so marked the sales will be considered fraudulent, and the misdemeanor punishable under the penal code. All sales effected thus far, amounting to some 600,000 or 800,000 francs, shall be canceled, and the money and stones returned to their respective owners.

The action taken by the syndicate has fully settled the position which this production will take among gem dealers, and there is little reason to fear that the ruby will ever lose the place it has occupied for so many centuries.

Estimated production of precious stones in the United States from 1883 *to* 1886.

Species.	1883.		1884.		1885.		
	Value of stones found and sold as specimens and curiosities, occasionally polished to beautify or show structure.	Value of stones found and sold to be cut into gems.	Value of stones found and sold as specimens and curiosities, occasionally polished to beautify or show structure.	Value of stones found and sold to be cut into gems.	Value of stones found and sold as specimens and curiosities, occasionally polished to beautify or show structure.	Value of stones found and sold to be cut into gems.	Total, 1886.
Diamond	......	......	......	$800	......	......	......
Sapphire gems	$200	$2,000	$250	1,500	......	$500	$500
Chrysoberyl	100	......	25	......	......	......	......
Topaz	1,000	......	200	300	$1,000	250	1,000
Beryl	200	300	300	400	250	500	5,550
Emerald	500	......	......	......	......	......	3,200
Hiddenite	100	500	......	......	......	......	4,500
Tourmaline	......	......	1,500	500	500	100	6,250
Smoky quartz	2,500	7,500	2,000	10,000	2,000	5,000	7,000
Quartz	10,000	1,500	10,000	1,500	10,000	1,500	11,500
Silicified wood	5,000	......	10,000	500	5,000	1,500	1,500
Garnet	1,000	5,000	1,000	3,000	200	2,500	3,250
Anthracite	......	2,500	......	2,500	......	2,500	2,500
Pyrite	1,500	500	2,000	1,000	1,500	500	2,000
Amazonstone	3,500	250	2,500	250	2,500	250	2,250
Catlinite (pipestone)	10,000	......	10,000	......	10,000	......	10,000
Arrow points	1,000	......	1,000	......	......	2,500	2,500
Trilobites	500	......	500	......	......	1,000	1,000
Sagenitic rutile	500	500	500	500	......	250	1,750
Hornblende in quartz	500	100	500	100	......	300	200
Peridot	50	250	50	100	......	50	50
Thompsonite	250	500	250	500	250	500	400
Diopside	200	100	......	......	100	......	2,000
Agate	1,000	500	4,000	500	1,000	1,000	1,000
Chlorastrolite	500	1,000	500	1,000	......	......	......
Turquois	1,500	500	1,500	500	1,500	2,000	3,000
Moss agate	1,000	2,000	1,000	2,000	500	2,000	2,000
Amethyst	2,000	250	2,000	250	2,000	100	2,100
Jasper	2,000	500	2,000	500	......	......	......
Sunstone	250	200	250	200	250	100	1,000
Fossil coral	500	250	500	250	......	......	......
Rutile	......	......	......	......	......	......	750
Total	47,350	26,700	54,325	28,650	38,550	24,900	78,750
Gold quartz	40,000	75,000	40,000	100,000	40,000	100,000	......

IMPORTS.

Diamonds and other precious stones imported and entered for consumption in the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Glazier's.	Dust.	Rough or uncut.	Diamonds and other stones not set.	Set in gold or other metal.	Total.
1867	$906	....	....	$1, 317, 420	$291	$1, 318, 617
1868	484	....	....	1, 060, 544	1, 465	1, 062, 493
1869	445	$140	....	1, 997, 282	23	1, 997, 890
1870	9, 372	71	....	1, 768, 324	1, 504	1, 779, 271
1871	976	17	....	2, 349, 482	256	2, 350, 731
1872	2, 386	89, 707	....	2, 939, 155	2, 400	3, 033, 648
1873	....	40, 424	$176, 426	2, 917, 216	326	3, 134, 392
1874	....	68, 621	144, 629	2, 158, 172	114	2, 371, 536
1875	....	32, 518	211, 920	3, 234, 319	....	3, 478, 757
1876	....	20, 678	186, 404	2, 409, 516	45	2, 616, 643
1877	....	45, 264	78, 033	2, 110, 215	1, 734	2, 235, 246
1878	....	36, 409	63, 270	2, 970, 469	1, 025	3, 071, 173
1879	....	18, 889	104, 158	3, 841, 335	538	3, 964, 920
1880	....	49, 360	129, 207	6, 690, 912	765	6, 870, 244
1881	....	51, 409	233, 596	8, 320, 315	1, 307	8, 606, 627
1882	....	92, 853	449, 313	8, 377, 200	3, 205	8, 922, 571
1883	....	82, 628	443, 996	7, 598, 176	(*a*)2, 081	8, 126, 881
1884	22, 208	37, 121	367, 816	8, 712, 315	....	9, 139, 460
1885	11, 526	30, 426	371, 679	5, 628, 916	....	6, 042, 547
1886	8, 949	32, 316	302, 822	7, 915, 660	....	8, 259, 747

a Not specified since 1883.

Imports of substances not included in the foregoing table, 1868 *to* 1886 *inclusive.*

Fisca. years ending June 30—	Unmanufactured agates.	Bookbinders' and other manufactured agates.	Carnelian.	Brazilian pebbles.	Amber.	Amber beads.	Unmanufactured coral.	Manufactured coral.	Unmanufactured meerschaum.	Total.
1868	....	....	....	....	....	....	....	$62, 270	....	$62, 270
1869	....	$70	$269	....	$427	....	....	22, 417	$6, 407	29, 590
1870	....	....	766	....	1, 433	....	....	18, 975	3, 998	25, 172
1871	....	1	661	....	180	....	....	37, 877	698	39, 417
1872	....	529	207	....	2, 426	....	$83	59, 598	2, 194	65, 037
1873	$151	1, 310	....	$1, 237	1, 534	$595	230	63, 805	5, 608	74, 470
1874	177	1, 524	....	....	1, 448	1, 057	527	28, 152	270	33, 155
1875	520	5, 165	....	57	7, 169	715	1, 278	33, 567	2, 902	51, 373
1876	293	1, 567	....	....	15, 502	187	109	33, 559	21, 939	73, 156
1877	579	1, 904	(*a*)69	....	17, 307	329	718	28, 650	9, 304	58, 860
1878	82	404	....	76	13, 215	1, 119	1, 252	12, 667	16, 308	45, 123
1879	138	364	....	....	17, 821	203	147	11, 327	19, 088	49, 088
1880	57	2, 346	....	....	36, 860	2, 317	62	5, 492	30, 849	77, 983
1881	486	1, 700	....	5	42, 400	1, 102	89	2, 501	72, 754	121, 037
1882	901	5, 084	....	111	72, 479	4, 174	1, 474	669	56, 118	141, 010
1883	14	2, 895	....	....	40, 166	3, 472	681	(*b*)1, 303	58, 885	107, 416
1884	....	6, 100	....	3, 496	56, 301	4, 692	158	....	43, 169	113, 916
1885	124	....	....	6, 541	21, 722	3, 242	659	....	42, 590	74, 878
1886	284	....	....	17, 379	27, 215	5, 665	219	....	23, 417	74, 179

a Not separately classified since 1877.

b Not specified since 1883.

FERTILIZERS.

Introductory.—The subject of fertilizers is considered here for the purpose of showing what mineral substances find use in this industry, rather than for giving a complete sketch of the subject. It frequently becomes necessary, however, to mention substances not mineral to show their relations to other constituents of manufactured fertilizers.

There are of course very many substances which contain one or another constituent useful in making soil fertile; these are used under varying conditions in such a way as to make an enormous list of substances called fertilizers, and it is a difficult question to decide whether any one shall be ruled out of use as being without any value. But aside from this use, which is chiefly local, of waste products variously named, the fertilizers which are sold commercially are becoming steadily simpler in character and more susceptible of statistical treatment.

The mineral constituents which it is meant to supply to the soil by fertilizers are practically three: phosphoric acid, potassium compounds included generally under the rough term "potash," and lime. The substances from which these are obtained are somewhat more numerous. Thus phosphoric acid is obtained principally from the phosphate rock, essentially tri-calcium phosphate, obtained at Charleston and Beaufort, South Carolina; but it is also obtained from bones, which contain a very large percentage of this same tri-calcium phosphate; from marls, which are principally soft limestone but contain small amounts of phosphoric acid, and from a peculiar form of phosphate rock called apatite, which is the main source of phosphoric acid in Canada, and in Spain and Portugal. Whatever be the source of the phosphoric acid, the substance cantaining it is usually treated with sulphuric acid to render it soluble; then it is so mixed with other substances that the resulting fertilizer will contain on the average from 10 to 15 per cent. of available phosphoric acid, and henceforth this percentage is the important question, and the original source of the phosphoric acid is a matter of small importance. In special cases, however, the material containing phosphoric acid, especially marl, is applied to the land without chemical treatment and with valuable results.

"Potash" is contributed to soils principally in the form of "muriate of potash" and kainite (containing potassium sulphate). High grade sulphate of potash is also used, and these three substances, which are imported from Stassfurt, Germany, contribute more than ninety-five per cent. of the potash which is added to the soil. The remainder is contained in cotton-seed meal and in ashes, which are used locally. Marls, land plaster (gypsum), and burned lime are, in the order of their importance, the substances furnishing lime to the soil.

The total amount of these raw materials used during 1886 is estimated in the following table:

Raw materials, principally of mineral origin, used in the production of fertilizers in the United States during 1886.

Substances.	Amount.	Value.
Produced in the United States.		
	Long tons.	
South Carolina phosphate rock	430, 549	$1, 872, 936
North Carolina phosphate rock	1, 400	$12, 600
Other phosphate rock	100	1, 000
Bones	100, 000	1, 000, 000
Marls	800, 000	400, 000
Gypsum	102, 000	405, 960
Guano (natural)	500	5, 000
Total	....	$3, 297, 496
Imports.		
Fertilizers:		
Bones, crude, not manufactured, burned, calcined, ground, or steamed, and bone dust and bone ash, for the manufacture of phosphates and fertilizers	19, 784. 31	325, 581. 00
Carbon, animal, fit for fertilizing only	1, 450. 70	25, 809. 00
Guano	14, 383. 37	341, 647. 00
Kieserite, kyanite (or cyanite), and kainite	102, 391. 36	650, 688. 73
Phosphate, crude or native, for fertilizing purposes	37, 980. 50	432, 591. 04
All other substances used expressly for manure	21, 364. 66	358, 170. 00
Total fertilizers imported	....	$2, 134, 486. 77

PHOSPHATE ROCK.

SOUTH CAROLINA.

The production of phosphate rock in South Carolina decreased from 437,549 long tons in 1885 to 430,549 tons in 1886. The average price per ton of crude land rock was $4.50 and for river rock $4. This decline in price, from an average of $6.50 in 1885, and the decline in production means severe depression in the trade. Several factors have contributed to this result. Most prominent was the dissolution of the Phosphate Miners' Exchange on September 4, 1885. This association of miners of land rock had maintained the price at $6.50, but could no longer control the market, as the river dredgers took no part in it. The low price may have been partly due to the efforts of the river dredgers to renew their nearly expired grants upon favorable terms. The following statistics of production during 1886 have been kindly furnished by Mr. Paul C. Trenholm, of Charleston, South Carolina.

Phosphate rock shipped from, and consumed in, South Carolina during the year 1886.

Destination.	Crude.	Ground.	Total.
From Charleston.	*Long tons.*	*Long tons.*	*Long tons.*
Domestic exports—			
Baltimore	63,794		63,794
Philadelphia	24,661	20	24,681
New Town Creek, New Jersey	2,675	1,813	4,488
Weymouth, Massachusetts	14,989		14,989
Wilmington, North Carolina	5,815		5,815
Boston (*a*)	1,165		1,165
Richmond, Virginia	3,489		3,489
Barren Island	5,050	700	5,750
Seaford, Delaware	920		920
New York	3,226	5,548	8,774
Mantua creek, New Jersey	2,741	1,068	3,809
Linden, New Jersey		450	450
Milford, Connecticut	500		500
Wilmington, Delaware	9,810		9,810
Staten Island, New York	4,596		4,596
Orient, Long Island	1,810		1,810
Elizabethport, New Jersey	2,314		2,314
Duxbury, Massachusetts	520		520
Union Landing, Massachusetts	837		837
South Carolina railway	5,241		5,241
Charleston and Savannah railway	22,260		22,260
Northeastern railroad	1,546		1,546
Total domestic	177,959	9,599	187,558
Foreign exports—			
Liverpool	1,865		1,865
Havre	716		716
Gothenburg	100		100
Newport, Wales	525		525
Nordköping, Sweden	60		60
St. Petersburg	70		70
Reval	240		240
United Kingdom	1,625		1,625
Cronstadt	125		125
Antwerp	200		200
Nantes	400		400
Total foreign	5,926		5,926
Grand total from Charleston	183,885	9,599	193,484
From Beaufort and vicinage.			
Domestic ports, except that mined in the marshes, on which no royalty is paid, and not cleared through custom house			14,622
Foreign ports			153,443
Total from Beaufort			168,065

a In part for reshipment to Weymouth.

Summary.

	Domestic.	Foreign.	Total.
	Long tons.	*Long tons.*	*Long tons.*
From Charleston	187,558	5,926	193,484
From Beaufort and vicinage	14,622	153,443	168,065
Estimated consumption at Charleston			60,000
Estimated consumption at Port Royal			9,000
Grand total shipped from and consumed in South Carolina in—			
1886			430,549
1885			437,856
Decrease in shipments in 1886 over 1885 (estimated consumption increased 9,000 tons at Port Royal)			7,307

Charleston shipments—	Tons.	
Increase, domestic	11,605	
Decrease, foreign	7,217	
		Tons.
Net increase		4,388
Beaufort shipments—		
Decrease, domestic	25,928	
Increase, foreign	5,233	
Net decrease, as above		20,695
Total decrease		16,307
Crude rock shipments from Charleston increased this year over last		4,388
Ground rock shipments from Charleston, decreased this year over last		10,405
Net decrease, shipments as above		6,017

NOTE.—Ninety-nine per cent. of the shipments from Charleston is "land" rock, and from Beaufort and vicinage is all "river" (and marsh) rock.

The production of phosphates in previous years is given in the following table. The years are trade years ending May 31, except 1886, which is the regular calendar year.

Phosphate rock (washed product) mined by the land and river mining companies of South Carolina.

Years ending May 31—	Land companies.	River companies.	Total.
	Long tons.	*Long tons.*	*Long tons.*
1867	6	....	6
1868	12,262	....	12,262
1869	31,958	....	31,958
1870	63,252	1,989	65,241
1871	56,533	17,655	74,188
1872	36,258	22,502	58,760
1873	33,426	45,777	79,203
1874	51,624	57,716	109,340
1875	54,821	67,969	122,790
1876	50,566	81,912	132,478
1877	36,431	126,569	163,000
1878	112,622	97,700	210,322
1879	100,779	98,586	199,365
1880	125,601	65,162	190,763
1881	142,193	124,541	266,734
1882	191,305	140,772	332,077
1883	219,202	159,178	378,380
1884	250,297	181,482	431,779
1885	225,913	169,490	395,403
1885 (June 1 to December 31)	149,400	128,389	277,789
1886 (calendar year)	253,484	177,065	430,549

The details concerning the disposition of these phosphates are given in the following tables, the years being trade years ending May 31, except 1886:

Detailed statement of total foreign and coastwise shipments and local consumption since June 1, 1874.

Periods.	Shipments and consumption.	Beaufort.	Charleston.	Other points.	Total.
		Long tons.	*Long tons.*	*Long tons.*	*Long tons.*
June 1, 1874, to May 31, 1875......	Foreign ports....	44, 617	25, 929	....	70, 546
	Domestic ports...	7, 000	25, 560	....	32, 560
	Consumed........	....	19, 684	....	19, 684
	Total.........	51, 617	71, 173	....	122, 790
June 1, 1875, to May 31, 1876.....	Foreign ports....	50, 384	25, 431	....	75, 815
	Domestic ports...	9, 400	28, 831	....	38, 231
	Consumed........	....	18, 850	....	18, 850
	Total.........	59, 784	73, 112	....	132, 896
June 1, 1876, to May 31, 1877......	Foreign ports....	73, 923	28, 844	....	102, 767
	Domestic ports...	6, 285	40, 768	....	47, 053
	Consumed........	....	13, 400	....	13, 400
	Total.........	80, 208	83, 012	....	163, 220
June 1, 1877, to May 31, 1878......	Foreign ports....	100, 619	21, 123	....	121, 742
	Domestic ports...	8, 217	60, 729	....	68, 946
	Consumed........	....	17, 635	....	17, 635
	Total.........	108, 836	99, 487	....	208, 323
June 1, 1878, to May 31, 1879.....	Foreign ports....	97, 799	21, 767	....	119, 566
	Domestic ports...	8, 618	52, 281	....	60, 899
	Consumed........	....	18, 900	....	18, 900
	Total.........	106, 417	92, 948	....	199, 365
June 1, 1879, to May 31, 1880.....	Foreign ports....	47, 157	14, 218	....	61, 375
	Domestic ports...	13, 346	94, 002	....	107, 348
	Consumed........	....	22, 040	....	22, 040
	Total.........	60, 503	130, 260	....	190, 763
June 1, 1880, to May 31, 1881......	Foreign ports....	62, 200	8, 568	....	70, 768
	Domestic ports...	65, 895	91, 929	....	157, 824
	Consumed........	....	38, 142	....	38, 142
	Total.........	128, 095	138, 639	....	266, 734
June 1, 1881, to May 31, 1882......	Foreign ports....	89, 581	22, 905	....	112, 486
	Domestic ports...	57, 465	111, 314	7, 875	176, 654
	Consumed........	....	42, 937	....	42, 937
	Total.........	147, 046	177, 156	7, 875	332, 077
June 1, 1882, to May 31, 1883......	Foreign ports....	94, 789	28, 251	....	123, 040
	Domestic ports...	36, 175	150, 545	26, 000	212, 720
	Consumed........	....	42, 620	....	42, 620
	Total.........	130, 964	221, 416	26, 000	378, 380
June 1, 1883, to May 31, 1884......	Foreign ports....	132, 114	20, 539	....	152, 653
	Domestic ports...	34, 711	181, 363	6, 329	222, 403
	Consumed........	5, 800	50, 923	....	56, 723
	Total.........	172, 625	252, 825	6, 329	431, 779
June 1, 1884, to May 31, 1885......	Foreign ports....	111, 075	11, 495	....	122, 570
	Domestic ports...	30, 963	161, 700	13, 170	205, 833
	Consumed........	12, 000	55, 000	....	67, 000
	Total.........	154, 038	228, 195	13, 170	395, 403
June 1, 1885, to Dec. 31, 1885......	Foreign ports....	105, 761	8, 581	....	114, 342
	Domestic ports...	16, 321	112, 126	....	128, 447
	Consumed........	5, 000	30, 000	....	35, 000
	Total for 7 months.....	127, 082	150, 707	....	277, 789
Jan. 1, 1886, to Dec. 31, 1886......	Foreign ports....	153, 443	5, 926	....	159, 369
	Domestic ports...	14, 622	187, 558	....	202, 180
	Consumed........	9, 000	60, 000	....	69, 000
	Total.........	177, 065	253, 484	....	430, 549

THE FERTILIZER TRADE IN NORTH CAROLINA IN 1886.

BY W. B. PHILLIPS.

About 100,000 tons of commercial fertilizers are used in North Carolina annually. It is sold by fifty-eight companies under ninety brands. Each brand pays an annual license tax of $500. Since the establishment of the Agricultural Department in 1877 and the inauguration of the experiment station and fertilizer control the number of brands and consumption of commercial fertilizers has shown a marked increase.

Brands of fertilizers entered and amounts consumed in North Carolina from 1879 to 1886 inclusive.

Years.	Brands.	Consumption.
		Short tons.
1879	42	60,000
1880	48	80,000
1881	58	85,000
1882	86	92,000
1883	92	95,000
1884	80	95,000
1885	85	95,000 to 100,000
1886	90	95,000 100,000

Each brand is subject to analysis at the experimental station, and valued by the following figures, allowed for "available" phosphoric acid (soluble and reverted), ammonia, and potash, at the seaboard:

Prices allowed per pound in 1886 at the seaboard.

	Per pound.
	Cents.
Available phosphoric acid	7½
Ammonia	16
Potash (K_2O)	5

Accepting these figures, agreed upon by the State chemists of North and South Carolina, Georgia, and Alabama, the following table will show the commercial valuation of representative ammoniated superphosphates, with potash ("complete fertilizers"), from 1880 to 1886, as given in the Report of the North Carolina Experimental Station for 1886, page 21:

Representative fertilizer valuation of ammoniated superphosphates with potash.

Years.	Available phosphoric acid.	Ammonia.	Potash.	Valuation on 1886 basis.
	Per cent.	*Per cent.*	*Per cent.*	
1880	7.40	2.70	1.30	$21.04
1882	8.91	2.60	1.82	23.51
1883	8.59	2.33	2.18	22.53
1884	8.15	2.67	2.13	22.90
1885	9.13	2.65	2.34	24.52
1886	8.69	2.53	2.30	23.44

The following table, taken from page 21 of the report referred to above, will show where the brands of fertilizers used in North Carolina are manufactured:

Origin of the brands of fertilizers used in Alabama.

Where manufactured.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Massachusetts	2	3	......	2	2	3	1
Connecticut	1	2	2	4	3	3	1
New York	3	6	5	3	2	4	3
New Jersey	3	3	1	1	1	2	3
Delaware	2	2	2	2	2	4	4
Maryland	21	25	45	42	30	31	35
Pennsylvania	......	......	1	1	......	......	1
Virginia	7	9	15	17	20	18	21
North Carolina	3	3	6	6	8	9	10
South Carolina	5	6	9	14	12	11	11
Total	47	59	86	92	80	85	90

Amounts of kainite, guano, acid phosphate, and phosphate rock received at the port of Wilmington, North Carolina, from January 1 to December 31 of each year.

Years.	Imported from—	Kainite.		Guano.		Acid phosphate.		Phosphate rock.	
		Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1877	Germany	1,200	$10,548						
1878	....do	300	2,098						
1879	.. do	1,257	9,262						
1880	....do	3,068	14,894						
1880	Nova Scotia							(a)1,150	$1,179
1881	Germany	3,334	23,696						
1882	....do	6,867	43,219						
1882	England			325	$18,414	400	$7,283		
1883	Germany	8,220	54,619						
1884	....do	13,348	82,503						
1884	England					950	23,809		
1885	Germany	9,084	62,951						
1885	England			980	11,760	1,200	15,113		
1886	....do			76	2,493	745	8,752		
1886	France			855	48,177				
1886	Germany	13,042	91,776						
	Total	59,720	395,566	2,236	80,844	3,295	54,957	1,150	1,179

a Including 550 tons of rock plaster, valued at $564.

In addition, there is brought into Wilmington from outside the United States from the Navassa islands, West Indies, about 5,000 tons per annum of Navassa phosphate rock, costing, say, free on board, $7, all of which is consumed by the Navassa Guano Company at Wilmington. One cargo of 500 tons Roncador Island phosphate rock was also brought into Wilmington, in February, 1885, but the venture was not successful, and no more has been brought.

The annual production of fertilizers in North Carolina, including guano, acid phosphate, and fine ground rock, has been as follows:

Production of fertilizers in North Carolina in 1886.

Companies.	Location.	Product.		
		Guano.	Acid phosphate.	Ground rock.
		Short tons.	*Short tons.*	*Short tons.*
Navassa guano	Wilmington	6,000	10,000	
Acme Manufacturing Company	do	2,152		
Goldsboro Oil Company	Goldsboro	2,250		
North Carolina Phosphate Company	Raleigh			(*a*)500
French Brothers	Rocky Point			900
Enterprise fertilizer	Tarboro	1,000		
Durham fertilizer	Durham	1,000		
Total		12,402	10,000	1,400

a Estimated.

The value of these products cannot be stated exactly, but will be very nearly expressed by the following figures:

Value of fertilizers produced in North Carolina in 1886.

	Quantity.	Price per ton.	Total value.
	Tons.		
Guano	12,402	$23	$285,246
Acid phosphate	10,000	14	140,000
Ground rock	1,400	9	12,600
Total	23,802		437,846

It must, however, be noted here that some of the companies buy North Carolina acid phosphate and mix it with cotton-seed meal, or other substances yielding ammonia, and sell it as guano. It is impossible to say exactly how much acid phosphate is thus counted twice, first as acid phosphate by the company selling it as such, and then by the purchaser as guano after it has been "dry mixed" with some ammonia compound. But there is reason for believing that this does not exceed 1,500 tons of the acid phosphate, corresponding to about 2,500 tons guano. A fair allowance would be 1,500 tons to be subtracted from the guano output.

The preceding table will then stand as follows:

	Quantity.	Price per ton.	Total value.
	Tons.		
Guano (12,402 tons, less 1,500 tons)	10,902	$23	$250,746
Acid phosphate	10,000	14	140,000
Ground rock	1,400	9	12,600
Total	22,302		403,346

The 1,400 tons of ground rock is not counted twice, as it is North Carolina phosphate rock, phosphatic conglomerate, etc., mined in the State, and sold as fine ground without being acidulated or ammoniated.

By reference to the table of production it will be seen that two companies make a specialty of fine ground rock; French Brothers, at Rocky Point, Pender county, and the North Carolina Phosphate Company, at Raleigh.

French Brothers have been in the business for several years, mining and grinding their own rock from contiguous deposits. The rock is a phosphatic conglomerate; a mass of phosphatic pebbles and nodules in a cement of carbonate of lime. It is burned in kilns, screened, and the residue ground, and may contain:

	Per cent.
Phosphate of lime	20.34
Lime as oxide and hydrate	37.52

Owing to insufficient machinery the company has not been able to place as much of their products on the market as it expects to before long. The ground rock has a good reputation as a fertilizer. The rock used by the North Carolina Phosphate Company is the same as that used by French Brothers, and is obtained at Castle Haynes, Pender county. They have a very complete mill, with a Foster crusher and two Frisbee-Lucop grinders, and are doing an increasing business, with a daily capacity of 30 tons.

Besides these two companies there are none that use North Carolina rock. The Navassa Guano Company of Wilmington, established in 1869, does the largest business of any company manufacturing in North Carolina. It uses 11,000 tons of crude rock per annum, of which 5,000 tons are Navassa, and the balance South Carolina rock. The daily capacity is: Ground rock, 33 tons; acid phosphate, 70 tons; guano, 75 tons.

The company makes its own acid, from sulphur, and is well equipped and well situated. Of its total production of 16,000 tons per annum, it sells 10,000 tons in North Carolina.

The Acme Manufacturing Company.—This company has works at Cronley, 17 miles from Wilmington on the North Carolina Central railroad. The year ending December 1, 1886, was really its first year in the business, as the company was experimenting and getting ready. South Carolina rock is used, and the works have the following daily capacity: Ground rock, 15 tons; acid phosphate, 30 tons; guano, 60 tons.

The proprietors make their own acid from sulphur, and are well equipped, though not very well situated. They sell nearly all their product in North Carolina.

The Goldsboro' Oil Company, the Enterprise Fertilizer Company, (Tarboro), and the Durham Fertilizer Company buy acid phosphate, and dry-mix their own guano.

The present outlook in North Carolina.—Opinions vary; some think the prospect fair, others are inclined to take rather despondent views. Fertilizers have declined in price, and the $500 license tax is not popular. There has been little or no mining of the regular North Carolina phosphate rock (20 to 22 per cent. phosphoric acid), for the reasons that it lies in "pockets" somewhat widely separated and the topography of the region is unfavorable for cheap mining. As long as Charleston rock, guaranteed to run 55 per cent. bone phosphate (25.19 per cent. phosphoric acid), can be bought free on board for $5.50 to $6.50 per ton, there is but little prospect of the North Carolina rock coming into market in any quantity. The first systematic investigation of this rock was made by the author, in September, 1883, at the request of the Navassa Guano Company. In his report to that company, published in pamphlet form as "North Carolina Phosphates," in October, 1883, he took the ground that the steepness of the slopes on the sides of most of the little streams where the rock occurs would necessitate an excessive amount of digging, with proportional increase of expense, which the low grade of the rock would not repay. In March, 1884, appeared the report of the North Carolina Experimental Station on North Carolina phosphates, and since that time numerous references have been made to the matter in the publications of the Station, and of the Agricultural Department.

While the rock makes an excellent quality of acid phosphate, it remains to be seen whether it can compete with Charleston rock. So far it has not competed, for the reason that none of it has been offered. As to how soon, if at all, it will be offered, is a very obscure question, and one which time, and it may be a good deal of it, alone can answer.

As to the other raw materials for the manufacture of fertilizers, viz., fish scrap and cotton-seed meal as nitrogenous matter, pyrites as a source of sulphuric acid, and bones, the following may be said:

Fish oil and scrap mills.—There are seven in the State, three of fair capacity and four small. Employment is given from April to November to about four hundred men, and the yearly value of the oil and scrap is about $150,000. The amount of North Carolina fish scrap bought by the Navassa Guano Company in two years ending February 5, 1885, was about 3,500 bags, 140 tons, and they buy most of the scrap made in the State. This will give 1,700 bags (75 tons) per annum, which is perhaps rather less than the real production. The true figures will not fall far short of 100 tons. It should yield 10 per cent. ammonia and 10 per cent. water.

The account will stand, 100 tons fish scrap, 10 per cent. at $2.50 per unit, $2,500; about one-third of this is made at the mouth of the Cape Fear river, and the other two-thirds on Pamlico sound, around Beaufort. The industry might be considerably enlarged, as there is always a good market for the scrap.

Cotton-seed oil mills.—There are nine in the State, with a total capacity in seed of 200 tons daily. A ton of seed should yield 800 pounds of cotton-seed cake. It is not known what proportion of the cake produced goes into fertilizers, probably not above 4,000 tons, but the product of two average-sized mills (the Acme and the Goldsboro') is almost entirely used in this way. Cotton-seed meal is worth $2.50 per unit of of ammonia, and should run 8.5 per cent.

Pyrites.—None mined in the State. All the sulphuric acid used in fertilizers is made from Sicilian sulphur.

Bones.—These are indeed collected, but only in a small way, not above 100 tons each year at $10 per ton.

Marl.—The use of marl is local, and confined almost entirely to the eastern part of the State. Very little, if any, is shipped by rail, each neighborhood using what is convenient and easily transported by wagons. This is to be regretted, as the heavy clay soils of the middle part of the State would respond very readily to such an application.

General observations.—The most marked feature of the fertilizer trade in North Carolina in 1886 was the increased demand for fine ground phosphate rock. The new mill at Raleigh was built to supply this demand, and the steady growth of the sales is an indication of the esteem in which the product is held. An analysis of this article, made at the North Carolina Experimental Station, is as follows:

Analysis of ground North Carolina phosphate rock.

	Per cent.
Bone phosphate	(a) 11.16
Carbonate of lime	64.26
Magnesia	.81
Potash	.40
Water	1.39

a Equivalent to phosphoric acid 5.11 per cent.

The fine ground rock offered by French Brothers is of a somewhat higher grade. The best grade produced by them shows:

Analysis of ground phosphate rock from North Carolina.

	Per cent.
Phosphate of lime	(a) 20.34
Carbonate of lime	....
Lime as oxide and hydrate	37.52
Oxides of iron and aluminum, and loss	5.65

a Phosphoric acid 9.31 per cent.

This represents the composition of the rock after being burned and screened.

Composition of phosphate rock before burning and screening.

	Per cent.
Phosphate of lime	(a) 16.42
Carbonate of lime	54.71
Lime as oxide and hydrate	....
Oxides of iron and aluminum, and loss	3.91

a Phosphoric acid 7.52 per cent.

The burning and screening separates the more phosphatic nodules from the cement of carbonate of lime, and converts this last into oxide and hydrate of lime. All three of these articles are growing in favor with the farmers. The use of raw ground rock in the preparation of home manures is one of the reasons why the prices of acid phosphate and guano have declined. Extra inducements have to be offered, now that the farmer has discovered that he can buy a good article for nearly 50 per cent. less than he has been accustomed to pay.

The following table shows the total value of all fertilizing materials raised or made in North Carolina in 1886:

Quantity and value of fertilizing materials raised or made in North Carolina in 1886.

Fertilizing materials.	Quantity.	Price per ton.	Total value.
	Tons.		
Guano	10,902	$23	$250,746
Acid phosphate	10,000	14	140,000
Ground rock	1,400	9	12,600
Fish scrap	100	25	2,500
Marl	....	....	....
Cotton-seed meal	4,000	22	88,000
Bones	100	10	1,000
Total value	....	....	$494,846

FLORIDA.

But little use has yet been made of the phosphates discovered by Prof. Lawrence Johnson principally near Gainesville, Florida. There is no doubt, however, of their ultimate use, as much benefit can be derived by using them even in the crude state without treatment with sulphuric acid.

During 1886 another locality was added to those in which phosphate rocks have been found in Florida. More than two years ago Mr. W. T. Duval, of Crawfordville, Wakulla county, found phosphatic material in his neighborhood. In 1886, Mr. John Kost, lately appointed State geologist, visited this locality in Wakulla county and states that the deposit is in the southwestern part of the county between the Sopchoppy and Ocklockonee rivers. When in place, this material is a sandstone in which are numerous fragments of fossil bones and teeth of sharks. Where the fossils are abundant in a sand deposit, as is the case in various places, this sand is rich in phosphoric acid to a depth of 12 to 14 inches. Samples were submitted to Messrs. Regis Chauvenet & Brother, who report that the "samples of earthy phosphates marked No. 1, Sopchoppy rock; No. 2, Ocklockonee rock; and No. 3, surrounding rock (matrix of fossils) left with us for qualitative examination, show quite an amount of phosphoric acid. Sample No. 1 is very rich, and we may say that it will analyze close to 20 per cent. in phosphoric acid. No. 2 will probably yield 10 to 15 per cent. of phosphoric acid; while No. 3 will not be found so high. On the whole the samples are quite rich enough for the market, and merit a further examination."

Prot. J. M. Pickel, of the Florida State Agricultural College, states that "the Sopchoppy phosphatic rock which you left with me for analysis contains 23.85 per cent. of phosphoric acid (P_2O_5), equivalent to 59.05 per cent. of bone phosphate of lime. No bone was included in the samples analyzed." Mr. Kost states that the deposit extends, through several townships in Wakulla county, and has a thickness of 12 to 14 inches and is resting at a depth of 3 to 5 feet below the surface. It is not known, however, that the deposit is continuous through the localities where found, or only in patches. The only firms manufacturing fertilizers in the State at the close of 1886, so far as known to this office, were W. W. Hicks, Fort Mason, Orange county; the Home Fertilizer Company, Sanford, Orange county; Walter Stowe, Stowe's Landing, Duval county, and the De Land Fertilizer Company, of De Land, Volusia county, and it is not known that any one of these companies uses any mineral constituents found in Florida.

ALABAMA AND MISSISSIPPI.

The extensive deposits of phosphate rock and marls in Alabama were described at length in "Mineral Resources of the United States, 1883, '84." Since that time it is remarkable that very little has been done towards utilizing these deposits. The chief reason for this seems to be the reluctancy to invest capital in an industry which can only turn out a product to be consumed locally. These phosphates and marls are, however, extremely valuable, and there is absolutely no reason why they should not be used in much larger quantities than in the prosperous State of New Jersey, where of marls alone at least 800,000 tons—by no means so rich in phosphoric acid—are annually applied to land which is, to begin with, perhaps richer than the average land accessible to the phosphate and marl beds of Alabama and Mississippi. The questionable opinion seems to be prevalent that only such fertilizers can be used to advantage in which the phosphoric acid is in a soluble condition. It is true that for quick benefit such fertilizers give most immediate returns, but the employment of ground bones shows the benefit which can be obtained from the use of fertilizers in which the phosphoric acid is insoluble. In the phosphate rock and marls of Alabama and Mississippi the percentage of phosphoric acid is lower than in ordinary commercial fertilizers and it is less soluble, but still the poorest of these marls contains many times the percentage of phosphoric acid of an ordinary rich soil. Therefore the question of ultimate benefit is simply as to how many tons of marl or phosphate must be applied per acre to add to the soil as much phosphoric acid as is contained in the quantity of commercial fertilizers ordinarily applied. This use will prove cheaper than commercial fertilizers when the freight charges are small, or, in other words, it seems that these marls and phosphates can be used to great advantage locally; that is, in the neighborhood of the deposits. A serious difficulty in selling the phosphates and marls is offered by the State laws, which rule out of the market the only mineral substances which these very States possess.

OTHER STATES.

In Arkansas it is proposed to work the marl bed found at Crowley's Ridge, Saint Francis county. The Union Stock Yards and Fertilizer Company has the matter in hand. Works for the employment of native phosphates have been erected at Sellman, Georgia, and at one or two other points in that State.

MARLS.

New Jersey.—This State continues most prominent in the use of marls as a direct application to the soil. The material is not rich enough to compete with artificial fertilizers when transported for any considerable distance. The use is local and consequently does not increase. In 1886 the production amounted to about 800,000 tons, with a nominal value of $400,000, covering merely the cost of digging and spreading upon the land.

Other States.—In North Carolina much attention is being paid by the State Agricultural Department to an exposition of the value of the marls occurring in large quantities in the eastern portion of the State. Concerning the marls in the southeastern part of the State between the South Carolina line and the Neuse River, the *North Carolina Bulletin* says: "This whole section is full of what are called coprolitic marls, containing distinct pieces of some phosphatic material, frequently bones; sometimes, though less frequently, true coprolites; most frequently they consist of simply phosphate rock like the bulk of the separate phosphate rock. These beds are cut through by the Cape Fear river and its tributaries, which should supply cheap transportation. Two new localities have been investigated by the Experiment Station. One is at Indian Wells Landing, in Bladen county, on the Cape Fear river. This marl contains 0.70 per cent. of phosphoric acid, while the nodules in it yield 6.36 per cent. The second deposit is south of Tarborough, Edgecombe county. The material here is composed of sand and phosphate of lime with very little carbonate, like the lowest grades of phosphates in Duplin county. The best specimen yielded 11.64 per cent. of phosphoric acid."

In Alabama the use and sale of the phosphatic marls has been begun by Mr. John F. Wiatt, at Coatopa, who has shipped considerable amounts to Meridian, Mississippi. Mr. W. S. Purifoy, of Furman, is operating a deposit 30 miles south of Selma, Alabama; Mr. T. J. Anderson, of Eutaw, Greene county, has opened a deposit in that town.

In Florida the local use of marls is increasing rapidly in several localities in the State, notably near Leesburgh and Crawfordsville.

The following extract from "Internal Commerce of the United States, 1886," shows the existence of marls in Kentucky and gives a good account of their composition. "One of the most interesting results of the geological survey was the discovery of potash and soda in some of the marls of the Chester group in such quantities as to prove them valuable as fertilizers. Attention was first directed to the deposits near Litchfield, Grayson county, and now they are searched for with interest wherever the Chester group is known to occur. They have been found in Grayson, Edmonson, Breckenridge, Caldwell, Christian, and Livingston counties. Their entire extent is unknown, but it is not improbable that further explorations may prove their existence wherever the Chester group is fully developed. Scarcely too high an estimate can be placed on these marls in Kentucky, as they constitute a ready and cheaper fertilizer for tobacco lands, the properties of the marl being to renew the vigor of the soil as it is impoverished by the tobacco. The lack of fertility of much of the land is largely due, not to original poorness, but to the exhaustion produced by tobacco. These potash marls are expected to serve in placing the lands once more in a fertile condition." Following is the analysis of a sample of marl collected from Haycraft's lick, Grayson county, and dried at 212° Fahr.:

Analysis of Kentucky marl.

	Per cent.
Alumina, iron etc., oxides	27.811
Lime, carbonate	.880
Magnesia	.824
Phosphoric acid	.109
Potash	5.554
Soda	.657
Water and loss	4.245
Silica and insoluble silicates	59.920
Total	100.000

GYPSUM.

Ohio and Michigan remain the principal States which produce gypsum, both for use as a fertilizer and for plaster of Paris or stucco. The production in the former State is given in the following table, furnished by Mr. George A. Marsh, of Sandusky, Ohio:

Production of stucco and land plaster in Ohio.

Years.	Stucco.			Land plaster.		
	Barrels.	Total value.	Average price per barrel.	Short tons.	Total value.	Average price per ton.
1881	12,409	$19,234	$1.55	3,705	$16,117	$4.35
1882	16,888	24,656	1.46	4,404	19,069	4.33
1883	20,919	29,496	1.41	4,678	19,414	4.15
1884	20,307	28,024	1.38	4,217	17,248	4.09
1885	(a)8,686	11,379	1.31	4,038	16,273	4.03
1886	21,256	26,420	1.25	4,186	16,660	3.98

a This is the production of five months only, the mills having remained closed during the busiest portion of the season in consequence of the introduction of new machinery.

In Michigan the production increased slightly, as shown below:

Amount of land plaster and calcined plaster produced in Michigan.

Years.	Land plaster.	Stucco, barrels of 300 pounds.	Years.	Land plaster.	Stucco, barrels of 300 pounds.
	Short tons.			*Short tons.*	
Land plaster, previous to 1866	100,000		1876	(a)39,131	64,386
1866	14,604		1877	(a)40,000	(a)55,000
1867	17,439		1878	40,000	48,346
Stucco, previous to 1868		(a)80,000	1879	43,658	50,800
1868	28,837	34,966	1880	49,570	106,004
1869	29,996	41,187	1881	33,178	112,813
1870	31,437	46,179	1882	37,821	135,165
1871	41,126	48,685	1883	(a)40,082	(a)159,100
1872	43,536	59,767	1884	27,888	156,677
1873	44,972	82,453	1885	28,181	141,575
1874	39,126	82,449	1886	29,398	153,274
1875	27,019	61,120			
			Total	826,999	1,719,946

a Partly estimated.

Aggregate production of land and calcined plaster in Michigan during the years named.

Manufacturers.	1883.	1884.	1885.
	Short tons.	*Short tons.*	*Short tons.*
Grand Rapids Plaster Company	9,843	6,528	7,928
F. Godfrey & Brother	9,968	8,940	8,887
Noble & Co	8,716	7,529	7,663
Union Mills	8,698	6,496	5,899
Wyoming Mills	7,483	4,925	5,656
Alabastine Company	9,415	8,307	5,053
B. F. Smith	9,227	7,545	7,317
Total	63,350	50,270	48,403

The trade remains practically steady, and the following estimate represents the total production in the United States for the past two years:

Estimated total production of plaster in the United States during 1885 *and* 1886.

	1885.			1886.		
	Land plaster.	Calcined plaster.	Total.	Land plaster.	Calcined plaster.	Total.
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
From native stone	49,100	26,000	75,100	50,000	26,000	76,000
From imported stone	51,500	46,200	97,700	52,000	46,000	98,000
Total	100,600	72,200	172,800	102,000	72,000	174,000

The average price of stucco and of land plaster declined slightly in 1886 to $1.29 per barrel for stucco and $3.98 per short ton for land plaster, chiefly the result of the imports of crude stone from Nova

Scotia. These imports are included in the following statements of the imports during 1886 and previous years:

TOTAL IMPORTS.

Gypsum imported and entered for consumption in the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Ground or calcined.		Unground.		Manufactured plaster of Paris.	Total.
	Quantity.	Value.	Quantity.	Value.		
	Long tons.		*Long cwts. (a)*			
1867	....	$29,895	1,959,020	$95,386	....	$125,281
1868	....	33,988	1,753,881	80,362	....	114,350
1869	....	52,238	2,740,785	133,430	$844	186,512
1870	....	46,872	2,144,733	100,416	1,432	148,720
1871	....	64,465	2,008,010	88,256	1,292	154,013
1872	....	66,418	1,906,787	99,902	2,553	168,873
1873	....	35,628	2,378,520	122,495	7,336	165,459
1874	....	36,410	2,474,350	130,172	4,319	170,901
1875	....	52,155	1,875,440	115,664	3,277	171,096
1876	....	47,588	2,794,263	127,084	4,398	179,070
1877	....	49,445	1,953,120	105,629	7,843	162,917
1878	....	33,496	1,784,774	100,102	6,989	140,587
1879	....	18,339	1,939,259	99,027	8,176	125,542
1880	....	17,074	2,406,540	120,642	12,693	150,409
1881	....	24,915	2,572,140	128,107	18,702	171,724
1882	5,737.14	53,478	2,567,740	127,067	20,377	200,922
1883	4,291.34	44,118	3,157,020	152,982	(b)21,869	218,969
1884	4,996.25	42,904	3,326,200	168,000	....	210,904
1885	6,418.00	54,208	2,343,220	119,544	....	173,752
1886	5,911.41	37,642	2,445,400	115,696	....	153,338

a 112 pounds. *b* Not specified since 1883.

Alabaster and spar ornaments imported and entered for consumption in the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Value.	Fiscal years ending June 30—	Value.
1867	$26,129	1877	$16,000
1868	27,891	1878	8,148
1869	21,564	1879	7,986
1870	22,982	1880	9,730
1871	47,633	1881	19,078
1872	23,108	1882	34,292
1873	22,011	1883	23,179
1874	16,463	1884	38,982
1875	16,185	1885	31,796
1876	18,323	1886	20,231

Gypsum in the Rocky Mountain division.—In Colorado nothing further has been done to increase the production of gypsum from the many known beds. The Colorado Stucco, Brick and Cement Company at Colorado City supplies the demand. The production at these works in 1886 was:

Production of gypsum in Colorado.

	Pounds.
Plaster of Paris	561,300
Cement	180,000
Land plaster	50,500

The supply of gypsum in the Black Hills, Dakota, is practically inexhaustible, and it can be mined at a very low price. Its quality is the best. The greater portion of the plaster of Paris made hitherto has been solely for local use, but in 1886 one lot of 30 tons was shipped to Norfolk, Nebraska, from Rapid City. The total number of tons of plaster made at Rapid City in 1886 was 80 tons, of which 50 were used locally. Small lots were also made at Sturgis and Spearfish for home consumption. If favorable rates were made for plaster to Missouri Valley points it is probable that quite an industry could be built up. With time the railways will no doubt give rates under which a large business can be created.

Gypsum on the Pacific coast.—The only plaster produced in the Pacific division is made at the Golden Gate mills, San Francisco, where about 2,500 tons of gypsum are received and ground annually. It is manufactured into all the various grades, such as building, casting for ornaments, molds, etc.; superfine, for sculptors and modelers' use; also for application to land, for which use there is as yet small demand on the Pacific coast. The supply of the sand material continues to be derived in about equal parts from the gypsum deposits of Santa Barbara county, California, and from the San Marcos islands, off the coast of Lower California. The plaster of Paris turned out at these mills is so superior to the best made abroad that importations at San Francisco, formerly large, have been much reduced, as shown by the following table of importations at that port for the past ten years.

Years.	Barrels.	Years.	Barrels.
1875	22,782	1881	5,850
1876	14,918	1882	4,777
1877	14,487	1883	6,300
1878	11,038	1884	5,700
1879	5,400	1885	9,690
1880	3,200	1886	8,000

The following localities have been added to the large list of deposits of gypsum which, however, have not yet been developed. A bed, said to be of good quality, has been found near Phœnix, Arizona Territory. At Lebo, Kansas, a two-foot vein of gypsum has been found at a depth of 30 feet. West of Tulare lake, in Tulare county, California, a deposit has been opened, and it is proposed to use the material on alkali lands.

MANUFACTURED FERTILIZERS.

Constituents.—In the preceding pages those mineral constituents of commercial fertilizers have been treated which are produced in the United States. These are sometimes applied to the soil just as they are found without any process of manufacture, or a grinding process is gone through with; but in general this yields only one single constituent of a fertile soil, so that other substances are often added for the purpose of furnishing a fertilizer which will, when used in sufficient quantity, insure a plentiful amount of each necessary element, and care is taken that the substance is furnished in the state of fine powder so as to mix with the soil easily and efficiently. Up to the present time the United States has supplied the bulk of the phosphoric acid for these mixtures and also the various nitrogenous substances which furnish ammonia to the plants. But potassium salts, the so-called "potashes," are, practically, all imported.

Potash salts.—Three forms of potassium salts are imported; the best known is kainite, which is impure sulphate of potassium, containing also a large percentage of magnesium compounds. High and medium grade potassium sulphate is the same kainite after it has been partially freed from its impurities; "muriate of potash" is also a very important article of import, as it is used not only for fertilizers but in many other industries. These substances are all derivatives from the Stassfurt mines in Germany. Concerning their occurrence an interesting account has also been published in an article by C. Napier Hake in the *Journal of the English Society of Chemical Industry.*

The amounts of these three compounds imported during 1886 are shown in the following tables:

Imports of potassium chloride (muriate of potash) from 1872 to 1886 inclusive.

Fiscal years ending June 30—	Tons.	Value.	Fiscal years ending June 30—	Tons.	Value.
1872	2,579	$126,418	1880	10,725	$331,489
1873	3,467	158,768	1881	10,179	335,799
1874	3,323	134,289	1882	19,409	743,825
1875	5,242	190,587	1883	13,729	535,259
1876	4,413	157,542	1884	21,751	731,409
1877	6,133	209,413	1885	20,420	613,674
1878	8,784	292,603	1886	23,412	721,736
1879	9,524	250,818			

Distribution of potassium chloride imports, for fiscal years ending June 30—

Ports.	1881.	1882.	1883.	1884.	1885.	1886.
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
New York	8,290	11,600	12,620	13,730	13,870	13,871
Philadelphia		2,117	1,599	1,645	1,850	3,404
Baltimore	4,155	4,406	3,500	2,896	2,290	2,599
Boston					1,594	1,418
Charleston					1,097	1,678
Savannah					50	
Port Royal					150	
Other ports					295	331
Total	12,445	18,123	17,719	18,271	21,196	23,301

Imports of agricultural salt from 1869 to 1885.

Fiscal years ending June 30—	Tons.	Value.	Fiscal years ending June 30—	Tons.	Value.
1869		$1,752	1880		$21,667
1870		9,698	1881		8,187
1871		2,436	1882		55,622
1874		114	1883		43,363
1875		1,867	1884	1,400	42,640
1879		2,480	1885	600	18,360

Distribution of kainite imports for the calendar years 1881 *to* 1886 *inclusive.*

Ports.	Years.					
	1881.	1882.	1883.	1884.	1885.	1886. (*a*)
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
New York	31, 045	7, 127	24, 012	24, 119	16, 967	16, 604
Philadelphia	....	10, 204	4, 579	15, 120	14, 102	16, 827
Baltimore	40, 645	12, 315	30, 738	22, 146	24 984	26, 521
Charleston	....	14, 823	25, 050	27,975	16, 335	12, 960
Savannah	....	4, 169	8, 365	5, 371	2, 488	7, 506
Wilmington, North Carolina	....	5, 494	9, 020	13, 355	9, 330	13, 042
Boston	....	....	....	....	492	594
Norfolk	....	....	....	991	500	1, 801
Other ports	....	....	....	1, 591	2, 437	2, 923
Total	71, 690	54, 132	101, 764	110, 928	87, 635	98, 778

a Kindly furnished by Mr. Hamilton H. Salmon.

Imports of medium grade potassium sulphate (containing 48 *to* 50 *per cent.* K_2SO_4*).*

Years.	Short tons.	Years.	Short tons.
1880	300	1884	2, 500
1881	500	1885	7, 525
1882	700	1886	*a*10, 900
1883	1, 000		

a Including about 500 tons of high-grade potassium sulphate.

Of high-grade potassium sulphate 450 short tons were imported in 1885.

Production and prices of manufactured fertilizers.—Fertilizers are made and shipped during the winter and spring, hence the production is given to April 30 of each year. Mr. A. de Ghequier, secretary of the National Fertilizer Association, has computed the product from May 1, 1885, to April 30, 1886, at 1,099,500 short tons. It was produced by the following States:

Estimated production of manufactured fertilizers, years ended April 30—

States.	1883.	1884.	1885.	1886.
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*
Alabama	3, 000	4, 000	4, 000	5, 000
Connecticut	15, 000	15, 000	15, 000	15, 000
Delaware	40, 000	45, 000	50, 000	50, 000
District of Columbia	7, 000	7, 000	7, 000	5, 000
Georgia	25, 000	30, 000	35, 000	40, 000
Illinois	30, 000	35, 000	35, 000	30, 000
Indiana	3, 000	4, 000	5, 000	5, 000
Iowa	1, 000	1, 000	1, 000	....
Kentucky	2, 500	3, 500	4, 000	7, 000
Louisiana	2, 000	2, 500	3, 000	15, 000
Maine	6, 500	7, 000	7, 500	7, 500
Maryland	260, 000	290, 000	300, 000	306, 000
Massachusetts	75, 000	80, 000	85, 000	80, 000
Michigan	2, 000	3, 000	3, 000	15, 000
Missouri	6, 000	6, 000	6, 000	6, 000
New Jersey	85, 000	90, 000	95, 000	90, 000
New York	90, 000	95, 000	100, 000	100, 000
North Carolina	15, 000	15, 000	15, 000	20, 000
Ohio	15, 000	15, 000	18, 000	20, 000
Pennsylvania	60, 000	65, 000	70, 000	80, 000
Rhode Island	12, 000	12, 000	12, 000	10, 000
South Carolina	90, 000	100, 000	110, 000	140, 000
Virginia	30, 000	40, 000	40, 000	50, 000
West Virginia	2, 000	2, 000	3, 000	3, 000
Total	877, 000	967, 000	1, 023, 500	1, 099, 500
Value	$23, 680, 000	$26, 110, 000	$27, 640, 000	$27, 487, 500

By obtaining statements of fertilizer shipments from the various transportation lines, Mr. de Ghequier has been able to approximate the consumption in the following States:

Estimated consumption of manufactured fertilizers in the following States, years ending April 30—

States.	1883.	1884.	1885.	1886.
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*
Alabama	45,000	45,000	45,000	40,000
Delaware	10,000	20,000	20,000	15,000
Florida	5,000	5,000	10,000	5,000
Georgia	125,000	170,000	180,000	160,704
Illinois	5,000	7,500	7,500	7,500
Indiana	8,000	8,000	10,000	7,500
Kentucky	6,000	6,000	10,000	8,000
Louisiana	5,000	5,000	5,000	10,000
Maryland	80,000	75,000	75,000	75,000
Michigan	5,000	5,000	5,000	10,000
Mississippi	20,000	10,000	10,000	5,000
Missouri	5,000	5,000	5,000	....
New York	30,000	30,000	35,000	30,000
New Jersey	35,000	40,000	45,000	50,000
New England States	60,000	75,000	100,000	100,000
North Carolina	90,000	95,000	90,000	95,000
Ohio	20,000	20,000	20,000	30,000
Pennsylvania	80,100	100,000	100,000	115,000
South Carolina	90,000	110,000	100,000	107,927
Tennessee	10,000	10,000	15,000	10,000
Virginia and West Virginia	80,000	100,000	100,000	100,000
Western States	26,000	25,000	30,000	25,000
Total	840,100	966,500	1,017,500	1,006,631

Valuation.—In regard to the system in use in some of the Southern States to establish by chemical analyses the relative values of the different fertilizers, little need be said beyond what was published in the preceding report on this subject, to which the reader is referred. Prof. Chas. U. Shepard, of Charleston, South Carolina, writes thus in regard to the practical working of this system in South Carolina: "I think that the fertilizer industry has sufficiently advanced to allow us to drop the idea that the good will of the manufacturer, or his individual skill, is capable of imparting to any brand of commercial manure anything of value besides a good mechanical condition and certain percentages of essential constituents, and a careful exclusion of certain comparatively worthless materials. The agricultural departments generally endeavor to compel the manufacturers 'to state what they sell, and to sell what they state;' they additionally give the farmers the quotations usually at some given point for the cash commercial valuations of the essential constituents, and I have never known these valuations to be otherwise than generous to the manufacturer.

"The chemist to the Department of Agriculture of South Carolina has his samples drawn at interior points where the manures are sold directly to the farmers, *i. e.*, he analyzes what the farmer actually gets (and this is quite different from what occurs in some other States). If an article falls below the guaranteed standard, other samples of the same brand are immediately analyzed; and thus it is ascertained whether the discrepancy is general or individual and accidental. In every case the manufacturer is given due notice before any condemnation is published.

"In South Carolina the only punishment for selling inferior goods lies in calling public attention to the discrepancies. But judging from the very general improvement of all the various classes of manures and the great carefulness exercised to run beyond the guarantee, it would seem that the conscientious and rigid work of the department in this State was serving its functions admirably."

The methods to be used by the agricultural chemists in determining the composition of commercial fertilizers are about the same as those of former years. A valuable treatise on this subject by Dr. H. W. Wiley will be found in Bulletin No. 12 of the Division of Chemistry, United States Department of Agriculture, where not only the exact directions are given, but also a valuable summary upon the pertinent foreign literature.

Basic slag as a fertilizer.—The use of this material simply ground to a fine powder is well established in Germany and is spreading in other countries. The efficiency of this material beyond what would be expected from the same quality of phosphate rock is beyond doubt, and it is only a matter of time when it will be used here. During the year 1886, 1,313,631 tons of steel were made by the basic process in foreign countries, involving the production of about 394,000 tons of slag containing from 30 to 35 per per cent. of phosphate of lime.

SALT.

By William A. Raborg.

The condition of the salt industry in 1886 did not vary in any essenti feature from that described in the last report of this series. The total output has increased from 7,038,653 barrels of 280 pounds each in 1885 to 7,707,081 barrels in 1886. All of the principal salt-produ regions shared in this increase, but Michigan to the greatest extent. The total value of the salt decreased, owing to a decline to 66 cents per barrel in the price of Michigan salt. In 1885 the total value was estimated at $4,825,345; in 1886 it was $4,736,585

Salt product of the United States in 1883, 1884, 1885, *and* 1886.

	1883.	1884.	1885.	1886.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*
Michigan	2,894,672	3,161,806	3,297,403	3,677,257
New York	1,619,486	1,788,454	2,304,787	2,431,563
Ohio	350,000	320,000	306,847	400,000
West Virginia	320,000	310,000	223,184	250,000
Louisiana	265,215	223,964	299,271	299,691
California	214,286	178,571	221,428	214,285
Utah	107,143	114,285	107,140	164,285
Nevada	21,429	17,857	28,593	30,000
Illinois, Indiana, Virginia, Tennessee, Kentucky, and other States and Territories, estimated	400,000	400,000	250,000	240,000
Total	6,192,231	6,514,937	7,038,653	7,707,081

MICHIGAN.

The salt production in Michigan was nearly one eighth greater in 1886 than in 1885. The wells, numbering 261, were operated during nine months of the year by 136 firms. The pumping was from an average depth of 1,000 feet, and the salinometer strength of the brine varie from 82° to 100°. The report of Mr. George W. Hill, State salt inspe tor, shows that during the year 1886, 116 steam and 24 pan blocks were in operation. The total number of blocks was 140, and of solar salt covers 4,500, with an estimated total manufacturing capacity of 5,165,0 barrels of salt. The new vacuum-pan and Alberger processes of manufacture were introduced during the year, and 16 new wells were drilled in the following counties: Saginaw, 3; Huron, 1; Bay, 1; Saint Clair, 4; Mason, 2; Manistee, 5.

New blocks.—Eight steam blocks, and one fine dairy-salt mill, with an estimated capacity of 500,000 barrels have been built, or are in course of construction, in Saint Clair county. At Manistee two large steam salt blocks have been completed during the year. At Ludington, Mason county, there are in course of construction two steam blocks. These will increase the capacity of the localities mentioned from 500,000 to 600,000 barrels.

"Common coarse salt."—During the year it was found necessary, in order to protect the standard of fine salt, to establish a new brand, to be known in the market as "common coarse salt." This brand simply means a salt of standard purity, but of imperfect grain, thus making the brand of fine salt more uniform and of a higher grade.

New processes of salt manufacture.—The following is a description of the new method of making table and dairy salt, adopted by the Diamond Crystal Salt Company, of Saint Clair, Michigan:

A detailed series of experiments was made in the Thompson salt block, to test the merits and applicability of a new process for the manufacture of salt, invented by Messrs. Williams & Alberger, of Buffalo, New York. The Diamond Crystal Salt Company was organized to erect a block on a full manufacturing scale of 100 to 150 barrels in twenty-four hours. The factory is operated by steam and the saving in fuel is made by what is known as a "double effect"—that is, the vapor from the brine is utilized to heat an equal amount of brine, and the condensed water is supplied to the boilers. The process is, however, an entirely new method of double effect, as it runs continuously, and no stoppage of the machinery occurs for any cause but a break down. The only place in the manufacture where the men have to handle the salt is in removing it from the centrifugal machine, which is employed to drain the salt rapidly and completely.

The apparatus consists of a pair of steel steam boilers, three tubular heaters, two closed evaporators and an open grainer. The heaters are steel shells containing brass tubes, the steam from the boilers is applied around the tubes, and the brine is forced through them under hydraulic pressure, and is heated to a temperature of 280° F. It then flows into a closed evaporator, and in this, the hydraulic pressure being released, steam arises from the brine and is condensed in heater No. 2, which is a counterpart of No. 1. The brine next passes into another evaporator from which steam also arises and is also condensed in a heater called No. 3. The brine now flows into the circular grainer, 41 feet in diameter, makes and deposits salt by evaporation and cooling, and then returns again through a Worthington pump to heaters No. 3, No. 2, and No. 1, consecutively, condensing the steam and receiving the heat arising from the evaporation of the brine in the two closed evaporators. Now, as 40 per cent. of the total evaporation occurs in the closed evaporators, and as the heat of this evaporation is not lost, but is used to produce another evaporation of brine, one can readily estimate the gain effected.

Attached to the first, or high temperature heaters, are vessels containing gravel; upon this and in the tubes of the heater all the sulphate and carbonate of lime is deposited in a granular form and is easily removed. Relay heaters are provided so that they are cleaned without stopping the action. The salt in the grainer is swept mechanically into the mixer, through which it falls wet with brine into the centrifugal. In this machine 1 to 1½ barrels of salt are drained in two minutes dry enough to barrel for ordinary salt. In making table salt, the surface of the brine in the grainer is agitated continuously by small pieces of metal hanging by chains fastened to four rotating arms. The device prevents the salt from forming in large crystals, by drowning the small ones as fast as they are made. The more the agitation the finer the salt, and the slower the motion the coarser the product. The table and dairy brands, after passing through the centrifugal, are transferred by an elevator to a steam drier, and the salt is there made absolutely dry. Then a bolting machine separates the sizes as desired.

A test was made of the amount of salt which could be made in twenty-four hours, the amount of coal consumed, and the cost of the coal required to make each barrel of salt. The result was 135 barrels of salt, in producing which 8 tons of coal were used, at a cost for the latter of 13½ cents for each barrel of salt.

SALT-PRODUCING DISTRICTS OF MICHIGAN.

Locality of each salt-producing district, and the number and capacity of the works.

Districts.	Counties.	Companies operating.	Steam blocks.	Pan blocks.	Covers.	Manufacturing capacity.
						Barrels.
Number 1	Saginaw	52	45	12	4,000	1,400,000
Number 2	Bay	31	34		500	1,300,000
Number 3	Huron	16	4	8		350,000
Number 4	Saint Clair	12	10	2		600,000
Number 5	Iosco	8	8			300,000
Number 6	Midland	4	3	1		100,000
Number 7	Manistee	10	9	1		900,000
Number 8	Mason	2	2			200,000
Number 9	Gratiot	1	1			15,000
Total		136	116	24	4,500	5,165,000

The following table shows the amount (barrels) of the different grades of salt inspected in each county of the State during 1886, and the increased and decreased inspection per district:

Salt inspected in each district of Michigan in 1886.

Districts.	Counties.	Fine bulk.	Fine barrels.	Coarse barrels.	Packers' barrels.	Solar barrels.	Second quality barrels.
Number 1	Saginaw	262,444	910,263	49	2,361	27,677	10,970
Number 2	Bay	186,431	709,077	568	1,815	3,500	5,993
Number 3	Huron	25,171	211,084		1,770		2,544
Number 4	Saint Clair	3,450	229,079	816	3,328		13,929
Number 5	Iosco		234,367	30	525		221
Number 6	Midland		61,226				5,895
Number 7	Manistee	19,727	620,744	2,154	12,422		28,056
Number 8	Mason		75,318	276			3,627
Number 9	Gratiot		350				
Total		497,223	3,051,508	3,893	22,221	31,177	71,235

Recapitulation.

Districts.	Counties.	Total barrels, 1886.	Total barrels, 1885.	Increase.	Decrease.
Number 1	Saginaw	1,213,764	1,178,910	34,854	
Number 2	Bay	907,384	951,810		44,426
Number 3	Huron	240,569	306,664		66,095
Number 4	Saint Clair	250,602	125,014	125,588	
Number 5	Iosco	235,143	236,543		1,400
Number 6	Midland	67,121	62,710	4,411	
Number 7	Manistee	683,103	432,637	250,466	
Number 8	Mason	79,221		79,221	
Number 9	Gratiot	350	3,115		2,765
Total		3,677,257	3,297,403	494,540	114,686

Salt made in Michigan, 1880 *to* 1886 *inclusive, by counties.*

[Barrels of 280 pounds.]

Counties.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
Bay	1,081,841	1,107,617	1,158,279	1,106,461	1,110,445	951,810	907,384
Gratiot			3,285	6,186	3,500	3,115	350
Huron	256,841	326,852	255,012	256,965	313,832	306,664	240,569
Iosco	147,800	147,579	211,667	210,644	224,687	236,543	235,143
Manistee		1,642	41,562	48,544	123,033	432,637	683,103
Midland	41,462	74,537	80,239	66,135	65,726	62,710	67,121
Saginaw	1,148,644	1,083,990	1,287,273	1,185,957	1,245,912	1,178,910	1,213,764
Saint Clair				4,780	74,671	125,014	250,602
Mason							79,221
Total	2,676,588	2,742,217	3,037,317	2,885,672	3,161,806	3,297,403	3,677,257

The following table shows the amount of salt inspected in Michigan since 1869, the first year of the establishment of the State salt inspection, for the years specified:

Grades of salt made in Michigan as reported by the inspectors.

Years.	Fine.	Packer's.	Solar.	Second quality.	Common coarse.	Total for each year.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
1869	513,989	12,918	15,264	19,117		561,288
1870	568,326	17,869	15,507	19,650		621,352
1871	655,923	14,677	37,645	19,930		728,175
1872	672,034	11,110	21,461	19,876		724,481
1873	746,702	23,671	32,267	20,706		823,346
1874	960,757	20,090	29,391	16,741		1,026,979
1875	1,027,886	10,233	24,336	19,410		1,081,865
1876	1,402,410	14,233	24,418	21,668		1,462,729
1877	1,590,841	20,389	22,949	26,818		1,660,997
1878	1,770,361	19,367	33,541	32,615		1,855,884
1879	1,997,350	15,641	18,020	27,029		2,058,040
1880	2,598,037	16,691	22,237	48,623		2,685,588
1881	2,673,910	13,885	9,683	52,821		2,750,299
1882	2,928,542	17,208	31,335	60,222		3,037,307
1883	2,828,987	15,424	16,735	33,526		2,894,672
1884	3,087,033	19,308	16,957	38,508		3,161,806
1885	3,230,646	15,480	19,849	31,428		3,297,403
1886	3,548,731	22,221	31,177	71,235	3,893	3,677,257

Salt production of Michigan previous to 1869.

Years.	Barrels.	Years.	Barrels.
1860	4,000	1865	477,200
1861	125,000	1866	407,077
1862	243,000	1867	474,721
1863	466,356	1868	555,690
1864	529,073		

Average price of Michigan salt in different years, 1866 *to* 1886 *inclusive.*

Years.	Price, per barrel.	Years.	Price, per barrel.
1866	$1.80	1877	85
1867	1.77	1878	85
1868	1.85	1879	$1.02
1869	1.58	1880	75
1870	1.32	1881	85
1871	1.46	1882	75
1872	1.46	1883	81
1873	1.37	1884	75½
1874	1.19	1885	90
1875	1.10	1886	66
1876	1.05		

NEW YORK.

The Onondaga reservation, operated by the State, and the Warsaw district, which has been developed by private enterprise, are the two sources from which salt is derived in New York. The former produced during the year 1886, 6,101,757 bushels, valued at $699,237, and the latter, 6,056,060 bushels, valued at $544,484, making a grand total of 12,157,817 bushels, valued at $1,243,721 for the State, an increase of 633,883 bushels, and of $369,463 in value over that of the year 1885.

The production for the past four years has been:

	1883.	1884.	1885.	1886.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*
Onondaga reservation	7,497,431	6,942,270	6,934,299	6,101,757
Warsaw district	600,000	2,000,000	4,589,635	6,056,060
Total	8,097,431	8,942,270	11,523,934	12,157,817

ONONDAGA RESERVATION.

The production on the Onondaga salt reservation includes 3,329,46[illegible] bushels produced in the fine salt works by artificial heat, and 2,772,34[illegible] bushels of coarse solar salt, which is divided among the following districts according to their respective grades:

Salt inspected at the Onondaga wells in 1886.

Districts.	Solar.	Fine ground.	Ground solar.	Ground dairy.	Aggregate.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Syracuse	392,656	113,759	48,087	529,888	1,084,390
Salina	651,107	131,956	60,130	1,005,360	1,848,553
Liverpool	727,745			210,963	938,708
Geddes	892,623	243,901		1,093,582	2,230,106
Total	2,664,131	489,616	108,217	2,839,793	6,101,757

The following is a statement of the number of bushels of salt made at the Onondaga salt springs since June 20, 1797, the date of the first lease:

Production of the Onondaga district, 1797 to 1886 inclusive.

[Bushels of 56 pounds.]

Years.	Solar.	Fine.	Total.	Years.	Solar.	Fine.	Total.
	Bushels.	*Bushels.*	*Bushels.*		*Bushels.*	*Bushels.*	*Bushels.*
1797		25,474	25,474	1842	163,021	2,128,882	2,291,903
1798		59,928	59,928	1843	318,105	2,809,395	3,127,500
1799		42,704	42,704	1844	332,418	3,671,134	4,003,552
1800		50,000	50,000	1845	353,455	3,408,903	3,762,358
1801		62,000	62,000	1846	331,705	3,507,146	3,838,851
1802		75,000	75,000	1847	262,879	3,688,476	3,951,355
1803		90,000	90,000	1848	342,497	4,394,629	4,737,126
1804		100,000	100,000	1849	377,735	4,705,834	5,083,569
1805		154,071	154,071	1850	374,732	3,894,187	4,268,919
1806		122,577	122,577	1851	378,967	4,235,150	4,614,117
1807		175,448	175,448	1852	633,595	4,288,938	4,922,533
1808		319,618	319,618	1853	577,947	4,826,577	5,404,524
1809		128,282	128,282	1854	734,474	5,068,873	5,803,347
1810		450,000	450,000	1855	498,124	5,584,761	6,082,885
1811		200,000	200,000	1856	709,391	5,257,419	5,966,810
1812		221,011	221,011	1857	481,280	3,830,846	4,312,126
1813		226,000	226,000	1858	1,514,554	5,518,665	7,033,219
1814		295,000	295,000	1859	1,345,022	6,549,250	6,894,272
1815		322,058	322,058	1860	1,462,565	4,130,682	5,593,247
1816		348,665	348,665	1861	1,884,697	5,315,694	7,200,391
1817		408,665	408,665	1862	1,983,022	7,070,852	9,053,874
1818		406,540	406,540	1863	1,437,656	6,504,727	7,942,383
1819		548,374	548,374	1864	1,971,122	5,407,712	7,378,834
1820		458,329	458,329	1865	1,886,760	4,499,170	6,385,930
1821		526,049	526,049	1866	1,978,183	5,180,320	7,158,503
1822		481,562	481,562	1867	2,271,892	5,323,673	7,595,565
1823		726,988	726,988	1868	2,027,490	6,639,126	8,666,616
1824		816,634	816,634	1869	1,857,942	6,804,295	8,662,237
1825		757,203	757,203	1870	2,487,691	6,260,422	8,748,113
1826		811,023	811,023	1871	2,464,464	5,910,492	8,374,956
1827		983,410	983,410	1872	1,882,604	6,048,321	7,930,925
1828		1,160,888	1,160,888	1873	1,691,359	5,768,998	7,460,357
1829		1,129,280	1,129,280	1874	1,667,368	4,361,932	6,029,300
1830		1,435,446	1,435,446	1875	2,655,955	4,523,491	7,179,446
1831		1,514,037	1,514,037	1876	2,308,679	3,083,998	5,392,677
1832		1,652,985	1,652,985	1877	2,525,335	3,902,648	6,427,983
1833		1,838,646	1,838,646	1878	2,788,754	4,387,443	7,176,197
1834		1,943,252	1,943,252	1879	2,957,744	5,364,418	8,322,162
1835		1,209,867	1,209,867	1880	2,516,485	5,482,265	7,998,750
1836		1,912,858	1,912,858	1881	3,011,461	4,905,775	7,917,236
1837		2,167,287	2,167,287	1882	3,032,447	5,307,733	8,340,180
1838		2,575,033	2,575,033	1883	2,444,374	5,053,057	7,497,431
1839		2,864,718	2,864,718	1884	2,353,860	4,588,410	6,942,270
1840		2,622,305	2,622,305	1885	2,439,332	4,494,907	6,934,299
1841	220,247	3,120,520	3,340,767	1886	2,772,348	3,329,409	6,101,757

The following table shows the strength of the brines in each district for each month in the season, as reported by Dr. F. E. Englehardt, State chemist:

Strength of Onondaga brines for the year 1886.

Months.	Syracuse.	Salina.	Liverpool.	Geddes.
	Degrees salinometer.	*Degrees salinometer.*	*Degrees salinometer.*	*Degrees salinometer.*
April	69.68	76.25	76.25	72.10
May	69.09	73.80	73.80	70.36
June	68.94	73.03	73.03	71.14
July	68.58	72.29	72.29	72.17
August	68.00	72.90	72.90	73.10
September	67.44	73.83	73.83	73.36
October	66.68	74.77	74.77	73.56
November	67.79	73.86	73.86	73.90
Average for the year	68.27	73.84	73.84	72.46
Average for all four districts	72.10			

The average salinometer strength of the brines for 1886 shows an increase, as was predicted in the last volume of "Mineral Resources," of about two and one-half degrees compared with 1885.

The following table shows the average strength of the brines in degrees of the salinometer (reduced to correspond with a temperature of 60° F.) in the years from 1865 to 1886 inclusive, except 1868, for which year there are no records:

Average strength of Onondaga brines.

Years.	Syracuse.	Salina.	Liverpool.	Geddes.	Average.
1865	66.17	66.47	60.65	66.17	64.86
1866	65.90	65.81	58.34	65.90	63.98
1867	64.44	64.35	64.35	63.95	64.27
1869	60.98	60.36	60.36	59.02	60.18
1870	59.49	58.94	58.94	59.34	59.17
1871	63.00	62.35	62.35	63.82	62.88
1872	65.10	66.00	67.00	66.20	66.07
1873	63.43	65.33	65.43	67.52	65.43
1874	63.80	66.15	66.15	67.15	65.81
1875	63.88	66.38	66.38	69.50	66.54
1876	66.75	67.70	67.70	69.33	67.87
1877	68.94	69.19	69.19	69.59	69.23
1878	69.93	70.58	70.58	70.02	70.27
1879	66.61	67.47	67.47	67.16	67.17
1880	66.13	67.10	67.10	67.55	66.97
1881	67.02	66.68	66.68	68.21	67.14
1882	67.75	67.24	67.24	68.63	67.71
1883	66.67	68.30	68.30	69.34	68.15
1884	67.88	71.58	71.58	70.10	70.28
1885	67.63	70.99	70.99	69.25	69.72
1886	68.27	73.84	73.84	72.46	72.10

The following analyses were made by Mr. F. E. Engelhardt, in 1885 and 1886, of the brines of the Gere, Salina, and Geddes groups:

Analyses of the brines of the Gere, Salina, and Geddes groups.

Group.	No. of well.	Specific gravity.	Sulphate of lime.	Chloride of calcium.	Chloride of magnesium.	Chloride of sodium. (*a*)	Total.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Gere	No. 1	1.160.15	0.2558	0.5793	0.2371	20.4128	21.4850
	No. 2	1.133.62	0.4399	0.2009	0.1876	17.4662	18.2946
	No. 2	1.144.84	0.5030	0.1926	0.1597	18.8292	19.6845
	No. 4	1.147.99	0.4232	0.2615	0.1551	19.0525	19.8923
	No. 5	1.156.81	0.2448	0.5213	0.2461	20.0301	21.0423
	No. 6	1.148.64	0.5141	0.1693	0.1547	19.0646	19.9027
Salina	No. 6	1.144.28	0.5238	0.1884	0.1883	18.7342	19.6347
	No. 7	1.145.9	0.5068	0.2015	0.1642	18.7555	19.6280
	No. 8	1.146.71	0.4570	0.2579	0.1915	18.9363	19.8427
	No. 9	1.143.11	0.4969	0.2140	0.1031	18.9430	19.7570
	No. 10	1.144.41	0.3632	0.5701	0.2852	18.4277	19.6462
Geddes	No. 9	1.142.04	0.5531	0.0966	0.1368	18.5595	19.3460

a Includes chloride of potassium. Bromide of magnesium found in traces. The protocarbonate of iron not determined.

Depth of the wells of the Onondaga district.

Wells.	Syracuse group.	Geddes group.	De Wolf group.	Gere group.	Salina group.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
No. 1	300	300	364	368	290
No. 2	305	304	366	369	295
No. 3	317. 8	310	367	370	300
No. 4	319. 8	316	368	371. 6	309
No. 5	321. 8	302	....	371. 9	305
No. 6	331	320	....	372. 6	315
No. 7	301. 4	318	....	....	320
No. 8	314	312	....	....	290
No. 9	303. 10	309	....	....	292
No. 10	316. 6	....	....	....	311
No. 11	303. 4	....	....	....	....

WARSAW SALT DISTRICT.

Localities.—The salt wells of the Warsaw district are situated at the following places in Wyoming, Genesee, and Livingston counties, New York State: Warsaw, Silver Springs, Castile, Perry, Rock Glen, Salt Vale, Wyoming, Pearl Creek, Le Roy, Mount Morris, Pifford, Conesus Lake, York, Cuylerville, and Leicester.

Production.—The total production of salt in the above district during the year 1886 amounted to 6,056,060 bushels, valued at $544,484.80. The production is divided among the following subdistricts:

Production of salt in the Warsaw district, New York.

Sub-districts.	Bushels.
Warsaw	2, 923, 000
Mount Morris	448, 500
Silver Springs	381, 600
Le Roy	503, 730
Pifford	1, 344, 230
Conesus Lake	355, 000
York	100, 000
Total	6, 056, 060

Of the total amount produced, about 1,000,000 bushels were converted into dairy and table salt; its price averaging about 14 cents per bushel, and the balance 8 cents per bushel.

New wells.—During the year about fifteen new wells were drilled in the district, making a total of forty wells in operation. Their depths varied between 800 feet at Le Roy to 2,300 feet at Warsaw, and penetrated salt beds which were from 15 to 80 feet in thickness. The brine does not vary much in strength during the months of the year, not being allowed to average more than 90° of the salinometer over the whole district.

The following is an analysis by Prof. S. A. Lattimore, of Rochester University, of a sample of salt made by the Duncan Salt Company, taken from a bed of pure rock salt 2,344 feet below the surface and refined by a new patent steam process:

Analysis of rock salt from Warsaw, New York.

	Per cent.
Pure salt	99.540
Gypsum	.345
Calcium chloride	.115
Magnesium	none.
Iron	none.
Total	100.000

The methods used in refining the salt are kiln drying, grinding, and sifting. The principal uses of the salt are as follows: For chemicals, manufacture of soap, table and dairy purposes, packing meats and fish, fertilizers, and curing hides. The figures showing the percentage which goes to each use are unattainable.

Rock salt has been found in a test well at Ithaca, Tompkins county, at a depth of 2,244 feet. The salt is said to be clear and pure and the six layers aggregate 206 feet of salt.

LOUISIANA.

The rock-salt mass of Petite Anse or Avery's island, situated on the shores of Vermilion bay, is the only source from which salt is procured to any extent in the State of Louisiana. The total production of the different grades during 1886 was 41,956 short tons with a spot value of $108,372. The following table will show the production and price per grade of salt made in 1886:

Production and price per grade of Petite Anse salt during the year 1886.

Grades.	Production.	Spot value.	Total value.
	Short tons.		
Lump	3,268	$5.00	$16,338
Crushed	12,789	2.50	31,973
Coarse	18,873	2.25	42,464
Fine	6,967	2.50	17,417
Table	60	3.00	180
Total	41,957	....	108,372

The following table will show the production of the Petite Anse mine from 1882 to 1886 inclusive:

Production of the Petite Anse mine from 1882 *to* 1886.

Grades.	1882.	1883.	1884.	1885.	1886.
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
Lump	20	405	1,485	3,267	3,268
Crushed	5,995	10,595	7,550	11,038	12,789
Coarse	16,595	22,480	15,750	20,585	18,873
Fine	2,940	3,625	6,280	6,958	6,967
Table	....	25	290	50	60
Total	25,550	37,130	31,355	41,898	41,957

OHIO AND WEST VIRGINIA.

The production of salt increased slightly in both these States during 1886. The price remained practically constant. The competition of Michigan was not felt so markedly, and the States seem better able to control their own markets, an effect probably due partly to increased freight rates from competing points.

Estimated production of salt in Ohio from 1882 *to* 1886.

Years.	Barrels.	Value.
1882	400,000	$300,000
1883	350,000	231,000
1884	320,000	201,600
1885	306,847	199,450
1886	400,000	260,000

Estimated production of salt in West Virginia from 1882 *to* 1886.

Years.	Barrels.	Value.
1882	400,000	$300,000
1883	320,000	211,200
1884	310,000	195,300
1885	223,184	145,070
1886	250,000	162,500

PACIFIC COAST.

Excepting a slight falling off in California, due to the shortness of the season, the condition of the salt industry of the Pacific coast States was much the same as that for several years past. The principal point of production in the State of California was the salines on the Alameda shore of San Francisco bay, at which locality the output amounted to 27,000 tons in 1866, against 30,000, the amount usually made of late years.

The slight decrease in production was caused by late rains and low tides, the former interfering with solar evaporation, the process by which salt is there made, and the latter preventing the companies filling their reservoirs with sea water. The salt produced by these companies has been steadily growing better, that turned out last year being the best they ever made, and nearly equal to Liverpool salt.

Dos Palmas deposit.—The production of salt at the Dos Palmas deposit, on the Colorado desert, San Diego county, amounted to 3,000 tons, which makes the total production for the State of California 30,000 tons. A detailed account of the Dos Palmas deposit was given in the last volume of this series. The company operating at that point supplies salt to the greater portion of southern California and western Arizona, the deposits being connected by rail with the Southern Pacific railroad, from which it is distant about two miles.

The quantity of salt made in California during the past seven years has been as follows, the amount made in excess of receipts at San Francisco being estimated:

Production in California from 1880 to 1886.

Years.	Short tons.
1880	14,000
1881	17,000
1882	19,000
1883	30,000
1884	25,000
1885	31,000
1886	30,000

Imports.—The importations of salt at the port of San Francisco in 1886 amounted to 12,688,426 pounds, being about the average rate for several years past. As heretofore, nearly the whole of this salt came from Liverpool.

Imports of salt at San Francisco.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
English	13,828,066	7,745,468	12,841,212	8,543,878	8,500,000	13,200,320	12,688,426
Carmen Island	3,542,000	2,730,000	761,600	21,046	15,000	....	....
Peru	....	....	1,200,000	....	....	....	....
Total	17,370,066	10,475,468	14,802,812	8,564,924	8,515,000	13,200,320	12,688,426

New discoveries.—Toward the end of the year a large bed of salt was discovered near the town of Daggett, on the Mojave desert, Mojave county, California. This deposit is represented to be more than 20 feet deep and to extend over many acres. It consists of 90 per cent. chloride of sodium and 10 per cent. potash. The deposit comes to the surface and can be worked as a quarry, but the material is so hard that it will have to be broken up with giant powder preparatory to removal. It is said that two men can get out 25 tons of it per day. Preparations have been made for supplying this salt to the silver mines near by, also for shipping it to points more distant, it being not far from the line of the Atlantic and Pacific railroad.

NEVADA.

There is a rich deposit of rock salt in Lincoln county, on the Rio Virgen, concerning which the *San Francisco Bulletin* states:

"If the salt formations of Nevada were in railroad communication there would be no market in this country for the foreign article. In Lincoln county, on the Rio Virgen, there is a deposit of pure rock salt which is exposed for a length of 2 miles, a width of half a mile, and is of unknown depth. In places cañons are cut through it to a depth of 60 feet. It is of ancient formation, being covered in some places by basaltic rock and volcanic tufa. The deposit has been traced on the surface for a distance of 9 miles. It is so solid that it must be blasted like rock. At Sand Springs, Churchill county, there is a deposit of rock salt 14 feet in depth, free from foreign substances, which can be quarried at the rate of five tons a day to the man. The great Humboldt salt field is about 15 miles long by 6 wide. When the summer heat has evaporated the surface water, salt to the depth of several inches may be scraped up and underneath is a stratum of pure rock salt of unknown depth."

UTAH.

Large quantities of salt are collected annually from the "salt farms" around the Great Salt Lake. The refined salt from the lake is superseding the importation of the qualities formerly used in dairies. The industry is growing in importance each year, and the season of 1886 was the best for some years. It is estimated that there were collected around the lake during the season of 1886 over 100,000 tons, of which there was use for only 23,000 tons. Of this, some 20,000 tons were used in the silver mills of Utah, Idaho, Montana, and Colorado, and the rest for stock ranges, dairies, table use, etc. The value of that sold was $100,000. Crude salt sold for $3 to $4 per ton on the cars, while the refined and ground brought $10 to $35 per ton, the higher price being paid for family use. The salt is collected by allowing the water to flow into basins or lagoons along the shore when the lake is high enough during the spring floods; the banks or levees are raised and the water evaporates, leaving the salt. Some makers pump water into the cisterns.

Of the rock salt in Utah the *Salt Lake Tribune* says:

"San Pete county has an interesting deposit of salt, or rather two deposits of it. Both are near the San Pete Valley railway, the first being 7 miles east of Nephi and one-fourth mile from it, while the other is 10 miles from Nephi and 3 miles from the road. Each deposit is in the point of a spur of the mountain, cutting across it, and shows a face of rock salt 40 feet high, and 50 to 60 feet wide. This salt is quarried out like rock, breaking into blocks of irregular shapes, in such sizes as are desired for convenience in handling. Although specimen pieces are often taken out almost as clear as plate glass, the most of it is mixed with a brown clay, giving it much the color of red brick. This clay is an important feature in its composition in one respect. This salt is chiefly used for salting stock on the ranges. Large lumps of it are placed in the pastures where stock can get at it. While stock get all the salt they want, the clay, being of a tenacious nature, prevents the salt being dissolved by storms or moisture and washed into the ground, and permits it to lie exposed to weather without serious deterioration. The mines are operated by Hyde & Whitmore, of Nephi, who own one of the mines and operate the other under a lease from the owner, Richard Jenkins. This salt is mined and sold on cars at $3.50 per ton, and is finding favor and a market among the stock men of Colorado, Wyoming, Idaho, Montana, Nevada, and Utah, and its market is all the time spreading over a larger district. During the past year the output was about sixty car loads, or 750 tons.

"Ten miles from Manti, on Ten Mile creek, there is another large deposit of rock salt, opened to some extent during the past season, and about 20 tons of salt were shipped to test its value. It is reported as being very free from foreign substances and of high per cent.

"There is still another rock salt deposit at Salina, which has produced during the past year about sixty car loads, or 700 tons, which was sent to Juab, a distance of 50 miles, by teams, and there loaded for the various stock ranges in the West. The People's Forwarding Company, of this city, handles this salt. It is from 90 to 98 per cent. pure, and is quarried out like granite, which it much resembles in texture and appearance, and like granite withstands the effects of climate wonderfully. At Salina there are some six or eight factories engaged in making table salt by first reducing by steam and hot water and then evaporating. This has become such an extensive business as to supply most of southern Utah and part of Arizona with table salt. It is sold at about $20 per ton at the factories.

"There is a similar deposit of salt near the southwest corner of this Territory. The silver mills of Silver Reef use that salt in working their sandstone ore, and find it an excellent article, much of which is almost pure. The output of that mountain of salt the past year was fully 1,000 tons."

Imports and exports.—The imports of salt into the United States since 1867 and the exports from this country since 1790 have been carried forward from the last report and are shown in the following tables. While the quantities are doubtless given correctly, there are apparent discrepancies in the values as reported:

Salt imported and entered for consumption in the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Cake.		In bags, barrels, and other packages.		In bulk.		For the purpose of curing fish.		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		*Pounds.*		*Pounds.*		
1867 ..	....	....	254, 470, 862	$696, 570	229, 304, 323	$336, 302	....	....	$1, 032, 872
1868 ..	....	....	308, 446, 080	915, 546	219, 975, 096	365, 458	....	....	1, 281, 004
1869 ..	....	$1, 752	297, 382, 750	895, 272	256, 765, 240	351, 168	....	....	1, 248, 192
1870 ..	....	9, 698	288, 479, 287	797, 194	349, 776, 433	507, 874	68, 597, 023	$87, 048	1, 401, 814
1871 ..	....	2, 436	283, 993, 799	800, 454	274, 730, 573	355, 318	64, 671, 139	66, 008	1, 224, 216
1872 ..	....	.... ..	258, 232, 807	788, 893	257, 637, 230	312, 569	57, 830, 929	60, 155	1, 161, 617
1873 ..	....	....	239, 494, 117	1, 254, 818	388, 012, 142	525, 585	86, 756, 628	86, 193	1, 866, 596
1874 ..	....	....	358, 375, 496	1, 452, 161	427, 294, 209	649, 838	105, 613, 913	126, 896	2, 228, 895
1875 ..	....	1, 867	318, 673, 091	1, 200, 541	401, 270, 315	549, 111	110, 249, 440	119, 607	1, 871, 126
1876 ..	....	....	331, 266, 140	1, 153, 480	379, 478, 218	462, 106	118, 760, 638	126, 276	1, 741, 862
1877 ..	....	....	359, 005, 742	1, 059, 941	444, 044, 370	532, 831	132, 433, 972	140, 787	1, 733, 559
1878 ..	....	....	352, 109, 963	1, 062, 995	414, 813, 516	483, 909	100, 794, 611	96, 898	1, 643, 802
1879 ..	....	2, 480	375, 286, 472	1, 150, 018	434, 760, 132	532, 706	94, 060, 114	95, 841	1, 781, 045
1880 ..	....	21, 667	400, 970, 531	1, 180, 082	449, 743, 872	548, 425	109, 024, 446	119, 667	1, 869, 841
1881 ..	1, 397, 579	8, 187	412, 442, 291	1, 242, 543	529, 361, 042	658, 068	133, 395, 065	144, 347	2, 053, 145
1882 ..	8, 954, 834	55, 622	329, 969, 300	1, 086, 932	399, 100, 228	474, 200	134, 777, 569	147, 058	1, 763, 812
1883 ..	7, 863, 756	43, 363	312, 911, 360	1, 035, 946	412, 938, 686	451, 001	142, 065, 557	154, 671	1, 684, 981
1884 ..	8, 416, 147	40, 646	340, 759, 010	1, 093, 628	441, 613, 517	433, 827	126, 605, 276	122, 463	1, 690, 564
1885 ..	11, 614, 534	52, 334	351, 276, 969	1, 030, 029	412, 322, 341	386, 858	140, 067, 018	121, 429	1, 590, 650
1886 ..	7, 935, 237	32, 722	322, 227, 674	982, 350	399, 563, 989	384, 147	129, 641, 792	126, 899	1, 526, 118

Salt, of domestic production, exported from the United States.

Fiscal years ending September 30 until 1842, and June 30 since.	Quantity.	Value.	Fiscal years ending June 30.	Quantity.	Value.
	Bushels.			*Bushels.*	
1790	31, 935	$8, 236	1858	533, 100	$162, 650
1791	4, 208	1, 052	1859	717, 257	212, 710
1830	47, 488	22, 978	1860	475, 445	129, 717
1831	45, 847	26, 848	1861	537, 401	144, 046
1832	45, 072	27, 914	1862	397, 506	228, 109
1833	25, 069	18, 211	1863	584, 901	277, 838
1834	89, 064	54, 007	1864	635, 519	296, 088
1835	126, 230	46, 483	1865	589, 537	358, 109
1836	49, 917	31, 943	1866	670, 644	300, 980
1837	99, 133	58, 472	1867	605, 825	304, 030
1838	114, 155	67, 707	1868	624, 970	289, 936
1839	264, 337	64, 272	1869	442, 947	190, 076
1840	92, 145	42, 246	1870	298, 142	119, 582
1841	215, 084	62, 765	1871	120, 156	47, 115
1842	110, 400	39, 064	1872	42, 603	19, 978
1843 (nine months)	40, 678	10, 262	1873	73, 323	43, 777
1844	157, 529	47, 755	1874	31, 657	14, 701
1845	131, 500	45, 151	1875	47, 094	16, 273
1846	117, 627	30, 520	1876	51, 014	18, 378
1847	202, 244	42, 333	1877	65, 771	20, 133
1848	219, 145	73, 274	1878	72, 427	24, 968
1849	312, 063	82, 972	1879	43, 710	13, 612
1850	319, 175	75, 103	1880	22, 179	6, 613
1851	344, 061	61, 424	1881	45, 455	14, 752
1852	1, 467, 676	89, 316	1882	42, 085	18, 265
1853	515, 857	119, 729	1883	54, 147	17, 321
1854	548, 185	159, 026	1884	70, 014	26, 007
1855	536, 073	156, 879	1885	(a)4,101,587	26, 488
1856	698, 458	311, 495	1886	4,762,657	29, 827
1857	576, 151	190, 699			

a Pounds.

BROMINE.

During the year 1886 the production of bromine in the United States has increased under the favorable conditions of the unusually high price which was reached in 1885 and which still prevails. The price has been arbitrarily arranged by the combination of producers controlling five-sixths of the production in the United States. The demand for bromine does not appear to have increased markedly.

Production.—The production of bromine in 1886, as obtained through the courtesy of the authorized agents of the combined producers amounted to 428,334 pounds. The estimate of production in 1885 was probably somewhat low.

Production of bromine in the United States, 1883 *to* 1886.

Sources.	1883.	1884.	1885.	1886.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Pomeroy, Ohio	171, 116	159, 881	110, 000	111, 866
Tuscarawas valley, Ohio	23, 334	21, 710	15, 000	15, 000
West Virginia	106, 650	99, 509	85, 000	126, 391
Pennsylvania			60, 000	49, 549
Michigan			40, 000	125, 528
Total	301, 100	281, 100	310, 000	428, 334

Price.—The prices of bromine prior to 1885 were low and subject to marked fluctuations because of the irregular way in which it was handled by brokers, who had no good methods for transporting this dangerous material. The formation of the National Bromine Company has done much, however, towards establishing a regular market and adopting the best precautions for shipment, etc. In the early part of 1885 the price of bromine had decreased to 25 cents per pound. It then began to advance, reaching 30 cents in April, and 33 cents by the close of the year. During 1886 the price remained practically constant at that figure, advancing occasionally to 35 cents. This price was sufficiently high to cause consumers to seek foreign supplies to a certain extent, and 22,099 pounds, valued at $6,288, were imported during the fiscal year 1886. This is the only importation of bromine that has been recorded within late years.

The manufacture of bromine in Michigan remains about the same as in 1885, owing to the fact that only one set of salt wells has been found to yield bromides in any notable quantity. There has been no change in the methods of manufacture of bromine given in the last report. The bromine obtained in proportion to salt, in 1886 was as follows in Ohio: In the Tuscarawas or Canal Dover district 6 pounds of bromine were made for every 7 barrels of salt. In the Pomeroy district, half a pound of bromine was obtained for each barrel of salt.

More than two-thirds of the bromine is used for the manufacture of potassium and sodium bromides for medicinal use and for photography. The remainder is used for aniline colors.

SULPHUR.

By Wm. C. Day.

The progress made during 1886 in the development of the sulphur industry in the United States was limited chiefly to preparations for increased output during 1887 on the part of the Dickert and Myers Sulphur Company, at the Cove Creek mines, Utah, and to the resumption of operations at Rabbit Hole Springs, Nevada, in September by the San Francisco Sulphur Company.

At the Cove Creek works a chamber for the manufacture of flowers of sulphur has been erected and put in operation, while another of double capacity is in course of construction. Improvements in transportation facilities are much needed, as the refined sulphur is still carted a distance of 25 miles to the railroad. There are some indications that two new railroads will cross that portion of Utah within the next few years. This would of course materially aid in the successful development of these vast sulphur deposits. The sulphur produced at these works during 1886 amounted to 2,000 tons.

The San Francisco Sulphur Company, whose mines and works are at Rabbit Hole Springs, Humboldt county, Nevada, after nearly two years of inactivity, resumed operations last September, and since that time have been producing about 4½ tons of refined sulphur per day. Whether the operations will be long continued remains to be seen, since (the Dayton Acid works having been destroyed by fire) the company is deprived of its only local market, and it has not been found profitable to ship to San Francisco on account of the heavy transportation charges.

Quite active prospecting for sulphur during the past year or two in the vicinity of Steamboat Springs, Washoe county, Nevada, has resulted in the discovery of a number of small lots of sulphur scattered over a considerable area. The mineral is found lying under 4 or 5 feet of soil, and when first exposed is so hot that it can scarcely be held in the hand. Unless found in larger masses these deposits are not likely to be of much commercial value.

Deposits of sulphur promising to be extensive were discovered last year in the mountains of Ventura county, California. Although no careful examination of the mineral has yet been made, the hope is expressed that it may be suitable for the manufacture of sulphuric acid. Tests to decide this point are to be made.

The consumption of sulphur on the Pacific coast has increased, amounting now to about 4,000 tons per year. Italy and Japan remain the principal sources of supply, with a considerable increase last year from the latter country. A small quantity of sulphur from Utah reached San Francisco during the year. The price of sulphur in San Francisco remains $35 per ton.

Nothing has yet been done towards the development of the Louisiana sulphur beds, nor does it now seem probable that any active measures will be taken during 1887.

No attempt has been made to utilize the sulphur of the deposits known to exist in Wyoming. The absence of railway facilities is the chief obstacle to enterprise in this region.

Imports.—The amount of crude sulphur imported during 1886 is larger than for any previous year, but the price is lower than it has been for many years. The following table shows the importations of sulphur including 1886:

Sulphur imported and entered for consumption in the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Crude.		Flowers of sulphur.		Refined.		Ore.(a)	Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Value.	
	Long tons.		*Long tons.*		*Long tons.*			
1867	24, 544. 10	$620, 373	110. 05	$5, 509	250. 55	$10, 915	....	$636, 797
1868	18, 150. 55	446, 547	16. 48	948	64. 75	2, 721	....	450, 216
1869	23, 589. 69	678, 642	96. 59	4, 576	645. 04	27, 149	....	710, 367
1870	27, 379. 60	819, 408	76. 34	3, 927	157. 24	3, 528	$1, 269	831, 132
1871	36, 131. 46	1, 212, 448	65. 54	3, 514	92. 26	4, 328	754	1, 221, 044
1872	25, 379. 55	764, 798	35. 97	1, 822	56. 94	2, 492	....	769, 112
1873	45, 533. 27	1, 301, 000	55. 29	2, 924	35. 97	1, 497	....	1, 305, 421
1874	40, 989. 55	1, 260, 491	51. 08	2, 694	56. 68	2, 403	....	1, 265, 588
1875	39, 683. 10	1, 259, 472	17. 83	891	....	....	....	1, 260, 363
1876	46, 434. 72	1, 475, 250	41. 07	2, 114	43. 87	1, 927	....	1, 479, 291
1877	42, 962. 69	1, 242, 888	116. 34	5, 873	1, 170. 80	36, 962	....	1, 285, 723
1878	48, 102. 46	1, 179, 769	158. 71	7, 628	149. 51	5, 935	....	1, 193, 332
1879	70, 370. 28	1, 575, 533	137. 60	6, 509	68. 94	2, 392	....	1, 584, 434
1880	87, 837. 25	2, 024, 121	123. 70	5, 516	158. 36	5, 262	....	2, 034, 899
1881	105, 096. 54	2, 713, 485	97. 66	4, 226	70. 96	2, 555	....	2, 720, 266
1882	97, 504. 15	2, 627, 402	158. 91	6, 926	58. 58	2, 196	....	2, 636, 524
1883	94, 539. 75	2, 288, 946	79. 13	3, 262	115. 33	4, 487	....	2, 296, 695
1884	105, 112. 19	2, 242, 697	178. 00	7, 869	126, 00	4, 765	....	2, 255, 331
1885	96, 839. 44	1, 941, 943	120. 56	5, 351	114. 08	4, 060	....	1, 951, 354
1886	117, 538. 35	2, 237, 989	2, 126. 09	8, 739	1, 160. 50	3, 877	....	2, 250, 605

a Latterly classed under the head of pyrites.

Statement by countries and by customs districts, showing the imports into the United States of crude sulphur or brimstone each fiscal year, from 1875 to 1886 inclusive.

[Quantities expressed in long tons.]

Countries whence exported and customs districts through which imported.	1876.		1877.		1878.		1879.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
COUNTRIES.								
Dutch West Indies and Guiana	1, 515	$15, 427	......	....	......	....	......	....
England	30	1, 211	425	$14, 631	(?)	$16	2	$335
Scotland	24	910	472	13, 231	160	3, 961	806	19, 287
Gibraltar	......	....	290	7, 789	......	....	......	....
Quebec, Ontario, Manitoba, etc	......	....	......	....	12	264	......	....
Italy	46, 941	1, 439, 839	41, 819	1, 194, 000	47, 494	1, 161, 367	64, 420	1, 453, 138
Japan	456	16, 291	437	13, 137	256	7, 548	224	4, 528
Portugal	......	....	......	....	......	....	467	10, 410
Total	48, 966	1, 473, 678	43, 443	1, 242, 788	47, 922	1, 173, 156	65, 919	1, 487, 698
DISTRICTS.								
Baltimore, Maryland	5, 157	157, 828	3, 882	105, 175	5, 455	138, 202	6, 969	157, 243
Barnstable, Massachusetts	......	....	......	....	......	....	600	13, 780
Boston & Charlestown, Massachusetts	5, 031	154, 883	3, 931	101, 215	5, 795	131, 945	7, 841	173, 506
Charleston, South Carolina	......	....	......	....	526	12, 267	605	13, 812
Delaware, Delaware	450	13, 500	......	....	......	....	890	21, 907
Huron, Michigan	......	....	......	....	12	264	......	....
Newark, New Jersey	......	....	1, 071	31, 802	462	13, 240	443	10, 175
New Orleans, Louisiana	172	5, 705	150	4, 750	......	....	100	2, 087
New York, New York	24, 524	721, 092	21, 867	654. 997	28, 240	690, 989	36, 543	827, 193
Philadelphia, Pennsylvania	12, 549	385, 071	9, 216	256, 224	6, 657	167, 222	11, 704	263, 467
Providence, Rhode Island	600	18, 232	1, 739	45, 487	519	11, 479	......	....
San Francisco, California	483	17, 367	862	27, 768	256	7, 548	224	4, 528
Savannah, Georgia	......	....	725	15, 370	......	....	......	....
Total	48, 966	1, 473, 678	43, 443	1, 242, 788	47, 922	1, 173, 156	65, 919	1, 487, 698

Countries whence exported and customs districts through which imported.	1880.		1881.		1882.		1883.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
COUNTRIES.								
England	1	$22	......	....	......	....	13	$379
Scotland	1, 664	36, 444	1, 668	$43, 311	755	$20, 294	3	88
France	988	23, 580	......	....	526	13, 770	34	858
French West Indies	......	....	......	....	2	8	......	....
Greece	......	....	......	....	500	13, 927	...	....
Italy	80, 301	1, 862, 712	102, 771	2, 645, 293	92, 944	2, 504, 862	92, 861	2, 248 870
Japan	282	4, 744	691	16, 253	2, 980	66, 356	1, 038	23, 714
San Domingo	......	....	......	....	240	7, 875	......	....
Spain	......	....	308	8, 637	......	....	500	12, 856
Spanish Possessions in Africa and adjacent islands	......	....	......	....	9	310	87	2, 030
Total	83, 236	1, 927, 502	105, 438	2, 713, 494	97, 956	2, 627, 402	94, 536	2, 288, 795
DISTRICTS.								
Baltimore, Maryland	13, 827	313, 342	16, 477	430, 917	13, 781	364, 384	11, 977	286, 438
Beaufort, South Carolina	......	....	......	....	540	13, 889	......	....
Boston and Charlestown, Massachusetts	8, 207	183, 486	8, 860	226, 801	7, 467	194, 317	7, 756	173, 569
Charleston, South Carolina	1, 061	25, 398	3, 065	78, 741	6, 025	161, 281	4, 051	106, 235
Middletown, Connecticut	......	....	......	....	9	310	......	....
New Orleans, Louisiana	280	7, 121	100	2, 646	220	6, 516	428	10, 378
New York, New York	46, 657	1, 083, 784	57, 608	1, 463, 082	46, 531	1, 260, 222	45, 385	1, 110, 313
Philadelphia, Pennsylvania	10, 679	254, 892	17, 987	477, 547	14, 839	408, 611	22, 772	549, 095
Providence, Rhode Island	1, 255	31, 155	650	17, 507	1, 244	33, 036	535	13, 830
Richmond, Virginia	......	....	......	....	660	17, 760	......	....
San Francisco, California	1, 270	28, 324	691	16, 253	6, 054	151, 234	1, 072	24, 572
Savannah, Georgia	......	....	......	....	586	15, 842	560	14, 365
Total	83, 236	1, 927, 502	105, 438	2, 713, 494	97, 956	2, 627, 402	94, 536	2, 288, 795

Statements showing the imports into the United States of crude sulphur, etc.—Continued.

Countries whence exported and customs districts through which imported.	1884 (*a*).		1885.		1886.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
COUNTRIES.						
Belgium	......	....	190	$4,766	60	$1,718
England	......	....	606	15,084	81	2,535
Quebec, Ontario, Manitoba, and the Northwest Territory	......	....	......	....	......	9
Italy	......	....	94,370	1,894,858	112,283	2,166,565
Japan	......	....	1,541	25,683	4,972	66,505
Spain	......	....	134	1,552	......	....
Total	105,143	$2,242,678	96,841	1,941,943	117,396	2,237,332
DISTRICTS.						
Baltimore, Maryland	15,037	303,226	14,505	285,006	19,307	364,958
Barnstable, Massachusetts	650	16,163	480	11,040	1,617	35,385
Beaufort, South Carolina	600	13,259	610	12,847	......	....
Boston and Charlestown, Massachusetts	5,294	112,152	5,125	99,712	3,681	69,898
Champlain, New York	......	....	......	....	......	9
Charleston, South Carolina	6,125	132,570	8,525	169,564	13,350	265,265
New Orleans, Louisiana	......	....	102	2,282	250	5,102
New York, New York	52,478	1,135,725	45,537	909,123	58,758	1,115,519
Philadelphia, Pennsylvania	18,786	401,468	18,696	381,010	15,568	300,749
Providence, Rhode Island	651	15,517	1,840	37,422	1,265	25,930
San Francisco, California	5,522	112,598	1,421	33,937	3,600	54,517
Total	105,143	2,242,678	96,841	1,941,943	117,396	2,237,332

a Sources not reported.

Price.—The price of crude sulphur at the close of 1886 was $19.50 to $19.75 per ton for seconds, while that for thirds was $19.25. Since 1881, when best unmixed seconds brought $31 per ton, it is noticeable that the price has been steadily declining. From $31 in 1881 it fell to $27.50 at the close of 1882, $27 in 1883, $23.50 in 1884, $22.40 in 1885, until at the present time, February, 1887, it has reached the amount stated above. The explanation of this decline is unquestionably to be found principally in the rapidly increasing consumption of pyrites in the manufacture of sulphuric acid. There seems to be no doubt that acid can be made from pyrites more cheaply than from sulphur, and inasmuch as the slight impurities (chiefly arsenic and iron) likely to be present in pyrites acid do not detract from its value for use in refining petroleum and in the manufacture of fertilizers, it is not surprising that the use of pyrites should in a great degree supersede that of sulphur in acid manufacture.

TELLURIUM.

During 1886 new discoveries of tellurium ores have been made as follows: In Hinsdale county, Colorado, a telluride, probably coloradoite containing, in addition to tellurium and mercury, sulphur and gold; the ore appears to be rich, but its extent is uncertain; at the Hotchkiss mine, petzite, containing tellurium, silver, and gold; the mineral is reported as being of considerable value; at the Golden Age mine a valuable telluride at a depth of about 800 feet. Near Redding, Shasta county, California, a rich tellurium ore has been found, the constituents of which were not reported. Tellurium is also found in quite a number of other places in California. It occurs in quantities in Mariposa county, near the Marble Spring mine, on the Merced river, in the Rawhide mine, near Chinese Camp, and in many mines in Tuolumne county; in Calaveras county; Oriental mines, Sierra county; Murchir mine, Nevada county; also in portions of Placer, Nevada, and Butte counties, associated with gold and arsenical pyrites.

In the principal mines of the Tombstone district, Arizona, tellurium occurs in small quantities in rich silver and gold ores. As tellurium is as yet of no commercial value, except as a constituent of interesting minerals, no attempts have been made to save it or to isolate it from the other substances with which it is associated.

An interesting paper, entitled "Tellurium in copper," by Dr. Thomas Egleston, was read at the recent meeting of the American Institute of Mining Engineers at Harrisburg. The author of this paper had occasion to examine some samples of black oxide of copper, and of pig copper for arsenic and antimony, which impurities, as was claimed by the metallurgists submitting the samples, had "poisoned" the furnaces in which the refining of the copper had been attempted. Only traces of arsenic and antimony were discovered, and it was found that the impurity which caused the "poisoning" of the furnaces was tellurium, which, by analysis, was found not only in the matte and the black copper made from it, but also in the refined copper.

The following analytical results were obtained:

Analysis.

	Matte.	Black copper.		Refind copper.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*
Copper	55.02	97.120	98.090	99.705
Gold	0.06	....	....	....
Silver	0.40	0.132	0.128	0.135
Lead	17.87	0.777	0.757	None.
Zinc and nickel	2.22	0.070	0.100	0.024
Iron	4.18	0.130	0.080	0.031
Sulphur	20.02	0.236	(*a*)	Trace.
Tellurium	0.12	0.093	0.097	0.083
Arsenic	(*a*)	0.006	(*a*)	0.091
Slag, etc	....	1.270	0.192	....
Totals	99.89	99,834	99.444	100.069

a No traces were found with the blowpipe.

The matte and the black copper were results of the treatment of copper ores with the tellurium ores of Colorado. In the laboratory no traces of white fumes were shown on charcoal; but when the metal in the furnace was subjected to the process of "dry roasting," as was unintentionally done, very dense white fumes were given off. When refined and cast into cake it had the ordinary appearance of cake copper. It was then reheated for rolling in the ordinary way, showing no signs of impurity. At the first pass in the rolls very fine cracks showed themselves, which opened in succeeding passes. At a thickness of about 0.03 meter the cracks on each side nearly penetrated the cake, and at about 0.008 meter it began to fall to pieces. It was heated and rolled at different temperatures, but always with the same result. When cold the metal is tough and malleable. Although the cakes in the mold showed no coating, when they were heated repeatedly and allowed to cool in the air they became covered with a white powder, which proved to be the oxide of tellurium. The copper as it comes from the cake molds has every appearance of being good copper.

It is claimed that this is the first time the presence of tellurium has been detected in commercial copper. But very little of it is removed in the treatment, as the four analyses show. It is surprising how small a quantity renders the copper red short, and consequently worthless for rolling.

PYRITES.

BY RICHARD P. ROTHWELL.(a)

Introduction.—As sulphuric acid must be regarded as the basis of the chemical industry, no study can be more profitable to our manufacturers than that relating to its economical production. A few prominent examples will suffice to demonstrate its utility. The average production of crude petroleum exceeds 20,000,000 barrels, and the greater portion is submitted to the refining process with sulphuric acid before it can be used here or exported. Again, to maintain the fertility of the vast agricultural section, we must naturally increase the large quantity of artificial fertilizing materials already annually employed principally as superphosphates. Then, disregarding the manufacture of explosive compounds and nitric and hydrochloric acids, in all of which large quantities of sulphuric acid are used, the value of what may be generally included under the name "heavy" chemicals, having sulphuric acid as the chief factor in their production, imported annually from various foreign countries, is shown by the following abstracts from the report for 1886, issued by the Bureau of Statistics of the Treasury Department:

Imports of heavy chemicals into the United States in 1886.

	Quantity.	Value.
	Short tons.	
Alkali and all salts of soda	199, 033	$5, 081, 000
Bleaching powder	50, 000	1, 353, 000
Fertilizers	37, 000	426, 000
Total	286, 033	6, 860, 000

A consideration of all these figures warrants the conclusion that 1,000,000 tons a year of this indispensable sulphuric acid might be made

a The pressure of my professional engagements having prevented me from devoting the necessary time to the preparation of this report, I was so fortunate as to secure the able co-operation of Dr. Francis Wyatt, to whom the credit for this work is almost entirely due. The limits of space allowed made it necessary to condense the original for this book, but the report will be published in full in the *Engineering and Mining Journal.*

R. P. ROTHWELL.

to advantage in this country, and that this must necessarily increase with the growth in other directions.

Methods of producing sulphuric acid.—The three most economical and clearly defined methods of obtaining sulphuric acid are: (1) By burning brimstone. (2) By the oxidation of metallic sulphides. (3) By the decomposition of certain natural and artificial sulphates.

Of these methods the principle involved in the second class is by far the most generally adopted throughout the world, the first being principally resorted to by makers of fine or medicinal chemicals and of ordinary acid in this country, while the third serves only to produce the Nordhausen or fuming sulphuric acid and sulphuric anhydride. Until about fifty years ago the custom in Europe, as in this country, consisted in manufacturing the acid exclusively from sulphur, but in 1838 the King of Sicily granted a monopoly of the Sicilian sulphur trade to a commercial firm in Marseilles. The effect of this was to advance the price from \$25 to \$70 dollars per ton, and manufacturers sought for raw materials in other directions. To give some idea of the energy displayed in the endeavor to find a substitute for Sicilian sulphur, Baron Liebig in one of his chemical letters states that during the short existence of the Sicilian monopoly no less than one hundred and fifty patents were taken out in Europe for the production of sulphuric acid from gypsum; they were all industrial failures. That the substitute was eventually found and a great change made in the industry is shown by the fact that in Europe native brimstone is now principally used only for making gunpowder, for bleaching, and for medical purposes; and that in order ever again to vie with pyrites as the basis of chemical processes it must undergo a reduction in price which will leave but little profit to those engaged in its exploitation.

OCCURRENCE OF PYRITES.

The most important of the mineral sulphides are those of antimony, arsenic, cobalt, nickel, zinc, lead, copper, and iron, the last four being chiefly used for sulphuric acid manufacture. Their occurrence is extremely general, and mines are now in active work on a large and continually increasing scale on this continent and in England, Wales, Ireland, France, Belgium, Germany, Norway, Sweden, Spain, and Portugal.

The following table of analyses will show the average composition of those ores that may be looked upon as most suitable, there being a large number which, on account of their high percentage of arsenic, are regarded with disfavor:

Average composition of the world's pyrites.

Localities.	Sulphur.	Iron.	Copper.	Arsenic.	Zinc.	Lead.	Carbonate of lime.	Silica.	Total.
Milan mine, New Hampshire:	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
No. 1	46.00	40.00	3.75	Traces	4.00	None.	....	6.25	100.00
No. 2	35.00	30.50	5.00	None.	8.00	....	....	21.50	100.00
Davis mine, Massachusetts	49.27	45.30	1.47	Traces	....	....	....	3.83	99.87
Elizabeth mine, Vermont	33.00	50 00	3.50	Traces	....	....	....	13.50	100.00
Saint Lawrence county, New York	38.00	34.00	3.00	Traces	....	....	....	25.00	100.00
Ulster county, New York	39.12	34.16	Traces	Traces	....	....	....	26.69	99.97
Arminius mine, Virginia	46.00	44.50	2.10	Traces	....	....	....	7.40	100.00
Gaston county, North Carolina	44.00	36.00	Traces	Traces	....	....	....	20.00	100.00
Paulding county, Georgia	41.00	37.00	4.00	Traces	....	....	....	18.00	100.00
Ducktown, Tennessee	35.00	40.00	5.00	None.	....	....	8.00	12.00	100.00
Capleton, Canada (*a*)	40.21	35.20	5.10	Traces	....	....	....	19.43	99.94
Rio Tinto mines, Spain (*a*)	48.50	40.92	4.21	0.33	0.22	1.52	0.90	3.46	100.06
Tharsis mines, Spain (*a*)	49.90	42.55	3.10	0.47	0.35	0.93	(*b*)0.87	2.20	100.37
San Domingo, Portugal (*a*)	49.07	44.28	3.25	0.38	....	....	(*c*)0.93	2.59	100.50
Swedish mines, average	38.05	42.80	1.50	None.	....	....	5.09	12.56	100.00
Norwegian mines, average (*d*)	46.15	44.20	2.10	Traces	1.20	....	2.50	3.65	99.80
French mines, average	46.60	39.70	None.	Traces	....	....	0.20	13.50	100.00
German mines, average	45.60	38.52	....	0.95	6.00	0.74	....	8.19	100.00
Belgian mines, average	42.80	36.70	....	0.20	0.40	0.92	(*e*)5.45	12.47	99.94
English mines, average	34.34	32.20	0.80	0.91	1.32	0.40	....	30.03	100.00
Irish mines, average	47.41	41.78	1.93	2.11	2.00	....	....	4.77	100.00

a Gold and silver variable.
b Includes sulphate of lime 0.50.
c Includes carbonate of magnesia 0.25.
d No gold or silver.
e Includes carbonate of magnesia 1.05, and sulphate of lime 0.65.

A reference to the volume "Mineral Resources of the United States," 1882, will show that nearly every State in this country contains more or less important deposits of pyrites, many of which have been actively developed and frequently described, but the only productive mines at present are in New Hampshire, Massachusetts, and Virginia, and it is therefore needless to allude to any others, as the able reports already furnished are practically complete.

The Milan mines of Copperville, Coos county, New Hampshire, were opened up in the spring of 1881, for the purpose of extracting copper and supplying sulphur to acid manufacturers.

Like many others of a similar character, the deposit proper consists of several parallel lenticular veins contained in a talco-schist formation 400 feet wide, and of great length. These lens-shaped veins overlap each other, and not infrequently join at the ends. The greatest width of solid ore has been 40 feet, the average width is 8 feet. Zinc blende was found in large quantities in the first lens opened down as far as 100 feet, but below that it disappeared.

The ore of this mine is purely a bisulphide, FeS_2, containing no arsenic; it is remarkably hard, and burns freely, without clinkering. The workings extend downward 200 feet and lengthwise on the lodes 600 feet. Many thousand tons of good ore are in sight, and although the veins have been traced many miles, no other developments than a few test pits have yet been made. There is an admirable surface equipment, capable of hoisting and handling 120 to 150 tons of ore in 10 hours. This company was the first to break and mechanically prepare ores for the acid trade, it having previously been the custom in chemical works to break them by hand, at considerable expense, both as to prime cost and loss from "fines." The attention of the managers has been directed especially to the introduction and adoption of labor-saving appliances, and they have consequently been enabled to load the ore at the mine bottom, and thence pass it along continuously until it is finally dumped into the cars of the Grand Trunk railway, which is connected with the mines by a tramway of two-foot gauge and 1,750 feet long, conveying cars of 3,000 pounds capacity. The average mining cost, determined by a series of yearly estimates based upon a daily production of 100 tons of rough material, 70 per cent. of which is used for acid making, exclusive of fines and waste, is as follows:

Average cost of pyrites mining at the Milan mines, Copperville, Coos county, New Hampshire.

	Cost per short ton.
Breaking and hoisting	\$0.60
Pumping expense	.05
Crushing and sorting	.20
Tramming and loading on cars	.15
Salaries and general expenses	.30
Total expense per ton	1.30

This makes the actual cost for ores Nos. 1 and 2 about \$1.70 per ton. The following are the rates of freight to the principal consuming centers:

Freight rates from the Milan pyrites mines in Coos county, New Hampshire.

	Freight per ton.
From the mines to—	
Detroit, Michigan	\$2.25
Buffalo, New York	2.50
Cleveland, Ohio	2.50
Chicago, Illinois	3.00
Portland, Maine	.90
From Portland to—	
Boston, by water	1.00
New York or Philadelphia	1.25

The Armenius Copper mines, of Louisa county, Virginia, have been very actively developed since the last issue of this series. Shaft No. 3 has been sunk to a depth of 365 feet on the incline, disclosing on that level a thickness of clean ore in the vein of 42 feet, part of which is close-grained, hard, white pyrites bearing 46 per cent. of sulphur. Considerable quantities of yellow copper are found at intervals from the 200-foot level to the bottom of the shaft, but no development work in this direction has yet been done, the shaft and levels alone furnishing sufficient ore for the trade.

Anticipating the utilization of whatever copper may be found in further opening of levels, the combination plant has now been completed for crushing, screening, and concentrating low-grade slaty pyrites and mixed copper ores, so that no ores need now be laid away on the surface, but everything from the mine can be treated forthwith. The crushing and screening capacity of the mill is 100 tons daily, the product being suitably prepared for shelf burners or Spence furnaces by sizing to one-fourth inch mesh. The crushing and concentrating capacity of the mill is 50 tons daily. These facilities now permit an output of 300 tons per day easily. The actual reserves of ore amount to 350,000; the average number of men employed is 45. Machinery is estimated as equal to 75 additional laborers. The total shipment of ore to various consumers during the year has amounted to about 12,000 tons. The average analysis of the whole output gave 45 per cent. sulphur. The total cost of mining is placed by the proprietors at the very low figures of $1 per ton; the freight is exactly $2 per ton to New York, which is the usual selling point.

MASSACHUSETTS.

The Davis mines, Franklin county, continue to be the only producers of pyrites in this State. The output for 1886 was 57,000 tons, more than half of which was delivered to acid makers. The work was actively pushed forward during the entire year with a daily average of 207 men. The additions to the plant included a new 100 horse power hoisting engine, a 120-horse power steel boiler, a new 10-inch Cornish plunger pump, two smaller engines and elevators, and two mechanical screens. To summarize briefly the effective work done: Shaft No. 1 was sunk another hundred feet, and a run of 1,400 feet of levels and drifts exposed the vein for nearly 800 feet in length. Shaft No. 2 is now 400 feet deep and the ore is ready for hoisting. The actual capacity of the mine is 400 tons per day. The composition of the ore will be found in the general table; it is said to be very regular. Its density, however, increases with the depth of the workings, and there is a notable decrease in the proportion of fines.

FOREIGN MINES.

As Spain and Portugal may be virtually considered not only as being the principal sources of the world's supply of pyrites, but as practically inexhaustible fields from which any quantity required may be drawn for a great many years, a short description of the Rio Tinto as typical of the Spanish pyrites mines will not be without interest.

Rio Tinto mines.—The mines are situated in the mountainous regions of Andalusia at a distance of 60 or 70 miles from the port of Huelva, whence shipments to the various destinations are principally made. The surrounding rocks belong to the Lower Silurian, and are of a schistose and slaty character, intermixed here and there with greenstone and feldspars of various descriptions. The existence of these sulphurous copper ores has been known for many years, and they were first exploited by the early Celts; then very extensively by the Phœnicians, and in due course by the Romans, who worked them for upwards of three hundred years, and left behind them traces, which can still be seen, of the gigantic nature of their operations. The mines were abandoned while the Moors were in possession of the country, and, indeed, were left unworked to the middle of the last century, when an enterprising Swede endeavored to turn them to account. The want, however, of sufficient skill and capital, combined with the difficulties of transportation and political troubles, caused all attempts to end in failure until, in 1873, the Spanish Government decided to dispose of the mines by selling to the Rio Tinto Company, limited. The deposits are somewhat irregular, and occur in lenticular masses. There are three important lodes: The South, the Dionisio, and the North, the mineral resources of all three being so immense as to be considered by the best authorities practically inexhaustible. The principal opening is in the south lode; it is 1,500 yards long, 100 yards deep, and 200 yards in width; it annually yields about 700,000 tons of ore. It is estimated to contain 200,000,000 tons, and in order to work it nearly four and a half million tons of earth, or overburden, have been removed. Beneath it are extensive underground works, reached by a tunnel 1,000 yards in length. When this tunnel attains a length of about 3 miles it will connect and open out the Dionisio lode, upon the center of which a shaft has already been sunk. According to the directors' report, the operations in 1886 resulted in a profit on the sales of produce, including the copper realized during the year and other items, such as the credit of revenue account, amounting to £429,468. Of this sum, after providing for all the expenses of administration, interest, income, and other taxes, consisting of £56,440, the amount of bonds drawn during the year; £8,556 16*s.* for plant, etc., written off, and £4,4761 1*s.* for bad debts, there was distributed to the shareholders a dividend of 6*s.* per share, producing a total of £97,500, the balance carried forward to revenue account being £7,602 15*s.* The quantity of ore extracted from the mine during the year amounted to 1,378,381 long tons, of which 1,041,833 were treated locally, and 336,548 tons were shipped to consumers in Great Britain, France, Germany, and the United States.

Tharsis Sulphur and Copper Company, limited.—There was an increase in the production of copper in these mines, the Esperanza schists having begun to yield results. Owing to the continued depression in the alkali trade, however, the deliveries of pyrites to the consumers have been less than in previous years. There was also a decrease in the deliveries of iron ore, silver, gold, and copper. The net profits for the year ending December 31, 1886, together with the balance of £11,609 19*s.* brought forward from 1885, amounted to £102,850. Of this, the sum of £88,099 10*s.* was appropriated to the payment of a dividend of 3*s.* per share, equal to 7½ per cent. on the paid-up capital of the company free of income tax, the balance of £14,750 being carried forward to the credit of 1887. A great amount of work has been done at both the Tharsis and Calanas mines. At the former the total overburden removed in 1886 was 250,000 cubic meters, against 260,655 meters in 1885. The mineral extracted weighed 502,443 tons, against 507,554 tons in 1885, a decrease of 5,111 tons. The overburden removed from the Esperanza deposit was 157,938 cubic meters, and 195,656 tons of schist were extracted for treatment in that department. There has been expended on preparatory work and explorations the sum of £10,121 18*s.*, which, added to the balance of £14,257 carried forward from the previous year, make together £24,378 19*s.* In accordance with the rule laid down formerly by which this class of expenditures is extinguished in three years, the sum of £14,305, 4*s.* has been written off. Special charges connected with investigations, agricultural operations, and the destruction of plantations by floods, etc., have also been written off; they involve an expenditure of £94,-801 7*s.*

The Calanas mine is rapidly being prepared for the increased extraction of mineral expected to begin early in 1888. The additions to the property and plant have been important, including a new hospital, forty workmen's houses, purchase of land, and other improvements. In explorations and preparatory work the sum of £1,556 7*s.* was expended. The mineral extracted in 1886 weighed 71,003 tons, against 79,749 tons in 1885. The reduced quantity is owing to the transitory state of the working arrangements, a large output being postponed until it can be raised without shaft extraction. The total mineral raised at Tharsis and Calanas for 1886 was 573,446 tons, as against 587,303 tons in 1885, a decrease of 13,857 tons.

PORTUGAL.

The Mason and Barry Company, limited.—The total quantity of ore broken and raised at this mine during 1886 was 289,767 tons, as against 350,387 tons in 1885, and the shipments during the same period amounted to 73,182 tons, against 59,021 tons in the previous year. The quantity of ore sold for its sulphur value during 1886 amounted to 74,871 tons, against 51,604 tons in 1885.

CANADA

The Crown and Albert mines at Capleton continue to be exploited with undiminished energy by the Orford Copper and Sulphur Company and Messrs. G. H. Nichols & Co., of New York. Both are situated within easy distances of the railroad at Sherbrooke, and have already been frequently described as consisting of a series of openings on a number of the usual lenticular masses of pyrites; the average thickness is from 10 to 15 feet, and the length about 300 feet on the strike. The country rock is chloritic slate, through which are distributed innumerable small veins of slightly auriferous quartz. During the past year the two companies employed an average of 300 men per day, and extracted and shipped for treatment at their respective works at Bergen Point, New Jersey, and Laurel Hill, New York, 37,000 tons of ore, averaging 40 per cent. of sulphur and 3½ per cent. of copper; the latter percentage is on the basis of dry assay. The recent discovery of an immense new lode, bearing nearly double this percentage of copper, is reported from the Albert mine, and this, together with the large local extraction works now in progress of erection, will doubtless give a general impetus to the operations of the enterprising owners.

TOTAL PRODUCTION OF PYRITES.

The roasting of sulphide of zinc, or blende, annually affords the manufacturers of spelter and zinc oxide large quantities of what Professor Lunge has very aptly termed metallurgical acid, as a by-product; and although at present this is only subsidiary, it may eventually become a very important factor. The works of the Mathiessen and Hegeler Zinc Company, of La Salle, Illinois, which were very fully described in "Mineral Resources of the United States, 1883 and 1884," consume large quantities of blende, and have two sets of acid chambers, with a total capacity of 480,000 cubic feet. The amount of 50 per cent. Baumé acid now daily derived from utilizing the sulphurous gases generated in the roasting kilns, which the company had previously allowed to go to waste, is estimated at from 40 to 50 tons.

Neglecting, however, the above class of ore as not strictly belonging to those under consideration, and confining ourselves to materials most suitable for the manufacture of commercial sulphuric acid, the quantities of iron and copper pyrites shipped or treated for the express purposes of that industry in this and the principal countries of Europe during the year 1886 are shown in the following table, the units being long tons of 2,240 pounds:

The statistics of pyrites production in 1886.

Countries.	Consumed for acid making where mined.	Imported for acid making.	Exported for acid making.	Copper contents.	Silver contents per ton.	Gold contents per ton.
	Long tons.	*Long tons.*	*Long tons.*	*Per cent.*	*Troy ounces.*	*Pwts.*
Spain and Portugal	....	....	711,419	3.05	1.50	2
United Kingdom	36,500	592,000	....	3.05	1.50	2
France	182,700	67,200	....	Variable	None	None.
Germany	132,000	73,000	....	Variable	Uncertain	....
Belgium	28,000	....	22,000	Variable	....	....
Norway and Sweden	....	....	46,000	1.50	....	....
United States	55,000	57,000	....	3.00	Variable	....
Canada	....	....	37,000	3.50	(a) 7	....

a The ores contain an average of 1 ounce of silver per unit of copper.

It is apparent from the above table that, making only a small allowance for the amount raised in the various works of minor mines in countries where no official returns have been available for this compilation, the total quantity of pyrites used in the production of sulphuric acid throughout the world, during 1886, was at least 1,265,000 tons, of which only 112,000 tons were burned in the United States, as follows:

Consumption of pyrites in the United States from 1881 to 1886.

Districts.	Number of works in 1886.	1881.	1882.	1883.	1884.	1885.	1886.
		Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Boston and eastern district	5	....	2,500	7,500	14,500	25,800	26,900
New York district	6	7,000	23,900	29,500	39,000	44,600	55,700
Philadelphia district	2	....	2,500	5,000	5,500	11,500	23,600
Baltimore and southern States	3	....	....	2,000	4,000	7,500	4,300
Western district	1	....	....	1,000	2,000	2,000	1,500
Total	17	7,000	28,900	45,000	65,000	91,400	112,000

This table shows that the use of pyrites in the United States is increasing, but not as fast as could reasonably be expected if the example of other, usually less progressive, countries were followed. Further, the figures indicate that more rapid progress is unlikely unless there is some abnormal rise in the price of brimstone, which is not looked for.

THE MANUFACTURE OF SULPHURIC ACID.

In considering the methods for the manufacture of sulphuric acid it may well be to preface a description of the most modern methods by a few historical notes of the development of the manufacture in England, for the methods of that country will be the principal ones for comparison with our own.

English makers originally prepared sulphuric acid by decomposing copperas in brick ovens at a high temperature and condensing the vapors which distilled off as impure oil of vitriol, the commercial value of which was 50 cents a pound. This process gave way to the use of sulphur and niter, which were mixed and the mass burned in enormous glass globes. The resulting acid was concentrated by boiling in glass retorts, the product being called "oil of vitriol made by the bell." In the year 1746 the first leaden chamber was erected in Birmingham by Messrs. Roebuck & Garbett. The proportions of raw material employed were 7 or 8 pounds of sulphur to 1 pound of saltpeter. This mixture was placed upon lead plates standing in water within the chamber, and was ignited by means of a red-hot iron bar inserted through a sliding panel in the wall. Shortly after this time came the introduction of a separate apartment for burning the sulphur in a current of air which was regulated by a slide moving in the iron furnace door, the vapors being taken off through the roof to the adjoining chamber. By various minor stages the industry in Europe has now reached a point which may be considered almost perfect, there being little room for improvement in works constructed to comply with all the requirements of modern progress. The points chiefly requiring consideration by our own manufacturers, if they would rival foreign works, may be shortly summed up thus:

(*a*) Of pyrites and native brimstone, which is the most economical and best source of sulphur?

(*b*) If the preference be given to pyrites, what kind of furnace and burner is best for effecting their complete combustion, including fines?

(*c*) What are the best dimensions for the leaden chambers in which are combined and condensed the gases produced by this combustion?

(*d*) How may the maximum results be produced from the sulphur ore at a minimum expenditure of nitrate of soda?

(*e*) How are the residual cinders to be treated or disposed of after desulphurization in order to lessen the first cost?

Theoretically the same amount of sulphurous-acid gas is, of course, always generated by the same weight of sulphur, whether it be in the form of brimstone or contained in pyrites. Therefore, in regard to the first problem there can be very little doubt that if all things were equal there would be no room for hesitation in giving preference to the cleaner, purer, and in every way simpler brimstone. It must even be admitted that insomuch as very few, if any, specimens of pyrites so far discovered and worked are absolutely exempt from all traces of arsenic, there are certain branches of chemical manufacture in which it would be inadvisable, and others in which it would be in the highest degree dangerous, to use them. These branches, however, call for only a very insignificant proportion of the enormous quantity of sulphuric acid annually required for the great chemical industries already referred to. In these large industries, as a rule, traces of arsenic in the sulphuric acid employed is a matter of indifference. We must, therefore, leave out of the question the interests of small works where only fine or medicinal chemicals are produced or where only comparatively small quantities of acid are required, and study only those works where the production is intended for refining petroleum or the manufacture of fertilizers, alkali, or explosive compounds.

In the attempted comparison of the relative cost of sulphuric acid derived from brimstone with that from pyrites, which will be given later, it must be borne in mind that in the latter we have to deal with two very distinct species of sulphides, those containing little or no copper and those bearing it in proportions varying from $1\frac{1}{2}$ to 10 per cent. Ores of the second category will, as it is hardly necessary to add, always be preferred as a source of sulphur when other things are equal, and will from that very fact serve the purpose of keeping the price of brimstone within reasonable limits. They are now almost exclusively used by the larger European chemical makers, who, compelled from lack of domestic material to import pyrites, have adopted the ores of Spain and Portugal, and by a very slight addition to their working plant actually recover from the cinders the copper, silver, and gold, applying the proceeds of their ready and profitable sale to the reduction of their first cost. There are, fortunately, a few cases where our own intelligent manufacturers have kept pace with the times and obtained notably brilliant results by using pyrites and adopting modern processes. These are, however, singular exceptions. The principal obstacle against the more extensive application of iron pyrites for the manufacture of sulphuric acid is the distance from centers of consumption. The actual cost of raising and rendering them suitable for the market would appear never to exceed $1.50 per ton, whereas the average cost of transportation to manufacturing centers may be roughly stated as double that amount. If, after making all deductions for every source of loss, their actual sulphur contents be estimated at 40 per cent., and if the cinders be treated as a valueless factor, it follows from the above figures that while in the vicinity of the mine the maximum cost of the sulphur in the pyrites would be only $4 per ton, the cost of transportation is so great that upon reaching the consumers' kilns it no longer offers sufficient advantage over brimstone to compensate for the inconvenience and additional manipulation which its treatment involves. The question of freight being therefore of so much moment, it is very probable, and certainly desirable, that sulphuric acid will be made and used nearer the pyrites mines. If, owing to some such arrangement, the cost of producing 50° Baumé acid can be reduced to an average, say, of $3.50 per ton, we might soon hope to see the chemical trade, which has certainly been somewhat neglected in the United States hitherto, assume a position similar in importance to that of the iron and steel industry, and become independent of foreign supply. In the following chapters the effort will be made to show what advantages can result from this change in the method of manufacturing sulphuric acid.

Furnaces.—The various forms of furnaces for burning pyrites introduced during the past few years in England, France, and Germany by Spence, Perret-Oliver, Juhel-Maletra, and Gerstenhœfer have all been accurately described by various popular writers, and it will suffice for the present purposes to point out the principal conditions to be realized with either lump ore or fines. These are—

1. To generate and convey to the lead chambers a maximum amount of sulphurous acid and a minimum excess of atmospheric air.

2. Combustion so perfect that no more than from 1 to 2 per cent. of sulphur shall remain in the cinder.

3. To avoid distillation of any sulphur or the formation of ferrous sulphide (FeS).

The simplest contrivance, and at the same time the best calculated, when properly handled, to fulfill all these conditions, appears to be the mechanical furnace, with double shelf burners, invented by Mr. Peter Spence, and greatly modified and improved by the American patentees. This furnace is well adapted for burning ore of varying quality, including those of quite low grade. The prevailing custom among those who buy ores for the main purpose of utilizing the sulphur contents is to seek for very high grades, and it is argued in defense of this practice that the cost of manipulating equal weights of sulphur must be considered less in rich than in poor pyrites; but it will be found upon examination of the facts that this argument, though apparently logical, is open to criticism, for there is ample evidence that in many cases most excellent results have been obtained from ores of low grade by competent and skillful managers. According to Mr. F. L. Bartlett, whose practical experience as a chemist and engineer has made him an authority, experiments with pyrites containing from 25 to 30 per cent. of sulphur have been carried on continually during the past two years at the Atwood Acid Works, in Portland, Maine. The results have been a complete success. It is commonly supposed that in burning low grades of pyrites largely increased kiln capacity is necessary in order to maintain a yield of acid equal to that from high grades. This is an error, for low-grade ores can be burned faster than high grades, and can be forced through the kilns so rapidly as to maintain the yield of sulphur, while excluding any unnecessary excess of air. The experiments carried out with the kilns of the Milan Company when burning copper ore for the cinder (the sulphur being allowed to pass into the air), demonstrated the fact that a mixture of 2,200 pounds of 25 per cent. ore and 600 pounds of fines could be burned down to 3 per cent. of sulphur in each twenty-four hours in a kiln having a grate area of 30 square feet. Since, however, in kilns connected with acid chambers the draft has to be regulated, favorable conditions for burning low-grade ore are as follows: The kilns must be charged to their fullest capacity, even to heaping; enough fines must then be spread over the top, and especially around the sides, to cover the ore from 2 to 6 inches deep. The kilns must be charged twice daily, and the grates must be sufficiently turned every six to eight hours to keep the dead-burned ore at the bottom and to allow the burned fines to work down and out. The theory is, that if the column of burned ore is high enough and the gas has to finally escape through a deep layer of burned fines, it must make its exit in quite as dense a form as when a lesser depth of richer ore is burned. Further, low grades cannot be burned closely unless the column of ore is very high or the draft is checked by a covering of fines so that the heat can be retained long enough to consume the last particle of sulphur. Fines can be burned readily, because, owing to the siliceous nature of the low-grade ore, the cinder remains whole and leaves interstices through which the burned fines easily drop out from the grates. The best results have been obtained as follows:

Proportions of fines and broken ore in pyrites furnaces.

	Charge for—		
	25 per cent. ores.	30 per cent. ores.	35 per cent. ores.
Broken ore ....pounds..	600	500	500
Fines ....do ..	150	100	50
Height of ore column........feet..	4	3½	3

The kilns are charged each 12 hours. The grates are slightly turned over in each 8 hours.

The necessary oxidation of the iron and the consequent proportionate increase of the lighter oxygen in the mixture of gases causes the volume of the latter produced by burning pyrites to be much greater than that proceeding from the combustion of pure brimstone, hence it will be understood that the proper regulation of the air supply, which is important under any condition, is especially so when pyrites is the substance employed.

Theoretically, for one kilogram of ordinary brimstone 1,500 grams or 1,055 liters of oxygen, or 5,275 liters of air, would be required, while for burning the same quantity of sulphur in iron pyrites 6,595 liters would be necessary. In practical industry, however, Mr. Schwarzenberg has shown that these figures do not suffice, and that it is necessary to introduce 6,199 liters of dry air in the case of brimstone and 8,114.9 liters in the case of pyrites, the quantities in each case being calculated on the basis of zero degrees centigrade under a barometric pressure of 30 inches. This demonstrates that the quantity of sulphur which can be burned profitably for each cubic foot of chamber space will fluctuate with the higher or lower situation of the works. The ingenious differential anemometer invented by Peclet and modified by Fletcher, and the simple apparatus for analyzing the chamber gases designed by Orsat have so facilitated the general process that a current of air may now be measured out to meet the varying requirements of both situation and material employed. An example of this is afforded by Buchner's careful analysis, which shows that the quantity of sulphurous acid gas passed from the burners to the chambers varies from 6 to 8 per cent., according to the nature of the pyrites, the construction of the furnace, and the management of the air supply. His greatest average by careful working was as follows:

Composition of gases from pyrites burners.

	Per cent.
Sulphurous acid, by volume..................................	6.07
Oxygen..	7.18
Nitrogen	86.74

As the sulphurous acid requires only 3.3 of the 7.18 per cent. of oxygen for its final transformation into sulphuric acid, it will be seen that after subtracting this quantity from the above percentage there still remains 4.15 per cent. to pass away with the nitrogen into the atmosphere. The greatest care should always be observed by chamber managers to keep as nearly as possible within these proportions. In a majority of the works where pyrites are burned it is still customary not to convey the hot gases from the burners directly to the chambers, but previously to cool and at the same time to cleanse them from the dust by which they are generally accompanied, by causing them to pass from the flues into an upright brick stack carried from an independent foundation to about 10 feet above the level of the furnace arch. From this they enter a range of cast-iron pipes, 2 feet 6 inches in diameter and 27 feet long, in three lengths cast in two pieces, and each provided with a man-hole to facilitate cleaning. These pipes are fitted into a tunnel of lead 5 feet square and 40 feet in length, connected at the opposite extremities with acid chambers by a 7-pound sheet-lead pipe, about 1½ feet in diameter. Intelligent managers have now discarded this antiquated system in favor of a far simpler and more rational arrangement of the plant, which consists of four essential parts, connected as follows: Pyrites burners, Glover tower, acid chambers, and Gay Lussac towers.

Acid chambers.—After varied experience and careful inspection of many working systems, it is submitted that the proper condensation of the gases can take place equally well in one large chamber or in a connected series of two or three, and that a choice of either system is a matter of personal taste and opinion. A very excellent arrangement consists of three chambers, adopting, as favorable dimensions, length, 125 feet; width, 24 feet; height, 18 feet. The connections may be made by a lead pipe, 15 to 18 inches in diameter, hanging from the roof and running across the passages, with a good fall at its final end to prevent the accumulation of any condensed acid. As to the necessary thickness of lead, there is almost as much diversity of opinion as upon the dimensions of the chambers. But remembering that a good chamber should last from ten to twelve years, 7-pound lead may be adopted for the first and 6-pound lead for the second and third chambers. The amount of chamber room should in no case be less than 20 cubic feet for every pound of sulphur consumed. The pressure of steam should be as evenly distributed as possible, and the faulty system sometimes adopted of introducing it from a single jet, which can only play upon one portion of the gases, must be carefully avoided. Since of every 100 tons of chamber acid one-half consists only of water originally injected in the form of steam, it has been urged by Dr. Sprengel that this warm steam expands the bulk of the gases unnecessarily, instead of lowering their temperature and causing them to shrink in volume. To obviate this inconvenience he has suggested the use of a spray of cold water to be forced into the chamber by a pump of his own invention. But the device, while ingenious, does not work well and has not been generally adopted. The preferred method has been to inject steam into the entrance end of the chamber and into its side rather more than half the way along.

The surest means of knowing accurately what is going on in the chambers is by the provision and maintenance in proper condition of drips and caps. The best apparatus for taking drips consists of a small lead dish placed within the chamber upon an earthenware pipe 15 inches in diameter, about 3 feet high and about 1½ feet from the side. A small (half-inch) lead pipe, shaped like the letter S, is fixed into the side of the dish, and pierces the chamber side with its mouth over a lead basin standing upon a leaden ledge outside. The liquid acid passes, as it forms, through the siphon and drips into the basin, and, overflowing upon the ledge, is carried back again by a small pipe. Two drips should be arranged in each chamber throughout the set, at equal distances from each other, and the contents of the basin will constantly represent the nature of the acid, indicating its strength and the amount of nitrous acid which it contains. Certain openings should be left in each chamber, a man-hole, and one near the end for sampling. A couple of windows will also be useful; one fixed in the darkest side, about 5 feet from the ground, and the other in a direct line with it upon the top. The light shining through this reveals to an experienced eye the exact condition of the gases.

The following indications are furnished by the caps of the chambers as to what is going on within. They are worthy of note.

When one of those covering the first chamber is slightly lifted the gases should rush out with great force. This should become less noticeable in the second chamber, and extremely feeble in the third. If the inside of the cap is quite dry and covered with small crystals which turn green when moistened, the evidence is certain of an insufficiency of steam. If, on the contrary, it be dripping wet it is equally certain that the steam is in excess, and in either case the remedy is obvious and at hand.

The regulation of the supply of niter is, after that of the draught, an extremely important point, its mismanagement inevitably entailing one of two evils. First, if the quantity is excessive it ruins the lead and excludes all possibility of profitable working; second, if the quantity is not sufficient there is inevitable escape of sulphurous acid. The oxide of nitrogen used in the process plays no other part than that of carrying from the air to the sulphurous acid the necessary oxygen by which, with water, it is converted into sulphuric acid. Consequently, whatever be the manner of its entry it should eventually be discharged from the chamber in its original form. This being allowed, it is immaterial whether it is introduced directly and separately into the chambers, as is customary in many large European works, by means which have frequently been described, or whether it is sent in by the older, more economical, and certainly simpler system of "potting." If the gases reach the chambers with a due excess of oxygen, and there meet with sufficient steam, none of the nitrogenous compounds will disappear. Should steam be absent, however, a nitro-sulphuric compound must naturally be formed which will be condensed and thus remove the nitrogen compounds from the action of the sulphurous acid. If the entering gases are deficient in oxygen, the nitrogen compounds are reduced in rapid succession to binoxide and then to protoxide. If, on the other hand, they contain too little sulphurous acid, the nitrogen compounds are changed to nitric acid by combination with steam, and in this state exercise a violent and destructive action on the lead. With the exercise of ordinary care and intelligence there should be little chance for any mishaps, and a glance at regular intervals through the side windows, or a slight removal of the caps, will always insure against them. The gases in the first working chamber must invariably be white, those issuing from the last cap of the second chamber will be tinged with yellow, while the contents of the third chamber must be of a very deep red color and emit strong nitrous fumes. The gases allowed to pass away from well-managed factories do not contain more than a maximum of 5 per cent. of oxygen, and we also know that when the red color of the last chamber lessens or fades away, it is because of the presence of sulphurous acid. If this were allowed to pass into the absorbing tower, it would not only denitrate the nitrous acid, but would cause the dissipation of all the recoverable nitrogen compounds. Sufficient attention to details, which, if small in themselves, are of the highest importance to the result, will bring a set of chambers to a state of perfect working order in a very short time; but it is positively essential that the operations be presided over by a competent chemist, who, in addition to a frequent examination of the furnace cinders as a check upon the burning of the ores, should also determine, by a careful analysis of the gases every day at their entry into, as well as at their exit from, the chambers the quantity of sulphurous acid contained in the one case and the amount of oxygen in the other.

Gay Lussac towers.—In order to save the nitrogen compounds which would otherwise escape from the chambers with the waste gas, advantage is taken of the solubility of nitrous acid in sulphuric acid containing less than four molecules of water. This was first used by Gay Lussac, who invented the columns bearing his name, with which even those who still refuse to use them are not unfamiliar. The towers may be indifferently round or square, and when strongly built of 8-pound sheet lead, should be from 40 to 50 feet high, with an interior diameter of from 5 to 6 feet, or such other dimensions as are necessary to insure a cubical capacity of about 2 per cent. of the entire chamber space. Either a brick or a wooden frame work may serve as a support, but the foundation must be solid and the tower itself kept plumb and completely accessible to the air. The packing must be carefully attended to, the proper plan being to commence with a few of the best firebricks at the bottom, following this with 1 or 2 feet of large chemically clean pure flints, and finishing up with large lumps of hard burnt oven (not gas) coke, this being not only an admirable absorbent, but also extremely cheap and sufficiently light to obviate any danger from lateral pressure. Into the exit pipe are fitted very small glass windows, through which it will be satisfactory to note occasionally that the escaping gases yield no red fumes by contact with the air. A few feet above the tower is placed a cistern, which, by means of a properly regulated tap, supplies the cold absorbing sulphuric acid of a strength equal to 62° Baumé. The great point to be attained is the maintenance of such a perfect and equal distribution in the form of a drizzling rain, that not a particle of the ascending gases may escape its contact. A convenient sampling arrangement is made at the bottom, and the nitrous vitriol is frequently tested by adding to a small sample a quantity of very cold water, when large volumes of red fumes will be thrown off if the absorption has been complete.

Glover towers.—A great improvement has been introduced in the mode of procedure by which the gases from the burners are led to the acid chamber, which was referred to in speaking of the furnace. A second tower has been adopted which is named after its inventor, Mr. John Glover, an English chemist. This tower may be briefly but accurately described as: 1, a most perfect, rapid, and economical concentrator of chamber acid; 2, an absolute "denitrator" of the nitrous vitriol; 3, an essential adjunct to the Gay Lussac tower.

It is an extraordinary fact, and one which can only be regretted, that the Glover tower is still far from universally used or even known in this country, and this gives sufficient reason for devoting space to its consideration here. The erection of a Glover tower is a matter requiring very great care. Occupying an intermediate position between the furnaces and the chambers, it receives the whole of the sulphurous and nitrous gases arising from the combustion. For a height of 25 to 30 feet by 7½ feet square, external measurement, its foundation must be solid and its outer framework offer no impediment to the free circulation of the air. It should be constructed throughout with 12-pound sheet lead without cross joints, and lined with small glass bricks and pounded glass filling to a thickness varying from a foot to a foot and a half. The dish destined to receive the concentrated acid must be of 25-pound lead and have a well formed lip; a loose sheet of lead is placed over its bottom to prevent injury from the lining. The cast-iron gas pipe leading from the furnace projects a little above the dish some 8 or 9 inches into the tower, and directly beneath an arch built either of pure quartz or glass brick leveled up with small lumps of pure silica or the broken ends of old bottles. Upon this arch comes the packing, concerning which there is much disagreement. All managers agree in admitting the utility of the tower, but all have pet theories as to the manner in which it is to be lined and packed in order to wear well and to be turned to profitable account. It is hardly necessary to state that, in the endeavor to settle these differences satisfactorily, innumerable expedients have been tried and abandoned. In a tower which has been continuously at work in England for nearly four years, about 8 feet of open packing with glass bricks are first placed upon the arch; into the interstices a sufficient quantity of minute siliceous pebbles is loosely distributed. Next are about 3½ feet of chemically clean and pure flints of moderate size, and finally up to within about 5 feet of the cover (which, together with the distributing apparatus, is the same as that described in the Gay Lussac tower) come successive layers of the best hand-picked, hard-burned oven coke. Immediately below the cover is an exit pipe 3 feet in diameter leading to the chamber with considerable fall, while upon the top of the tower are two tanks placed side by side, and suitably covered, but accessible to the cooling influence of the air. Into one of these tanks is put the whole of the acid from the Gay Lussac tower, and into the other all or any of the 50° Baumé acid from the lead chambers. Pipes lead from each to a reaction wheel under the cover of the tower, whence, with the same careful observance of minute and equal distribution already insisted upon, the two liquids meet and combine in equal proportions and trickle down. Among the best working towers of this country are those in use at the Laurel Hill Chemical Works on Long Island. They are built and packed according to the design of their inventor, Mr. Herreschoff, and bear his name. A full and illustrated description of these modified Glovers will be found in the *Engineering and Mining Journal* of April 17, 1886. The acids from the chambers and from the bottom tanks must be continually hoisted to the cistern on the summit of the towers, and compressed air will carry them to any height without exercising any decomposing action on the liquids. The description of the kind of syphon or "egg" best adapted to the purpose is made of thick cast-iron and shaped like an English soda-water bottle, It is placed in position upon a somewhat lower level than the bottom tanks, requires no lead lining, and is closed at one end by a manhole door of wrought iron. On its top three flanged openings filled with a corresponding number of pipes are provided, one for the blower, one for the acid charger, and the third, which extends right through to a hollowed-out space in the under side, for delivery. Valves and cushions are fitted to the pipes leading from the tanks to the main passage into the egg, such main being also provided with a perfect fitting strong screw valve and a long rod. Near the bottom is a guide; the upper part traverses a very strong wooden frame in which is fixed the screw worm, and upon its top a small handwheel. When ready to charge, this valve is turned up and the cistern plug removed. When the egg is full the cistern plug is reseated, and the screw valve over the egg firmly fixed in its place. The engine chosen for working the egg should have both a steam and air cylinder worked with a direct stroke, and should be constructed to force acid through the delivery pipe to the required height with ease and freedom. The whole pumping gear must be kept scrupulously clean and in perfect repair, and it is a wise measure of precaution to provide two eggs for each set of towers, so as to avoid any stoppage of the process by mishaps. Since the absorbing powers of concentrated sulphuric acid are known to become less proportionately with the increase in its temperature, the absolute necessity for effectually cooling that which runs from the Glover before passing it on to the Gay Lussac tower need hardly be insisted upon. A sufficiently long leaden worm pipe immersed in water, constantly kept cool, will answer all purposes. The action which takes place in the denitrating column is extremely complicated. Briefly stated, it may be said that the gases from the furnace and the niter pots pass into and up the column at a temperature of from 900° to 1,000° F., being met and traversed in their course by a fine rain of acids received from the two cisterns placed at the summit of the tower. Thus thorough denitration and concentration ensue simultaneously; the nitrous compounds given off by the acid from the Gay Lussac tower and the steam resulting from the evaporation of the weak acid both being carried into the chamber by the thoroughly cooled furnace gases. The acid which flows into the bottom cistern is concentrated by the loss of its water to from 62° to 63° Baumé.

The proper position naturally indicated for a Glover tower is therefore as close a proximity to the burners as may be compatible with perfect safety from fire; since the hotter the gases the greater will be the evaporation and higher the degree of concentration of the acid flowing through it.

About ten years ago Mr. Scheurer-Kestner pointed out that during the combustion of pyrites there is formed in the furnace a large quantity of sulphuric anhydride, which being carried into the denitrator with the other gases is presumably responsible by its corrosive action for the rapid decomposition of the fire bricks generally used for the base of the interior lining. Having continued his experiments up to the present time this author has quite recently published further and still more elaborate analyses entirely confirming his first discovery, and has proved by incontrovertible evidence that the addition to a sulphuric acid plant of a Glover tower invariably results in an increase of production amounting, according to its dimensions and the excellence of its construction, to from 10 to 20 per cent., with no increase in the material employed. His operations were conducted at his own works at Thann, with shelf burners consuming daily 5½ tons of pyrites fines averaging 48 per cent. sulphur. The whole of the acid produced in the chambers was passed through the Glover tower where an evaporation of not less than 3½ tons of water was noted in every twenty-four hours. Starting with an accurate knowledge of the quantities contained in the chamber and various apparatus, the total daily production was accurately recorded during a period of 16 days, at the end of which matters were so arranged as to be exactly in the same position that they were at the commencement of the experiment. Of the 96 tons of 66° Baumé acid thus obtained 15.152 tons, or 15.7 per cent. must have been formed in the tower. A second experiment by what may be termed an indirect method confirmed this result. In this case the exact quantity of sulphuric acid condensed in a leaden chamber was accurately determined with an absolute knowledge of what should be theoretically obtained from the amount of pyrites burned. The difference between this quantity and that actually obtained represented the excess formed or condensed in the Glover tower, thus:

	Tons.
Sulphuric acid of 66° B. produced	48.300
Sulphuric acid of 66° B. condensed in the chamber	40.378
Difference representing acid formed in Glover tower	*7.922

*Or 16.30 per cent.

To these figures must be added the sulphuric acid which, passing with the gases through the tower in a state of vapor, were condensed in the connecting pipe. This being exactly measured every day during the course of each experiment was found to represent from 2 to 2½ per cent. of the total product, the entire gain being thus brought up to the extraordinary total of about 18 per cent. Mr. Scheurer-Kestner says that before the Glover tower was erected at his works at Thann his sets of chamber produced in each twenty-four hours 6 tons of oil of vitriol on the basis of 66° Baumé. Ever since the tower has been adopted and brought to proper working order the production has increased to 7.280 tons, and the difference 1.280 tons obtained in actual working, therefore represents 17.5 per cent. of the total output. He attributes the formation of this sulphuric acid outside the leaden chamber to two causes, about one-half being due to the anhydride produced during the combustion and dissolved by a descending current of liquid in the tower, and the other half being spontaneously formed by the action of the nitrous compounds on the ascending sulphurous acid.

Cost of production.—From what has preceded it is perfectly clear that the actual cost of sulphuric acid depends entirely upon three chief conditions: 1, the price of sulphur; 2, the resources, adaptability, and excellence of the working plant; and 3, skill of the working management. It would, therefore, be obviously unfair to make any allowance for shortcomings which have no right to exist; and as the object in view is to show what is being done by means of new methods, it will be well to assume perfection in every detail. A correct basis of calculation is furnished by what is commonly known as chamber acid; that is to say, the crude product daily formed in the chambers and not subjected to any kind of concentration. With proper care it will always have a specific gravity of at least 1.530, and be equal to 50° Baumé or 106° Tralles. For such purposes as the decomposition of natural phosphates, the manufacture of alkali, caustic soda, bleaching powder, nitric and hydrochloric acids, stearic acid, and many other articles, no greater average strength than this is required, and probably about one-half of all that is now made goes into these channels. Where it is customary, as in many European works, to run all that comes from the chambers through the Glover tower, the concentrated liquid is easily reduced to 50° Baumé by the addition of water.

The composition of pure sulphuric acid, H_2SO_4, is 81.63 parts of sulphuric anhydride and 18.37 parts of water. For every hundred pounds by weight it contains—

Composition of 100 *pounds of sulphuric acid.*

	Pounds.
Hydrogen	2.041
Sulphur	32.653
Oxygen	66.306

Hence the quantity of acid produced by a hundred pounds of sulphur should be—

	Pounds.
Sulphur	100.00
Hydrogen	6.20
Oxygen	199.80
Total, H_2SO_4	306.00

In other words, 1 pound of sulphur, when properly burned, yields, theoretically, 3.16 pounds of the monohydrate, with a specific gravity of 1.842 at 15° C., or 66° according to Baumé's hydrometer, and in practice a regular average yield of about 2.95 pounds of 66° Baumé, or even 4.50 pounds of 50° Baumé is considered an excellent result. The statements of manufacturers who claim to do better than this are exceptional, and it may be laid down as axiomatic that from every pound of sulphur burned, whether it be in the form of brimstone or pyrites, the same amount of sulphurous-acid gas, and consequently of sulphuric acid, will be produced under all equal conditions.

A reference to the analytical table elsewhere set forth will show that the average quantity of sulphur contained in the pyrites mined and imported into or used in this country may be fairly taken at 46 per cent. A long and varied experience has demonstrated that of this amount at least 6 per cent. is commonly unavailable, and may be regarded as lost. The prices of raw materials given in the following table are intended to cover all costs of delivery at works in either the

New York or Philadelphia district, and are designedly fixed at the lowest limits at which contracts have recently been offered for pyrites and brimstone. In the pyrites estimate considerable additions have been made to the items of niter and labor, and it has been considered wise in both cases to write off the whole value represented by the works in ten years; experience of this system in practice having proved highly satisfactory. Despite sundry drawbacks, the balance of advantage is unequivocally shown to be on the side of pyrites, even when utilized at centers so far from the sources of production as to entail the heavy freights already referred to.

Table of comparison, showing the actual cost of producing one ton of 50° Baumé sulphuric acid from brimstone and pyrites in the districts of New York and Philadelphia.

Brimstone.	Cost per ton.	Pyrites.	Cost per ton.
1 ton (2,000 pounds) of brimstone "thirds," 98 per cent. sulphur	$19.00	2½ short tons of iron pyrites at 46 per cent. sulphur, at 10 cents per unit per ton	$11.50
50 pounds of nitrate of soda, at 2½ cents per pound	1.25	60 pounds nitrate of soda, at 2½ cents	1.50
5 cwt. coal at, say, $4 per ton	1.00	5 cwt. of coal at, say, $4 per ton	1.00
Workmen's wages	2.25	Workmen's wages	3.00
Superintendence and management	2.00	Superintendence and management	2.00
General jobbing repairs	.50	General jobbing repairs	.60
Interest on capital of $75,000 (*a*)	4.60	Interest on capital of $100,000 (*a*)	6.15
Total	30.60	Total	25.75
Product=4½ tons of 50° Baumé, cost per ton	6.80	Product=4½ tons of 50° Baumé, cost per ton	5.50

a At 10 per cent. per annum, the works being calculated to last only 10 years, and to produce during that time 20 tons of acid daily.

To offer the same advantages as pyrites on the above basis, all other conditions being equal, brimstone must be sold at $14 per ton.

The feasibility of manufacturing the acid in the vicinity of the mines has already been alluded to. Its practicability must be established by clearly demonstrating the cost of carrying other raw material, such as coal, phosphates, salt, etc., or even the 66° Baumé acid itself, to be less in the end than the freights now paid upon pyrites ore. This problem deserves to be inquired into by capitalists, since its favorable solution would further reduce costs as follows:

Cost of acid production at the mines.

	Cost.
Two and one-half tons of iron pyrites, containing 46 per cent. sulphur, at a maximum of 4 cents per unit, delivered	$4.60
Other charges same as given in preceding table	14.25
Total cost of 4½ tons of 50° Baumé acid	18.85
Cost per ton	4.20

The same results would be obtained from brimstone at $7.25 per ton; or, in other words, the manufacturer at the mines will be working upon sulphur which, on exactly equivalent basis of calculation, would cost him $11.75 less per ton than the price paid for brimstone by his New York competitor.

Purification.—Pyrites acid generally contains impurities which are not encountered in that made from brimstone. Thus, for example, arsenic acid, arsenious acid, antimonic oxide, selenium, thallium, lead, iron, and aluminum have all been found in the various descriptions of ore. The most objectionable, of course, are the arsenical compounds. There are many of the industries already named, notably the purification of petroleum, manufacture of fertilizers, sulphate of soda, and explosive compounds, in which arsenic has no injurious influences, and may be disregarded. The opposite to these are such as the manufacture of any chemical likely to be used in the preparation of medicinal or food products, and here the purification of the sulphuric acid by eliminating noxious compounds is an essential feature. Of the innumerable but, for the most part, highly unsatisfactory methods of purification hitherto suggested only two have been successfully applied, and deserve description:

1. All the arsenic is transformed into H_3AsO_4 by the addition of a small quantity of nitric acid. A little ammonium sulphate is then introduced to destroy the NO_2 thus produced in the mixture, and when the whole is carefully distilled no arsenic comes over.

2. The chamber or Glover acid is diluted to 45° Baumé, and charged with an excess of washed sulphurous acid gas. This transforms the HNO_3 and H_3AsO_4 into nitrous and arsenious acids. The liquid is next charged to saturation with hydrogen sulphide. The vessel is closed and left standing at a moderate temperature to facilitate the precipitation of the sulphides of arsenic and lead. When the supernatant liquid has become perfectly clear it is introduced into a low, spherical glass retort, and very quietly distilled.

Cost of concentration.—Sulphuric acid, which is used for the purification of petroleum and other mineral oils, for refining gold and silver, in the manufacture of nitro compounds, and in some other considerable industries, must be concentrated to a degree beyond the ability of a Glover tower, and it is customary to effect this either in platinum stills or glass retorts. The absolute superiority of the platinum still appears to require further demonstration, and is, indeed, so far an open question that a great number of important factories continue to use glass, and they justify the preference on the ground of economical working. It is averred that with the exercise of sufficient care in the exclusion of all drafts very little loss need be incurred by breakage, and the method has the advantage over platinum of being equally adaptable to the concentration of both chamber acid and Glover tower acid. Further, it offers the immense advantage of marking, by the visible loss of color, the progress of concentration. The considerable extent to which platinum is soluble in concentrated sulphuric acid combines with its high price to make the concentration extremely costly, in stills of this metal, and any statement prepared without duly weighing this fact and making proper allowances for it would be worthless. All attempts to obtain information upon this point from our own manufacturers have proved abortive. In England, owing to the excellence and cheapness of the best lead glass, platinum is said to be going out of fashion and giving place to carefully blown, slowly cooled retorts of perfectly even thickness, weighing about 60 pounds each, and costing from 25 to 30 cents per pound. The costs given below are compiled from actual working figures actually furnished by, A, a large English works producing 8 tons of 66° Baumé acid per day in these glass retorts; B, a firm in France (where platinum stills are universally used), which is working with a Faure and Kessler apparatus, and which estimates its daily average production at 5 tons 66° Baumé.

Table of comparison, showing the actual cost of concentrating 1 ton of sulphuric acid to 66° Baumé in glass retorts and in platinum stills.

A.—Glass retorts, concentration of 60° Baumé acid from Glover towers.	Cost per ton.	B.—Platinum still, concentration of 50° Baumé acid from the chambers.	Cost per ton.
1 ton of coal	$4.00	18 cwt. of coal, at $4.00 per ton	$3.60
Wages and superintendence	10.00	Wages and superintendence	7.50
Breakage of retorts	2.00	Wear and tear of the apparatus calculated as interest on this addition to the working plant (b)	6.85
Wear and tear of other material and interest on this addition to the working plant(a)	1.40	Total cost for concentrating 5 tons	17.95
Total cost for concentrating 8 tons	17.40	Cost per ton	3.60
Cost per ton	2.18		

a Estimated to cost $1,000, at 50 per cent. per annum, calculated to 8 tons per day.
b Actually costing $10,000 and estimated to last four years, at 25 per cent. per annum, on an output of 5 tons per day.

Utilization of pyrites residue.—In the manufacture of sulphuric acid from pyrites, the utilization of the desulphurized cinder has at length come to be universally recognized as a factor in the economy of the process, whereby in a great many cases the cost of the acid itself may be so reduced as to become insignificant. Burnt ores devoid of copper have hitherto been largely used for road-making, or what is commonly called "filling," and when works are situated in marshy or inaccessible districts there can be little doubt about the excellence of the results from this practice. A limit, however, is quickly attained to the quantity that may thus be profitably employed, and it is therefore necessary to seek other outlets for what by its accumulation soon becomes a very serious and unsightly incumbrance. From the official statistics it would appear that, although the quantity of iron ores annually extracted from our own mines is enormous in its proportions, we yet continue to import about 1,000,000 tons per year. It seems that the cinder from the iron pyrites from which the sulphur has been burned down to within less than 1 per cent., and which contains no phosphorus and only a trace of copper might be advantageously substituted for a part of this imported material. Nor does the attitude of the principal iron masters imply that they would refuse their willing co-operation in this direction consistently with other personal interests. The reduction of the sulphur to the prescribed limit has been hitherto an insurmountable obstacle in the way of the acid makers, but the combustion of the ore as fines and the adoption of improved and inexpensive shelf burners or Spence mechanical furnaces appear to have practically overcome this difficulty, while increasing the yield of acid. Several important contracts are said to have been recently made with smelters by New York manufacturers (who use these furnaces) for a regular supply of all their cinders from fines at from $3 to $4 per ton.

The treatment of cupriferous burnt ores, both by smelting and by the wet process, has been the subject of many exhaustive treatises, and has now assumed immense industrial proportions all over the world. The relative merits of the two methods, with a view to absolute preference of one or the other, is beyond discussion, since the choice of either must be governed by such strictly local conditions as the cost of fuel, the cost of dissolving and precipitating agents, and last, but by no means least, the character and composition of the ore itself. It will suffice to state broadly that in districts where fuel is cheap, smelting will be most profitable for cupriferous cinders with a higher percentage of silica and but little silver, whereas if fuel is dear, or if cinders be comparatively rich in silver and gold and poor in siliceous matter, the wet mode of treatment will yield the best results. The principal ores of this country belong to the first category. Those of Spain and Portugal to the second. Evidence of what can be accomplished by a combination of chemical knowledge and engineering skill in the utilization of desulphurized copper pyrites may now be seen at the Laurel Hill Chemical Works, on Long Island, New York, and the Orford Copper and Sulphur Works, Bergen Point, New Jersey. Canadian ores from the Crown or Albert mines of Capleton are used for the manufacture of acids. The self-fluxing cinders, containing about 3½ per cent. copper and 13 or 14 per cent. silica, are smelted at the Laurel Hill Works, in Herreschoff water-jacket furnaces, with sufficient raw fines to bring up the sulphur to 7 per cent., gas coke being used for fuel. The average resulting matte runs as high as 50 to 60 per cent. of copper, and not more than about 0.5 per cent. is lost in the slag. The average daily charge for each furnace is as follows:

Furnace charges in smelting pyrites cinders.

	48-inch furnace.	60-inch round furnace.	Rectangular furnace.
	Tons.	*Tons.*	*Tons.*
Roasted ore	57.7	76.	76.6
Raw fines	4.3	8.	13.2
Sand	2.8	12.	5.3
Iron slag	....	9.5	....
Total stock	58.8	105.5	[illegible]
Coke	(*a*)11.5	(*b*)17.	[illegible]

a Or 20 per cent. *b* Or 16 per cent. *c* Or 18 per cent.

Only ten men are daily employed. The gas-house coke costs $2.50 a ton, and repairs are exceptionally low. The total cost per ton of ore cannot, therefore, aggregate 80 cents, or on the ton of 50 per cent. matte about $10, or for ingot copper 1 cent per pound. From the exhaustive inquiry throughout the country it appears that during the year 1886 there were burned for acid-making 112,000 tons of pyrites, equivalent to 44,800 tons of sulphur, on the basis of a net average contents of 40 per cent. available sulphur, and 90,200 tons brimstone; from all sources, total 135,000 tons available sulphur. Calculated on the basis of 50° Baumé, it may be assumed that the entire production of chamber acid was 607,500 tons. Of this quantity a trifle over 80 per cent. went either directly into fertilizers or the refinement of petroleum, the remainder being used for explosive compounds and various smaller channels of consumption. These figures prove beyond question that our economical manufacture, in the accepted sense of the term, is practically insignificant, and the undoubted tendency of the trade at large is to rely upon foreign sources for nearly all of the substances in the long list of chemicals which could be easily and with great profit produced at home.

PHOSPHORUS.

By George M. Turner.

The manufacture of phosphorus was begun in the United States in 1870 by Messrs. Rose & Lowell at Mount Holly, New Jersey. Phosphorus was then selling at $1.25 per pound, but the price was lowered by English competitors to 70 cents in 1873, when Messrs. Rose & Lowell failed. The manufacture then ceased. In 1875, when the price had risen to $1.20, the manufacture of phosphorus was undertaken again by Mr. Moro Phillips, who previously had purchased the works of Messrs. Rose, Lowell & Co. The works were removed to Camden, New Jersey. Phosphorus has been manufactured by him and his successor, Mr. Frederick Phillips, in varying quantities every year since that time. In 1886 about 30,000 pounds were prepared for market by this firm. At present this is the only firm in the United States which attempts the manufacture of phosphorus. Since England is the great source of phosphorus, as soon as its manufacture is undertaken in this country to any extent the English competitors lower the price to crush out the industry. As a matter of fact, it is for the interest of consumers of phosphorus in this country to pay a little more than the market price to manufacturers here for small quantities, in order to keep the works in operation, and to prevent a monopoly in England.

The principal use of phosphorus in this country is in the manufacture of matches. This industry is mainly controlled by the Diamond Match Company, which has its headquarters in New York, Philadelphia, Baltimore, and Boston. It is stated that the Diamond Match Company obtained its phosphorus from Oldbury, England. The Phosphor-bronze Smelting Company, of Philadelphia, consumed quite an amount of phosphorus, but no data concerning the amount or source could be obtained. A comparatively small amount of phosphorus is consumed in chemical laboratories throughout the country.

Production of phosphorus in other countries.—Russia and England.—The manufacture of phosphorus in Russia dates from the year 1871, when J. K. Tupizyn set up at Perm the first phosphorus factory in Russia. Nothing of the kind had ever been heard of before in that district, nor had the founder ever seen a phosphorus factory or even received the advantage of a technical training. Notwithstanding the very defective construction of this foundry Tupizyn managed to turn out 347 poods—12,534 pounds avoirdupois—in 1872. Hitherto all lucifer matches had been made from English phosphorus, for which the Russian manufacturers paid prices varying from $50 to $100 per pood. As soon as Tupizyn's phosphorus was brought into the Russian market, the price of the English phosphorus was lowered to crush out the new Russian establishment. This forced the new firm to reduce its price some $10 to $12 on a pood. However, in spite of the English competition the Russian factory turned out 700 poods in 1873 and 1,200 poods in 1874. In 1875 it became necessary to enlarge the factory. The new works turned out that year 1,800 poods, while in 1878, 2,350 poods were placed on the market. In 1878 the founder died, but the business was carried on by his widow, who caused the factory to turn out 3,000 poods in 1879. At this time the agent for the English phosphorus entered into a contract with Tupizyn's factory to raise the price of phosphorus so that in 1881 and 1882 it was sold at the former price of $50 a pood. The contract was, however, soon broken and the Russian factory turned out, in 1883, 4,000, and in 1884, 4,300, poods of phosphorus. From 1870 to 1874, inclusive, the average annual import from England was 3,015 poods, and 1875 to 1879, 2,102 poods per year, while from 1880 to 1884, inclusive, 1,827 poods were brought on an average each year from England. This shows a decline since the 1870–'74 importations of about 39 per cent. The total consumption of phosphorus for matches in Russia is estimated at 6,000 poods. Of this quantity only about 1,500 poods are now imported from England. Other small establishments for the manufacture of phosphorus have recently sprung up in Russia. According to data supplied by Rudolf Wagner the production of phosphorus in 1880 in France was 3,345,000 pounds, in England 3,780,000 pounds, and in Camden, New Jersey, 37,800 pounds.

The phosphorus imported into this country in 1886 by way of New York was from England and amounted to 179,850 pounds, with a value of $97,702. No Russian phosphorus has as yet reached this country. Of the 179,850 pounds imported to this country, probably 165,000 pounds came from one firm, Albright & Wilson, of Oldbury, England. The market price of phosphorus for 1886 in this country, according to Messrs. Charles Pfizer & Co., the American agents for Messrs. Albright & Wilson, was 62 cents per pound. Of the phosphorus imported into this country about nine-tenths is consumed by the match industry.

BORAX.

California and Nevada continue as the only States which produce this salt, and they are also the only countries on the western continent which produce it in any considerable quantity. The history of the industry in these States has been varied, and one of disaster to many who embarked in it. Commenced nearly thirty years ago when prices were high, the business was in the course of a few years so overdone that prices declined below the cost of production, those engaging in the manufacture of the salt forgetting that this is one of the commodities the consumption of which is not greatly extended by reason of cheapness, and overlooking the additional fact that its production must necessarily be attended with heavy expense owing to the remoteness and the desert character of the region where the crude material occurs and where its manufacture has to be carried on.

In the expectation that the price of borax would be greatly advanced by reason of the duties imposed upon the importation of the foreign article several years ago, large quantities were rushed into this country prior to the enforcement of the new law, the business of its manufacture here having been much stimulated by the same cause. As a consequence the American market was so overstocked that prices declined till thèy reached, in 1886, lower figures than had ever before obtained, with a result the very reverse of what was anticipated. From the extreme depression prevailing a few months since, prices have partially recovered, the concentrated article selling now (May, 1887) in San Francisco at 5 cents and the refined at 6 cents per pound, with little prospect of any early improvement in the market. Formerly 35 cents per pound was paid for borax. To some extent the companies have still to compete with the foreign article, which, with the sharp rivalry existing between themselves, reduces their profits to a very narrow margin, so narrow that there is nothing to tempt new producers to enter the field. It is even more than likely that some of the companies already engaged in the business would be glad to retire could they do so without wholly sacrificing the large sums they have invested.

Borax receipts and exports for 1886.

	Pounds.	Pounds.
Receipts at San Francisco	7, 887, 000	
Shipped from other points in California	1, 891, 290	
		9, 778, 290
Shipments to points in the United States:		
Shipped by sea	5, 713, 241	
Shipped by rail	4, 009, 600	
		9, 722, 841
Exports to other countries:		
England	1, 964, 283	
France	45, 337	
Other countries (China, Japan, Mexico, etc.)	32, 392	
		2, 042, 012
Total shipments and exports		(*a*)11, 764, 853

a Equals 5,882 short tons.

The surplus of shipments and exports shown by the foregoing was drawn from a considerable accumulation of stocks on the Pacific coast, resulting from the general depression of business during the two preceding years. Making too little allowance for this, some have estimated the production in 1886 at a somewhat larger figure than is here given.

The annual production of borax on the Pacific coast during the past eleven years has been approximately as follows:

Production of borax.

Years.	Pounds.
1876	5, 180, 810
1877	3, 727, 280
1878	2, 802, 800
1879	1, 584, 966
1880	3, 860, 748
1881	4, 045, 405
1882	4, 236, 291
1883	6, 500, 000
1884	7, 000, 000
1885	8, 000, 000
1886	9, 778, 290

It should be stated that the above figures, while they cannot be far out of the way, are not absolutely correct. There being no official record of the quantity of borax made annually by the several companies engaged in the business, round numbers have latterly been adopted in estimating the same. The employment of more precise figures has been found impracticable on account of the practice of individuals and small companies in the borate fields of making a few tons of borax and selling it to the local merchants, who in turn dispose of it directly to buyers and consumers in San Francisco. None of those parties keep any account of the small lots so handled.

Shipments of borax from California and Nevada in 1883, 1884, 1885, *and* 1886.

To—	1883.	1884.	1885.	1886.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
East by rail	3, 288 200	2, 995, 880	1, 500, 000	4, 009, 600
New York by sea	1, 911, 116	3, 446, 326	5, 081, 557	5, 713, 241
Liverpool	1, 287, 777	740, 291	2, 312, 827	1, 964, 283
China	20, 231	33, 862	28, 656	
Japan	8, 882	3, 327	20, 498	
Victoria	1, 200	2, 487	....	
Mexico	6, 301	3, 555	7, 916	
Honolulu	4, 200	475	120	32, 392
Australia	820	21, 542	29, 589	
Central America	....	200	600	
Antwerp	....	22, 500	....	
British Columbia	....	....	807	
France	....	....	23, 630	45, 337
Total	6, 528, 727	270, 445	9, 006, 200	11, 764, 853

Borax, boracic acid, and borate of lime imported and entered for consumption in the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Refined borax.		Crude borax.		Boracic acid.		Borate of lime.		Total.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		*Pounds.*		*Pounds.*		
1867	49, 652	$6, 601	5, 672	$711	770, 756	$73, 396	....	....	$80, 708
1868	79, 183	10, 127	22, 293	2, 985	243, 993	22, 845	....	....	35, 957
1869	89, 695	12, 799	54, 822	8, 011	988, 033	109, 974	....	....	130, 784
1870	97, 078	14, 511	2, 616	322	1, 166, 145	173, 806	33, 529	$1, 666	190, 305
1871	134, 927	20, 705	5	1	1, 204, 049	185, 477	45, 600	2, 248	208, 431
1872	35, 542	6, 288	....	....	1, 103, 974	191, 575	22, 500	800	198, 663
1873	9, 284	2, 152	....	....	1, 222, 006	255, 186	....	....	257, 338
1874	3, 860	1, 253	588	78	233, 955	52, 752	....	....	54, 083
1875	5, 153	1, 224	....	....	41, 742	6, 280	....	....	7, 504
1876	3, 145	691	....	....	137, 518	15, 711	....	....	16, 402
1877	3, 500	676	55	12	107, 468	11, 231	....	....	11, 919
1878	3, 492	514	286	61	178, 798	14, 925	....	....	15, 500
1879	3, 472	490	....	....	306, 462	21, 888	....	....	22, 378
1880	15, 278	2, 011	....	....	243, 733	18, 473	22, 122	742	21, 226
1881	4, 136	865	....	....	187, 053	15, 771	....	....	16, 636
1882	15, 710	3, 774	....	....	536, 334	71, 348	....	....	75, 117
1883	5, 611	1, 359	....	....	4, 334, 432	580, 171	....	....	581, 530
1884	7, 332	1, 691	142	34	44, 512	4, 494	....	....	6, 219
1885	240	41	....	....	48, 517	4, 035	....	....	4, 076
1886	4, 625	770	4	1	(*a*)430, 655	26, 237	....	....	27, 008

a 393,832 pounds were "commercial," the remainder pure.

ALUM.

In addition to the localities furnishing alum clays and shales mentioned in "Mineral Resources of the United States, 1883 and 1884," a few deposits have been found in the past two years. A bed of clay and slate was discovered near Corry, Pennsylvania, in the latter part of 1885, which may prove valuable for the alum it contains. Several new deposits of native alum are reported in the West, particularly near Tuscarora, in Elko county, and near Steamboat Springs, Washoe county, Nevada. In Graham county, Arizona, a noteworthy deposit has been found near Clifton, but it is doubtful whether the cost of transportation will admit of mining any of these western deposits, except that near Steamboat Springs, where a company has been formed to produce alum from the clay.

Production.—The alum made in 1885 is estimated by a leading manufacturer as 80,000,000 pounds, with a total value of $1,400,000. In 1886 the production was about 90,000,000 pounds, valued at $1,350,000. It is probable that the use of domestic sources is now more considerable than is implied in the report for 1883 and 1884. In Lawrence and Owen counties, Indiana, particularly, large quantities of clays are used, and New Jersey, South Carolina, and Alabama also share in the production of aluminous clays and shales. The total production since 1882 is given below:

Alum made in the United States from 1882 *to* 1886.

Years.	Quantity.	Price per pound.	Value.
	Pounds.	*Cents.*	
1882	36, 000, 000	2	$720 000
1883	35, 000, 000	$2\frac{1}{8}$	743, 750
1884	38, 000, 000	$1\frac{7}{8}$	712, 500
1885	80, 000, 000	$1\frac{3}{4}$	1, 400, 000
1886	90, 000, 000	$1\frac{1}{2}$	1, 350, 000

There was a slight decline in the average price of alum from $1\frac{7}{8}$ cents per pound in 1884 to $1\frac{3}{4}$ cents in 1885 and to $1\frac{1}{2}$ cents in 1886. There are three grades which make up this average. The poorest sold for $1\frac{1}{4}$ cents per pound; the next, called crystal alum, brought $1\frac{3}{4}$ cents, and high grade concentrated alum $2\frac{1}{4}$ cents, in 1886.

Imports.—Bauxite and cryolite, and probably some alum clays and shales, are imported for making alum. Various manufactured products are also imported, as follows:

Alum (classed as alum, alum substitute, aluminous cake, and sulphate of alumina) imported into the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Quantity.	Value.	Fiscal years ending June 30—	Quantity.	Value.
	Pounds.			*Pounds.*	
1867	5, 573, 285	$85, 760	1877	8, 259, 175	$112, 275
1868	3, 110, 095	47, 887	1878	8, 645, 248	107, 394
1869	2, 038, 549	34, 385	1879	5, 961, 057	65, 708
1870	2, 485, 722	39, 969	1880	2, 112, 570	23, 435
1871	4, 712, 840	74, 450	1881	2, 086, 950	22, 331
1872	3, 996, 826	64, 465	1882	2, 487, 188	29, 930
1873	4, 218, 621	66, 243	1883	1, 695, 661	21, 126
1874	4, 053, 588	67, 913	1884	1, 461, 041	19, 497
1875	6, 951, 396	112, 516	1885	2, 243, 920	37, 707
1876	7, 266, 735	103, 152	1886	2, 070, 125	35, 343

Uses.—A new modification of the usual process of preparing alum from its sources has been patented. This is designed to admit the use of clays containing iron. The usual process consists in treating the clay with sulphuric acid, adding sulphate of potassium or sodium and crystallizing out the resulting double sulphate after evaporation. The improvement consists in insuring the conversion of all the iron into the ferric state by the addition of some oxidizing agent. The ferric sulphate shows less tendency to crystallize and is hence retained in the mother liquor. The principal uses for alum are in preparing sizing for paper and fabrics and in baking powders. It is also used for preserving meats.

BLUESTONE.

The production of bluestone (sulphate of copper) has increased during the last two years. From a satisfactory canvas of the producers it appears that in 1885 the total production was about 10,000,000 pounds, valued at $400,000, while in 1886 the production increased to 13,400,000 pounds, with a total value of $536,000, at 4 cents per pound.

Bluestone made in the United States from 1882 *to* 1886.

Years.	Quantity.	Average price.	Value.
	Pounds.	*Cents.*	
1882	3, 325, 000	5. 75	$191, 187
1883	5, 344, 000	5	267, 200
1884	4, 224, 000	4. 30	181, 632
1885	10, 000, 000	4	400, 000
1886	13, 400, 000	4	536, 000

Of the production in 1882, about 15 per cent. was obtained from foreign ores and matte. In subsequent years domestic copper oxide furnished practically the whole supply. The imports of bluestone for the past few years have been insignificant.

Sulphate of copper (blue vitriol or bluestone) imported and entered for consumption in the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Quantity.	Value.	Fiscal years ending June 30—	Quantity.	Value.
	Pounds.			*Pounds.*	
1867	1, 971, 902	$118, 166	1877	190, 657	$10, 283
1886	726, 452	44, 469	1878	65, 400	3, 433
1869	917, 818	48, 377	1879	2, 552	123
1870	53, 553	2, 793	1880	2, 750	141
1871	45, 809	2, 340	1881	20	4
1872	74, 693	4, 575	1882	20	3
1873	79, 466	4, 726	1883	536	28
1874	14, 598	1, 015	1884	10	1
1875	77, 215	6, 657	1885	1, 287	61
1876	4, 129	247	1886	422	19

The increased production of copper sulphate has extended its use, keeping the price tolerably constant. About 40 per cent. of the total output is consumed in electric batteries; 30 per cent. for the manufacture of Paris green; 15 per cent. in woolen mills; 5 per cent. in pan amalgamation, and 15 per cent. for many scattered uses, including the use as the basis for other salts of copper.

COPPERAS.

The production of copperas, or ferrous sulphate is at present limited principally to the large rolling mills, where it is a waste product very easy to save. Frequently manufacturers of galvanized iron are obliged to produce this salt, as the authorities will not allow the mother liquors to escape from the works. By means of full returns from these producers it seems that the total production of copperas in the United States in 1886 amounted to 22,000,000 pounds, or 11,000 short tons, valued at $110,000, at an average price of 50 cents per hundredweight. The production in 1885 was slightly less, but the value practically the same. The production since 1882 is given below:

Production of copperas in the United States since 1882.

Years.	Quantity.	Average price per 100 pounds.	Value.
	Pounds.	*Cents.*	
1882	15,000,000	75	$112,500
1883	16,500,000	65	107,250
1884	15,500,000	60	93,000
1885	20,000,000	55	110,000
1886	22,000,000	50	110,000

The principal manufacturers are now limited to the Cleveland Rolling Mill Company, Cleveland, Ohio; the Pillar Copperas Works, Worcester, Massachusetts; the S. P. Wetherill Company, limited, Philadelphia, Pennsylvania; the Phœnix Chemical Works, New York City; the Keystone Chemical Works and the Pennsylvania Salt Company, Philadelphia, Pennsylvania; the Orford Copper and Sulphur Company, New York City; the Johnstown Chemical Works, limited, Johnstown, Pennsylvania; the Trenton Iron Company, Trenton, New Jersey; and the Passaic Chemical Company, New York City.

Uses.—The principal uses for copperas are as a mordant in dyeing; for making Prussian blue; for the preparation of the various oxides of iron which are used as pigments (in the manufacture of pigments the sulphate of iron is decomposed by heat, leaving an oxide which is red or brown according to the circumstances under which the calcination is conducted); and, finally, for disinfecting purposes. It is estimated that one-third of the total supply is used in dyeing, an equal quantity for producing oxides, 20 per cent. for disinfecting purposes, and the balance is divided among a number of minor uses in paper mills, bleaching houses, plate-glass works, chemical manufacturing establishments, in making ink, in precipitating gold, in leaching works, in preparing blue prints for photography, and in medicine.

Imports.—As will be seen from the accompanying table, small quantities of sulphate of iron are still imported.

Sulphate of iron (copperas) imported and entered for consumption in the United States, 1867 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Quantity.	Value.	Fiscal years ending June 30—	Quantity.	Value.
	Pounds.			*Pounds.*	
1867	2, 267, 575	$15, 096	1877	34, 791	$230
1868	181, 354	1, 062	1878	46, 875	256
1869	597, 418	3, 362	1879	87, 450	481
1870	994, 850	5, 280	1880	240, 258	1, 437
1871	1, 842, 308	9, 083	1881	151, 496	956
1872	637, 474	3, 899	1882	23, 517	195
1873	225, 590	1, 516	1883	38, 964	290
1874	170, 511	1, 279	1884	285, 691	1, 555
1875	138, 473	1, 171	1885	165, 653	860
1876	69, 802	385	1886	121, 609	387

GRAPHITE.

BY WILLIAM A. RABORG.

Occurrence.—Deposits of graphite occur in many of the States and Territories. The only place, however, where it is worked to any considerable extent is at the mines of the Joseph Dixon Crucible Company at Ticonderoga, Essex county, New York. The operations at this locality, for previous years, have been described at length in "Mineral Resources of the United States, 1883–'84."

During 1885 and 1886 specimens of graphite were received from the following localities: Romney, West Virginia; Acworth, Georgia; Los Angeles, California; Pitkin, Colorado; Springdale, Arkansas; Selina and Birmingham, Alabama; Roanoke, Virginia; Walhalla, South Carolina; Raleigh and Louisburg, North Carolina; Manchester, New Hampshire; Allentown, Pennsylvania, and Painesville, Ohio. None of the samples thus presented had much commercial value; they were either too lean, impossible of concentration, insufficient in quantity, or too distant from cheap transportation. Graphite has recently been found in a promising condition in Loudoun county, Virginia.

Pennsylvania.—At the graphite mines of the Plumbago Mining Company at Byers, Chester county, Pennsylvania, valuable discoveries have been reported. The tract, including leased land, covers between 500 and 600 acres, the greater portion of which is traversed by seams of graphite. A perpendicular shaft was sunk to the depth of 125 feet, and a bed of plumbago not less than 30 feet in thickness was uncovered. The mineral occurs in veins, two of which are of a thickness of 6 feet each, of a rich soft graphite. The other veins are of a crucible ore. The workings at the mine during 1886 were more in the way of development and the erection of machinery to cheapen the preparation of the stock. No statement of actual production has yet been made.

Rhode Island.—Near Cranston a carbonaceous substance containing impure graphite, associated with a considerable percentage of oxide of iron, is mined. The mine is worked to a depth of 65 feet and has 300 feet of levels. During the year the production amounted to 500 short tons, which was shipped to Pittsburgh, Pennsylvania; its principal use being in connection with the Eames "graphite process" for producing iron and steel. It is expected that this new enterprise will, in time, consume about 25 tons per day of the substance. As the production was solely for use in the above process by the owners of the mine, there was no market value for the graphitic carbon.

Pacific coast States.—Many deposits of graphite are known to exist on the Pacific coast, and some of them have been worked in times past; it seems difficult, however, to find the ore of a sufficiently high percentage and purity to make its mining profitable. No deposits of value were discovered or developed in 1886, nor was any of the substance mined on the Pacific coast.

Production.—During 1885 the Ticonderoga mines produced 327,883 pounds, worth, at an average spot value of 8 cents per pound, $26,230. The production in 1886 was 415,525 pounds, valued at $33,242.

Uses.—In addition to the various uses to which graphite is applied, Mr. John A. Walker, secretary of the Dixon Crucible Company, states that graphite, properly prepared, is a substitute for red lead for making joints and connections. It is now put on the market, under the name of Dixon's graphite smear grease. It is stated that this article will not "set" under any conditions, and a joint made with it opens with perfect ease when the pipe-tongs are applied. It makes a perfect joint and preserves the iron from rust.

Imports.—The following table shows the quantity and value of graphite imported and entered for consumption in the United States from 1867 to 1886 inclusive:

Graphite imported and entered for consumption in the United States, 1867 *to* 1886 *inclusive*

Fiscal years ending June 30—	Unmanufactured.		Manufactured.	Total.
	Quantity.	Value.		
	Cwts.			
1867	27,713	$54,131	....	$54,131
1868	68,620	149,083	....	149,083
1869	74,846	351,004	....	351,004
1870	80,795	269,291	$833	270,124
1871	51,628	136,200	3,754	139,954
1872	96,381	329,030	....	329,030
1873	157,539	548,613	....	548,613
1874	111,992	382,591	....	382,591
1875	46,492	122,050	....	122,050
1876	50,589	150,709	17,605	168,314
1877	75,361	204,630	18,091	222,721
1878	60,244	154,757	16,909	171,666
1879	65,662	164,013	24,637	188,650
1880	109,908	278,022	22,941	300,963
1881	150,927	381,966	31,674	413,640
1882	150,421	363,835	25,536	389,371
1883	154,893	361,949	21,721	383,670
1884	144,086	286,393	1,863	288,256
1885	110,462	207,228	....	207,228
1886	83,368	164,111	....	164,111

Of the 110,462 cwts. of graphite imported during 1885, 99,150 cwts. were from Ceylon; 10,498 cwts. from Germany, and the balance from Nova Scotia, Austria, and Italy.

During 1886 the importations showed a decrease of 25,283 cwts. as compared with that of 1885, attributable to the increase of product[ion] of the American article. The importations by countries were as follow[s]:

Imports of graphite, by countries, during the fiscal year ending June 30, 1886.

	Cwts.
Ceylon	69,216
Nova Scotia, New Brunswick, and Prince Edward Island	6,403
Germany	4,208
Austria	1,849
Italy, England, and Mexico	3,503

Foreign sources.—The principal sources from which foreign graphite is obtained, are the island of Ceylon, and Bavaria, Germany, the former taking the lead. There is a characteristic difference between the articles from the above places. The graphite from Ceylon is very pure, containing considerably more than 90 per cent. of carbon, and is useful for all the purposes of the arts. Bavarian graphite is, more strictly speaking, a graphitic clay.

The graphite from Ceylon is laid down in New York at from 1½ to 4 cents per pound; that from Bavaria from ¾ to 6 cents per pound.

According to a communication by Mr. H. Putz in the *Jahresberi[cht] des naturhistorischen Vereins Passau,* the Passau (Bavarian) graphite has been almost entirely supplanted in the market by Ceylon graphite.

Experiments having for their object the purification of various kinds of graphite were carried out by Mr. Putz; briefly described they were as follows:

The earths were crushed, care being exercised to avoid excessiv[e] fine division; 10 grams of the sample were then placed in a small Erlenmeyer flask, and enough ordinary petroleum added to make a thin emulsion; the vessel was then half filled by adding water, which was shaken vigorously with the other contents of the flask, after which it was entirely filled with water and allowed to stand quietly. The graphite with the petroleum formed a layer at the surface, while the sand and clay settled to the bottom. By inclining the vessel and carefully adding water, so as not to disturb the material at the bottom, the upper layer was caused to overflow, and was collected in another vessel.

The kinds of graphite investigated had the percentage compositio[n] shown by the following table:

Composition of Bavarian graphites.

	Water.	Carbon.	Ash.
Pfaffenreuth	3.28	53.78	42.95
Kropfmühle, flinty grains	5.02	31.72	63.26
Germanusdorf, brown earth	3.45	34.54	62.01
Kropfmühle, selected earth	3.66	54.49	41.85
Krophmühle, brown earth	2.88	36.22	61.80
Stierweide bei Germanusdorf, black earth	2.70	45.25	52.05

The Pfaffenreuth earth has progressed farthest in weathering; next follows the good earth of Kropfmühle; the others are harder, and require the expenditure of considerable effort in grinding, while the former may be broken up by gentle pressure.

Treated in the manner above described, the following results were attained:

Results obtained by process above described.

Graphite from—	Graphite scales obtained.	Earthy residue.	Composition of graphite scales.		Composition of earthy residue.	
			Carbon.	Ash.	Earth.	Carbon as loss.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Pfaffenreuth	63. 8	32. 92	82. 41	17. 44	96. 66	3. 34
Kropfmühle	50. 11	44. 87	53. 82	40. 21	96. 10	3. 90
Germanusdorf, brown earth	46. 41	50. 14	70. 76	29. 24	96. 61	3. 39
Kropfmühle, good earth	57. 09	39. 25	80. 97	19. 03	78. 86	21. 14
Kropfmühle, brown earth	22. 43	74. 69	76. 62	23. 38	74. 72	25. 28
Stierweide, black earth	17. 23	80. 07	83. 20	16. 80	61. 52	38. 48

From this table it is evident that from various kinds of graphite from the Passau region, graphite scales of quite uniform and favorable ash contents may be obtained by the use of petroleum, and, moreover, almost the entire amount contained in the earth if the latter is sufficiently weathered.

In judging of a graphite for crucible purposes, Mr. Putz, contrary to the views of Mr. C. Bishof, lays greatest stress upon difficult combustibility of graphite, while he regards the fusibility of the ash constituents as of only secondary importance. Comparative tests of various kinds of graphite of the same size of granule gave the following results in regard to combustibility of carbon:

Combustibility of carbon in various kinds of graphite.

Kinds of graphite.	Moisture.	Carbon.	Ash.	Percentage loss upon ignition of the graphite previously freed from volatile matter; calculated on equal weights of carbon (100).				No. of hours elapsing before attaining constant weight of ash.
				1 hour.	2 hours.	3 hours.	4 hours.	
	P. ct.	*P. ct.*	*P. ct.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
Ceylon, of excellent quality	0. 0	97. 5	2. 5	89. 74	96. 16	100	100	3
Ceylon, best quality on the market	7. 5	83. 5	9. 0	71. 85	85. 5	93. 85	99. 68	8
Ceylon, ordinary quality	5. 0	62. 5	32. 5	61. 58	71. 00	80. 83	90. 94	14
Pfaffenreuther, purified	0. 0	85. 0	15. 0	69. 41	80. 58	87. 5	88. 24	10
Pfaffenreuther, freed from ash by means of hydrofluoric acid	0. 0	100	Trace	94. 5	97. 5	100	....	3

According to this table, it appears that the Passau graphite is more refractory than the Ceylon graphite.

It is noticeable that the combustibility of the carbon is considerably diminished by the ash present, so that in judging of the quality of crucibles the proportion of carbon can by no means serve as the only guide.

LITHOGRAPHIC STONE.

Production.—Owing to the fact, as stated in previous reports, that the supply of the best quality of lithographic stone from Bavarian quarries is decreasing with considerable rapidity, and that being largely monopolized in Europe it is less readily obtained in this country, considerable attention has been directed during 1886 to stone obtained from a number of localities in the United States.

Although it cannot be said that as yet any American stone has established itself upon the market as a worthy competitor of the better qualities of Bavarian stone, still there are promising indications that during the current year this may be realized.

According to the most reliable evidence available, the best lithographic stone tested and examined by lithographers during 1886 was taken from a bed situated in Clay and Overton counties, Tennessee. A number of lithographers have subjected samples of this stone to practical tests, and as a result of their experience express themselves as highly pleased with it and in one case it was pronounced superior to any German stone previously used by them. The samples of this stone which have been tested were taken from a projection only 9 inches thick, which yielded some single-faced slabs, the reverse being weather-beaten. The largest slab, 23 by 29 inches, was put in use by a lithographing establishment in December, 1886, and has been in constant use since, giving great satisfaction. None of the stone in Clay and Overton counties, Tennessee, has been thoroughly quarried, the samples obtained having been taken from readily available outcrops and projections and which have in many cases shown imperfections in the way of quartz veins and "specks."

It remains to be seen whether the stone from the deposit above referred to is not in all respects equal to the best German stone, and as a company, headed by Mr. Ira P. Jones, of Nashville, Tennessee, is to be organized during 1887, for the purpose of quarrying this stone, and putting it into the hands of lithographers, it will probably not be long before its quality in the interior of the bed will be known. This stone has the specific gravity 2.73, and appears to be free from quartz granules and iron compounds, and to be homogeneous throughout.

The American Lithographic Stone Company, of Louisville, Kentucky, was organized in the latter part of 1868, for the purpose of operating quarries in Overton county, Tennessee. Only 50 tons were produced in 1886, but the production for 1887 is expected to amount to very much more. Some fine stones were taken out during the year; these were of the various shades, blue, blue-gray, buff, and yellow, and some of them were 48 by 60 inches in area, and of the customary thickness, 3½ to 4 inches.

Lithographic stone from the vicinity of Burnet, Burnet county, Texas, was tested during 1886, and found not to be adapted for fine work, owing to particles of foreign material disseminated through it; further development may, however, bring to light a better product when the deposit is penetrated to a greater depth. It does not, however, seem likely that much will be done during the current year.

A drawback which has thus far presented itself in the development of deposits of lithographic stone in the United States consists in obtaining men sufficiently skilled in quarrying, selecting, and dressing the stone to put it into the hands of the consumers in the best shape.

This difficulty, and also the necessity of penetrating deeply into the deposit to obtain the best quality of stone, are conditions better appreciated at present than they have been in the past, and when they are met in a satisfactory manner a domestic stone fully capable of competing with the foreign will probably be the result.

Foreign stone.—The prices of the best quality of imported stone remain undiminished, averaging about 22 cents per pound, but there has been a falling off of about 10 per cent. in the prices of inferior grades, and they are lower now than ever before.

Imports.—The imports of unengraved lithographic stone during late years have been as follows:

Lithographic stone imported and entered for consumption in the United States, 1868 *to* 1886 *inclusive.*

Fiscal years ending June 30—	Value.	Fiscal years ending June 30—	Value.
1868	$13,258	1878	$42,709
1869	17,044	1879	37,746
1870	14,225	1880	56,310
1871	21,311	1881	77,894
1872	36,146	1882	111,925
1873	44,937	1883	104,313
1874	36,902	1884	128,035
1875	41,963	1885	54,022
1876	47,101	1886	71,009
1877	44,503		

FLUORSPAR.

Localities at which fluorspar is produced.—Fluorspar was produced during 1886 principally at Roseclare, Hardin county, Illinois, and at Weston, Crittenden county, Kentucky, 3,500 tons being produced at the former locality. The mineral also occurs in the Trenton limestone of Boyle, Mercer, Garrard, Jessamine, Fayette, Woodford, Anderson, Franklin, and Henry counties, Kentucky; at Westmoreland, Cheshire county, New Hampshire; in small quantities in Chester county, Pennsylvania; Shepherdstown, Jefferson county, West Virginia. Other localities containing the mineral in small quantities are also known.

Uses.—Fluorspar is used as a flux in melting iron in foundries, and in smelting silver, copper, and lead; this is the most important application of the mineral and requires by far the greatest part of the total production. It is also used in glass works for the purposes of producing opalescent glass; about 400 tons were used for this purpose during 1886; this amount while small, represents an increase over that consumed in 1885, owing to an increase in demand for this kind of glass, the manufacture of which is of quite recent date. The mineral is used in small proportions as a constituent of the glass which when first manufactured is transparent like ordinary glass, but on being reheated and maintained for a time at a temperature near the fusing point becomes opalescent, frequently showing streaks produced by the hottest parts of the flame in which the glass was heated; some very beautiful effects are thus secured. It is also used in glass manufacture as a flux for the purpose of rendering certain more fusible constituents.

Another use for fluorspar is in producing hydrofluoric acid for etching; about 350 tons were used for this and other chemical purposes in 1886.

Production.—The total amount produced during 1886 was about 6,000 short tons, valued at $18,000, or $3 per ton at the mines. There is a tendency toward increase in production; fluorspar as a flux is increasing in popularity, particularly in the melting of stove iron, etc. Very little indeed, if any, is at present imported, domestic production being fully equal to all demand.

Cryolite.—This mineral is used for a number of technical purposes, especially for making alum, also for soda manufacture and in making a white porcelain-like glass. The source of the mineral remains as heretofore reported, Ivigtok, Greenland.

The amount imported in 1885 was 8,502 tons, valued at $113,847; in 1886, 6,866 tons, valued at $91,890.

A new discovery of cryolite in the Yellowstone Park has recently been made, but no particulars in regard to quality or extent are yet available.

Imports of cryolite for the years 1871 to 1886 inclusive.

Years.	Amount.	Value.
	Tons.	
1871	....	$71,058
1872	....	75,195
1873	....	84,226
1874	....	28,118
1875	....	70,472
1876	....	103,530
1877	....	126,692
1878	....	105,884
1879	....	66,042
1880	....	91,366
1881	....	103,529
1882	3,758	51,589
1883	6,508	97,400
1884	7,390	106,029
1885	8,502	113,847
1886	6,866	91,890

MAGNESIUM.

Sources.—The magnesium minerals of greatest importance and interest from the technological standpoint, and from which magnesium itself and its important compounds are either directly or indirectly obtained, are as follows: Magnesite, or carbonate of magnesium, $MgCO_3$; dolomite, a double carbonate of magnesium and calcium, $MgCO_3, CaCO_3$; kieserite, or magnesium sulphate, $MgSO_4 + H_2O$; kainite, $MgSO_4 + K_2SO_4 + MgCl_2 + 6H_2O$; carnallite, $MgCl_2 + KCl + H_2O$. Magnesium sulphate, $MgSO_4 + 7H_2O$, is present in a number of saline springs and the chloride $MgCl_2$ occurs in sea water. The minerals containing magnesium are very widely distributed.

Magnesium itself has thus far been of technical importance because of the bright light emitted when it is burned. This light has been employed for signaling for military and naval purposes and in pyrotechny. The high price of the metal has, however, greatly restricted its use for producing light. The process recently patented by Graetzel for obtaining magnesium by means of electrolysis of the chloride has very considerably reduced the price of magnesium, so that instead of \$40 per pound it may now be purchased for \$10 per pound. The works at which magnesium is thus produced are located in Bremen, Germany, and are known as the "Aluminium und Magnesium Fabrik." This reduction of price is having the effect of stimulating investigation for other practical applications of magnesium both by itself and as a constituent of alloys. It is claimed that the magnesium manufactured according to the Graetzel patent is very pure, and since it contains no alloyed potassium it does not tarnish readily.

Magnesia.—The term magnesia properly applies to the oxide of magnesium, MgO, but is frequently used to designate the carbonate, the oxide being distinguished by the term "calcined" magnesia. In this article the name magnesia will be applied only to the oxide, while the carbonate will be designated as such, or if the natural carbonate is meant the term magnesite will be used.

Magnesia, as such, does not occur pure in nature, but is prepared from other magnesium compounds, particularly for technical purposes from magnesite, which, as already stated, occurs quite frequently, although not often in large deposits.

Uses.—Magnesia is largely used as a medicine. Aside from this purpose, however, the manufacture of the substance is beginning to assume proportions abroad which make it a subject of general interest. The refractory character of magnesia has long been known, but at present its use on account of this property is rapidly advancing. A few years since, investigation to determine the best basic refractory material was actively prosecuted in Germany, and magnesia preheated at the highest white heat was pronounced by Mr. A. Wasum as the best material for basic brick. Magnesite when calcined yields magnesia, which, however, still contains the impurities in the magnesite, an average analysis of which presents the following results:

Analysis of magnesite.

	Per cent.
Lime	1.69
Magnesia	44.88
Silica	.10
Alumina	.84
Protoxide of iron	1.63
Protoxide of manganese	.29
Carbonic acid	50.57
Total	100.00

The presence of silica in magnesite is an objection, because it is liable to have a fluxing effect at the high temperatures reached in steel furnaces.

The waste water of the Stassfurt potash works is utilized as a source of magnesia, there being 372.7 grams of magnesium chloride present in every liter of water. This chloride is heated with burnt dolomite; the following reaction represents the resulting change: $MgCl_2+CaO, MgO =CaCl_2+2MgO$. The precipitated hydrated magnesia is then washed, pressed, and dried. This is known as the Clonan process.

Another method, which has been described by Prof. B. Scheibler, of Berlin, is applicable to dolomite alone; it consists in mixing dolomite previously diffused through water with a weak solution of sugar; heat is applied, expelling carbon dioxide; in a short time soluble saccharate of lime is formed, while the magnesia separates as hydrate, which may be collected by decantation. By decomposing the saccharate of lime, the sugar solution may be obtained for renewed use.

At Aignes-Mortes, a town of France, three miles from the Mediterranean, works have been established for the purpose of producing magnesia from sea water. The process employed is to precipitate magnesia from the chloride and sulphate present in sea water by means of milk of lime. The sea water is pumped into a large masonry tank and the proper quantity of milk of lime is added to it, the regulated flow of both being continuous; the mixture is briskly stirred by horse or steam power agitators. The precipitate is obtained by filtering through sand, after which it is dried in the sun. The finished product is manufactured into magnesia bricks to be used for purposes requiring basic refractory material.

Another method of manufacturing magnesia from the waste liquors of the Stassfurt potash works is that in use by Messrs. Ramdohr, Blumenthal & Co. It consists in heating the chloride by means of an oxidizing flame and simultaneously treating with superheated steam which results in the production of nearly chemically pure magnesia and hydrochloric acid. The product is shipped to Duisberg, where it is manufactured into refractory brick said to be of good quality.

About two years ago a valuable deposit of magnesite was discovered at Styria, Austria. The following is an analysis of the magnesia obtained by calcining the mineral:

Analysis of magnesia from Styrian magnesite.

	Per cent.
Magnesia	86.20
Lime	2.25
Silica	2.50
Oxide of iron	7.63
Oxide of manganese	.72
Carbon dioxide	.70
Total	100.00

The deposits are being actively worked; about 700 tons, it is said, have been shipped to the United States.

Rocky Mountain Division.—Early in the fall of 1886 a small force of men was set to work on the deposits of magnesite discovered on Cedar mountain, Alameda county, California. Since that time several car loads of the mineral have been gotten out and shipped by rail to New York, these deposits being only a few miles from the line of the Central Pacific railroad. The mineral occurs here in a decomposed serpentine rock and in a yellow clay in which are imbedded large bowlders. It lies in pockets and small veins, the latter running in every direction. The richest spots are found under the bowlders, where the mineral is quite pure. A machine is used to sift out the small stones from the powdered magnesite, a good deal of which is met with. A number of veins of this mineral has been exposed by the occurrence of land slides on the side of the mountain where they are situated; only a few of them, however, contain good mineral, nor is there any certainty as to how long these will last. The claims are being opened by tunnels, of which two have been started. The process of gathering this mineral is slow, as every piece has to be cleaned by hand and the whole has to be carefully assorted according to purity. Having been divided into three classes, it is put up in sacks weighing from 80 to 100 pounds each. This sacking is preliminary not only to shipping but to getting it down from the mountains, which can be done only on the backs of animals. While carbonate of magnesia occurs at a great many places in California and elsewhere on the Pacific coast, the above is the only deposit of this mineral that is being worked. An artificial article of this kind is obtained as a by-product in the manufacture of salt by the Union Pacific Salt Company of California.

Kieserite, Epsomite, and Kainite.—Kieserite, $MgSO_4+H_2O$, occurs in considerable quantity at the Stassfurt salt mines, where it is separated on the large scale from other salts with which it occurs. The process of separation employed consists in placing the crude kieserite on sieves in water; magnesium chloride and sodium chloride dissolve while the kieserite falls through the meshes in fine powder, larger pieces of rock salt, anhydrite, and earthy impurities remaining behind. The kieserite powder is then allowed to harden in conical wooden molds, when it is in condition to be exported without further packing.

Epsomite, $MgSO_4+7H_2O$, although it occurs in nature in small quantities, is on account of its scarcity only of scientific interest as a mineral, but the same substance under the name Epsom salts is obtained from solution in sea water and saline springs and is a manufactured product obtained either from kieserite or from other minerals containing magnesium. Kieserite is converted into Epsom salts by mere exposure to the air, when it becomes opaque from the absorption of moisture, which act constitutes the transformation into Epsom salts, although the product must then be crystallized from a hot concentrated solution. Kieserite is also used at Stassfurt for the manufacture of sulphate of soda, which, however, can only be carried on during the winter months when the thermometer is at 0° C. The raw material used in this process is the mixture left after dissolving out the potassium chloride from the raw potash or "carnallite salt" as it is taken from the mines; this mixture has the following percentage composition:

Analysis of mixture.

	Per cent.
Sulphate of magnesia (present as kieserite)	26.8
Common salt	34.2
Chloride of magnesium	9.9
Chloride of potassium	2.1
Sulphate of calcium	8.5
Anhydrite	10.3
Water	8.2
Total	100.0

After this mixture has been exposed in large heaps to the air until the kieserite has been changed by absorption of moisture into the soluble Epsom salts, hot water is allowed so flow over the entire mass and is then led by a channel into a large tank; from the solution thus formed all the sulphate of soda obtainable will crystallize in a single cold night. As much as 10,000 tons of sulphate of soda have been produced at Stassfurt during one winter.

Imports.—The following table shows the amounts and values of magnesium compounds imported during the years 1869 to 1886 inclusive:

Imports of magnesium compounds for the years 1869 *to* 1886 *inclusive.*

Years.	Metallic magnesium.	Magnesia.				Magnesium.			
		Calcined.		Carbonate.		Sulphate.		Acetate.	
	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
		Pounds.		*Pounds.*		*Pounds.*		*Pounds.*	
1869	....	18, 306	$6, 042	114, 654	$13, 546	....	....	....	....
1870	....	24, 904	8, 406	123, 040	12, 382	....	....	....	....
1871	$516	24, 878	7, 881	132, 619	15, 031	85, 582	$1, 168	....	....
1872	....	17, 428	5, 395	102, 669	11, 851	137, 769	1, 631	127	$138
1873	....	20, 006	6, 403	120, 902	12, 904	43, 293	633	39	24
1874	....	12, 988	4, 499	192, 269	20, 138	66, 793	934	....	....
1875	....	22, 251	7, 492	185, 106	17, 543	21, 593	364	346	1, 535
1876	....	8, 936	2, 915	243, 843	27, 910	21, 962	390	2	1
1877	....	22, 196	7, 987	246, 296	27, 642	33, 930	587	....	....
1878	....	14, 154	5, 482	355, 447	38, 726	37, 542	440	....	....
1879	....	19, 535	7, 267	227, 284	25, 816	47, 785	578	....	....
1880	....	13, 826	4, 542	288, 598	30, 350	29, 421	376	....	....
1881	197	20, 815	6, 182	350, 140	35, 232	17, 410	293	....	....
1882	....	20, 826	6, 076	188, 769	21, 107	9, 422	153	....	....
1883	....	14, 228	4, 187	261, 295	27, 149	21, 046	327	....	....
1884	....	16, 728	4, 668	240, 381	25, 207	9, 972	143	....	....
1885	2, 004	10, 971	3, 043	91, 847	9, 505	9, 106	135	....	....
1886	93	12, 647	3, 280	72, 589	6, 836	14, 187	188	....	....

NOTE.—In 1885, 117,037 pounds of magnesite, valued at $577, and in 1886, 1,676,716 pounds, valued at $6,245, were imported.

STRONTIUM.

Occurrence.—The most important minerals containing strontium are celestine or strontium sulphate, and strontianite, or strontium carbonate. Celestine occurs pure or as calcio-celestine, and baryto-celestine according as it contains calcium or barium. It is usually associated with limestone or sandstone of Silurian, Devonian, Jurassic, and other geological formations. It is also found in beds of gypsum, rock salt, and clay, and with sulphur in some volcanic regions. In the United States it occurs in the Trenton limestone around Lake Huron and particularly on Strontian island; also at Kingston, Canada. In New York State it has been found at the following localities: Chaumont bay, Schoharie, Lockport, the Rossie lead mines, Depauville, and Stark. A blue fibrous variety occurs near Frankstown, Huntington county, Pennsylvania, associated with pearl spar and anhydrite. The foreign occurrences are Girgenti, Sicily, where it has been found, with gypsum and sulphur, in fine crystals. At Bex, Switzerland, and Conil, Spain, fine specimens are found; at Dornburg, near Jena, a fibrous variety occurs which is bluish in color. Other occurrences are the department of the Garonne, France; the Tyrol; Retzbauya, Hungary; Nörten, Hanover; at Ischl, Austria, it occurs in rock salt. In England it is found at Aust Ferry, near Bristol; near Tantallan, East Lothian; at the Calton Hill, Edinburgh; near Knaresborough, in Yorkshire; also at Popayan, New Granada.

Strontianite, carbonate of strontium, frequently contains a little lime which takes the place of strontia. In the United States it occurs in the hydraulic limestone at Schoharie, New York, where it is found in crystals as well as in granular and columnar masses, and associated with barite, pyrite, and calcite. At Muscalonga Lake a massive and fibrous variety is found. Chaumont bay and Theresa, in Jefferson county, New York, are other localities. The foreign occurrences are the following: Argyleshire, Scotland; Yorkshire, England; Giant's Causeway, Ireland; Clausthal, in the Harz; Bräunsdorf, Saxony; Leogang, in Saltsburg.

Both of those minerals are sources from which other compounds of strontium are derived. The chloride and nitrate of strontium have long been used in pyrotechnics for the production of a crimson flame. These salts are prepared on the large scale by heating pounded celestite with one-third of its weight of bituminous coal, dissolving the resulting sulphide in water and then treating with nitric or hydrochloric acid to produce, respectively, the nitrate or chloride.

Within the past few years a use for strontium hydrate in the extraction of sugar from beet molasses in Europe has been developed. This use depends upon the fact that when a saturated solution of strontium hydrate is added slightly in excess to beet molasses mono-strontium saccharate, $C_{12}H_{22}O_{11}SrO$, is produced. This compound is only slightly soluble, but when the mixture is first made a clear solution is the result. Crystallization is effected by adding to the solution a certain quantity of the same body in crystals and allowing it to stand for a number of hours, when the crystallization of the whole takes place.

Without going into the details of the whole process of sugar extraction, it will be sufficient to state that the strontium hydrate, after serving its purpose, is converted, by means of carbon dioxide, into strontium carbonate. The carbon dioxide used is derived from strontianite, the ignition of which gives at the same time the necessary hydrate. Any bicarbonate found in the treatment with carbon dioxide is converted into carbonate by heating. The carbonate thus found, after being separated as completely as possible by appropriate means from foreign material, is ready for ignition and consequent reconversion into hydrate.

The natural strontianite has heretofore served as the source of the hydrate, but celestine could be advantageously employed to produce a carbonate purer than the natural strontianite. A complete description of this entire process of beet sugar extraction may be found in *Dingler's Polytechnisches Journal*, vol. 260, page 37.

According to E. O. v. Lippmann and G. Lunge (*Dingler's Journal*, vol. 259, 1886, page 90) after repeated ignition of the carbonate obtained in the above process and extraction of the resulting hydrate, no considerable amount of this body is obtained, the reason being, apparently, that the strontium is no longer present as carbonate, but as silicate, aluminate, sulphate, etc., and is also rendered impure by the presence of lime and oxides of iron and aluminum. These authors recommend treatment of such residue with concentrated hydrochloric acid as free as possible from sulphuric acid. By this means, after cooling, silica is separated and the solution contains chlorides of strontium, calcium, iron, and aluminum. The separated silica is useful for a number of technical purposes.

The strontium chloride contained in this solution may be separated in a number of ways from the other ingredients, and converted by simple processes back into strontium hydrate ready to be used again for sugar extraction. The introduction into the United States of this process, involving the use of strontium compounds, would doubtless act as a stimulus for the production of strontianite and celestine.

The following statement shows the value of the strontium compounds imported in 1885 and 1886:

Imports of strontium compounds in 1885 *and* 1886.

	1885.	1886.
Oxide of strontia and strontianite	$893.00	$512.00

FELDSPAR.

By Wm. C. Day.

Occurrence.—During the year 1886 the deposit of feldspar discovered in 1885 at Embreville, Chester county, Pennsylvania, has been slightly developed and some 200 tons have been quarried, but operations have not yet gone far enough to justify a definite statement in regard to what may be expected from this source in the future, although the outlook is still good.

No further developments of the other new discoveries noted in the last report on feldspar have been made during 1886.

A deposit of orthoclase near La Fayette station, on the Reading railroad, in Montgomery county, Pennsylvania, was opened during the summer of 1886. The mineral is of a light pink color, with an occasional streak of white granular quartz running through it. The bed is about 12 feet wide at the outcrop, and occurs in syenite rock. Twenty-five or thirty tons were quarried when work was discontinued for the winter. Little is yet known in regard to the extent of this deposit, and further developments will have to show its value as a source of feldspar for pottery purposes.

The mica veins of western North Carolina often contain quartz and feldspar of great purity. This material may prove valuable for porcelain manufacture when the conditions of transportation render it possible to market it.

Production.—The following table shows a decided gain for the past year over the three previous years:

Production of feldspar from 1883 *to* 1886.

States.	1883.	1884.	1885.	1886.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*
Maine	3,200	900	2,500	900
Connecticut	6,000	6,000	4,500	7,500
Massachusetts	500	500	1,000	500
New York	500	500	2,000	1,000
Delaware	900	1,000	2,250	2,800
Pennsylvania	3,000	2,000	1,350	2,200
Total	14,100	10,900	13,600	14,900

Value.—Crude feldspar is valued at $5 per long ton in Trenton, New Jersey, and at $7.50 in East Liverpool, Ohio.

Pulverized feldspar is valued at $11 per ton in Trenton, and $13 in East Liverpool.

MINERAL PAINTS.

By Marcus Benjamin.

Under this title it is proposed to describe the principal pigments derived either directly from minerals, such as ocher, umber, sienna, metallic paint, barytes, terra alba, whiting, Paris white, and graphite; or from metals, by various methods of treatment, such as white lead, zinc white, the oxides of lead, vermilion; and also a few independent products of some importance which involve the use of mineral substances in their preparation, such as artificial vermilion and ultramarine.

White lead.—There are at present about thirty-five white lead corroders in the United States, most of whom belong to a combination and manufacture by the so-called Dutch process. The principal firms are located as follows:

Principal manufacturers of white lead.

Boston Lead Company, Boston, Massachusetts.(*a*)
Salem Lead Company, Salem, Massachusetts.
Cornell Lead Company, Buffalo, New York.
Atlantic White Lead Company, New York City.(*a*)
Jewett White Lead Company, New York City.
Brooklyn White Lead Company, New York City.(*a*)
Ulster White Lead Company, New York City.
Union White Lead Manufacturing Company, New York City.(*a*)
Bradley White Lead Company, Brooklyn, New York.(*a*)
John T. Lewis & Brother, Philadelphia, Pennsylvania.(*a*)
The S. P. Wetherill Company, Philadelphia, Pennsylvania.(*a*)
Harrison Brothers & Co., Philadelphia, Pennsylvania.(*a*)
The Davis and Chambers Lead Company, Pittsburgh, Pennsylvania.(*a*)
Beyner, Bauman & Co., Pittsburgh, Pennsylvania.(*a*)
Armstrong & McKelvey, Pittsburgh, Pennsylvania.(*a*)
Pennsylvania White Lead Company, Pittsburgh, Pennsylvania.(*a*)
M. B. Suydam & Brother, Pittsburgh, Pennsylvania.
Fahnestock White Lead Company, Pittsburgh, Pennsylvania.(*a*)
Maryland White Lead Company, Baltimore, Maryland.(*a*)
Saint Louis Lead and Oil Company, Saint Louis, Missouri.(*a*)
Collier White Lead Company, Saint Louis, Missouri.(*a*)
Southern White Lead Company, Saint Louis, Missouri.(*a*)
Kentucky Lead and Oil Company, Louisville, Kentucky.
Josiah Gebhardt & Co., Dayton, Ohio.(*a*)
Eckstein White Lead Company, Cincinnati, Ohio.(*a*)
Anchor White Lead Company, Cincinnati, Ohio.(*a*)
Eagle White Lead Company, Cincinnati, Ohio.
J. H. Morley & Co., Cleveland, Ohio.(*a*)
Acme White Lead Works, Detroit, Michigan.
D. B. Shipman White Lead Company, Chicago, Illinois.
McBirney & Johnson, Chicago, Illinois.
Carter White Lead Company, Omaha, Nebraska.
Whittier, Fuller & Co., San Francisco, California.(*a*)

a Also manufacture lead oxides.

A very close estimate of the output of these works during the year gives 60,000 short tons as the amount produced. Of this quantity one third was manufactured on the Atlantic coast and the remainder inland

and west. The price has advanced to 6 cents per pound for dry and 6¼ to 6¾ cents for white lead ground in oil, owing to the higher cost of pig lead, which has averaged $4.75 in New York and $4.50 in Saint Louis.

The imports for the United States for the fiscal years ending June 30 were as follows:

Imports of white lead, 1885 *and* 1886.

Fiscal years ending June 30.	Pounds.
1885	705,535
1886	755,193

About 80 per cent. of the total is received in New York.

The white lead made in Kremnitz, Hungary, has the reputation of being the finest in the world. As the process used has recently been introduced into this country it is herewith described: The oxide of lead to be used, if in lump, is ground down to a powder. To every hundredweight of lead 10 quarts of No. 24 acetic acid (proof vinegar) are added, with sufficient water to make consistent dough or paste. This is spread upon trays covered with sheet lead, which are set one above another, provision being made for the free admission of gas between each. Carbon dioxide, produced by the combustion of coke, is then admitted to the chamber, the gases being first washed by passing through filters formed of wet scraps of lead, which arrest smut, which would impair the color of the lead. Where sulphur is suspected in the coke the water is impregnated with alkali. The absorption by lead oxide of the carbon dioxide present in the gas is shown by a gradual change of color to white. The work requires from three to six days, during which time the lead is stirred up by means of rakes. When the operation is complete the result is white lead. This is spread in store rooms and allowed to dry, then ground with water in a mill, floated, dried again, and is ready for use. (*a*)

In the "Consular Reports" for February, 1887 (pages 492 to 504), there are valuable articles on the manufacture of white lead in Belgium, the Netherlands, and in Germany. As the processes used in the countries referred to are described in great detail in these papers, it will be well for those interested in the subject to refer to them.

Oxides of lead.—This term includes red lead, or minium, litharge, and orange mineral. These oxides are manufactured largely by the lead corroders previously mentioned, and principally by those designated by (*a*). Red lead and litharge are made by oxidizing pig lead. The simplest process is by roasting the pig lead in furnaces and keeping the mass agitated by means of a rake, thus exposing all the particles to the ac-

a See also "The manufacture of white lead" in *House Painting and Decorating* vol. 1, pp. 79 and 111.

tion of the air. This method is unsatisfactory, as the oxides lack uniformity. An improved process consists in oxidizing the crude material in retorts which are made to revolve over hot furnaces by steam power. The revolution of the retort insures the same agitation as that produced by the rake in the former method, and a very satisfactory degree of uniformity is secured. About 12,000 tons of these two oxides were produced in 1886. The price of red lead was from 6 to 6¼ cents per pound, and the litharge sold at from 5¼ to 5¾ cents per pound. Orange mineral, which is made by heating the carbonate of lead, and thus driving off the carbon dioxide, is a newer product, and one not yet largely manufactured in the United States. It is extensively used in combination with other colors, as an artificial vermilion. The output of this oxide was about 1,000 tons, which sold at from 7½ to 8 cents per pound. The imports were as follows:

Imports of oxides of lead in 1885 *and* 1886.

Fiscal years ending June 30.	1885.	1886.
	Pounds.	*Pounds.*
Red lead	216,449	466,855
Litharge	35,283	23,770
Orange mineral	693,781	1,412,151

During the calendar years 1885 and 1886 the following amounts were received in New York:

Imports of oxides of lead into New York in 1885 *and* 1886.

Calendar years.	1885.	1886.
	Pounds.	*Pounds.*
Red lead	185,363	485,172
Litharge	14,326	46,729
Orange mineral	993,666	1,310,981

Zinc white—The six companies making this pigment have largely increased their output during the year, and a quantity exceeding 18,000 short tons was produced. This advance is due principally to a growing demand for the material, which is the best white color available in the manufacture of liquid or mixed paints where white lead cannot be used. It is estimated that two-thirds of the zinc oxide produced is sold to paint dealers, while the remainder is divided equally among the India-rubber and wall-paper manufacturers. The process of manufacture is exceedingly simple. In the United States the zinc ore is mixed with hard coal, reduced and vaporized by means of heat. A current of air is then passed through this vaporized zinc and white flakes of the oxide result, which are collected in bags. The process used abroad is somewhat different; having no hard coal to mix with the ore, the vapor is obtained directly from bar zinc, or spelter, and freshly prepared oxide is submitted to hydraulic pressure and a considerable amount of heat at the same time. A whiter oxide is the result on account of no coal dust or smoke coming in contact with the pigment during the course of production. In consequence of the increased demand and higher price of labor the value of the pigment was from 3¾ to 4½ cents a pound during the year. The foreign zinc oxide, of which there are three brands, is extensively imported and finds use in the manufacture of the best grades of paints. The most important of these is the French, or Vieille Montagne, and the amount contracted for was 7,000 casks (of 220 pounds each), but the imports probably exceeded this amount by several hundred casks. Three grades of this color are received, and they sell according to quality at from 5½ to 8½ cents a pound. There are two German brands of zinc oxide sent to the United States; of which the "B. and S.," coming in two grades and commanding respectively 5½ and 6½ cents a pound each, was imported to the extent of about 2,500 casks, while the "L. Z. O.," which sells at 5⅝ to 5¾ cents a pound, is imported to the extent of 1,800 casks. The total importation into the United States in 1885 and 1886 was as follows:

Imports of zinc oxide in 1885 *and* 1886.

Fiscal year ending June 30—	Dry.	In oil.
	Pounds.	*Pounds.*
1885	2,233,128	98,566
1886	2,670,019	106,042

Imports of zinc oxide through New York custom-house in 1885 *and* 1886.

Calendar years.	Dry.	In oil.
	Pounds.	*Pounds.*
1885	2,115,849	81,044
1886	2,242,922	60,638

Barytes.—During 1886 Burgess & Newton, of New Haven, Connecticut, imported from Germany about 4,500 long tons of crude barytes, mined principally in the Hartz mountains. Experience has shown that the German ore is softer than that obtained from other localities, and hence easier to work. This fact has led in recent years to its almost exclusive use in manufacturing. The cost of the crude material at New York is from $7 to $8 a ton, and the selling price continues to range from $18.50 to $21.50 a ton delivered in New York. A description of the process of manufacture was given in the "Mineral Resources of the United States, 1885," page 525, and has not changed since then.

Tanner, Bliss & Co., of Lynchburg, Virginia, sell the barytes ground by them, through the south, and also enter the New York market to a certain extent. They obtain the crude material from localities in Virginia and North Carolina. Their quotations in New York are from

$17.50 to $19 a ton, according to quality. An inferior grade of barytes, known as "off color," and used in the adulteration of colored mixed paints, sells at from $12.50 to $14 a ton.

The Page and Krausse Manufacturing and Mining Company, of Saint Louis, Missouri, uses annually about 4,800 tons of barytes, mined in Missouri, which they manufacture into a so-called "floated barytes;" this sells in New York at from $30 to $32 a ton. A full description of the process is given in the "Mineral Resources of the United States, 1885," page 525.

Besides the foregoing there are several smaller firms who grind barytes, but concerning whom no definite information is available.

The most important brand of manufactured barytes that comes to the United States is made from crude ore mined both in the Thuringian forest and the Hartz mountains; after grinding and washing it is sent to this country. During 1886 this firm imported 2,400 casks of manufactured barytes, amounting to about 1,078 short tons, which sold in New York at from $22 to $25 a ton, and all of which, it is believed, was used by paint manufacturers. The imports were as follows:

Imports of barytes in 1885 *and* 1886.

Fiscal years ending June 30—	1885.	1886.
	Pounds.	*Pounds.*
Manufactured barytes	4, 100, 173	4, 019, 280
Crude barytes	9, 622, 822	5, 300, 266

Imports of barytes through New York custom-house in 1885 *and* 1886.

Calendar years.	1885.	1886.
	Pounds.	*Pounds.*
Manufactured barytes	3, 123, 613	3, 118, 006
Crude barytes	8, 569, 006	6, 520, 749

Terra alba.—There has been no change in this article during the year. Two grades of gypsum are imported from the Dominion of Canada, and are worth, for No. 1, from $5 to $7 per ton, and for No. 2, from $3 to $3.50 per ton, and are ground into terra alba by the Phœnix Plaster Mills in New York, and by the Newburgh Plaster Works in Newburgh, New York. The manufactured product sells in New York at from $14 to $15 a ton for No. 1 and $8 to $10 a ton for No. 2. A finer quality of terra alba is imported from France and England, which is quoted in New York at from 70 to 80 cents a pound for the French and from 75 to 80 cents for the English.

Imports of terra alba through New York custom-house in 1885 *and* 1886.

Calendar years.	Pounds.
1885	4, 995, 200
1886	3, 804, 045

Whiting.—The chalk from which whiting is ground is all imported and comes from Hull, England. It is entered at New York and at Philadelphia and the grinders have their mills in these two cities. Four grades of whiting are made, which sell as follows: Common whiting 40 to 45 cents a hundredweight, gilders' whiting 60 to 65 cents, extra gilders' whiting 70 to 75 cents, and American Paris white 80 to 85 cents. Whiting is used to a limited extent in the manufacture of paints, but finds greater demand among makers of calcimine, rubber, wall paper, picture-frame moldings, oil-cloth, and pottery. It is estimated that during 1886 the output was 280,000 barrels of 340 pounds, or 47,600 short tons.

Paris white.—A white substance, similar to whiting, called Paris white, is made by grinding cliffstone, which likewise comes from Hull, England. It is used for the same purposes as whiting, with the exception of picture-frame moldings. The price of this material is slightly lower than last year and is now quoted at from 90 cents to $1.15 a hundredweight. The consumption of Paris white made in the United States from English cliffstone during 1886 is estimated at 10,000 short tons. A certain amount comes direct from England already ground and commands a slightly higher figure.

Imports of Paris white through New York custom-house in 1885 *and* 1886.

Calendar years.	Pounds.
1885	280, 654
1886	109, 623

Ultramarine.—At present there are three factories in the United States producing this pigment, viz: The American Ultramarine Works, in Newark, New Jersey; the Germania Ultramarine Works, in Whitestone, Long Island, and the International Ultramarine Works, in Westfield, Staten Island, New York, with offices in New York City. The plant of the first was destroyed by fire in March, 1885, but has since been rebuilt, and now consists of double buildings, constructed of fireproof material, and so arranged that in the event of any accident occurring in one of the buildings the output in the other will not be interfered with. During 1886 the respective outputs of these works were as follows:

Output of ultramarine works in the United States during 1886.

	Pounds.
American Works	1, 600, 000
Germania Works	950, 000
The International Works (ten months)	448, 000
Total	2, 998, 000

The International Works did not go into operation until February 17, and, like the other factories, it uses crude materials, which are imported, with the exception of a small amount of rosin. Prices remained almost unchanged. A general decline of 10 per cent. in sympathy with other pigments is reported, but the market quotations are from 7 to 25 cents a pound, according to quality. Ultramarine is used chiefly in the manufacture of paints, but it finds extensive sale for calico printing, in paper staining and bleaching, for printers' inks, in sugar refining, for laundry blue, and other less important purposes. According to the official returns for the year ending June 30, the importations were as follows:

Total imports of ultramarine into the United States in 1885 *and* 1886.

Fiscal years ending June 30—	Pounds.
1885	999,128
1886	1,060,547

These imports are principally to New York.

Imports of ultramarine into New York in 1885 *and* 1886.

Calendar years.	Pounds.
1885	1,186,168
1886	747,365

It is claimed by American manufacturers that the cheaper grades of ultramarine used are almost entirely of home production, but that a certain amount of conservatism is still manifested by buyers of the more expensive grades of foreign make, which they use for delicate shades.

A description of the American Ultramarine Works appeared in the *Scientific American* for August 21, 1880, under the title, "American Industries—The Manufacture of Ultramarine," and as "The Ultramarine and Aniline Industries of the United States" in the *Oil, Paint, and Drug Reporter* for February 16, 1887. The International Works is described in the same journal for November 24, 1886, under the heading, "How Ultramarine is Made."

Ocher.—A description of the different grades of ocher, their commercial distinction and general characteristics, was given very fully in "Mineral Resources of the United States, 1885," page 526. The localities at which a good quality of ocher is issued are few. The State of Pennsylvania produces more marketable ocher and of a higher grade than any other State in the Union, while the bulk of the medium ocher comes from Virginia. Following the definition given last year, that the term ocher be applied to the lighter yellow earths containing iron per oxide, we find the discovery reported of an ocher mine near Rutledge, Tennessee; also of deposits in Chilton county, and one near Coosada, Elmore county, Alabama. It is natural to expect in the great developments of the iron industries along the southern portion of the Appalachian chain of mountains that there will be continual discoveries of ocher and mineral paint deposits. Of the medium grade of American ochers, that mined by the Bermuda Ocher Company, in Chesterfield county, Virginia, is the most important. The output during 1886 was but slightly increased, and amounted to 1,000 short tons. There are three grades of this ocher, having a value of $16, $19, and $25 a ton at the mine, to which must be added the freight to the selling point. The Oxford Ocher Company, with deposits at Marksville, Virginia, mined about 750 tons during 1886, which sold at the mine for $15 a ton, and in New York for $20 a ton. The Bethlehem ochers marketed by Henry Erwin continue in steady demand, and an output of upwards of 2,000 short tons is reported. These ochers vary in quality, and have an average value of $10 a ton at the shipping point. Much of the cheaper grades is used by the oil-cloth makers. The "Bonne Fortune" ocher controlled by Mr. Erwin has been found to be one of the best ochers ever discovered in the United States. Upwards of 700 tons have been marketed during 1886, and sold at $40 a ton in New York. Wallace Dunbar, of New York, handles an ocher mined near Easton, Pennsylvania, of which the annual output is about 200 short tons, selling at $15 a ton at the mine and at $17.50 a ton at the selling point. He also controls an ocher coming from near Bethlehem, Pennsylvania, consisting essentially of washings from iron mines, which he sells in the crude condition at $10 to $15 a ton at the mine. The ocher handled during 1885 by the Franco-American Mining and Ocher Company, mined near Morley, Scott county, Missouri, is no longer on the market, and no information concerning this deposit is available. It may well be questioned whether any material from this source was ever sold in New York. The "Peruvian" ocher found near Atlanta, Georgia, was not mined to any extent during 1886, but the recent discovery of excellent grades of this material in the immediate vicinity has led to the reopening of the deposits, and at present (1887) Peruvian ocher is being sold in New York. The Luzerne Ocher Company, owning mines in Luzerne county, Pennsylvania, has an output of 1,500 tons per year of a crude material valued at from $8.50 to $9 a ton, which is principally used by the oil-cloth manufacturers. An excellent grade of medium ocher is mined not very far from San Francisco. Most of it is used by Whittier, Fuller & Co., of that city. It is estimated that during 1886 about 150 tons of this material were marketed, which, after grinding and washing, sold at about $14 a ton in San Francisco. Efforts are being made to put it on the New York market. There is great difficulty in obtaining definite information concerning the ochers mined in the United States, as the material when first discovered promises to rival the imported in quality, but after a few months or years the deposit changes in character and becomes valueless. The foregoing dealers represent the leading ocher companies in the United States, but there is a large amount of ocher used locally concerning which no information is available, and there is also a considerable quantity that goes into consumption among paint-grinders who control small deposits or pockets of ocher, which of themselves are too insignificant to mention.

Imported ocher.—Ochers are mined in France, England, Germany, and Italy, but the preference is given in the United States to that mined in France. There are principally two varieties of French ocher, the "Rochelle" and the "Auxerre." The former is mined near Neuvy sur-Loire, about 100 miles south of Paris, and known in the United States as the "N. M. B." brand. During 1886 there were imported into New York 2,000 casks of 750 pounds each, which sold at the rate of from 1.32½ to 1.35 cents a pound. The "Auxerre" ochers are of three brands: the "J. C. L." (jaune lavé commune), the "J. C. L. S." (jaune lavé commune superfine), and the "J. L. F. S." (jaune lavé fine superfine); of these from 1,200 to 1,500 casks of 700 pounds each were imported during 1886. They range in price as follows: "J. C. L." 2¼ to 2½ cents a pound, "J. C. L. S." 2¼ to 2½ cents a pound, and "J. L. F. S." 3¼ to 3½ cents a pound. Owing to the discovery of fine grades of ocher in the United States there has been a steady diminution in the amount of this variety imported during the last few years. During 1886 there were imported from England by Hemingway & Company, of New York, from 2,500 to 3,000 tons of an oxide of iron, of which two-thirds is used by the paint manufacturers and the remainder is used by the paper trade. It sells at from 1½ to 10 cents a pound, according to fineness and purity. The imports of ocher and ochery earth were as follows:

Imports of ocher and ochery earth in 1885 *and* 1886.

Fiscal years ending June 30—	Dry.	Ground in oil.
	Pounds.	*Pounds.*
1885	5,312,564	79,467
1886	5,413,086	127,757

Imports of ocher through New York custom-house.

Calendar years.	Dry.	Ground.
	Pounds.	*Pounds.*
1885	4,736,870	12,461
1886	4,422,213	368

Concerning French ochers see the article in *House Painting and Decoration* on "Ocher" contained in the October and November issues for 1885.

Metallic paint.—This term is commercially understood to have reference to the brown and darker shades of iron oxide mixed with earth. The opening of a number of new deposits is reported. Of these the deposit at Clifton, Wayne county, Tennessee, is said to be very large. It is further stated to be very pure, oily in its feeling, and resembling Venetian red in color. It is an excellent article for painting tin or sheet iron, as it sticks to tin or iron much better than white lead does. The deposit comprises several millions of tons which can be mined at 50 cents a ton, and it may be ground as easily as soft fireclay. In the vicinity of Birmingham, Jefferson county, Alabama, a deposit has been discovered from which the mineral will be used to manufacture iron paint, and a local company has been organized for this purpose. The Clinton Metallic Paint Company, of Clinton, New York, has come into existence during the year and has established mills for the purpose of using the Clinton iron ore. From Baraboo, Sauk county, Wisconsin, comes the announcement of the discovery of the "only iron paint thus far produced which is absolutely red in color." Other accounts of deposits in Lycoming county, Pennsylvania, in Morris county, on the Raritan river, near Mendham, New Jersey, and in Alexander county, near Cairo, Illinois, are reported, but the accounts are too vague to allow of more than mere mention. Of the large firms mining and manufacturing their own paints we have the following: The Prince Manufacturing Company, of New York, has extended its plant during 1886 by the addition of a new furnace and mill. The company has also opened three new mines near Prince, Carbon county, Pennsylvania. The output for the year was about 2,500 tons of the manufactured pigment, which sells in New York at from $25 to $27.50 a ton. The demand for this paint, which is now a standard article, is steadily on the increase. Rutherford metallic paint is manufactured from a magnetic iron ore mined in the Stony Ridge region of the Lehigh valley, Carbon county, Pennsylvania. The ore is carefully selected, thoroughly and evenly roasted, and then ground to the finest powder by improved machinery. During 1886 there were 2,000 tons of this paint mined, all of which, however, may not have reached the market; it sold in New York at from $25 to $27.50 a ton. The Lowes Metallic Paint Company, of Chattanooga, Tennessee, manufactures a paint from the red iron ore obtained in Tennessee and elsewhere in the South. The product meets with a local demand and it is estimated that the company grinds about 1,000 tons of paint a year. Other firms through the Southwest produce an equal quantity of paint from the fossiliferous iron ore obtained from Tennessee, Georgia, and Alabama. The Iron Clad Paint Company, of Cleveland, Ohio, continues the sale of paints, but no report was received from it concerning the output during the year.

Rocky Mountain vermilion.—During 1886 Messrs. F. W. Devoe & Co. ground about 100 tons of this material into paint; see "Mineral Resources of the United States, 1885," page 531. The crude ore is worth

$20 per ton at the mine, and after transportation and grinding sells in New York at $60 per ton.

Peroxide red.—Under the foregoing name the Nickel Smelting and Peroxide Color Company has recently put a pure iron oxide on the New York market, which, it is claimed, has great body and covering power, and to be equally applicable to surfaces of wood, brick, or canvas, to which it adheres with great tenacity; it is practically indestructible. The crude ore is a nickeliferous pyrite obtained from Rockland county, New York, and has the following composition:

Analysis of nickeliferous pyrite from Rockland county, New York.

	Per cent.
Iron	23.34
Copper	.93
Nickel and cobalt	.37
Sulphur	17.14
Rock	58.22
Total	100.00

This material is transported to Jersey City, where it is smelted in a shaft furnace and the resulting metal is then dissolved, the oxides separated by precipitation and heated to a white heat. By this means not only is the iron oxide obtained, but also the copper, nickel, and cobalt oxides. As yet the condition of the plant is experimental and no definite statistics are available as regards the output, although some 700 tons of the ore were brought to the works during 1886. The prepared pigment, "peroxide red," sells in New York at $100 per ton.

Sienna.—This earth is mined principally near Bethlehem and Easton, Pennsylvania, where some 200 tons were obtained during 1886, having a value in New York of from 1½ to 4 cents per pound. A fine quality of sienna, considered fully equal to the imported, was mined during the past year near Phillipsburg, Warren county, New Jersey, by Henry Erwin. An output of 75 tons of this Bonne Fortune ("B. F.") sienna is reported which readily sold in New York at 4 cents per pound. Later the mine became flooded, so that at present nothing is obtainable from this source. Other deposits are now being developed in New Jersey and from which valuable sienna is obtained, but in small quantities only. The imported article comes chiefly from Italy, and sells in New York at from 4 to 6 cents per pound. The imports were as follows:

Imports of sienna in 1885 and 1886.

Fiscal years ending June 30—	Dry.	Ground in oil.
	Pounds.	*Pounds.*
1885	682,509	....
1886	962,366	8,459

Imports of sienna through New York custom house in 1885 *and* 1886.

Calendar years.	Pounds.
1885	950, 045
1886	840, 862

Umber.—There is very little, if any, umber mined in the United States equal in quality to that imported from Turkey. A few deposits are worked in Pennsylvania and in Vermont, from which an annual output not exceeding 500 tons is obtained. This material is frequently mixed with the imported article and sold as a fine American umber. A new deposit is receiving attention in western Mississippi. The quality is said to be unusually good. The crude native umber sells in New York at from 1 to 1¼ cents a pound, while the imported commands from 1¼ to 4 cents a pound according to quality and condition, lump or ground. The imports were as follows:

Imports of umber in 1885 *and* 1886.

Fiscal years ending June 30—	Dry.	Ground in oil.
	Pounds.	*Pounds.*
1885	1, 198, 060	6, 822
1886	1, 094, 593	200

Slate.—The employment of the ground refuse from slate quarries in the manufacture of paints prevails to a limited extent. So far as known there are but three firms mining this material. The Grafton Paint Company, of Grafton, New York, reports that its output for 1886 was fully 2,000 tons, which sold in Yew York at $10 to $15 per ton according to quality. A large amount of this material is used as a filler for coach bodies and some is exported to England for this purpose. A smaller amount is manufactured into paints. The Plastic Slate and Roofing Company of New York used 500 tons of ground slate during 1886 in the preparation of roofing material; it cost from $10 to $15 per ton laid down in New York. The Indiana Paint and Roofing Company of New York grinds annually about 1,200 tons of refuse slate from Slatington, Pennsylvania, of which 400 tons, worth from $8 to $10 a ton in New York, are used in the manufacture of paints.

Graphite.—The Joseph Dixon Crucible Company reports that 12,000 pounds of graphite were ground by that firm into a black paint during the year, having a value of from 12 to 15 cents a pound according to the quantity purchased. The crude material was mined near Fort Ticonderoga, New York.

Imitation vermilion.—This color has increased in use during the year and is made in many ways, the simplest of which is by simply mixing orange mineral with eosine. A variety of tints may be produced by the addition of other bases until the desired shade is produced. Favorable opinions concerning the comparative permanency of this pigment are expressed by some manufacturers. In price it ranges from 7 to 25 cents per pound.

Vermilion.—The number of firms included in the syndicate manufacturing this pigment was increased to six during the past year, as follows: C. T. Reynolds & Co., D. F. Tieman & Co., Sondheim, Alsberg & Co., A. B. Ansbacher & Co., and Pfeiffer & Lavanburg, of New York, and H. G. Glahn & Co., of Philadelphia. No information concerning the process used in the manufacture of vermilion is available, and while it is said to be very difficult and to require much skill, still the method described on page 296 of the "Mineral Resources of the United States, 1885" may be regarded as correct in a general way. It is stated that $88\frac{1}{18}$ pounds of quicksilver are required to produce 100 pounds of vermilion. During 1886 a condition of affairs similar to that of previous years existed concerning the purchase of quicksilver and dealers continue to buy that which is cheaper at the time being; and in New York the foreign quicksilver is generally lower, although some houses claim that two-thirds of the quicksilver used by them was domestic. The estimated output of American quicksilver vermilion made by the combination during 1886 was 700,000 pounds. From January 1 to June 14 the price was 52 cents a pound, and then until October 1 it was 57 cents, after which it was 60 cents until the end of the year. The value of quicksilver vermilion imported during fiscal years is as follows: 1885, $8,244; 1886, $10,767.28.

The use of the imported article is restricted to the finest class of work. It is reported by certain dealers that there is no call for it at all and they claim superiority for the American vermilion; indeed it is exported to a certain extent by several New York firms.

Prices of vermilion, 1886. (*a*)

	Cents per pound.
Vermilion:	
Imported English	65 to 70.
American quicksilver:	
Bulk	60.
Bags	61 to 67.
Chinese	72 to 77.
Trieste	72 to 77.
American	10½ to 11½.
Artificial	7 to 25.

a Oil, Paint, and Drug Reporter, December 29, 1886.

Literature.—The leading journals that pay special attention to paints in the United States are *The Oil, Paint, and Drug Reporter*, New York; *The Painters' Magazine*, New York; *The Philadelphia Paint and Oil Reporter*, Philadelphia; *House Painting and Decoration*, Philadelphia, and the *Chicago Oil and Paint Review*, Chicago.

MINERAL WATERS.

BY A. C. PEALE.

Contrary to expectation, the returns of mineral waters for 1886 show a slight decrease in the production for the year as compared with 1885. This may, however, be only an apparent reduction. Of the fifty-three springs making no report for 1886, twenty-three reported sales of over a million and a half gallons in 1885. They have been estimated at about one-third of this for 1886. Among them are some of our best known commercial waters, and this estimate is undoubtedly low. If they had all reported for 1886 it is probable that the figures would show an increase, even though we take it for granted that many of them had decreased sales in 1886, and for that reason have not reported. The imports of artificial mineral waters have increased largely, while those of natural mineral waters have decreased, leaving the total importation a little below that of the previous year.

Alabama.—The number of mineral waters of Alabama that are used commercially remains the same for 1886 as it was in 1885, viz, six, of which five sent returns showing little change in the figures of the preceding year. The springs reporting are: Bailey springs, Bailey Springs, Lauderdale county; Bladen springs, Bladen Springs, Choctaw county; Cullum springs, Bladen Springs, Choctaw county; Healing springs, Healing Springs, Washington county; White Sulphur springs, Sulphur Springs, De Kalb county.

Arkansas.—The five commercial waters of Arkansas have slightly increased in their production and total value in 1886. They are: Dovepark springs, Dovepark, Clark county; Eureka springs, Eureka Springs, Carroll county; Fairchild's potash sulphur springs, Potash Sulphur, Garland county; Mountain Valley springs, Mountain Valley, Garland county; Siloam springs, Siloam Springs, Benton county.

California.—The number of commercial waters for California was nine during 1886, a decrease of one from the preceding year.

Of these eight have sent reports showing an increase in production and value. The springs reporting are: Azule mineral spring, San José, Santa Clara county; Castalian mineral water, Olancha, Inyo county; El Paso de Robles springs, Paso Robles, San Luis Obispo county; Geyser soda spring, Litton's Station, Sonoma county; Litton's seltzer spring, Litton's Station, Sonoma county; Napa soda springs, Napa Soda Springs, Napa county; Pacific Congress springs, Saratoga, Santa Clara county; Tolenas soda springs, near Suisun City, Solano county.

Colorado.—Both of Colorado's commercial waters are included in the returns for 1886, and with largely increased sales. The springs are:

Manitou springs, Manitou Springs, El Paso county; Springdale seltzer springs, Springdale, Boulder county.

Connecticut.—The two springs on the list for Connecticut for 1885 increased to five for 1886. All have sent reports, and there is a large increase in the number of gallons sold, and consequently also in the value of the production. The springs reporting are: Aspinock mineral spring, Putnam Heights, Windham county; Bozrah mineral spring, Bozrah, New London county; Oxford mineral spring, Oxford, New Haven county; Highland Rock spring, Highland, Hartford county; Highland Tonica spring, Highland, Hartford county.

Georgia.—Only one spring reports the sale of waters, viz.: Ponce de Leon spring, Atlanta, Fulton county.

Illinois.—All of the Illinois springs reported for 1886. The total production was more than twice that of 1885. The springs reporting are: Alcyone spring, Western Springs, Cook county; Glen Flora mineral springs, Waukegan, Lake county; Perry springs, Perry Springs, Pike county; Zonian springs, near Elgin, Kane county.

Indiana.—Two of Indiana's springs sent no returns for 1886. The figures, however, are slightly in excess of those of 1885. The following springs reported: French Lick springs, French Lick, Orange county; King's mineral springs, Muddy Fork, Clark county; New Point Comfort springs, Blue Lick, Clark county; West Baden springs, West Baden, Orange county.

Iowa.—Although three springs reported for 1886, as in 1885, there was a falling off in the total number of gallons sold. The springs reporting are: Colfax springs, Colfax, Jasper county; Dunbar's mineral springs, College Springs, Page county; Ottumwa mineral springs, Ottumwa, Wapello county.

Kansas.—Four of the Kansas mineral springs reported sales for 1886, and one of those giving figures in 1885 now reports the water as being free. The following gave figures for 1886: Geuda springs, Geuda Springs, Sumner county; Iola mineral well, Iola, Allen county; Kansas artesian mineral wells, Manhattan, Riley county; Topeka mineral wells, Topeka, Shawnee county.

Kentucky.—Only three springs reported their sales for 1886, viz.: Grayson springs, Grayson Springs, Grayson county; Lower Blue Lick springs, Blue Lick Springs, Nicholas county; Upper Blue Lick springs, Davidson, Nicholas county.

Maine.—Only five of Maine's eleven springs sent statistics for 1886, they are: Addison mineral spring, Addison Point, Washington county; Auburn mineral spring, Auburn, Androscoggin county; Hartford cold spring, Hartford, Oxford county; Poland springs, South Poland, Androscoggin county; Scarborough mineral spring, Scarborough, Cumberland county.

Maryland.—The only mineral spring in Maryland reporting sales of water is the Maryland strontia spring, Brooklandville, Baltimore county.

Massachusetts.—The number of mineral waters of Massachusetts used commercially has increased from seven to eight. Of these, six sent in reports for 1886. They are: Allandale mineral spring, West Roxbury, Suffolk county; Berkshire soda springs, Sheffield, Berkshire county; Commonwealth mineral spring, Waltham, Middlesex county; Crystal mineral spring, Stoneham, Middlesex county; Echo Grove mineral spring, Lynn, Essex county; Everett crystal spring, Everett, Middlesex county.

Michigan.—Two springs report sales for 1886, viz.: Mount Clemens mineral spring, Mount Clemens, Macomb county; Ypsilanti mineral spring, Ypsilanti, Washtenaw county.

Minnesota.—The only spring reporting sales of water is Inglewood spring, Minneapolis, Hennepin county.

Mississippi.—All of Mississippi's commercial waters are represented in the returns for 1886. The springs reporting are: Castalian springs, Durant, Holmes county; Chalybeate acid springs, Grenada, Grenada county; Cooper's well, Raymond, Hinds county; Godbold mineral well, Summit, Pike county.

Missouri.—Four springs have reported their sales for 1886. They are: Eldorado springs, Eldorado Springs, Cedar county; Mooresville mineral springs, Mooresville, Livingston county; Randolph medical springs, Randolph, Randolph county; Reiger springs, Mercer county (post-office address, Lineville, Wayne county, Iowa).

New Hampshire.—All of the springs have reported for 1886. They are: Birchdale medical springs, Concord, Merrimack county; Bradford mineral springs, Bradford, Merrimack county; Milford (or Ponemah) springs, Milford, Hillsborough county; Moultonborough mineral springs, Moultonborough, Carroll county; White Mountain mineral spring, Conway, Carroll county.

New Mexico has but one mineral spring that reported sales for 1886. It is Joseph's hot springs (Ojo Caliente), Ojo Caliente, Rio Arriba county.

New York.—Only about half of New York's commercial waters are represented in our figures for 1886. They include the following springs: Adirondack spring, Whitehall, Washington county; Avon springs, Avon, Livingston county; Ballston Artesian Lithia spring, Ballston, Saratoga county; Ballston Washington Lithia well, Ballston, Saratoga county; Deep Rock spring, Oswego, Oswego county; Massena springs, Massena, Saint Lawrence county; Nunda mineral spring, Nunda, Livingston county; Saratoga Carlsbad spring, Saratoga Springs, Saratoga county; Saratoga Champion spouting spring, Saratoga Springs, Saratoga county; Saratoga Excelsior spring, Saratoga Springs, Saratoga county; Saratoga High Rock spring, Saratoga Springs, Saratoga county; Saratoga New Putnam spring, Saratoga Springs, Saratoga county; Saratoga Star spring, Saratoga Springs, Saratoga county; Saratoga Union spring, Saratoga Springs, Saratoga county; Saratoga Vichy spring, Saratoga Springs, Saratoga county; Sharon white sulphur springs, Sharon Springs, Schoharie county; Slaterville Magnetic springs, Slaterville, Tompkins county; Verona springs, Verona, Oneida county; Victor mineral spring, Darien Centre, Genesee county.

North Carolina.—One new spring is added to the North Carolina list, making a total of eight. Of these seven reported for 1886. They are: All Healing springs, All Healing, Gaston county; Leinster Poison springs, Statesville, Iredell county; Panacea springs, Panacea Springs, Halifax county; Park's Alkaline springs, Caswell county (postoffice address, Danville, Virginia); Seven springs, Seven Springs, Wayne county; Thompson's Bromine Arsenic springs, Seven Mile Ford, Smyth county, Virginia.

Ohio.—Six of Ohio's seven commercial waters are included in the figures for 1886. They show an increase over the reports for 1885. The springs making returns are: Bellbrook magnetic springs, Bellbrook, Greene county; Electro-magnetic springs, (Fountain Park,) Woodstock, Champaign county; Green spring, Green Spring, Seneca county; Lea-a-pe Magnetic springs, Delaware, Delaware county; Ohio Magnetic springs, Magnetic Springs, Union county; Wyandot Magnetic springs, Upper Sandusky, Wyandot county.

Oregon.—The waters of two of Oregon's mineral springs were on sale during 1886, and both have reported. They are: McCallister's soda springs, 35 miles east of Jacksonville, Jackson county; Wilhoit springs, Wilhoit, Clackamas county.

Pennsylvania.—Only three of Pennsylvania's commercial mineral waters are represented in our statistics of 1886. They are: Black Barren mineral springs, Pleasant Grove, Lancaster county; Blossburg chalybeate springs, Blossburg, Tioga county; Minnequa springs, Minnequa, Bradford county.

Rhode Island.—Both of the Rhode Island springs sent reports for 1886. They are: Holly spring, Woonsocket, Providence county; Ochee mineral springs, Providence, Providence county.

South Carolina.—There is a slight increase in the figures given by South Carolina's springs. The springs reporting are: Chick's springs, Chick's Springs, Greenville county; Garrett's spring, Spartanburgh, Spartanburgh county; Glenn springs, Spartanburgh, Spartanburgh county.

Tennessee.—Reports have been received from six springs, the figures showing a slight increase for 1886. The following springs are represented in the statistics: Horn's mineral spring, Lebanon, Wilson county; Hurricane springs, Tullahoma, Coffee county; Idaho springs, near Clarksville, Montgomery county; Red boiling springs, Red Boiling Springs, Macon county; Rhea springs, Rhea Springs, Rhea county. Tate spring, Tate Springs, Grainger county.

Texas.—Seven springs have reported for 1886, showing an increase in the production over that of 1885. The following springs have sent returns, viz: Hynson's Iron Mountain springs, Marshall, Harrison county; Lampasas springs, Lampasas, Lampasas county; Mineral wells, Mineral Wells, Palo Pinto county; Sour lake, Sour Lake, Hardin county; Crabtree sour wells, Sulphur, Hopkins county; Texas sour springs, Luling, Caldwell county; Wootan wells, Wootan Wells, Robertson county.

Vermont.—Three of Vermont's springs included in the lists of previous years now report the water as free at the springs. Four springs give the figures of sales for 1886, showing an increase over 1885. They are: Alburgh springs, Alburgh Springs, Grand Isle county; Brunswick white sulphur spring, Brunswick, Essex county; Clarendon springs, Clarendon Springs, Rutland county; Elgin spring, Panton (P. O. Vergennes), Addison county.

Virginia.—Three new commercial waters have been added to the Virginia list since 1885. Twenty springs have reported for 1886, showing a slight increase in the totals for those springs as compared with the returns for 1885. The springs reporting are: Alleghany springs, Alleghany Spring, Montgomery county; Bath alum springs, Bath Alum, Bath county; Bear lithia springs, Elkton, Rockingham county; Belmont lithia springs, near White House Station, New Kent county; Blue Ridge springs, Blue Ridge Springs, Botetourt county; Chase City mineral water, Chase City, Mecklenburgh county; Cold sulphur springs, Goshen Bridge, Rockbridge county; Farmville lithia springs, Farmville, Prince Edward county; Healing springs, Healing Springs, Bath county; Hunter's Pulaski alum spring, Dublin, Pulaski county; Jordan white sulphur springs, Stephenson, Frederick county; Massanetta springs, Harrisonburgh, Rockingham county; Powhatan lithia and alum springs, Ballsville, Powhatan county; Rawley springs, Rawley Springs, Rockingham county; Rock Enon springs, Rock Enon Springs, Frederick county; Rockingham springs, Rockingham, Rockingham county; Seven springs, Abingdon, Washington county; Shenandoah alum springs, Shenandoah Alum Springs, Shenandoah county; Wallawhatoola alum springs, Millboro Depot, Bath county; Wolf Trap lithia springs, Wolf Trap, Halifax county.

Washington Territory.—The water of Medical lake, in Spokane county, still remains the only mineral water of the Territory that is on sale. The returns made include the equivalent in gallons of the condensed salts obtained upon evaporation of the water.

West Virginia.—All of West Virginia's localities reported for 1886, but with a slight decrease in the total production for the whole State. The Springs reporting are: Capon springs, Capon Springs, Hampshire county; Greenbrier white sulphur springs, White Sulphur Springs, Greenbrier county; Irondale springs, Raccoon, Preston county; Mineral wells, Parkersburgh, Wood county; Red sulphur springs, Red Sulphur Springs, Monroe county; Salt sulphur springs, Salt Sulphur Springs, Monroe county.

Wisconsin.—The number of mineral waters of Wisconsin used commercially has increased by one for 1886. Only four of the springs have not reported. Those sending returns for 1886 are as follows: Arcadian mineral spring, Waukesha, Waukesha county; Bethesda mineral spring, Waukesha, Waukesha county; Black Earth mineral spring, Black Earth, Dane county; Gihon mineral spring, Delavan, Walworth county; Glenn spring, Waukesha, Waukesha county; Horeb mineral spring, Waukesha, Waukesha county; Mineral rock spring, Waukesha, Waukesha county; Shealtiel mineral springs, Waupaca, Waupaca county; Sheboygan natural mineral water, Sheboygan, Sheboygan county; Siloam mineral spring, Waukesha, Waukesha county; Saint Croix mineral spring, East Farmington, Polk county; White Rock mineral spring, Waukesha, Waukesha county.

Summary of reports of mineral springs for 1886.

	Springs reporting.	Springs not reporting.	Total used commercially.		Springs reporting.	Springs not reporting.	Total used commercially.
North Atlantic States:				Northern Central States:			
Maine	5	6	11	Ohio	6	1	7
New Hampshire	5	0	5	Indiana	4	2	6
Vermont	4	2	6	Illinois	4	0	4
Massachusetts	6	2	8	Michigan	2	0	2
Rhode Island	2	0	2	Wisconsin	12	4	16
Connecticut	5	0	5	Minnesota	1	0	1
New York	19	14	33	Iowa	3	2	5
New Jersey	0	0	0	Missouri	4	2	6
Pennsylvania	3	2	5	Dakota	0	0	0
South Atlantic States:				Nebraska	0	0	0
Delaware	0	0	0	Kansas	4	1	5
Maryland	1	0	1	Western States and Territories:			
District of Columbia	0	0	0				
Virginia	20	4	24	Alaska	0	0	0
West Virginia	6	0	6	Wyoming	0	0	0
North Carolina	7	1	8	Montana	0	0	0
South Carolina	3	0	3	Colorado	2	0	2
Georgia	1	2	3	New Mexico	1	0	1
Florida	0	0	0	Arizona	0	0	0
Southern Central States:				Utah	0	0	0
Kentucky	4	2	6	Nevada	0	0	0
Tennessee	6	2	8	Idaho	0	0	0
Alabama	5	1	6	Washington	1	0	1
Mississippi	4	0	4	Oregon	2	0	2
Louisiana	0	0	0	California	8	1	9
Texas	7	2	9				
Indian Territory	0	0	0	Total	172	53	225
Arkansas	5	0	5				

PRODUCTION.

Natural mineral waters sold in 1884, 1885, *and* 1886.

	Springs reporting in 1884.	1884.		Springs reporting in 1885.	1885.		Springs reporting in 1886.	1886.	
		Gallons sold.	Value.		Gallons sold.	Value.		Gallons sold.	Value.
North Atlantic States	38	3, 345, 760	$328, 125	51	2, 527, 310	$192, 605	49	2, 715, 050	$177, 969
South Atlantic States	27	464, 718	103, 191	32	908, 692	237, 153	38	720, 397	123, 517
Northern Central States	37	2, 070, 533	420, 515	45	2, 925, 288	446, 211	40	2, 048, 914	401, 861
Southern Central States	21	1, 526, 817	147, 112	31	540, 436	74, 100	31	822, 016	58, 222
Western States and Territories	6	307, 500	85, 200	10	509, 675	86, 776	14	781, 540	137, 796
	129	7, 715, 328	1, 084, 143	169	7, 411, 401	1, 036, 845	172	7, 087, 917	899, 365
Estimated	60	2, 500, 000	375, 000	55	1, 737, 000	276, 000	53	1, 862, 400	384, 705
Total	189	10, 215, 328	1, 459, 143	224	9, 148, 401	1, 312, 845	225	8, 950, 317	1, 284, 070

IMPORTS.

Mineral waters imported and entered for consumption in the United States, 1867 *to* 1883 *inclusive.*

Fiscal years ending June 30—	In bottles of 1 quart or less.		In bottles in excess of 1 quart.		Not in bottles.		All, not artificial.		Total.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Bottles.		*Quarts.*		*Gallons.*		*Gallons.*		
1867	370, 610	$24, 913	3, 792	$360		$137			$25, 410
1868	241, 702	18, 438	22, 819	2, 052	554	104			20, 594
1869	344, 691	25, 635	9, 739	802	1, 042	245			26, 682
1870	433, 212	30, 680	18, 025	1, 743	2, 063	508			32, 931
1871	470, 947	34, 604	2, 320	174	1, 336	141			34, 919
1872	892, 913	67, 951			639	116			68, 067
1873	35, 508	2, 326			355	75	394, 423	$98, 151	100, 552
1874	7, 238	691			95	16	199, 035	79, 789	80, 496
1875	4, 174	471			5	2	395, 956	101, 640	102, 113
1876	25, 758	1, 899					447, 646	134, 889	136, 788
1877	12, 965	1, 328				22	520, 751	167, 458	168, 808
1878	8, 229	815					883, 674	350, 912	351, 727
1879	28, 440	2, 352			3	4	798, 107	282, 153	284, 509
1880	207, 554	19, 731					927, 759	285, 798	305, 529
1881	150, 326	11, 850			55	26	1, 225, 462	383, 616	395, 492
1882	152, 277	17, 010					1, 542, 905	410, 105	427, 115
1883	88, 497	7, 054					1, 714, 085	441, 439	448, 493

It appears from the foregoing table that previous to 1873 natural mineral waters were not distinguished from the artificial waters. Since 1884 the artificial waters have not been classified according to the receptacles in which they have been imported.

Imports for the fiscal years 1884, 1885, *and* 1886.

	1884.		1885.		1886.	
	Gallons.	Value.	Gallons.	Value.	Gallons.	Value.
Artificial mineral waters	29, 366	$4, 591	7, 972	$2, 157	63, 134	$16, 903
Natural mineral waters	1, 505, 298	362, 651	1, 660, 072	397, 875	1, 521, 642	358, 595
Total	1, 534, 664	367, 242	1, 668, 044	400, 032	1, 584, 776	375, 498

EXPORTS.

Exports of natural mineral waters, of domestic production, from the United States.

Fiscal years ending June 30—	Value.	Fiscal years ending June 30—	Value.
1875	$162	1881	$1, 029
1876	80	1882	421
1879	1, 529	1883	459
1880	1, 486	1884, 1885, and 1886	None.

The amount of artificial mineral waters exported is also trifling.

MINING LAW.

By E. R. L. Gould.

The subject of mining law has been treated in Vol. XIV. of the Tenth Census, but the regulations there quoted are mainly federal and territorial. Not much attention is given to the enactments of States lying to the east of the Mississippi. The object of the present sketch is to deal only with this ground, giving a brief topical analysis of leading provisions. The Revised Statutes of the various States have been the principal sources of information, though, where possible, subsequent enactments have also been quoted.

MINING CORPORATIONS.

In some States, Pennsylvania, Michigan, and Tennessee, for example, mining companies have been made the subjects of distinct legislation, but, in the great majority of cases, their organization and conduct are governed by the same rules as those prescribed for manufacturing and kindred corporations.

ORGANIZATION.

The general method of organization is for three or more persons to draw up articles of association, stating the names and residences of the incorporators, the amount, number of shares, and conditions for payment of capital stock, the kind of business to be done, the place of business, the number of directors or trustees, and the length of the period during which the corporation is to have succession. These articles, when properly acknowledged and filed with the recorder of deeds, clerk of the town, or clerk of the county court, in the county where the business is done, and in the office of the secretary of State, constitute an organization under general law. There are, however, exceptions to this general rule. The minimum number of persons who may associate is two in Alabama, five in Tennessee, New Hampshire, Virginia, Pennsylvania, and Maryland, six in Louisiana, and not limited at all in Florida and Kentucky. In South Carolina the incorporators make out an application for a charter, giving all essential facts, and file it with the clerk of the county court for his ratification. The applicants must give thirty days' notice, and if, within ten days, fifty persons in the county who may be affected or interested shall, in writing, object to the granting of the same, the clerk, if he deems the ground sufficient, shall refuse to give the charter until the judge of the circuit shall have passed upon the merits of the case. If application for a charter is made to the general assembly, ninety days' notice is required.

Publication of the articles of association in some newspaper in the county, or convenient to the locality where the business is carried on, is enjoined by the laws of Vermont, Connecticut, Kentucky, Louisiana, and Florida. In the first two States mentioned no definite period of time is prescribed, the third specifies three weeks, and the fourth and fifth each one month.

In Maine and Pennsylvania the organization certificate must be submitted to the attorney-general for examination, to ascertain if all the requirements of State law have been fulfilled, before the charter is granted. In Massachusetts this office is performed by the commissioner of corporations, and in Maryland and Virginia by the judge of a circuit court.

DURATION OF CORPORATIONS.

The succession of corporations is limited in the following States: In Florida and Pennsylvania, to twenty years; in Louisiana and Kentucky, to twenty-five years; in Michigan and Virginia, to thirty years; in Maryland, to forty years; in Indiana, New York, and New Jersey, to fifty years; in North Carolina, to sixty years; in Illinois, to ninety-nine years.

LIMITS OF CAPITAL STOCK.

The amount of capital stock of corporations is limited as follows:

Limits of capital stock of corporations in States where provided for.

States.	Minimum.	Maximum.
New Jersey	$2,000	....
Vermont	500	$500,000
New Hampshire	1,000	1,000,000
Maine	1,000	2,000,000
South Carolina	5,000	3,000,000
Michigan	10,000	2,500,000
Pennsylvania	....	500,000
Maryland	....	3,000,000
Virginia	5,000	(a)

a Not more than twenty times the minimum.

In Florida and West Virginia 10 per cent. of the capital stock must be paid up; in Alabama and Wisconsin, 50 per cent. must be subscribed and 20 per cent. paid in; in Vermont and New Jersey, 50 per cent. paid in, and in Illinois the capital stock must be fully subscribed before certificates permitting the commencement of business are issued.

Pennsylvania and Illinois fix the maximum par value of shares at $10, Indiana at $50, Florida and Vermont at $100, and Connecticut at $25 if the capital does not exceed $3,000, if more, at $25, $50, or $100.

The minimum value of shares is placed at $10 in Virginia, $50 in New Hampshire and North Carolina, and $100 in Illinois.

REAL ESTATE OF CORPORATIONS.

The laws of most of the States limit the amount of real estate which corporations may hold by the very general restrictions, "as much as may be necessary for the carrying on of their business." In a few cases, however, a specific limit is set. Michigan allows no corporation to hold more than 50,000 acres of land. In Maryland a mining company is restricted to the possession of 1,000 acres at one time in Alleghany county, or 500 in any other county. In West Virginia companies established for the purpose of mining and manufacturing lead, iron, or copper ore may possess themselves of 10,000 acres for each charcoal blast furnace, and 3,000 acres for every other furnace. Coal mining companies may hold 10,000 acres each, and salt, oil, or other mining corporations 3,000 acres. Massachusetts places the limit of real estate to be held at three-fourths of the capital stock in value.

Corporations are also authorized to lay out towns in West Virginia and Tennessee. In the former State they cannot exceed 640 acres each in extent. They may govern these communities until they are large enough for municipal organization. Virginia and Pennsylvania both require that the amount of real estate which a mining company proposes to hold shall be stated in the application for a charter.

In Illinois if real estate, such as is not useful for business, is acquired to offset indebtedness, it must be offered for sale at least as often as once a year, and sold when the sum offered is sufficient to cover the amount of the debt and the expenses incurred. If this is not done within five years from the date of acquisition, the State's attorney must enforce the law. The annual report of the corporation must state the amount of real estate acquired in this manner. In New Hampshire real estate acquired for indebtedness must be sold within two years after.

DIRECTORS.

The minimum number of directors required for a corporation is 3 in Maine, Vermont, Massachusetts, Connecticut, New York, New Jersey, Alabama, Florida, Indiana, Michigan, Wisconsin; 4 in Maryland, and 5 in South Carolina. A maximum of 9 is fixed by New York, Michigan, and Alabama, of 11 by Indiana, and 12 by Maryland.

The directors are in all cases required to be stockholders. In Maryland all of them must be citizens of the United States or unnaturalized residents who have made formal declaration of intention to become citizens, and a majority of them citizens of the State; in New York all of them must be citizens of the United States and a majority citizens of the State; in Ohio a majority must be citizens of the United States; in Indiana and West Virginia all must be residents of the United States;

and in New Hampshire, Vermont, and Michigan at least one director must be an actual inhabitant of the State.

LIABILITY OF DIRECTORS.

Many of the States in question have stringent laws under this head. If dividends are declared when a corporation is insolvent, or which would render it insolvent, directors are liable in Massachusetts, New York, New Jersey, West Virginia, South Carolina, Tennessee, and Illinois for an amount equal to the dividend, and in Vermont, Connecticut, Maryland, Indiana, and Wisconsin for all existing debts.

If a dividend is paid out of the capital stock the laws of Illinois make directors responsible for all existing debts and all others contracted thereafter during their term of office; those of New Jersey to the amount of the dividend, while those of Maine decree as a penalty a fine not exceeding \$10,000 and imprisonment for not less than one year.

Directors are forbidden to make loans to stockholders and are made liable for the amount of the loan in New Hampshire and Tennessee, to double its amount in Maryland, and for all debts contracted between the time of making and the time of repayment of the loan in Massachusetts and New York.

Directors are forbidden to contract indebtedness in excess of the capital stock, and are made liable if they do in Massachusetts, New York, Pennsylvania, Illinois, and Tennessee. In Vermont directors may not contract indebtedness in excess of two-thirds of the capital stock paid in; in New Hampshire in excess of one-half of the capital stock paid in and unimpaired, and the other property and assets.

If any part of the capital stock of a corporation is withdrawn or refunded so that insufficient would then be left to pay the debts, directors are jointly and severally liable under the laws of New Hampshire and New Jersey.

Directors signing any statement knowing it to be false are liable by the laws of Massachusetts, New York, Indiana, Illinois, and Tennessee for the damages caused thereby. Intentional fraud or failure to observe corporation law is punished by a fine from \$100 to \$1,000 or imprisonment from three to twelve months in Kentucky, and the participation of the directors as a board in any fraudulent statement involves the forfeiture of the charter in Tennessee. If directors intentionally neglect or evade the law they are made responsible by the statutes of Connecticut, New York, and Indiana for all debts contracted during that time.

LIABILITY OF STOCKHOLDERS.

The laws of Alabama, Louisiana, Kentucky, Indiana, Illinois, Pennsylvania, and New Jersey make stockholders liable only for the amounts unpaid on their capital stock. In Florida, Georgia, Virginia, Massachusetts, Maine, and Wisconsin the liability extends to the amount of capital stock held. In New York, Vermont, New Hampshire, and Maryland stockholders are liable to the amount of their capital stock until it has been fully paid in. The statutes of Ohio and West Virginia are more strict, and ordain that stockholders are liable for an amount equal to the capital stock held or subscribed in addition to such stock. Massachusetts summarizes the liabilities of stockholders under the four following heads:

1. For debts contracted before the original capital is fully paid in.
2. For payment of all debts existing at the time when capital is reduced or withdrawn, to the extent of such reduction or withdrawal.
3. When special stock is created, the general stockholders are liable for all debts contracted until the special stock is fully redeemed.
4. For sums of money due to employés for services rendered within six months previously.

New York, Michigan, and Tennessee also make stockholders personally and ratably liable for services rendered to a corporation by its salaried officers and employés. In Kentucky the charter of incorporation is made to state whether or not the private property of stockholders is exempt from corporation debts.

LIENS.

Corporation employés in Maine have a prior lien upon mining products for services performed within thirty days immediately preceding. Massachusetts gives them also a first lien for a sum not exceeding $100 each for services performed within a year, and Pennsylvania for an amount not more than $200 for services rendered during six months previously. Illinois and New Jersey give to wages a first lien without placing any limit, in case a corporation becomes insolvent. Wisconsin makes stockholders personally liable for the amount due for services performed during six months preceding, and West Virginia a prior lien on the real and personal estate of corporations to the extent of nine months' services. Tennessee grants a lien for wages, but subordinates it to valid liens existing at the time proceedings are begun.

FOREIGN CORPORATIONS.

Most of the States concede the same privileges to foreign as to domestic corporations. In Michigan, previous to 1871, a foreign mining corporation was restricted to a holding of 6,000 acres of land. In Indiana a foreign corporation must file with the clerk of the county court in the county where the business is done, an order from the board of directors authorizing citizens or residents of the State having any claims against it to sue within the State, and an agreement to acknowledge service on its agent as valid. Non-compliance with these conditions brings about the forfeiture of the privileges.

Georgia recognizes the corporations of those States which extend comity to its companies in their courts.

CONSOLIDATION OF CORPORATIONS.

New York, Pennsylvania, and Alabama permit the consolidation of corporations without restriction; Ohio when the consent of two-thirds, Michigan of three-fifths, of the stock of these companies is obtained. Illinois only allows corporations doing like business to consolidate, and further restricts the number which may unite to two.

REPORTS.

Reports are always required from corporations where the capital stock is taxed, but in many States further publicity is given to their affairs, for the benefit of stockholders and the public.

Massachusetts requires an annual report to the commissioner of corporations, which is afterward filed with the secretary of State. If any company fails to do this for two consecutive years, it is *ipso facto* dissolved. The penalty for non-compliance is the same in Connecticut. In New Hampshire, an annual report, making a full exposition of all business affairs of the company, must be made to the town clerk and filed with the secretary of State. The report must also be published in some newspaper at Concord. Neglect to make the yearly statement involves the directors in responsibility for all debts. In New York, an annual report of business affairs must be published in a newspaper and filed with the clerk of the county court; neglect to do so involves the trustees in liability for all debts contracted before it is made. Indiana and Tennessee require the publication of the annual report in some convenient newspaper, and Florida likewise, except that semi-annual publication is obligatory. Wisconsin and Maryland ordain an annual report for the benefit of stockholders, and this is recorded at the principal place of business within the States. By the laws of Virginia, a corporation must exhibit its books and property whenever called upon to do so by an agent appointed by the State legislature. In Michigan, the yearly statement assumes a somewhat more comprehensive scope. In addition to an exposition of business affairs pure and simple, corporations must, when called upon by the commissioner of mineral statistics, report the number of gross tons of copper and iron mined and shipped, of mineral coal produced, of pig iron manufactured; also the statistics of production of any other mineral or ore, and the amount of slate or stone quarried.

TAXATION.

The general practice seems to be to tax mining companies on their capital stock and real estate separately. Other forms of taxation also occur, and these are given below, by States.

Maine.—Mines of gold, silver, or of baser metals, when opened and in process of development, are exempt from taxation for ten years. This exemption, however, does not apply to lands or surface improvements, which are taxed at the same rate as similar lands and buildings in the vicinity. The buildings, lands, and other property of mining and smelting companies made personal by their charter, and not exempt from taxation, are to be taxed to the corporations or the persons having possession of their property or stock in the municipality where the company is established or stock held. Shares of capital stock of such corporations are not taxed to their owners.

New Hampshire.—The real estate of mining companies or of persons owning or discovering mines of gold, silver, copper, lead, iron, tin, or zinc is appraised and taxed at its value, independently of the existence of such mines, until the companies or proprietors are able out of the profits of their business to declare dividends.

Vermont.—Mines and quarries, together with the machinery used, including tramways, are exempt from taxation for five years from the date of opening. This exemption may be extended to ten years if a majority of the legal voters of the municipality so elect.

Massachusetts.—Foreign quarrying, mining, or oil companies doing business outside the State, but who keep an office within the State, must pay a semi-annual tax of one-fortieth of 1 per cent. upon the par value of their capital stock in lieu of all other taxes, provided that the sum paid by any one corporation does not exceed $300.

Connecticut.—Quarries, mines, and ore-beds must be valued at their true valuation and set in a list separately; if owned by a corporation the whole stock, property, and franchise are set in the list together.

New York.—The real estate of mining companies is taxed separately from their capital stock. If the dividend declared by a mining company is 6 per cent. or more the tax is one-quarter mill on each 1 per cent. of the dividend. If the dividend is less than 6 per cent. or if there is no dividend at all the tax is one and one-half mills on each dollar of capital stock. Where there is no dividend the secretary and treasurer appraise, under oath, the capital stock and make the return to the State comptroller.

New Jersey.—Corporations, if not exempted by their charters, are assessed and taxed on the full amount of their capital stock paid in and on their accumulated surplus. Real estate belonging to the company and situated in another State is not considered a part of the surplus. Real estate situated in New Jersey is taxed separately and the amount deducted from the surplus. Foreign corporations pay taxes on the amount of capital stock employed in doing business in the State.

Maryland.—Corporations must pay a tax on their stock whether they declare any dividends or not. Real estate is taxed separately.

North Carolina.—Formerly corporation property was exempt from taxation, but since 1877 it has been taxed the same as individual property.

South Carolina.—Personal property used in connection with mines and mining claims, and land not actually mined, are assessed and taxed like other real and personal estate. Where the land is actually mined it is not itself taxed, but instead the gross proceeds of the mines.

Florida.—No taxes can be levied in this State for the benefit of any corporation.

Georgia.—The State cannot surrender the power to tax corporations.

Kentucky.—Mining companies must pay a tax on each $100 worth of property owned, equivalent to a tax on real estate. Individual stockholders are not required to list their shares for taxation.

West Virginia.—The produce of mines, salt and oil wells, remaining unsold in the hands of producers or agents on the first day of February is exempt from taxation. The real and personal estate, after the indebtedness has been deducted, form the objects of taxation.

MISCELLANEOUS.

West Virginia, Ohio, and Tennessee allow mining companies to take stock in a railroad corporation for the purpose of facilitating transportation. Wisconsin permits the purchase of stock in corporations for generating power or light as a mechanical agency to facilitate mining operations.

In Illinois a corporation cannot remove its place of business from a place which has at any time given it pecuniary inducement to locate there.

In Connecticut no dividend above 10 per cent. can be declared until a surplus equal to 20 per cent. of the capital stock has been accumulated. North Carolina allows no dividend when the debts exceed two-thirds of the assets.

The laws of Pennsylvania are especially strict on the subject of the increase or diminution by corporations of their capital stock. The step requires a preliminary notice published in two newspapers once a week for three weeks, and written notification to each stockholder. The sanction of a two-thirds vote is required.

In Virginia, if four-fifths of the capital stock becomes, at any time, the possession of less than five persons, or if more than one-half of the stock be, for six months, the property of one person, corporation privileges cease.

Tennessee gives to residents of that State priority as creditors of an insolvent corporation.

RIGHTS OF ALIENS.

In most of the States under consideration aliens are privileged to hold land in the same manner and to the same extent as natural-born citizens. There are, however, some exceptions to this general rule. The laws of Georgia restrict the ownership of real estate to 160 acres until the alien has declared his intention to become a citizen. Those of Pennsylvania prohibit an acquisition greater than 5,000 acres or having a net annual income of more than $20,000 by a foreigner. Kentucky grants the same privileges to the subjects of a foreign country in the matter of land holding as are granted by that particular power to citiizens of Kentucky. In New York it is necessary to make the declaration of intention to become a citizen before a foreigner can hold land in fee. Resident aliens in Alabama are in no way discriminated against. "Any alien not a resident of Connecticut or of the United States may acquire and hold any real estate in this State (Connecticut) for the purpose of quarrying, mining, dressing, or smelting ores on the same, or converting the products of such quarries and mines into articles of commerce," but if the said real estate is not used for the purpose for ten consecutive years the title is forfeited to the person last owning, or his heirs if resident in the United States, and if not so resident then to the State of Connecticut.

MINES AND MINING.

Not many of the States here treated have a full code of mining regulations. The most comprehensive enactments on this subject belong to Pennsylvania, West Virginia, Ohio, Indiana, and Illinois. It would be too difficult a matter to attempt a topical analysis of the statutes relating to mining, so, instead, a digest of the provisions in force in different States is presented in some cases, in others a full text of the acts themselves.

Massachusetts.—County commissioners have the right to authorize owners or lessees of mines to construct roads, railroads, tunnels, etc., upon filing a bond to pay for all expenses. It is left with the commissioners to determine if the improvement is necessary and to assess the damages.

Maryland.—The law requires an inspector of mines to be appointed for Alleghany and Garrett counties. The qualifications for the position and the duties enjoined do not differ materially from those required of similar officers in Pennsylvania and Ohio.

The daily hours of labor for miners in the above-named counties must not exceed ten.

The proprietors or lessees of mines may construct railroads, roads, canals, etc., not more than 10 miles in length, from a public highway to their mines. Such roads cannot go through any city, or town, or house, warehouse, stable yard, or garden without the consent of the proper authorities or owners. Disputes arising regarding condemnation of property and assessment of damages are settled by the board of public works.

A law of this State provides for free evening schools in Alleghany county, to give instruction in mining and mechanics.

Virginia.—Mine operators are not allowed to sink a shaft within 5 feet of the boundary of their claim without the consent of the owners of adjoining lands, under the penalty of $500. The operators must permit parties interested freely to enter and survey the mine, to ascertain if any encroachments upon their property is being made. A survey is not allowed oftener than once a month.

Georgia.—This State gives to mine operators the right of way from a public highway to their mines. Disputes arising in regard to the damages due for property condemned are settled by arbitration. They may divert water courses and may enter on lands necessary to cut such courses or canals. They can also construct drainage facilities for their mines.

North Carolina.—Mining companies or other operators of mines must apply to the clerk of the superior court for the privilege of carrying water to mines over the property of others. Jurors are appointed to assess proper damages.

Alabama.—The provisions regulating the construction of railways, roads, canals, etc., by mining corporations or individuals, are precisely similar to those in force in Maryland, and have already been quoted.

Tennessee.—Tennessee gives to mine operators the right of way, not exceeding 30 feet in width, to construct railways, roads, tramways, etc., forming an outlet to some public highway. The laws of this State contain also a wholesome provision, absolutely prohibiting the sale of liquor, except in incorporated towns, within a radius of 5 miles from any mine or quarry under construction or in operation.

The geologist of the bureau of agriculture, statistics, and mines acts as inspector of mines. His salary is $600 and his office is located at Chattanooga. He must obtain and keep on file maps and plans of coal mines in operation in the State, and other papers relative thereto.

Kentucky.—Mine operators are allowed the right of way to construct roads, railways, tramways, etc., not more than 3 miles in length, leading directly from the mines to a public highway. All damages must be paid before these sideways can be opened.

Michigan.—The owners or lessees of mines are given the right to use streams which flow through their property, for the purpose of washing or cleansing ores, but are made liable for any damages caused to a person using the water.

Examination of mining property at the instance of owners of adjoining lands to ascertain if any encroachment is being made under the surface of the ground is also permitted. The survey may be made as often as once every twenty days.

Wisconsin.—Certificates of sale of public lands do not confer the right to take away minerals therefrom. For this the written consent of the commissioner of public lands must be obtained.

A lease or license, verbal or written, to a miner is not revocable after a valuable mineral deposit has been discovered, unless the miner forfeits his rights by negligence.

A discoverer of minerals on rented lands is entitled to the ores, subject only to the rent due his landlord, but he must give notice of his claim.

Concealing mines or minerals or neglect to pay rent effects forfeiture of right.

Miners are allowed to conduct water from shafts, levels, etc., across the lands of others. The drainage of mines over adjoining property is also permitted.

Smelters and purchasers of ores and minerals must keep an account at the furnace of all ores daily received, mentioning where they were obtained, giving the name of the seller, and the locality where mined. The written conveyance of the right to mine lead ore does not convey a property right in the land. The lease of an exclusive right does not convey the exclusive right to work a vein on another portion of the same land, where no connection exists within the tract.

NEW YORK.

The mining laws of New York differ considerably from those of other States and contain many interesting though antiquated provisions. A complete text is given below:

[Title XI, Chapter IX, Part one of the Revised Statutes.]

SECTION 1. The following mines are, and shall be, the property of the people of this State, in their right of sovereignty:

(1.) All mines of gold and silver discovered, or hereafter to be discovered, within this State.

(2.) All mines of other metals discovered, or hereafter to be discovered, upon any lands owned by persons not being citizens of any of the United States.

(3.) All mines of other metals discovered, or hereafter to be discovered, upon lands owned by a citizen of any of the United States, the ore of which, upon an average, shall contain less than two equal third parts, in value, of copper, tin, iron, and lead, or any of those metals.

SEC. 2. All mines and all minerals and fossils discovered, or hereafter to be discovered, upon any lands belonging to the people of this State, are, and shall be, the property of the people, subject to the provisions hereinafter made to encourage the discovery thereof.

SEC. 3. All mines of whatever description, other than mines of gold and silver, discovered, or hereafter to be discovered, upon any lands owned by a citizen of any of the United States, the ore of which, upon an average, shall contain two equal third parts or more, in value, of copper, tin, iron, and lead, or any of those metals, shall belong to the owner of such land.

SEC. 4. Every person who shall make a discovery of any mine of gold or silver within this State, and the executors, administrators, or assigns of such persons, shall be exempted from paying to the people of this State any part of the ore, produce or profit of such mine for the term of twenty-one years, to be computed from the time of giving notice of such discovery, in the manner hereinafter directed.

SEC. 5. No person discovering a mine of gold or silver within this State shall work the same until he gives notice thereof, by information in writing, to the secretary of this State, describing particularly therein the nature and situation of the mine. Such notice shall be registered in a book to be kept by the secretary for that purpose.

SEC. 6. After the expiration of the term above specified the discoverer of the mine, or his representatives, shall be preferred, in any contract, for the working of such mine, made with the legislature or under its authority.

SEC. 7. Nothing contained in this title shall affect any grants heretofore made by the legislature to persons having discovered mines, nor be construed to give any person a right to enter on or break up the lands of any other person, or of the people of this State, or to work any mine in such lands, unless the consent, in writing, of the owner thereof, or of the commissioners of the land office, when the lands belong to the people of this State, shall be previously obtained.

SEC. 8. In all cases in which a person or persons shall have discovered a mine or mines, and become entitled to work the same, pursuant to title eleven, chapter nine, part first of the Revised Statutes, and such person or persons shall form a corporation pursuant to chapter forty of the laws of eighteen hundred and forty-eight and the several acts subsequent thereto and amendatory thereof, if the consent in writing to enter upon and break up the lands of any person in or upon whose lands said mine or mines are found, shall be refused or cannot be obtained by agreement, or by reason of the infancy or the absence of such person from the State, or other legal disability of the owner of such lands, the said corporation so formed, may enter upon and break up the lands of such person for the purpose of working such mine or mines in the manner hereinafter provided, and the right and easement so to do shall be deemed granted for public use, and for the public purpose of obtaining minerals reserved to the State, and the said right and easement are hereby granted to the corporation so formed, on their filing with the Commissioners of the Land Office a full description of the location of such land, and obtaining a grant therefor from said Commissioners, who are hereby authorized to make such grant and file the terms thereof.

SEC. 9. The said company entitled to work such mines may file a petition in the supreme court of the State, setting forth the facts upon which they claim such right, and the reasons which prevent their entering upon the land necessary for their mining operations; and upon such petition the court may appoint three disinterested persons as commissioners to examine into the matter, ascertain and fix the damages aforesaid, and report to the court. Notice of the filing of such petition shall be published in one of the papers printed in the county, or in each of the counties where the mine or mines are situated, and in the State paper, and a copy of such notice shall be served personally upon the owners of the land, or, if they are infants, upon their guardians, or, if lunatics, or under any other legal disability, on the committee having charge of them and their property. And the publication of such notice in the State paper shall be deemed a sufficient notice to such owners as are residents in other States or in other countries, or are temporarily absent from the State, provided that when the actual residence of such absentee is known or can be ascertained, a copy of such notice and petition shall be sent them by mail. All the parties interested shall be entitled to a hearing before such commissioners, at such time or times as said commissioners shall appoint. The report of the commissioners shall state:

(1) The existence of the mine or mines proposed to be worked.

(2) The names of the parties owning the land in which the mine or mines are situated, and the owners of the adjacent lands, so far as they are affected by the application, and the nature and value of their interest in the same, individually. A map of such lands, from actual survey by metes and bounds, shall accompany the report.

(3) An estimate of the damages to such owners from the contemplated use and occupation of their lands.

(4) Such other information as the court may direct.

SEC. 10. The report of the commissioners shall be made within a reasonable time, to be fixed by the court. An order shall be made, in the discretion of the court, either denying the petition or granting it, determining the quantity of land necessary for working the mine or mines, the damages to the property by taking possession thereof, and the annual rent or the compensation to be paid to the owner, lessee, or occupant thereof so long as the use and occupation shall continue. And thereupon the company in whose favor the order shall be made, upon payment of the damages and upon entering into an agreement, to be approved by the court, to pay the annual rent of the compensation and damages thus determined, shall have the right to enter upon and occupy and use the land set apart by such order, or so long as they or their assignees shall work the said mine or mines, and shall pay the said annual rent or compensation.

SEC. 11. If the parties owning the land are infants, or otherwise incompetent to act, the court shall appoint guardians to take care of their interests, and shall direct how any damages assessed, or compensation or rents to become due, shall be paid and invested to their benefit.

OHIO.

[Revised Statutes, sections 290 to 296.]

Mining districts.—For the purpose of facilitating an efficient and thorough inspection of mines in Ohio, and to provide an adequate inspecting force therefor, the State is hereby divided into mining districts, as follows:

The counties of Lawrence, Gallia, Meigs, Washington, Morgan, Hocking, Athens, Vinton, Jackson, Scioto, Pike, Ross, Pickaway, Fairfield, Fayette, Greene, Clinton, Highland, Adams, Brown, Clermont, Hamilton, Butler, Warren, Montgomery, and Preble shall compose the first district.

The counties of Monroe, Belmont, Harrison, Jefferson, Tuscarawas, Carroll, Guernsey, Noble, Muskingum, Perry, Licking, Coshocton, Knox, Holmes, Franklin, Delaware, Morrow, Marion, Union, Madison, Clarke, Champaign, Logan, Hardin, Allen, Van Wert, Mercer, Auglaize, Shelby, Miami, and Darke shall compose the second district.

The counties of Columbiana, Mahoning, Trumbull, Ashtabula, Lake, Geauga, Portage, Stark, Summit, Cuyahoga, Lorain, Medina, Wayne, Richland, Ashland, Huron, Erie, Crawford, Wyandot, Seneca, Sandusky, Ottawa, Lucas, Wood, Hancock, Putnam, Paulding, Henry, Defiance, Williams, and Fulton shall compose the third district.

Chief inspector and district inspectors.—The governor shall appoint one chief inspector, who, with the approval of the governor, shall appoint three district inspectors of mines; the chief inspector shall hold his office for the term of four years, and the district inspectors shall hold their office for the term of three years, from the first day of May after their respective appointments, and until their successors are appointed and qualified; the first appointments hereunder shall be made within thirty days from the passage of this act; in case of the resignation, removal, or death of the chief inspector, or any district inspector, the vacancy shall be filled, in the manner above provided for original appointments for the unexpired term only, of the position so made vacant. No person shall be appointed chief inspector of mines unless he is possessed of a competent knowledge of chemistry, the geology of Ohio, and mineralogy, in so far as those sciences relate to mining, and has a practical knowledge of mining engineering and the different systems of working and ventilating mines, and the nature and properties of the noxious and poisonous gases of mines, particularly fire damp, and of the best means of preventing and removing the same; and no person shall be appointed district inspector of mines unless he be a practical miner of at least five years' experience and a resident of the district for which he is appointed, for at least two years, and is possessed of a practical knowledge of the best mode of working and ventilating mines, of the means of detecting the presence of bad or foul air, noxious and poisonous gases, and of the best means of preventing and removing the same.

Before entering upon the discharge of the duties of their respective offices, the chief inspector and district inspectors shall give bond to the State, the former in the sum of five thousand dollars, and the latter in the sum of two thousand dollars each, to be approved by the governor, conditioned for the faithful performance of their duties, respectively; said bonds, with an oath of office on each, and approval of the governor indorsed thereon, shall be forthwith deposited with the secretary of state; the inspectors, while in office, shall not act as agent, manager, or mining engineer for any operator, or in any way be interested in operating any mine.

Duties of inspectors.—The chief inspector and district inspectors shall give their whole time and attention to the duties of their offices, respectively; it shall be the duty of the district inspectors to examine all the mines in their respective districts as often as possible, to see that all the provisions and requirements of this chapter are strictly observed and carried out; they shall particularly examine the works and machinery belonging to any mine, examine into the state and condition of the mines as to ventilation, circulation and condition of air, drainage, and general security; they shall make a record of all examinations of mines in their respective districts, showing the date when made, the condition in which the mines are found, the extent to which the laws relating to mines and mining are observed or violated, the progress made in the improvement and security of life and health sought to be secured by the provisions of this chapter, number of accidents, injuries received, or deaths, in or about the mines (and for this purpose every person having charge of any mine, whenever loss of life occurs by accident connected with the working of such mine, or by explosion, shall give notice thereof forthwith, by mail or otherwise, to the inspector of mines, and to the coroner of the county in which such mine is situated, who shall hold an inquest upon the body of the person or persons whose death has been caused, and inquire carefully into the cause thereof, and shall return a copy of the finding and all the testimony to the inspector); the number of mines in their respective districts, the number of persons employed in or about each mine, together with all such other facts and information of public interest concerning the condition of mines, development and progress of mining in their respective districts, as they may think useful and proper, which record shall, on or before the first Monday of every month, be filed in the office of the chief inspector, to be by him recorded, and so much thereof as may be of public interest, to be included in his annual report; in case of any controversy or disagreement between a district inspector and the owner or operator of any mine, or the persons working therein, or in case of conditions or emergencies requiring counsel, the district inspector may call on the chief inspector for such assistance and counsel as may be necessary; should the district inspector find any of the provisions of this chapter violated, or not complied with, by any owner, lessee, or agent in charge of any mine, he shall immediately notify such owner, lessee, or agent in charge of such neglect or violation, and unless the same is, within a reasonable time, rectified, and the provisions of this chapter fully complied with, he shall institute a prosecution under the provisions of section six thousand eight hundred and seventy-one (6871) of the revised statutes. For the purpose of making the inspection and examinations provided for in this section, the chief inspector and the district inspectors shall have the right to enter any mine at all reasonable times, by night or by day, but in such manner as shall not unnecessarily obstruct the working of the mine; and the owner or agent of such mine is hereby required to furnish the means necessary for such entry and inspection; the inspection and examination herein provided for shall extend to fire-clay, iron ore, and other mines, as well as coal mines.

Rules governing district inspectors.—The chief inspector shall issue such instructions, make such rules and regulations for the government of the district inspectors, not inconsistent with the powers and duties vested in them by law, as shall secure uniformity of action and proceedings throughout the different districts; and he may order one district inspector to the assistance of any other district inspector, or make temporary transfers of district inspectors, when, in his judgment, the efficiency or necessity of the service demands or permits; and he may, with the consent of the governor, remove any district inspector at pleasure; the district inspectors are hereby invested with all the powers and authority of county auditors, as sealers of weights and measures in the different counties of this State, and for any service performed as such sealers they shall receive the same compensation as now provided by section ten hundred and sixty-two of the revised statutes; but said inspectors shall exercise said authority in connection with weights and measures only at mines in their respective districts; the chief inspector shall render such personal assistance to the district inspectors as they, from time to time, may require, and shall make such personal inspection of mines as he may deem necessary and his other duties will permit; he shall keep in his office and carefully preserve all maps, surveys and other reports and papers required by law to be filed with him, and so arrange and preserve the same as shall make them a permanent record of ready, convenient and connected reference; he shall compile and consolidate the reports of district inspectors, and annually make report to the governor of all his proceedings, as well as those of the district inspectors, the condition and operation of the different mines of the State, the number of mines and the number of persons employed in or about such mines, the amount of coal, iron ore, limestone, fire-clay, or other mineral mined in this State; and for the purpose of enabling him to make such report, the owner, lessee, or agent in charge of such mine, or who is engaged in mining, is hereby required to give accurate information as to the foregoing facts, on blanks to be furnished by the chief inspector, under penalty of one hundred dollars, to be recovered at the suit of the chief inspector in the name of the State of Ohio, for refusal to furnish such information on demand of the chief inspector; he shall also include in such report such facts relative to the mineral resources of the State, and the development of the same, as shall, in his judgment, be of public interest; he shall enumerate all accidents, and the manner in which they occurred, in or about mines, and give all such other information as he thinks useful and proper, and make such suggestions as he deems important relative to mines and mining, and any other legislation that may be necessary on the subject for the better preservation of the life and health of those engaged in such industry.

Maps, plans of mines, etc.—The chief inspector shall have an office in the state house, in which shall be carefully kept the maps and plans of all mines in the state, and all records, correspondence, papers, and apparatus and property pertaining to his duties, belonging to the State, and shall be handed over to his successor in office; the district inspectors shall keep their offices in such place in their respective districts as will be most central and convenient to the mining region of their respective districts, and shall keep and preserve in their offices all maps, plans, surveys, and other papers belonging to their offices, in such manner as shall be of easy access and convenient reference to persons entitled to examine them. The district inspector shall receive an annual salary of twelve hundred dollars ($1,200) per annum, and the chief inspector shall receive the same salary as is now provided for inspector of mines under section twelve hundred and eighty-four of the revised statutes.

Instruments, etc.—There shall be provided for the inspectors weights and measures and all instruments and chemical tests necessary for the discharge of their respective duties under this chapter, which shall be paid for on the certificate of the chief inspector, and shall belong to the State.

The owner or agent of any mine having an excavation of not less than fifteen thousand cubic yards, shall make, or cause to be made, an accurate map or plan of the working of such mine on a scale of not less than two hundred feet to the inch, showing the area mined or excavated, and the location and connection with such excavation of the mine of the lines of all adjoining lands, and the name or names of each owner or owners, so far as known, marked on each tract, and the owner or agent shall annually thereafter make, or cause to be made, an addition to said map, showing the progress and plan of the working of such mine during the previous year up to the date of survey; provided, that said additions shall be made semi-annually whenever the mine inspector deems it necessary and so directs. The map shall be kept at the office of such mine, and open to the inspection of the mine inspector, or his assistants, at all reasonable times, and at the request of the inspector the owner or agent shall file a correct copy of such map with said mine inspector at Columbus, and in case of refusal on the part of the owner or agent to make and file such map, the inspector is authorized and required hereby to cause such map or maps to be made in duplicate, at the expense of said owner or agent, the cost of which shall be recoverable against the owner or agent in the name of the State mine inspector; and in case of refusal by said owner or agent to make, or cause such map and the additions thereto to be made, for sixty days after notice by the mine inspector, said agent or owner shall be liable to a fine of five dollars for each and every day until said map is made, which shall be collected in the name of the State of Ohio, at the suit of the State mine inspector, and the amount so recovered shall be paid into the township school fund of the township when collected. And when any mine is exhausted or abandoned, and before the pillars are drawn in any portion of the mine, the owner or agent thereof shall cause to be made a correct map of such mine, showing the area and working of the same to the day of abandoning, or of drawing pillars for the purpose of abandoning, and file such map within ninety days thereafter at the office of the county recorder in the county where such mine is located: said map shall have attached thereto the sworn certificate of the mining engineer making the map, and of the mine boss in charge of the underground workings of said mine; such map shall be properly labeled and filed by the recorder, and be preserved as a part of the records of the land on which such mines are located, and the recorder shall receive for said filing from said owner or agent a fee of fifty cents.

Outlets required.—It is unlawful for the owner or agent of any coal mine, worked by a shaft, to employ or permit any person to work therein, unless there are, to every seam of coal worked in each mine, at least two separate outlets, separated by natural strata of not less than one hundred feet in breadth, by which shafts or outlets distinct means of ingress and egress are always available to the persons employed in the mine; but it is not necessary for the two outlets to belong to the same mine, if the persons employed therein have safe, ready and available means of ingress and egress by not less than two openings. This section shall not apply to opening a new mine while being worked for the purpose of making communication between said two outlets, so long as not more than twenty persons are employed at any one time in such mine, neither shall it apply to any mine, or part of a mine in which the second outlet has been rendered unavailable by reason of the final robbing of pillars previous to abandonment, so long as not more than twenty persons are employed therein at any one time. The cage or cages and other means of egress shall at all times be available for the persons employed, where there is no second outlet. The escapement shafts shall be fitted with safe and available appliances by which the persons employed in the mine may readily escape in case an accident occurs deranging the hoisting machinery at the main outlets. To all other coal mines, whether slopes or drifts, two such openings or outlets must be provided within twelve months after shipments of coal have commenced from such mine; and in case such outlets are not provided as herein stipulated, it shall not be lawful for the agent or owner of such slope or drift to permit more than ten persons to work therein at any one time. In case a coal mine has but one shaft, slope, or drift, for the ingress or egress of the men working therein, and the owner thereof does not own suitable surface ground for another opening, he may select and appropriate any adjoining land for that purpose, and for approach thereto, and shall be governed in his proceeding in appropriating such land by the provisions of law in force, providing for the appropriation of private property by corporations, and such appropriation may be made, whether he is a corporator or not; but no land shall be appropriated under the provisions of this chapter until the court is satisfied that suitable premises cannot be obtained upon reasonable terms.

Ventilation.—The owner or agent of every coal mine, whether shaft, slope, or drift, shall provide and maintain for every such mine, an amount of ventilation of not less than 100 cubic feet, per minute, per person employed in such mine, which shall be circulated and distributed throughout the mine in such a manner as to dilute, render harmless, and expel the poisonous and noxious gases from each and every working-place in the mine, and no working-place shall be driven more than sixty feet in advance of a break-through, or air-way; and all break-throughs, or air-ways, except those last made near the working-faces of the mine shall be closed up and made air-tight by brattice, trap-doors, or otherwise, so that the currents of air in circulation in the mine may sweep to the interior of the mine, where the persons employed in such mine are at work, and all mines governed by the statute shall be provided with artificial means of producing ventilation, such as forcing, or suction fans, exhaust steam, furnaces, or other contrivances, of such capacity and power as to produce and maintain an abundant supply of air, and all mines generating fire damp, shall be kept free from standing gas, and every working place shall be carefully examined every morning with a safety lamp, by a competent person or persons, before any of the workmen are allowed to enter the mine. All underground entrances to any places not in actual course of working or extension, shall be properly fenced across the whole width of such entrances so as to prevent persons from inadvertently entering the same.

Safety apparatus and precautions.—The owner or agent of every coal mine operated by shaft, in all cases where the human voice can not be distinctly heard, shall forthwith provide and maintain a metal tube from the top to the bottom of such shaft, suitably calculated for the free passage of sound therein, so that conversation may be held between persons at the bottom and top of the shaft; there shall also be provided an approved safety catch, and a sufficient cover overhead, on all carriages used for lowering and hoisting persons, and in the top of every shaft an approved safety gate, and an adequate brake shall be attached to every drum or machine used for lowering or raising persons in all shafts or slopes; and there shall also be provided in every shaft a traveling or passage way from one side of a shaft bottom to the other, so that persons working therein may not have to pass under descending cages; and all slopes or engine planes, used as traveling ways by persons in any mine, shall be made of sufficient width to permit persons to pass moving cars with safety; but if found impracticable to make any slope or engine plane of sufficient width, then safety-holes of ample dimensions, and not more than sixty feet apart, shall be made on one side of said slope or engine plane. Such safety holes shall always be kept free from obstructions, and the roof and sides shall be made secure. The boilers used for generating steam, and the building containing the boilers shall not be nearer than sixty feet to any shaft or slope, or to any building or inflammable structure connected with or surrounding said shaft or slope; but this section shall not apply to any shaft or slope, until the work of development and shipment of coal has commenced.

Engineers.—No owner or agent of any coal mine operated by a shaft or slope shall place in charge of any engine used for lowering into or hoisting out of such mine persons employed therein, any but experienced, competent and sober engineers; and no engineer in charge of such engine shall allow any person, except such as may be deputed for that purpose, by the owner or agent, to interfere with it or any part of the machinery, and no person shall interfere or in any way intimidate the engineer in the discharge of his duties; and in no case shall more than ten men ride on any cage or car at one time, and no person shall ride upon a loaded cage or car in any shaft or slope.

Safety lamps and ventilating apparatus.—All safety lamps used for examining coal mines, or which are used in any coal mine, shall be the property of the owner of the mine, and shall be under the charge of the agent thereof, and in all mines, whether they generate fire damp or not, the doors used in assisting or directing ventilation of the mine, shall be so hung or adjusted that they will shut of their own accord and can not stand open; and all main doors shall have an attendant, whose constant duty shall be to open them for transportation and travel, and prevent them from standing open longer than is necessary for persons or cars to pass through; and the mining boss shall keep a careful watch over the ventilating apparatus and the airways, and he shall measure the ventilation at least once a week, at the inlet and outlet, and also at or near the face of all the entries, and the measurements of air so made shall be noted on blanks, furnished by the mine inspector; and on the first day of each month the mining boss of each mine shall sign one of such blanks, properly filled, with the said actual measurements, and forward the same to the mine inspector. The owner or agent of every mine shall give notice of all deaths or serious injuries from accidents, in or about the mine, to the chief inspector of mines, in writing, and shall specify the name, age and occupation of the person killed or injured, and also the nature and character of the accident, and of the injury caused thereby. He shall also give notice to the chief inspector of mines in any or all of the following cases:

1. Where any working is commenced for the purpose of opening a new shaft, slope or mine to which this act applies.

2. Where any mine is abandoned or the working thereof discontinued.

3. Where the working of any mine is recommenced after any abandonment or discontinuance for a period exceeding three months.

4. Where the pillars of a mine are about to be removed or robbed.

5. Where a squeeze or crush, or any other cause or change may seem to affect the safety of persons employed in any mine, or where fire occurs, or a dangerous body of gas is found in any mine.

Boys under twelve must not be employed in mines, etc.—No boy under twelve years of age shall be allowed to work in any mine, nor any minor between the ages of twelve and sixteen years, unless he can read and write, and in all cases of minors applying for work, the agent of such mine shall see that the provisions of this section are not violated.

In case any coal mine does not, in appliances for the safety of the persons working therein, conform to the provisions of this chapter, or the owner or agent disregards the requirements of this chapter, any court of competent jurisdiction may, on application of the inspector, by civil action, in the name of the State, enjoin or restrain the owner or agent from working or operating such mine, with more than ten miners at once, until it is made to conform to the provisions of this chapter; and such remedy shall be cumulative, and shall not take the place of or affect any other proceedings against such owner or agent authorized by law for the matter complained of in such action.

Board of examiners.—When written charges of gross neglect of duty or malfeasance in office against any inspector are made and filed with the governor, signed by not less than fifteen coal miners, or one or more operator, of mines, together with a bond in the sum of five hundred dollars, payable to the State, and signed by two or more responsible freeholders, and conditioned for the payment of all costs and expenses arising from the investigation of such charges, the governor shall convene a board of examiners, to consist of two practical coal miners, one chemist, one mining engineer, and one operator, at such time and place as he deems best, giving ten days' notice to the inspector against whom the charges are made, and also to the person whose name appears first in the charges, and the board, when so convened, and having been first duly sworn, truly to try and decide the charges made, shall summon any witnesses so desired by either party, and examine them on oath, which may be administered by any member of the board, and depositions may be read on such examination, as in other cases; and the board shall examine fully into the truth of such charges, and report the result of their investigation to the governor; and the board shall award the costs and expenses of such investigation against the inspector or the persons signing the bond according to their finding, against said inspector or in his favor, which costs and expenses shall include the compensation of such board, of five dollars per day for each member, for the time occupied in the trial, and in traveling from and to their homes; and the attorney general shall forthwith proceed to collect such costs and expenses, and pay the same into the state treasury, being in the first instance paid out of the state treasury on the certificate of the president of such board.

Right of access to mines, etc.—In all coal mines in the State, the miners employed and working therein, the owners of the land or other persons interested in the rental or royalty of any such mine, shall at all proper times have full right of access and examination of all scales, machinery or apparatus used in or about such mine to determine the quantity of coal mined, for the purpose of testing the accuracy and correct-ness of all such scales, machinery or apparatus; and such miners, land owners, or other persons, may designate or appoint a competent person to act for them, who shall at all proper times have full right of access and examination of such scales, machinery or apparatus, and seeing all weights and measures of coal mined, and the accounts kept of the same; but not more than one person on behalf of the miners collectively, or one person on behalf of the land owners or other persons interested in the rental or royalty jointly, shall have such right of access, examination and inspection of scales, weights, measures and accounts at the same time, and that such persons shall make no unnecessary interference with the use of such scales, machinery or apparatus; and the miners employed in any mine may, from time to time, appoint two of their number to act as a committee to inspect, not oftener than once in every month, the mine and the machinery connected therewith, and to measure the ventilating current, and if the owner, agent, or manager so desires, he may accompany said committee by himself or two or more persons which he may appoint for that purpose; the owner, agent, or manager shall afford every necessary facility for making such inspection and measurement, but the committee shall not in any way interrupt or impede the work going on in the mine at the time of such inspection and measurement, and said committee shall, within ten days after such inspection and measurement, make a correct report thereof to the inspector of mines, on blanks to be furnished by said inspector for that purpose; and if such committee make to the inspector a false or untrue report of the mines, such act shall constitute a violation of this section.

Mines to which this chapter is not applicable.—The provisions of this chapter shall not apply to or affect any coal mine in which not more than ten men are employed at the same time; but on the application of the proprietor of or miners in any such mine, the inspector shall make, or cause to be made, an inspection of such mine, and shall direct and enforce any regulations in accordance with the provisions of this chapter that he deems necessary for the safety of the health and lives of miners.

Penalties, etc.—Whoever knowingly violates any of the provisions of sections two hundred and ninety-seven, two hundred and ninety-eight, two hundred and ninety-nine, three hundred, three hundred and one, three hundred and two, and three hundred and five, or does any act whereby the lives or health of the persons or the security of any mine and machinery are endangered, or any miner or other person employed in any mine governed by the statute, who intentionally and willfully neglects or refuses to securely prop the roof of any working place under his control, or neglects or refuses to obey any order given by the superintendent of a mine in relation to the security of the mine in the part thereof where he is at work, and for fifteen feet back from the face of his working place, or any person having charge of a mine, whenever loss of life occurs by accident connected with the working of such mine, or by explosion, who neglects or refuses to give notice thereof forthwith, by mail or otherwise, to the chief inspector of mines, and to the coroner of the county in which such mine is situate, or any such coroner who neglects or refuses to hold an inquest upon the body of the person whose death has been thus caused, and return a copy of his finding and all the testimony to the inspector, shall be fined not less than fifty dollars, or imprisoned in the county jail not more than thirty days, or both.

Mining operators are prohibited from paying their employés in script or in anything, in fact, except legal money. Wages must be paid twice in each month. Two other enactments require notice. One forbids employers from selling goods to their laborers at a higher rate than current retail cash prices. The other provides for the creation of voluntary tribunals to arbitrate differences between the representatives of labor and capital in the mining industry.

WEST VIRGINIA.

The following enactment is the only mining law in force in this State:

An act to regulate the working, ventilation, and drainage of coal mines in this State, to provide for the appointment of mine inspectors, and to repeal chapter seventy, of the acts of one thousand eight hundred and eighty-three. (Passed February 25, 1887.)

1. *Be it enacted by the legislature of West Virginia:* For the purpose of adopting an efficient system of mine inspection, the State of West Virginia is hereby divided into two mining districts, as follows:

The counties of Barbour, Berkeley, Brooke, Calhoun, Doddridge, Gilmer, Grant, Hampshire, Hancock, Hardy, Harrison, Jackson, Jefferson, Lewis, Marion, Marshall, Mason, Mineral, Monongalia, Morgan, Ohio, Pendleton, Pleasants, Preston, Putnam, Randolph, Ritchie, Roane, Taylor, Tucker, Tyler, Upshur, Wetzel, Wirt, and Wood shall compose the first district.

The counties of Boone, Braxton, Cabell, Clay, Fayette, Greenbrier, Kanawha, Lincoln, Logan, McDowell, Mercer, Monroe, Nicholas, Pocahontas, Raleigh, Summers, Wayne, Webster and Wyoming shall compose the second district.

2. *Mine inspectors.*—The governor shall, on or before the first day of July, one thousand eight hundred and eighty-seven, and in every four years thereafter, appoint one inspector of mines for each of the districts created by the next preceding section, who shall, unless he be sooner removed, as hereinafter provided, continue in office until his successor is appointed and qualified.

Every person so appointed must be a citizen of West Virginia, of temperate habits, and of good repute as a man of personal integrity, and must possess a competent, practical and theoretical knowledge of mining and mine engineering, and properly ventilating and draining mines, and of the nature and constituent parts of the noxious gases and impure air of mines, and of the best methods of preventing and removing the same; and he shall not, while in office, be interested as owner, operator, agent, stockholder, superintendent, or mining engineer of any coal mine.

An inspector of mines may be removed from office by the governor for incompetency, neglect of duty, drunkenness, malfeasance in office, or for other good cause. Vacancies in office of inspector shall be filled by appointment by the governor for the unexpired term.

3. *Inspector's oath, etc.*—Every person appointed inspector of mines shall, before entering on the discharge of the duties of his office, take an oath before some person authorized by law to administer oaths, that he will support the Constitution of the United States and the constitution of the State of West Virginia; and that he will faithfully and impartially, and to the best of his ability, discharge the duties of his office, and file a certificate of his having done so in the office of the secretary of state, and he shall give a bond in the penalty of three thousand dollars, with sureties, to be approved by the governor, conditioned that he will faithfully and impartially discharge the duties of his office. The salary of each inspector shall be one thousand dollars per annum, and his traveling expenses, which shall not exceed seven hundred dollars per annum; such salary and expenses shall be paid quarterly, out of the State treasury: *Provided*, That before payment of traveling expenses shall be made to the inspector, he shall file an account of such expenses, and make oath that they were incurred in the discharge of his official duties.

4. *Examinations as to ventilation, etc.*—Each inspector shall examine the mines of his district as often as practicable, to see that all the provisions of this act are observed and strictly carried out. He shall particularly examine into the condition of the mines as to ventilation, drainage and general safety, and shall make a record of all such examinations.

He shall also for each year, ending with the thirtieth day of June, make a report to the governor, of his proceedings as such inspector, stating therein the number of mines in his district, the number of persons employed in each mine, the condition in which the mines were found, the extent to which this act is obeyed or violated; the number of accidents and deaths resulting from injuries received in or about the mines, with the cause of each of such accidents and deaths, and such other information in relation to mines and mining as he may deem of public interest. He shall also suggest or recommend such legislation on the subject of mining as he may think necessary. Such report shall be filed with the governor on or before the thirteenth day of December, next succeeding the year for which it is made.

5. *Maps.*—The operator or agent of every coal mine shall, within six months after the passage of this act, make, or cause to be made, an accurate map or plan of such mine, on a scale to be stated thereon, not exceeding one hundred feet to the inch. Such map or plan shall show the openings or excavations, the shafts, slopes, entries, air-ways, headings, rooms, pillars, etc., the general inclination of the coal strata, and so much of the property lines and of the outcrop of the coal seam of the tract of land on which said mine is located, as may be within one thousand feet of any part of the workings of such mine.

A true copy of such map or plan shall, within the six months aforesaid, be delivered by such operator, to the inspector of his district, to be preserved among the records of his office and turned over to his successor in office; and the original map, or a true copy thereof, shall be kept by such operator, at the office of the mine, and open at all reasonable times for the examination and use of the inspector; and such operator shall twice within every twelve months, and not more than seven months apart while the mine is in operation, cause such mine to be surveyed and the map thereof extended so as to accurately show the progress of the workings, the property lines and outcrop as above provided; and he shall immediately thereafter deliver, to the inspector of his district, a map or plan and statement of the progress of the workings and extensions aforesaid, so as to enable the inspector to trace the same on the map or plan furnished him as above required.

Before any mine or part of a mine is abandoned, or the pillars drawn therein, it shall be accurately surveyed, and the maps thereof extended as aforesaid, and within one month after any mine is abandoned the person who was the last operator thereof shall file with the clerk of the county court of the county, in which the mine is located, a correct map, showing all the excavations of such mine, to be preserved as a part of the records of the county.

If any operator fail to comply with any provision of this section, the inspector is hereby authorized to have the survey and maps made or extended, as may be necessary in such case, at the expense of such operator, and the reasonable fees and expenses may be recovered in any court of competent jurisdiction, by the person performing the work.

6. *Outlets.*—After six months, from and after the passage of this act, it shall be unlawful for the operator, or agent, of any coal mine, to employ any persons at work in said mine, or permit any persons to be in said mine for the purpose of working therein, unless they are in communication with at least two openings or outlets, separated by natural strata, of not less than one hundred feet in breadth, if the mine be worked by shaft, and of not less than fifty feet in breadth, if worked by slope or drift. To each of said outlets there shall be provided, from the interior of the mine, a safe and available roadway, which shall at all times while the mine is in operation be kept free from all obstructions that might prevent travel thereon in case of an emergency, and if either of said outlets be by shaft, it shall be fitted with safe and available appliances, such as ladders, stairs, or hoisting machinery, which shall at all times, when the mine is in operation, be kept in order and ready for immediate use, whereby persons employed in the mine may readily escape in case of an accident.

This section shall not apply to any mine while work is being prosecuted with reasonable diligence in making communication between said outlets, so long as not more than twenty persons are employed at any one time in said mine; neither shall it apply to any mine, or part of a mine, in which the second outlet has been rendered unavailable by reason of the final robbing of pillars preparatory to abandonment, so long as not more than twenty persons are employed therein at any one time.

7. *Appropriation of adjoining land.*—In case a coal mine has but one opening, and the owner thereof does not own suitable surface ground for another opening, as required by the next preceding section, he may select and appropriate any adjoining land for that purpose and for approach thereto, and he shall be governed in his proceeding in appropriating such land, by the laws in force providing for the appropriation of private property by corporations, and such appropriation may be made whether he is a corporator or not; but no lands shall be appropriated under the provisions of this act until the court is satisfied that suitable premises can not be obtained on reasonable terms.

8. *Signals and hoisting machinery.*—The operator or agent of every coal mine worked by shaft shall forthwith provide, and hereafter maintain, a metal tube from the top to the bottom of such shaft, suitably adapted to the free passage of sound, through which conversation may be held between persons at the top and at the bottom of the shaft, also the ordinary means of signaling, and an approved safety catch and a sufficient cover overhead on every carriage used for lowering or hoisting persons, and at the top of the shaft an approved safety gate, and adequate brakes on the drum of every machine used to lower or hoist persons in such shaft; and the said operator or agent shall have the machinery used for lowering or hoisting persons into or out of the mine, kept in safe condition and inspected once in each twenty-four hours by some competent person.

9. *Charge of machinery.*—No operator or agent of any coal mine, worked by shaft or slope, shall place in charge of any engine, used for lowering into or hoisting out of said mine persons employed therein, any but competent and sober engineers; and no engineer in charge of such machinery shall allow any person except such as may be deputed for that purpose, by the operator or agent to interfere with any part of the machinery; and no person shall interfere with or intimidate the engineer in the discharge of his duties; and in no case shall more than ten persons ride on any cage or car at one time, and no person shall ride on a loaded cage or car in any shaft or slope.

All slopes or engine-planes, used as traveling-ways by persons in any mine, shall be made of sufficient width to permit persons to pass moving cars with safety, or refuge holes of ample dimensions, and not more than sixty feet apart, shall be made on one side of said slope or engine-plane. Such refuge-holes shall be kept free from obstructions, and the roof and sides thereof shall be made secure.

10. *Ventilation.*—The operator or agent of every coal mine, whether worked by shaft, slope or drift, shall provide and hereafter maintain for every such mine, ample means of ventilation, affording not less than one hundred cubic feet of air per minute for each and every person employed in such mine, and as much more as the circumstances may require, which shall be circulated around the main-headings and cross headings and working places, to an extent that will dilute, render harmless and carry off the noxious and dangerous gases generated therein; and as the working places shall advance, break-throughs for air shall be made in the pillars, or brattices shall be used, so as to keep such working-places well and properly ventilated.

Fire-damp precautions.—All mines generating fire-damp shall be kept free of standing gas in the worked out or abandoned parts of the same as far as practicable, and the entrances thereto shall be properly closed and cautionary notice posted to warn persons of danger, and the doors used therein for directing the ventilation shall be so hung as to close themselves, and every working-place and all other places where gas is known to exist or is liable to exist, shall be carefully examined by some competent person appointed for that purpose, to be known as "fire-boss," immediately before each shift, with a safety lamp, and in making such examinations it shall be the duty of the fire boss at each examination, to leave at the face of every place, so examined, evidence of his presence, and no workman shall enter or be permitted to enter, any mine or part of a mine, generating fire damp until it has been examined by the fire-boss as aforesaid and reported by him to be safe. In all mines generating fire-damp accumulations of fine, dry, coal dust shall as far as practicable be prevented, and such dust shall, whenever necessary, be kept properly watered down. The safety lamps used for examining any mine, or which may be used for working therein, shall be furnished by, and be the property of the operator of the mine, and shall be in charge of an agent thereof; and at least one safety lamp shall be kept at every coal mine whether such mine generates fire-damp or not.

11. "*Mining boss.*"—In order to better secure the proper ventilation of every coal mine and promote the health and safety of persons employed therein, the operator or agent shall employ a competent and practical inside overseer, to be called "mining boss," who shall be a citizen and an experienced coal miner, or any person having two years' experience in a coal mine, and shall keep a careful watch over the ventilating apparatus and the air-ways, traveling ways, pumps and drainage; and shall see that as the miners advance their excavations, proper break-throughs are made as provided in section ten of this act, and that all loose coal, slate and rock overhead in the working-places, and along the haulways, be removed or carefully secured so as to prevent danger to persons employed in such mine; and that sufficient props, caps and timbers are furnished of suitable size and cut square at both ends, and as near as practicable to the proper lengths for the places where they are to be used; and such props, caps and timbers shall be delivered and placed in the working-places of the miners, and every workman in want of props or timbers and cap-pieces, shall notify the mining boss or his assistant of the fact at least one day in advance, giving the length and number of props or timbers and cap-pieces required; but in case of an emergency the timbers may be ordered immediately upon the discovery of any danger; and the place and manner of leaving the orders for timbers shall be designated in the rules of the mine; and shall have all water drained or hauled out of the working places before the miners enter, and the working-places kept dry, as far as practicable, while the miners are at work. On all haul-ways, space not less than ten feet long and two feet six inches wide between the wagon and the rib, shall be kept open at distances not exceeding one hundred feet apart, in which shelter from passing wagons may be secured. It shall further be the duty of the mining-boss to have bore-holes kept not less than twelve feet in advance of the face, and, when necessary, on the sides, of the working-places that are being driven towards and in dangerous proximity to an abandoned mine or part of a mine suspected of containing inflammable gases or which is filled with water.

The mining-boss or his assistant shall visit and examine every working-place in the mine at least once in every three days, and oftener when necessary, while the miners of such places are at work, and shall direct that each and every working place shall be secured by props or timbers wherever necessary, so that safety in all respects be assured, and no person shall be directed to work in an unsafe place, unless it be for the purpose of making it safe. The mining-boss shall notify the operator or agent of the mine of his inability to comply with any requirements of this section; it shall then become the duty of such operator or agent at once to attend to the matter complained of by the mining-boss, to comply with the provisions hereof.

12. *Inspectors' facilities.*—The operator or agent of every coal mine shall furnish the inspector proper facilities for entering such mines, and making examinations or obtaining information; and if any inspector shall discover that any mine does not, in its appliances for the safety of the persons employed therein, conform to the provisions of this act, or that by reason of any defect or practice in or at such mine, the lives or health of persons employed therein, are endangered, he shall immediately, in writing, notify such operator or agent thereof, stating in such notice the particulars in which he considers such mine to be defective or dangerous, and if he deem it necessary for the protection of the lives or health of the persons employed in such mine, he shall, after giving notice to the said operator or agent of his intention so to do, apply with-

out bond, to the circuit court of the county in which said mine is located, or to the judge thereof in vacation, for an injunction to restrain the operating of said mine until said danger be removed; and such court or judge, when so applied to, shall at once proceed to hear the case and determine the same, and if the cause appear to be sufficient, and such danger appear to exist, after hearing the parties and their evidence he shall issue an injunction restraining the operating of said mine until the cause of such danger be removed, and the cost of the proceedings, including the charges of the attorney prosecuting the same, shall be borne by the operator of the mine, but no fee exceeding twenty-five dollars shall be taxed in any one case for the attorney prosecuting such case; but if said court or judge shall find the cause not sufficient, then the case shall be dismissed and the costs shall be paid by the county in which the mine is located.

13. *Age of employees.*—No boy under twelve years of age, nor female person of any age, shall be permitted to work in any coal mine, and in all cases of doubt the parents or guardians of such boys shall furnish affidavits of their ages.

14. *Injury to property.*—No miner, workman, nor other person, shall knowingly injure any shaft, lamp, instrument, air course, or brattice, or obstruct or throw open air-ways, or carry matches or open lights into places worked by safety-lamps, or disturb any part of the machinery, or open a door used for directing the ventilation and not close it again, or enter any part of the mine against caution, or disobey any order given in carrying out the provisions of this act, or do any other act whereby the life or health of any person employed in the mine, or the security of the mine, is endangered. Nor shall any person or persons or combination of persons, by force, threats, menace, or intimidation of any kind, prevent, or attempt to prevent, from working in or about any mine any person or persons who have the lawful right to work in or about the same and who desire so to work.

15. *Accidents.*—Whenever by reason of any explosion or other accidents in any coal mine, or the machinery connected herewith, loss of life or serious personal injury shall occur, it shall be the duty of the superintendent of the colliery, and in his absence the mining boss in charge of the mine, to give notice thereof forthwith, by mail or otherwise, to the inspector of the district, stating the particulars of such accident, and if any one is killed thereby, to the coroner of the county also, or in his absence or inability to act, to any justice of the peace; and the said inspector shall, if he deem it necessary from the facts reported, immediately go to the scene of such accident and make such suggestions and render such assistance as he may deem necessary for the future safety of the men; and investigate the cause of such explosion or accident, and make a record thereof, which he shall preserve with the other records of his office; and to enable him to make such investigation, he shall have the power to compel the attendance of witnesses, and to administer oaths or affirmations; and the costs of such investigation shall be paid by the county in which such accident occurred, in the same manner as the costs of coroner's inquests are now paid. If the coroner or justice shall determine to hold an inquest upon the body of any person killed, as aforesaid, he shall impanel a jury, no one of whom shall be directly or indirectly interested, and the inspector of mines, if present at such inquests, shall have the right to appear and testify and to offer any testimony that may be relevant, and to question and cross-question any witness, and the coroner or justice shall deliver to the inspector a copy of the testimony and verdict of the jury.

16. *Annual reports to inspector.*—The operator or agent of every coal mine shall annually, during the month of July, mail or deliver to the inspector of his district a report for the preceding twelve months, ending with the thirtieth day of June. Such report shall state the names of the operator and officers of the mine, the quantity of the coal mined, and such other information, not of a private nature, as may from time to time be required by the inspector. Blank forms for such reports shall be furnished by the inspector.

17. *Penalties.*—The operator or agent of any coal mine who shall neglect or refuse to perform the duties required of him by any section of this act, or who shall violate

any of the provisions hereof, and any person who shall neglect or refuse to perform the duties required of him by sections nine, ten, eleven, thirteen or fourteen, or who shall violate any of the provisions thereof, or knowingly do any act whereby the health or life of any person employed in a mine, or the security of a mine, is endangered, shall be guilty of a misdemeanor, and upon conviction shall be punished by a fine of not less than ten nor more than one hundred dollars. In default of payment of such fine and costs, for the space of ten days, the defendant may, in the discretion of the court, be imprisoned in the county jail for a period not exceeding three months.

18. *To what mines this act applies.*—The provisions of this act shall apply only to coal mines in which ten or more persons are employed in a period of twenty-four hours.

19. *Acts repealed.*—Chapter seventy, of the acts of one thousand eight hundred and eighty-three, and all other acts and parts of acts inconsistent with this act, are hereby repealed.

INDIANA.

[1879, p. 19. In force May 1, 1879.]

1. *"Mine" defined.*—The term mine, as used in this Act, includes every shaft, slope, or drift which is used, or has been used, in the mining and removing of coal from and below the surface of the ground.

2. *Number of employés—Outlets.*—Six months from and after the taking effect of this Act, it shall not be lawful for the owner or agent of any coal mine now operated, or which may be hereafter opened, worked by shaft, slope, or drift, wherein over fifteen thousand square yards have been excavated, to employ more than ten persons to work in such mine, unless there are, to every seam or stratum of coal worked in such mine, at least two separate outlets, separated by natural strata of not less than one hundred feet in breath, by which shafts or outlets distinct means of ingress or egress are always available to the persons employed in the mine; but it shall not be necessary for the two outlets to belong to the same mine. In every mine opened after the passage of this act, and after fifteen thousand square yards shall have been mined out, it shall be unlawful for the owner or agent to employ more than ten persons to work in said mine in every twenty-four hours, unless there are two distinct outlets; and in all slopes, drifts, and main entries, a sufficient number of refuge holes shall be established.

3. *Maps.*—At the request of the owner of any coal mine, the owner of the land, the miners working therein, or other person interested in the working of such mine, the mine inspector shall cause to be made an accurate map or plan of the workings of such mine, on a scale of not less than one inch to the one hundred feet, showing the area mined or excavated, and the location and connection of the lines of all adjoining lands with such excavation of the mine, and the name of the owners of such lands, so far as known, marked on each tract of land. Such map shall show the complete working of the mine; which map, when complete, shall be sworn to by the mine inspector to be a correct map of the working of such mine, and shall be kept on file in the office of the mine inspector for inspection at all times. The mine inspector shall be allowed a reasonable fee for making such survey, provided that he employs a surveyor to make the same, but he shall not be allowed anything for making the map of same. All expenses shall be paid by the party causing such survey and map to be made.

4. *Copy of map, when furnished.*—Upon payment of the fees, the Mine Inspector shall make, within a reasonable time, and deliver to the party so demanding the same, an accurate copy of any map or plan of the working of such mine that may be on file in his office.

5. *Map or copy, evidence.*—The original map or plan of any coal mine, or the copy filed with the Inspector, or a certified copy, issued under the hand and seal of such Inspector, shall be evidence in any Court of justice in this State.

6. *"Owner" and "agent" defined.*—The term "owner," as used in this act, is hereby defined to mean the immediate proprietor, lessee, or occupier of any coal mine or any part thereof; and the term "agent" is hereby defined to mean any person other than the owner thereof, having the care and management of any coal mine, or any part thereof; and in case the mine is owned or occupied by a corporation, then any of its officers shall be deemed its agent.

7. *Ventilation.*—The owner or agent of every coal mine shall, within six months from the time this Act takes effect, provide and establish a circulation of sufficient amount of pure air to dilute and expel therefrom the noxious and poisonous gases, to such an extent that the entire mine shall be in a fit state, at all times, for the men to work therein, and be free from danger to their health and lives from said gases and impure air—said ventilation to be produced by any suitable appliance that will produce and insure a constant supply of pure air throughout the entire mine. But in no case shall a furnace be used at the bottom of the shaft in the mine for the purpose of producing a hot up-cast of air, where the hoisting apparatus and buildings are built directly over the top of the shaft. Every such mine shall have ventilation affording one hundred cubic feet per minute for each and every person employed in such mine, which shall be circulated through the main-headings and cross-headings, to an extent that will dilute and render harmless the noxious gases generated therein.

8. *Precautions as to gas and water.*—When a place is likely to contain a dangerous accumulation of water or gases, the working, approaching such place, shall not exceed eight feet in width, and there shall be constantly kept, at a sufficient distance (not less than three yards in advance), one bore-hole near the centre of the working, and sufficient flank bore-holes on each side, and when two veins are worked in the same shaft, the upper shall be so protected that no danger will occur to the miners working in the lower vein.

9. *Management of engines and cages.*—No owner or agent of any coal mine shall place in charge of any engine used for conveying into or hoisting out of such mine, any but experienced, competent, and sober engineers. No engineer in charge of such engine shall allow any person, except such as may be deputed for that purpose by the owner or agent, to interfere with it or any part of the machinery; and no person shall interfere, or in any way intimidate the engineer in the discharge of his duties. In no case shall more than six men ride on any cage or car at one time; and no person shall ride upon a loaded cage or car when the same is being hoisted out of or being conveyed into the mine.

10. *Covers for cages.—Safety-gate, safety-spring, brake-indicator.*—The owner or agent of every coal mine operated by shaft or slope shall provide a sufficient cover overhead on all carriages or cages used for lowering and hoisting persons into and out of the mine, and on the top of every shaft an approved safety-gate; also an approved safety-spring on the top of every slope. An adequate brake shall be attached to every drum or machine used for lowering or raising persons into or out of all shafts or slopes; and also a proper indicator, in addition to any mark on the rope, which shall show to the person who works the machine the position of the cage or load in the shaft. And there shall be cut in the side of every hoisting-shaft, at the bottom thereof, a traveling way sufficiently high and wide to enable persons to pass the shaft in going from one side to the other, without passing over or under the cage or other hoisting apparatus.

11. *Fencing shafts.*—The owner or agent of every coal mine shaft or slope, at the end of six months from the time this Act takes effect, shall keep the top of every such shaft or slope, and the entrance thereof, securely fenced off by vertical or flat gates, covering and protecting the mouth of such shaft or slope. The entrance of an abandoned shaft or slope shall be securely fenced off, so that no injury can arise therefrom. The owner or agent, or either of them, violating the provisions of this section shall be fined in any sum not exceeding one hundred dollars for each day or part of a day the same is violated.

12. *Injuring Appliances.*—Any miner, workman, or other person, who shall, knowingly, injure or interfere with any safety lamp, air-course, or with any brattice, or

obstruct or throw open doors, or disturb any part of the machinery, or ride upon a loaded car or wagon in any shaft or slope, or do any act whereby the lives or health of the persons, or the security of the mines and machinery are endangered, shall be deemed guilty of a misdemeanor, and, upon conviction, shall be fined in any sum not exceeding ten dollars.

13. *Examination of machinery and books.*—The Mine Inspector, miners employed and working in about the mine, the owner of the land, or other persons interested in the royalty or rental of such mine, shall, at all proper times, have full right of access and examination of all scales, machinery, or apparatus used in or about said mine, including the bank-book in which the weight of coal is kept, to determine the amount of coal mined, for the purpose of attesting the accuracy thereof.

14. *Liens, how acquired—Wages.*—In all coal mines in this State, the miners and other persons employed and working in and about the mines, and the owners of the land and others interested in the rental or royalty on the coal mined therein, shall have a lien on said mine and all machinery and fixtures connected therewith, including scales, coal-bank cars, and everything used in and about the mine, for work and labor performed within two months, and the owner of the land, for royalty on coal taken out from under his land, for any length of time not exceeding two months; and such liens shall be paramount to and have priority over all other liens, except the lien of the State for taxes; and such liens shall have priority, as against each other, in the order in which they accrued, and for labor over that for royalty on coal. Any person, to acquire such lien, shall file in the recorder's office of the county where the coal mine is situate, within sixty days from the time the payment became due, a notice of his intention to hold a lien upon such property for the amount of his claim, stating in such notice the amount of his claim, and the name of the coal-works, if known, or any other designating, describing the location of said mine; and the recorder shall record the said notice, when presented, in a book used for recording mechanics' liens, for which the recorder shall receive a fee of twenty-five cents. Suits brought to enforce any lien herein created shall be brought within one year from date of filing said lien in the recorder's office; and all judgments rendered on the foreclosure of such liens shall include the amount of the claim found to be due, with the interest on the same from the time due, and with a reasonable attorney's fee, the judgment to be collected without relief from valuation, appraisement or stay laws. All wages of miners and other persons working in or about the mine shall be due and payable on the second Saturday of the month after the month in which the work was done, and all payments shall be made in bankable funds of the State of Indiana.

15. *Daily examinations.*—The rope used for hoisting and lowering in every coal mine shall be examined by some competent person every morning before the men descend into the shaft. When gas is known to exist there shall be a competent fire-boss, whose duty it shall be to examine each and every place in the mine before the men are permitted to enter and work; and the said fire-boss shall be at the mouth or bottom of the mine each day, to inform every man as to the state of his room or entry. Said works shall be carefully examined every morning with a safety-lamp, by a competent person, before any workmen are allowed to enter.

16. *Mine inspector—Appointment—Oath—Bond.* (*a*)—Within thirty days after this act shall take effect, the Governor, with the advice and consent of the Senate, shall appoint a Mine Inspector, who shall hold his office for two years and until his successor shall be appointed and qualified. Such inspector shall be a resident of the State of Indiana, and a practical miner in said State; and no person shall be eligible to hold the office of Mine Inspector who is or may be pecuniarily interested in any coal mine within this State directly or indirectly. Said Mine Inspector before entering upon the duties of his office, shall execute a bond with sufficient surety, payable to the State of Indiana, in the sum of one thousand dollars, for the faithful discharge of the duties of his office, which bond shall be approved by and filed with the Secretary of

a In force March 5, 1881.

State. He shall take an oath of office, which shall be indorsed on the back of his bond.

17. *Office—Salary.*—The Mine Inspector shall hold his office in some central part of the mining district; and, for his services he shall receive the annual compensation of fifteen hundred dollars, to be paid quarterly on the first days of January, April, July, and October of each year, out of any moneys in the State Treasury not otherwise appropriated.

18. *Inspector's and mine-owner's duty.*(a)—It shall be the duty of the Mine Inspector appointed under this act to enter, examine, and inspect any and all coal mines and the works and machinery belonging thereto at any reasonable time by day or by night, but so as not to hinder or obstruct the working of any coal mine more than is reasonably necessary in the discharge of his duties; and the agent or owner of such coal mine is hereby required to furnish the necessary facilities for such entry, examination, and inspection. Should the owner or agent fail or refuse to permit such inspection or furnish such facilities, the owner or agent so failing shall be deemed to have committed a misdemeanor, and it is hereby made the duty of such inspector to charge such owner or agent with such violation, under oath, in any court having jurisdiction, and, upon conviction, the owner or agent, or either or both, shall be fined in any sum not exceeding one hundred dollars for each offense.

19. *Inspector's duties—Report.*—The Inspector appointed under this act shall devote his entire time and attention to the duties of his office. He shall make personal inspection at least twice each year of all coal mines in this State, and shall see that every precaution is taken to insure the health and safety of the workmen therein employed, that the provisions and requirements of this Act are faithfully carried out, and that the penalties of the law are enforced against all who willfully disobey its requirements. He shall also collect and tabulate the following facts: The number and thickness of each vein or stratum of coal and their respective depths below the surface, which are now worked or may be hereafter worked; the kind or quality of coal; how the same is mined, whether by shaft, slope, or drift; the number of mines in operation in each county; the owners thereof; the number of men employed in each mine and the aggregate yearly production of tons from each mine; estimate the amount of capital employed at each mine; and give any other information relative to coal and mining that may be deemed necessary, all of which facts, so tabulated, together with a statement of the condition of mines as to safety and ventilation, he shall freely set forth in an annual report to the Governor, together with his recommendation as to such other legislation on the subject of mining as he may think proper.

20. *No boys under fourteen employed.*—No boy under fourteen years of age shall be employed to work in any of the mines of this State.

21. *Violating Act, a misdemeanor.*—Any person violating any of the provisions of this Act shall be deemed guilty of a misdemeanor, and, upon conviction thereof, shall be fined in any sum not exceeding five hundred dollars for each offense.

22. *To what mines Act does not apply.*(b)—Nothing in this Act, or the Act which this Act amends, shall apply to any coal mine when there is less than ten men used in and about such mine.

23. *Inspection of scales—Notice—Penalty.*—It shall be the duty of the Mine Inspector, in addition to his other duties, to examine all scales used at any coal mine in this State for the purpose of weighing coal taken out of said mine; and on inspection, if found incorrect, he shall notify the owner or agent of any such mine that the same is incorrect; and after such notice it shall be unlawful for any owner or agent to use or suffer the same to be used, until the same is so fixed that the same will give the true and correct weight. Any person violating the provisions of this section shall, upon conviction, be fined in any sum not less than ten dollars nor more than one hundred dollars for each day or part of a day the same is so used.

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a In force May 1, 1879. *b* In force March 5, 1881.

[Approved, March 6, 85.]

24. It shall not be lawful for any owner, agent, or operator to allow more than ten persons to work in any mine, shaft, slope, or drift, in every twenty-four hours, after 5,000 square yards have been excavated, until the second outlet shall have been made. The said outlet, or manway, shall be separated from the hoisting shaft by at least 100 feet in width of natural strata, and shall be available at all times to all employés engaged in the mines, and that for every shaft used as a manway there shall be provided stairways at an angle of not more than 60 degrees, with landings at easy and convenient distances, and with guard rails attached to each set of stairs from the top to the bottom of the same. The gangways or traveling roads to said outlet shall be not less than 4 feet high and 3 feet wide, and shall be kept as free from water as average hauling roads in mines. All water coming from the surface or out of the strata in the shaft shall be conducted by rings or otherwise to be prevented from falling down the shaft so as to wet persons who are ascending or descending the stairway of the shaft. The mine inspector shall see that the provisions of this section are complied with.

25. Breaks through or air-ways shall be made in every room, at least every 75 feet, and all breaks through or air-ways, except those last made near the working faces of the mine, shall be closed up and made air-tight by brattice, trap-doors or otherwise. The doors used in assisting or directing the ventilation of the mines shall be so hung and adjusted that they will close themselves, or be supplied with springs or pulleys, so that they can not be left standing open, nor shall any driver or other person, by prop or otherwise, cause the same to stand open. Air courses shall be driven properly adjoining all entries and as nearly parallel thereto as may be; such air courses not to exceed such width as will render them safe, with a sufficient pillar of coal left between them to secure the roof from falling on account of weight of the superincumbent strata forming the roof over the coal seam.

26. The owner, agent or operator of any coal mine shall keep a sufficient supply of timber at the mine so that the workmen may, at all times, be able to properly secure the workings from caving in, and the agent, owner or operator shall deliver, when selected, all props, of proper lengths, and timbers, to the rooms of the workmen when needed and required.

27. Before a mine, or any part of a mine, that adjoins other lands is abandoned, the owner or agent shall make a survey showing the farthest extremity of the entries or rooms worked in such mine toward the lines of adjoining lands, and also to have the mine properly staked on the surface and a map thereof made and filed, within thirty days thereafter, at the office of the county recorder in the county where such mine is located; said map shall have attached thereto the affidavit of the mining engineer making the map, and of the mine boss in charge of the underground workings of said mine. Such map shall be properly labeled and filed by the recorder and be preserved as a part of the record of the land on which such mines are located, and the recorder shall receive for said filing, from said owner or agent, a fee of 50 cents.

28. Approved safety-catches shall be attached to every cage used for the purpose of hoisting or lowering persons.

29. Miners' bosses shall visit their miners in their working places at least once every day where any number, not less than 10 nor more than 50 miners are employed, and as often as once every two days when more than 50 miners are employed. Any person violating the provisions of this act shall be deemed guilty of a misdemeanor, and upon conviction shall be fined in any sum not less than $10 nor more than $500.

30. All laws and parts of laws in conflict herewith are hereby repealed.

ILLINOIS.

The laws of this State are as follows:

1. *Maps.*—That the owner, or agent, or operator of each and every coal mine in this State, shall make, or cause to be made, at the discretion of the inspector, or person

acting in that capacity, an accurate map or plan of the workings of such coal mine, and of each and every vein thereof, showing the general inclination of the strata, together with any material deflections in said workings, and the boundary lines of said coal mines, and deposit a true copy of said map or plan with the inspector of coal mines, to be filed in his office, and another true copy of said map or plan with the recorder of the county in which said coal mine is situated, to be filed in his office, both of which said copies shall be deposited as aforesaid within three (3) months from the day when this Act shall go into effect; and the original, or a copy of such map or plan, shall also be kept for inspection at the office of such coal mine; and during the month of January, of each and every year after this Act shall go into effect, the said owner, agent or operator shall furnish the inspector and recorder, as aforesaid, with a statement and further map or plan of the progress of the workings of such coal mine, continued from the last report to the end of the December month just preceding; and the inspector shall correct his map or plan of said workings in accordance with the statement and map or plan thus furnished; and when any coal mine is worked out or abandoned, that fact shall be reported to the inspector, and the map or plan of such coal mine in the office of said inspector shall be carefully corrected and verified. The several coal mine inspectors in this State shall furnish copies of all maps or plans of mines to be filed with the Bureau of Labor Statistics.

2. *Inspector may make map at cost of owner.*—Whenever the owner, agent, or operator of any coal mine shall neglect or refuse to furnish the said inspector and recorder, as aforesaid, with the statement, the map or plan, or addition thereto, as provided in the first section of this act, at the times and in the manner therein provided, the said inspector is hereby authorized to cause an accurate map or plan of the workings of such coal mine to be made at the expense of said owner, agent or operator, and the cost thereof may be recovered by law from said owner, agent, or operator in the same manner as other debts, by suit in the name of the inspector and for his use.

3. *Escapement shaft—Roadway.*—In all coal mines that are or have been in operation prior to the first day of July, in the year of our Lord 1879, and which are worked by or through a shaft, slope or drift, if there is not already an escapement shaft to each and every said coal mine, or communication between each and every coal mine, and some other contiguous mine, then there shall be an escapement shaft or other communication, such as shall be approved by the mine inspector, making at least two distinct means of ingress and egress for all persons employed or permitted to work in such coal mine. Such escapement shaft or other communication with a contiguous mine as aforesaid shall be constructed in connection with every vein or stratum of coal worked in such coal mine, which shall be at least three and one-half feet high and at least five feet wide, and in no instance shall the height of said roadway be less than the thickness of the vein or stratum of coal through which it is driven; and the time to be allowed for such construction shall be one year when such mine is under one hundred (100) feet in depth; two years when such mine is over one hundred (100) feet in depth and under three hundred (300) feet, and three years when it is over three hundred (300) feet and under four hundred (400) feet, and four years when it is over four hundred (400) feet in depth, and five years for all mines over five hundred (500) feet, from the first day of July, A. D. 1879; and in all cases where the working force of one mine has been driven up to or into the workings of another mine, the respective owners of such mine, while operating the same, shall keep open a roadway at least five feet high and five feet wide, thereby forming a communication as contemplated in this act; and for a failure to do so shall be subject to the penalty provided for in section 10 of this act, for each and every day such roadway is unnecessarily closed; each and every such escapement shaft shall be separated from the main shaft by such extent of natural strata as shall secure safety to the men employed in such mines, such distance to be left to the discretion of the mine inspector or person acting in that capacity, and in all coal mines that shall go into operation for the first time after the first day of January, A. D. 1880. And in all cases where such mine or mines shall hereafter be put in operation in this State, the owner

thereof or the lessee or occupant of the same shall construct such an escapement shaft as is now required by law in this State, at the rate of two hundred feet per annum until such escapement shaft shall have been fully completed: *And provided, further*, That nothing in this section shall be construed to extend the time heretofore allowed by law for constructing escapement shafts in mines going into operation for the first time before the said first day of January, A. D. 1880.

4. *Ventilation—Daily examination with safety lamp—Furnace.*—The owner, agent or operator of every coal mine, whether operated by shaft, slope or drift, shall provide and maintain for every such mine a sufficient amount of ventilation, to be determined by the inspector, at the rate of one hundred cubic feet of air per minute, measured at the foot of the down-cast, which shall be forced and circulated to the face of every working place throughout the mine, so that said mine shall be free from standing gas of whatsoever kind; and in all mines where fire damp is generated, every working place where such fire damp is known to exist shall be examined every morning with a safety lamp by a competent person before any other persons are allowed to enter. The ventilation required by this section may be produced by any suitable appliance, but in case a furnace shall be used for ventilating purposes, it shall be built in such a manner as to prevent the communication of fire to any part of the works by lining the up-cast with incombustible material for a sufficient distance up from said furnace: *Provided*, It shall not be lawful to use a furnace for ventilating purposes, or for any other purpose, that shall emit smoke into any compartment constructed in or adjoining any coal-hoisting shaft or slope, where the hoisting shaft or slope is the only means provided for the ingress or egress of persons employed in said coal mines. That it shall be unlawful where there is but one means of ingress and egress provided at a coal shaft or slope, to construct and use a ventilating furnace that shall emit smoke into a shaft as an up-cast, where the shaft or slope used as a means of ingress and egress by persons employed in said coal mines is the only means provided for furnishing air to persons employed therein.

5. *Bore holes.*—The owner, agent, or operator shall provide that bore holes shall be kept twenty feet in advance of the face of each and every working place, and if necessary, on both sides, when driving towards an abandoned mine or part of a mine suspected to contain inflammable gases, or to be inundated with water.

6. *Signals—Hoistways—Children.*—The owner, agent or operator of every coal mine operated by shaft shall provide suitable means of signaling between the bottom and the top thereof, and shall also provide safe means of hoisting and lowering persons in a cage covered with boiler iron, so as to keep safe, as far as possible, persons descending into and ascending out of such shaft; and such cage shall be furnished with guides to conduct it on slides through such shaft, with a sufficient brake on every drum to prevent accident in case of the giving out or breaking of the machinery; and such a cage shall be furnished with spring catches intended and provided, as far as possible, to prevent the consequences of cable-breaking or the loosening or disconnecting of the machinery; and no props or rails shall be lowered in a cage while men are descending into or ascending out of said mine: *Provided*, That the provisions of this section in relating to covering cages with boiler iron shall not apply to coal mines less than one hundred (100) feet in depth where the coal is raised by horse power. No person under the age of fourteen years, or females of any age, shall be permitted to enter any mine to work therein. Any party or person neglecting or refusing to perform the duties required to be performed by sections three (3), four (4), five (5), six (6), seven (7) and eight (8), shall be deemed guilty of a misdemeanor and punished by fine in the discretion of the court trying the same, subject, however, to the limitations as provided by section 10 of this act.

7. *Operating hoistway—Competent engineer.*—No owner, agent or operator of any coal mine, operated by shaft or slope, shall place in charge of any engine, whereby men are lowered into or hoisted out of the mines, any but an experienced, competent and sober person not under the age of eighteen years; and no person shall ride upon a

loaded cage or wagon used for hoisting purposes in any shaft or slope, and in no case shall more than twelve persons ride on any cage or car at one time, nor shall any coal be hoisted out of any coal mine while persons are descending into such coal mine; and the number of persons to ascend out of or descend into any coal mine on one cage shall be determined by the inspector; the maximum number so fixed shall not be less than four, nor more than twelve, nor shall be lowered or hoisted more rapidly than six hundred feet to the minute.

8. *Boilers examined—Fencing shaft—Safety valves—Signals—Places of refuge.*—All boilers used in generating steam in and about coal mines shall be kept in good order, and the agent, owner or operator, as aforesaid, shall have said boilers examined and inspected by a competent boiler-maker or other qualified person, as often as once every six months, and oftener if the inspector shall deem it necessary, and the result of every such examination shall be certified, in writing, to the mine inspector; and the top of each and every shaft, and the entrance to each and every intermediate working vein, shall be securely fenced by gates properly covering and protecting such shaft and entrance thereto; and the entrance to every abandoned slope, air or other shaft shall be securely fenced off; and every steam boiler shall be provided with a proper steam-gauge, water-gauge and safety-valve; and all underground, self-acting or engine planes, or gangways, on which coal cars are drawn and persons travel, shall be provided with some proper means of signaling between the stopping places, and the end of said planes or gangways, and sufficient places of refuge at the sides of such planes or gangways shall be provided at intervals of not more than twenty feet apart.

9. *Accidents—Duty of district inspector.*—Whenever loss of life, or serious personal injury, shall occur by reason of any explosion, or of any accident whatsoever, in or about any coal mine, it shall be the duty of the person having charge of such coal mine to report the facts thereof, without delay, to the mine inspector of the district in which said coal mine is situated; and if any person is killed thereby, to notify the coroner of the county also, or, in his absence or inability to act, any justice of the peace of said county; and the said inspector shall, if he deem it necessary from the facts reported, immediately go to the scene of the accident, and make such suggestions and render such assistance as he may deem necessary for the safety of the men. And the inspector shall investigate and ascertain the cause of such explosion or accident and make a report thereof, which he shall preserve with the other records of his office; and to enable him to make such investigations he shall have the power to compel the attendance of witnesses, and administer oaths or affirmations to them, and the cost of such investigations shall be paid by the county in which such accident has occurred, in the same manner as costs of coroners' inquests are now paid. And the failure of the person in charge of the coal mine in which any such accident may have occurred, to give notice to the inspector or coroner, as provided for in this section, shall subject such person to a fine of not less than twenty-five dollars ($25), nor more than one hundred dollars ($100), to be recovered in the name of the people of the State of Illinois, before any justice of the peace of such county, and such fine, when collected, shall be paid into the county treasury for the use of the county in which any such accident may have occurred.

10. *Fines and penalties.*—In all cases in which punishment is provided by fine under this act for a breach of any of its provisions, the fine for a first offense shall not be less than $50 and not more than $200, and for the second offense not less than $100 or more than $500, in the discretion of the court, except as specially provided for in section 9 of this act.

11. *Five inspection districts—Inspectors—Bond—Compensation—Assistant inspectors.*—This State shall be divided into five inspection districts, as follows, viz: The first district shall be composed of the counties of Boone, McHenry, Lake, De Kalb, Kane, Du Page, Cook, La Salle, Kendall, Grundy, Will, Livingston, Kankakee, and Iroquois. Second district, the counties of Jo Daviess, Stephenson, Winnebago, Carroll, Ogle, Whiteside, Lee, Rock Island, Henry, Bureau, Mercer, Stark, Putnam, Marshall,

Henderson, Warren, Knox, Hancock, McDonough, Schuyler, Adams, and Brown. The third district, the counties of Fulton, Peoria, Woodford, Tazewell, McLean, Ford, Mason, Cass, Menard, Logan, De Witt, Piatt, Champaign, and Vermilion. The fourth district, the counties of Pike, Scott, Morgan, Sangamon, Calhoun, Greene, Jersey, Madison, Bond, Macoupin, Montgomery, Christian, Fayette, Macon, Moultrie, Shelby, Effingham, Douglas, Coles, Cumberland, Jasper, Edgar, Clark, Crawford, Clay, Richland, and Lawrence. The fifth district, the counties of St. Clair, Clinton, Washington, Marion, Jefferson, Wayne, Edwards, Wabash, Hamilton, White, Monroe, Randolph, Perry, Jackson, Franklin, Williamson, Saline, Gallatin, Union, Johnson, Pope, Hardin, Alexander, Pulaski, and Massac. The governor shall, upon the recommendation of a board of examiners selected for that purpose, composed of two practical coal miners, two coal operators, and one mining engineer, to be appointed by the Bureau of Labor Statistics of this State, all of whom shall be sworn to a faithful discharge of their duties, appoint five properly qualified persons to fill the offices of inspectors of coal mines of this State, (being one inspector for each district provided for in this act), whose commissions shall be for the term of one year, but they shall at all times be subject to removal from office for neglect of duty, or malfeasance in the discharge of duty, as hereinafter provided for; and the inspectors so appointed shall have attained the age of thirty years, be citizens of this State, and have a knowledge of mining engineering sufficient to conduct the development of coal mines, and a practical knowledge of the methods of conducting mining for coal in the presence of explosive gases, and of the proper ventilation of coal mines. They shall have had a practical mining experience of ten years, and shall not be interested as owner, operator, stockholder, superintendent or mining engineer of any coal mine during their term of office, and shall be of good moral character and temperate habits, and shall not be guilty of any act tending to the injury of miners or operators of mines during their term of office. They shall be provided by the State with the most approved modern instruments for carrying out the intentions of this act. The inspectors, before assuming the duties of their several offices, shall take an oath of office as provided for by the Constitution, and shall be required to enter into a bond to the State in the sum of five thousand dollars ($5,000), with sureties to be approved by the governor, conditioned upon the faithful performance of their duties in every particular, as required by this act; said bond, with the approval of the governor endorsed thereon, together with the oath of office, shall be deposited with the Secretary of state. The salaries of the inspectors provided for by this act shall be eighteen hundred dollars ($1,800) per annum, each, and the auditor of public accounts is hereby authorized to draw his warrant on the treasury in their favor, quarterly, for the amount specified in this section for the salary of each inspector: *Provided*, That the county board of any county may appoint an assistant inspector for such county, who shall act under the direction of the district inspector in the performance of his duties, and shall receive not less than three dollars ($3) nor more than five dollars ($5) per day, for the time actually employed, to be paid out of the county treasury; and he may be removed by such county board at any time.

12. *Inspectors' duties—Statistics—Investigation by bureau of labor statistics.*—The inspectors provided for by this act shall devote their whole time and attention to the duties of their office, and make personal examination of every mine within their respective districts, and shall see that every necessary precaution is taken to insure the health and safety of the workmen employed in such mines, and that the provisions and requirements of the mining laws of this State are faithfully observed and obeyed, and the penalties of same enforced. They shall also make annual reports to the bureau of labor statistics of their acts during the year in the discharge of their duties, with the recommendations as to legislation necessary on the subject of mining, and shall collect and tabulate upon blanks furnished by said bureau all desired statistics of the mines and miners within their districts, to accompany said annual report; they shall also furnish such information as they may have obtained on this subject

when called for, to the State geologist. Upon a petition signed by not less than three reputable coal operators, or ten coal miners, setting forth that any inspector of coal mines neglects his duties, or that he is incompetent, or that he is guilty of malfeasance in office, or guilty of any act tending to the injury of miners or operators of mines, it may be lawful for the bureau of labor statistics of this State to issue a citation to the said inspector to appear at no less than fifteen days' notice, on a day fixed, before them, when the said bureau shall proceed to inquire into and investigate the allegations of the petitioners; and if the said bureau find that the said inspector is neglectful of his duty, or that he is by reason of causes that existed before his appointment, or that have arisen since his appointment, incompetent to perform the duties of said office, or that he is guilty of malfeasance in office, or guilty of any act tending to the injury of miners or operators of mines, the said bureau shall declare the office of inspector of the said district vacant, and a properly qualified person shall be appointed to fill the office in compliance with the provisions of this act; and the cost of said investigation by the said bureau shall be borne by the removed inspector; but if the allegations of the petitioners are not sustained by the final decision of said bureau, the costs shall be paid by the petitioners.

11. *Board of examiners.*—The board of examiners provided for in section 11 of this act shall be appointed at the annual meeting of the bureau of labor statistics, and shall hold their offices one year. They shall meet annually at the State capital on the first Monday in September, in each year, and special meetings may be called at any time by the bureau of labor statistics when the office of coal-mine inspector becomes from any cause vacant. They shall receive as compensation the sum of three dollars ($3) per day, each, for time actually employed in the duties of their office, and the actual traveling expenses, to be verified by affidavit: *Provided,* That in no case shall the *per diem* received by any member of the said board exceed the sum of thirty dollars ($30) per annum. The auditor of public accounts is hereby authorized to draw his warrant in favor of each member of the board of examiners at th close of their annual session, for the full amount due them for attending annual and special session, and expenses, upon vouchers sworn to by them and approved by the secretary of the bureau of labor statistics, and the governor.

13. *Inspection of mines—Refusal of owner to permit—Injunction.*—It shall be lawful for the inspector, provided for in this act, to enter, examine and inspect any and all coal mines and machinery belonging thereto, at all reasonable times, by day or by night, but so as not to obstruct or hinder the necessary workings of such coal mine, and the owner, agent or operator of every such coal mine is hereby required to furnish all necessary facilities for entering such examination and inspection, and if the said owner, agent or operator aforesaid shall refuse to permit such inspection, or to furnish the necessary facilities for such entry, examination and inspection, the inspector shall file his affidavit setting forth such refusal, with the judge of the circuit court in said county in which said mine is situated, either in term time or vacation, or, in the absence of said judge, with the master in chancery in said county in which said mine is situated, and obtain an order on such owner, agent or operator so refusing as aforesaid, commanding him to permit and furnish such necessary facilities for the inspection of such coal mine, or to be adjudged to stand in contempt of court and punished accordingly, and if the said inspector shall, after examination of any coal mine and the works and machinery pertaining thereto, find the same to be worked contrary to the provisions of this act, or unsafe for the workmen therein employed, as said inspector shall, through the State's attorney of his county, or any attorney, in case of his refusal to act, acting in the name and on behalf of the State, proceed against the owner agent or operator of such coal mine by injunction without bond, after giving at least two days' notice to such owner, agent or operator; and said owner, agent or operator shall have the right to appear before the judge or master to whom the application is made, who shall hear the same on affidavits and such other testimony as may be offered in support as well as in opposition thereto, and if

sufficient cause appear, the court, or judge in vacation, by order shall prohibit the further working of any such coal mine in which persons may be unsafely employed contrary to the provisions of this act, until the same shall have been made safe and the requirements of this act shall have been complied with, and the court shall award such costs in the matter of the said injunction as may be just; but any such proceedings so commenced shall be without prejudice to any other remedy permitted by law for enforcing the provisions of this act.

14. *Injuries—Remedies for widow and persons dependent.*—For any injury to person or property, occasioned by any willful violations of this act or willful failure to comply with any of its provisions, a right of action shall accrue to the party injured for any direct damages sustained thereby; and in case of loss of life by reason of such willful violation or willful failure as aforesaid, a right of action shall accrue to the widow of the person so killed, his lineal heirs or adopted children, or to any other person or persons who were before such loss of life, dependent for support on the person or persons so killed, for a like recovery of damages for the injuries sustained by reason of such loss of life or lives.

15. *Conduct of miners—Injury to machinery—Disobedience.*—Any miner, workman or other person who shall knowingly injure any water-gauge, barometer, air-course or brattice, or shall obstruct, throw open any air-ways, or carry any lighted lamps or matches into places that are worked by the light of safety lamps, or shall handle or disturb any part of the machinery of the hoisting engine, or open a door in the mine and not have the same closed again, whereby danger is produced either to the mine or those at work therein; or who shall enter into any part of the mine against caution; or who shall disobey any order given in pursuance of this act; or who shall do any willful act whereby the lives and health of persons working in the mine, or the security of the mine or mines, or the machinery thereof, is endangered, shall be deemed guilty of a misdemeanor, and, upon conviction, shall be punished by fine or imprisonment, at the discretion of the court.

16. *Timber for props.*—The owner, agent or operator of any coal mine shall keep a sufficient supply of timber, where required to be used as props, so that the workmen may at all times be able to properly secure the said workings from caving in; and it shall be the duty of the owner, agent or operator to send down all such props when required.

17. *Repeal.*—All acts or parts of acts inconsistent with the provisions of this act are and the same are hereby repealed.

18. *Buildings to be covered with fire-proof materials—Disobedience—Injunction.*—That all mines hoisting coal by steam-power from shaft or slope, having no other means of ingress or egress than that afforded to persons employed therein than by said shaft or slope, shall, within ninety days after July first, A. D. 1883, have all engine and boiler houses roofed and sided with fire-proof materials, and they shall be situated not less than fifty feet from the mouth of the said shaft or slope; that the hoisting derricks erected over said hoisting shaft or near said slope, if inclosed, and all the coal chutes, buildings and constructions within a radius of fifty feet of the mouth of the said hoisting shaft or slope, shall be covered and sided with fire-proof materials, and the person in charge, the owners or operators thereof, shall provide a steam-pump and have the same conveniently situated, and a sufficient supply of water and hose, always ready for use in any part of the buildings, chutes or construction within a radius of fifty feet of said coal-hoisting shaft or slope; and if the person in charge of any such coal shaft or slope shall refuse or neglect to comply with the provisions of this act, then the inspector of coal mines for the county in which the said shafts or slope are situated shall proceed, through the State's attorney of his county or any attorney, in case of his refusal to act, acting in the name and on behalf of the State, against the owner, agent or operator of said shaft or slope, by information without bond, after giving at least two days' notice to such owner, agent or operator; and the said owner, agent or operator shall have the right to appear before the judge or master to whom the application is made, who shall hear the same on affidavits, and such other testimony as

may be offered, in support as well as in opposition thereto; and if it be found that the owner, agent or operator of said shaft or slope has refused or neglected to comply with the provisions of this act, the court, or judge in vacation, by order, shall prohibit the further working of any such coal shaft or slope until the owner, agent or operator shall have complied with the terms of the act.

19. *Copper implements for coal blasts.*—That all miners and employés engaged in mining coal shall use copper needles, in preparing blasts in coal, and not less than five (5) inches of copper on the end of all iron bars used for tamping blasts of powder in coal, and the use of iron needles, and iron tamping bars, not tipped with five inches of copper, is hereby declared to be unlawful. Any failure on the part of a coal miner, or an employé in any coal mine, to conform to the terms and requirements of this act shall subject such miner or employé to a fine of not less than $5, nor more than $25 with costs of prosecution, for each offense, to be recovered by civil suit, before any justice of the peace, said fines, when collected, to be paid into the treasury of the county where the offense was committed, to the credit of the fund provided for the payment of the county inspector of mines.

LOCATION OF MINES.

1. *Making drains, roads or railroads.—Eminent domain.*—Whenever any mine or mining place shall be so situated that it cannot be conveniently worked without a road or railroad thereto, or ditch to drain the same or to convey water thereto, and such road, railroad or ditch shall necessarily pass over, through or under other land owned or occupied by others, the owner or operator of any such mine or mining place may enter upon such lands, and construct such road, railroad or ditch, upon complying with the law in relation to the exercise of the right of eminent domain.

And the commissioners of highways of any county under township organization, and the county board in counties not under township organization, may, when the public good requires, cause to be laid out and opened public highways, or private roads or cartways, from any coal mine to a public highway or to a railway as the public good may require, in the same way as now is or may hereafter be provided by law for the laying out and opening of public highways or private roads or cartways, and may permit the owner, lessee or operator of any coal mine to lay down and operate a horse or dummy railway thereon, or upon any highway or private road or cartway now or hereafter laid out and opened for public or public and private use, but always in such a manner and way, and upon such place thereon, as to not unnecessarily interfere with ordinary public travel.

2. *Trespass by mining—Surveyor appointed.*—If the owner of any land adjacent to any lands worked as lead, coal, iron or other mine shall make complaint, in writing, verified by affidavit, to the judge of any court of record in the county where the land is situated, that he has reasonable grounds to believe, and does believe, that the owner or operator of such mine is trespassing upon his lands by mining thereon, it shall be the duty of the judge to appoint some county surveyor or other competent and suitable person to descend into such mine, and make such examinations and surveys as may be necessary to ascertain whether the same is being worked upon the land of the person making the complaint.

3. *Powers of surveyor—Penalties.*—The person so appointed shall have the right, at all reasonable times, to descend into such mine and make such examinations and surveys; and whoever shall willfully obstruct or hinder such person from entering into any such mine, or any gallery or place therein, or from making any such examination or survey, shall, for each offense, be fined not exceeding $200, to be recovered before any justice of the peace of the county. Any person accepting any such appointment, and failing or refusing to make such survey upon the request of the petitioner, may be proceeded against as for a contempt of court, or he may be fined not exceeding $500.

4. *Expenses.*—The expense of such examination and survey shall be paid by the person making the complaint, but if such person shall recover damages against the

owner or operator of such mine for working the same upon his land, he shall have the right to have such expenses added to the damages.

5. *Penalty for trespass.*—Whoever shall willfully trespass upon the land of another by mining thereon, shall, in addition to the damages now authorized by law, be liable to a penalty not to exceed $500, which may be recovered in an action of debt by the owner thereof, in any court of competent jurisdiction.

6. *Conveyance of mining right.*—Any mining right, or the right to dig for or obtain iron, lead, copper, coal, or other mineral from land, may be conveyed by deed or lease, which may be acknowledged and recorded in the same manner and with like effect as deeds and leases of real estate.

7. *Effect of conveyance.*—When the owner of any land shall convey, by deed or lease, any mining right therein, such conveyance shall be considered as so separating such right from the land that the same shall be taxable separately, and any sale of the land for any tax or assessment shall not include or affect such mining right.

8. *Record of purchases of lead mineral to be kept.*—Every person purchasing lead mineral shall keep a book, in which he shall keep an account of all lead mineral purchased by him, stating clearly the amount, from whom and time when purchased, and the place where it was dug; and for the purpose of ascertaining such facts, he shall make diligent inquiry of the person offering such mineral for sale, and if satisfactory answers are not given, it shall not be lawful for him to buy the same.

9. *Book open for inspection.*—Such purchaser shall keep such book at his usual place of business, open at all reasonable times for the inspection of miners, owners of mineral lands, and smelters of lead ore.

10. *Report to smelter, when purchaser has no place of business.*—When any such purchaser has not a usual place of business, he shall, within twenty-four hours from the time of making any such purchase, make return to the nearest smelter of lead ore to the place of procuring the same, stating the amount thereof, when, of whom and where purchased, and from what place the same was dug or taken; and such smelter shall minute the same in his book, to be kept pursuant to this act.

11. *Purchase from child under twelve, forbidden.*—No person shall be allowed to purchase lead mineral from any child under twelve years of age.

12. *Penalties.*—Any person who shall purchase lead mineral without keeping the book or making the entries or returns as herein provided, or shall refuse to allow their inspection as herein provided, shall forfeit for each offense the sum of $25; and whoever violates any of the other provisions of the four preceding sections, shall forfeit for the first offense the sum of $5 and costs, and for every subsequent offense $10 and costs—one-half to the informer, and the other half to the school fund of the school district where the suit is brought. Said penalties shall be recoverable by action of debt before any justice of the peace of the county where the offense is committed.

13. *Track and platform scales.*—The owner, agent or operator of each and every coal mine or colliery in this State shall furnish, or cause to be furnished, and placed upon the switch or railroad track adjacent to said coal mine or colliery, a "track scale" of standard manufacture, and shall weigh all coal hoisted from said mine or colliery before or at the time of being loaded on cars, wagons, or other vehicle of transportation: *Provided,* That in cases where track scales can not be used, or the product of such mine or colliery will not justify the expense of a track scale, the owner, agent or operator of same shall be permitted to furnish (in lieu of a track scale) a platform scale of sufficient capacity to weigh each box as it is hoisted from such mine or colliery.

14. *Weight of coal—Basis of wages.*—All coal produced in this State shall be weighed on the scales as above provided; and the weight so determined shall be considered the basis upon which the wages of persons mining said coal shall be computed.

15. *Check weigher for employés.*—It shall be lawful for the miners employed in any coal mine or colliery in this State, to furnish a check weigher at their own expense, whose duty it shall be to balance said scales and see that the coal is properly weighed;

and keep a correct account of same, and for this purpose he shall have access at all times to the "beam box" of said scale while such weighing is being performed. That the agent employed by persons mining coal, to act as check weighman, shall be an employé in the mines where the coal to be weighed was produced, [and] a citizen of the State and county wherein the mine is situated. He shall on application to the owner, agent or operator of the mine producing the coal to be weighed, be furnished with a written permit, that shall entitle him to enter and remain in the room or place where the àccounting by him of the weights of coal is to be done, and the said permit shall not be transferable: *Provided*, That the provisions of this act shall apply only to coal miners doing business on the shipping coal by railroad or by water.

16. *Penalties.*—Any person, owner or agent, operating a coal mine or colliery in this State, who shall fail to comply with the provisions of this act, or any person who shall obstruct or hinder the carrying out of its requirements, shall be deemed guilty of a misdemeanor, and punished accordingly.

PENNSYLVANIA.

In addition to the references already made to the mining regulations of Pennsylvania under the topics which they concern, the following law, which was passed in the session of 1885, is given in full:

An act relating to bituminous coal mines and providing for the lives, health, safety and welfare of persons employed therein.

SECTION 1. *Maps. Be it enacted, &c.*, That the owner, operator or superintendent of every bituminous coal mine, shall make or cause to be made an accurate map or plan of such coal mine, on a scale not exceeding one hundred feet to the inch, which map or plan shall exhibit all the openings or excavations, the shaft, tunnels, slopes, planes, gangways, entries, cross-headings, rooms, *et cetera*, and shall show the direction of the air currents therein, and shall accurately delineate the boundary lines between said coal mine and adjoining mines operated by other parties, and show the relation and proximity of the workings thereto. The maps shall also show the changes of level of the lowest entry in use for drainage connecting with each independent opening. The said map or plan, or a true copy thereof, together with a record of all the surveys of said boundary lines and openings and excavations aforesaid, shall be kept at such mine by the said owner, operator, or superintendent for the use of the mine inspector, and for the inspection of any miner working in said mine, whenever said miner shall have cause to fear that the working place, where he is working, is becoming dangerous by reason of its proximity to other workings, which may be supposed to contain water or dangerous gas. The said owner, operator, or superintendent shall, as often as once in every six months, accurately place or cause to be placed on the map or plan of said coal mine, a plan of the excavations made of all the working places, or other parts of such coal mine, during the preceding six months; and, whenever the workings or excavations of said coal mine, or any part of the same, have been driven to within ten feet of the boundary line, or when said coal mine, or any part of the same, is abandoned, the owner, operator, or superintendent thereof shall furnish the mine inspector, within three months after, the proximity to the boundary line as aforesaid, or after abandonment of the said mine, or any part of the same, with a correct copy, on tracing muslin, of the map or plan of said mine, which shall accurately show all excavations and workings of such mine to date, exhibiting clearly the part or parts abandoned, and the part or parts in proximity to the boundary line aforesaid. The maps or plans of the several coal mines in each district, which are furnished to mine inspector as last aforesaid, shall be the property of the Commonwealth, and shall remain in the care of the inspector of the district in which the said mines are situated, to be transferred by him to his successor in office, and in no case shall any copy of the same be made without the consent of the owner, operator, or his agent. If the mine inspector shall find, or have good reason to believe that any map or plan of any coal mine, made or furnished in pursuance of the provisions of this act, is materially inaccurate or imperfect, he is hereby authorized to cause a correct map or plan of said coal mine to be made, at the expense of the owner or operator thereof, the cost of which shall be recoverable from said owner or operator as other debts are recoverable by law: *Provided, however*, That if the map or plan which is claimed to be inaccurate, shall prove to have been correct, then the Commonwealth shall be held liable for the expenses incurred in making said test survey, and the same shall be paid by the State treasurer, upon warrants of the auditor-general, who shall require proper vouchers and satisfactory proof of the same.

SEC. 2. *Two openings to be made to each mine.*—It shall not be lawful for the owner, operator, contractor, lessee or agent of any bituminous coal mine, or for any firm, company, corporation or association, their clerks, servants, agents or employés, to employ any person at work within said coal mine, or permit any person to be in said coal mine for the purpose of working therein, unless they are in communication with at least two openings, if the mine be worked by shaft or slope, which two shafts or slopes shall be separated by natural strata at all points by a distance of not less than one hundred and fifty feet, except in mines already opened, such distance may be less, if in the judgment of the mine inspector one hundred and fifty feet is impracticable; and if the mine be worked by drift, two openings, exclusive of the air-shaft, and not less than twenty-four feet apart, shall be required, except in drift mines heretofore opened, where the mine inspector of the district shall deem it impracticable: *Provided, however*, That an aggregate number, not exceeding twenty persons, may be employed in the mine at any one time until the second opening shall be reached and made available, which said second opening the mine inspector shall cause to be made without necessary delay; and, in case of furnace ventilation being used before the second opening is reached, the furnace shall not be placed within forty feet of the foot of the shaft, slope or drift, and shall be well secured from danger from fire, by brick or stone walls of sufficient thickness, while being driven for making and perfecting the second opening.

SEC. 3. *Second opening to be used exclusively for purpose of ingress or egress.*—When the second opening or outlet is made, which does not exceed seventy-five feet in vertical depth from the surface to the seam or stratum of coal that is being mined, it shall be set apart exclusively for the purpose of ingress or egress to or from the mine by any person or persons employed therein, and it shall not be clogged or obstructed with ice, machinery, pumps, or currents of heated air or steam; and if the opening is a shaft, it shall be fitted with safe and convenient stairs, not less than two feet wide and to not exceed an angle of sixty degrees descent, and landings of not less than eighteen inches wide and four feet long, at easy and convenient distances, and all water coming from the surface or out of the strata in the shaft shall be conducted by rings casing or otherwise, and be prevented from so falling down the shaft as to wet persons who are ascending or descending the stairway of the shaft; if the second opening is a slope for a traveling way, it shall not have a greater angle of descent than twenty degrees and may be of any depth; but when the seam or stratum of coal, at main outlet or escapement shaft in connection with any mine, exceeds seventy-five feet in vertical depth from the surface, the miners or other employés in the mine shall be lowered into or raised from the said mine by machinery, and when the employés are lowered into or raised from the said mine at the main outlet, the escapement shaft shall be fitted with safe and available machinery, or safe and convenient stairs, by which persons employed in the mine may readily escape in case of accident. The hoisting machinery and stairs used for lowering or raising the employés into or out of the mine shall be kept in a safe condition, and inspected once each twenty-four hours by a competent person employed in whole or in part for that purpose. And such machinery and the method of its inspection shall be approved by the mining inspector of the district where the mine is situated: *Provided*, That when miners are not at work in the mine, the said second shaft or slope may be used for the purpose of lowering material: *Provided further*, That the requirements of this section shall not be applicable to stairways now in use, when, in the judgment of the inspector, they are sufficient. The owner, operator, lessee or agent shall provide and maintain a metal tube from the top to the bottom of the shaft, suitably adapted to the free passage of sound, through which conversation may be held between persons at the bottom and at the top of the shaft, also the ordinary means of signaling to and from the top and bottom of the shaft, and an approved safety catch, and sufficient cover overhead on every carriage used for lowering and hoisting persons; and the said owner, operator, lessee or superintendent shall see that sufficient flanges are attached to the sides of the drum of every machine that is used for lowering and hoisting persons in and out of the mine, and also that adequate brakes are attached to the drum; the main coupling chain, attached to the socket of the wire rope, shall be made of the best quality of iron, and shall be tested by weights or otherwise to the satisfaction of the inspector of the district; and bridle chains shall be attached to the main socket from the cross pieces of the carriage, so that no single chain shall be used for lowering or raising persons into or out of the mine; and no greater number of persons shall be lowered or hoisted at any one time than may be permitted by the inspector of the district; and notice of the number so allowed to be lowered or hoisted at any one time shall be kept posted up by the owner, operator or superintendent in a conspicuous place at the opening of the shaft.

SEC. 4. *Ventilation of mines.*—The owner or agent of every bituminous coal mine, whether shaft, or slope, or drift, shall provide and hereafter maintain for every such mine ample means of ventilation, affording not less than one hundred cubic feet per minute for each and every person employed in said mine, and as much more as the circumstances may require, which shall be circulated around the main headings and cross-headings and working places to an extent that will dilute, carry off and render harmless the noxious or dangerous gases generated therein; and all mines generating fire-damp shall be kept free of standing gas in the worked-out or abandoned parts of the same as far as practicable, and the entrance thereto shall be properly closed, and cautionary notice shall be posted to warn persons of danger; and every working place, and all other places, where gas is known to exist or supposed to exist, shall be carefully examined by the fire boss, immediately before each shift, with a safety lamp, and in making said examination, it shall be the duty of the fire boss at each examination to leave at the face of every place, so examined, evidence of his presence; and it shall not be lawful for any miner to enter any mine or part of a mine generating fire-damp, until it has been examined by the fire boss as aforesaid and reported by him to be safe.

SEC. 5. *Mining boss to be employed.*—In order to better secure the proper ventilation of every coal mine, and promote the health and safety of the persons employed therein, the owner or agent shall employ a competent and practical inside overseer, to be called mining boss, who shall be a citizen and an experienced coal miner, and shall keep a careful watch over the ventilating apparatus and the air-ways, traveling-ways, pumps and pump timbers and drainage; and shall see that, as the miners advance their excavations, all loose coal, slate and rock overhead are carefully secured against falling therein, or on the traveling-ways; and that sufficient props, caps and timbers are furnished, of suitable size and cut square at both ends and as near as practicable to a proper length, for the places where they are to be used; and such props, caps or timbers shall be delivered and placed in the working places of the miners, and every workman in want of props or timber and cap pieces shall notify the mining boss or his assistant of the fact, at least one day in advance, giving the length and number of props or timbers and cap pieces required, but in cases of emergency the timbers may be ordered immediately upon the discovery of any danger (the place and manner of leaving the orders for the timber shall be designated and specified in the rules of the mine) and said working places shall be vacated until supplied with the timber needed; and shall see that all water be drained or hauled out of all working places before the miner enters, and as far as practicable kept dry while the miner is at work. And it shall be the duty of the mining boss to see that proper cut-throughs are made in the room pillars of the miners' places, at such distances apart as in the judgment of the inspector may be deemed requisite, not more than thirty-five nor less than sixteen yards each, for the purpose of ventilation. And in all traveling-ways or road, holes for shelter shall be made at least every thirty yards and be kept whitewashed, a space two feet six inches between the wagon and the rib shall be deemed sufficient for shelter. And the mining boss shall measure the air current, at least once a week, at the inlet and outlet and at or near the face of the headings, he shall keep a record of such measurements, which shall be placed by him in a book kept for that purpose, the said book to be open for the examining of the inspector of the district; he shall also, on or about the fifteenth day of each month, mail to the inspector of his district a true copy of the air measurements given, stating also the number of persons employed in or about said mine, the number of mules and horses used, and the number days worked in each month. Blanks for such purpose shall be furnished him by the inspector of the district.

It shall be the further duty of the mining boss to immediately notify the agent or owner of the mine, in writing, of his inability to comply with the provisions of this section. It shall then become the duty of said superintendent, operator, lessee or owner, at once to attend to the matter complained of by the mining boss, to comply with the provisions hereof. The safety lamps used for examining mines, or which may be used in working therein, shall be furnished by and be the property of the owner of said mines, and shall be in charge of the agent of such mine; and in all mines, the doors, used in assisting or directing the ventilation of the mine, shall be so hung and adjusted that they will close themselves, or be supplied with springs or pulleys so that they cannot be left standing open; and bore holes shall be kept not less than twelve feet in advance of the face, and when necessary, on the sides of working places, which are being driven towards and in dangerous proximity to an abandoned mine, or part of a mine suspected of containing inflammable gases, or which is inundated with water. The mining boss, his assistant, or assistants, shall visit and examine every working place in the mine, at least once every alternate day, while the miners of such place are or should be at work, and shall direct that each and every working place be properly secured by props or timber, so that safety in all respects be assured, and that no person shall be directed to work in an unsafe place, unless it be for the purpose of making it safe. All owners or operators of bituminous coal mines shall keep posted, in a conspicuous place about their mines, printed rules, submitted to and approved by the district mining inspector, defining the duties of all persons employed in or about said mines or collieries, which said notice shall be printed in the language or languages used by any ten miners working therein.

SEC. 6. *Willful injury to shaft, lamp, &c., declared a misdemeanor.*—Any miners, workmen or other person, who shall intentionally injure any shaft, lamp, instrument, air-course or brattice, or obstruct or throw open air-ways, or carry lighted pipes or matches into places that are worked by safety lamps, or handle or disturb any part of the machinery, or open a door and not close it again, or enter any place of the mine against caution, or disobey any order given in carrying out the provisions of this act, or do any other act whereby the lives or the health of persons, or the security of the mines or the machinery, is endangered, shall be deemed guilty of a misdemeanor, and may be punished in a manner provided in the twenty-first section of this act; all machinery about mines shall be properly fenced off, and there shall be cut, in the side of every hoisting shaft at the bottom thereof, a traveling way sufficiently high and wide to enable persons to pass the shaft, in going from one side of the mine to the other, without passing over or under the cage or other hoisting apparatus.

SEC. 7. *Proceedings for making openings on adjoining lands.*—If any person, firm or corporation is or shall hereafter be seized in his or their own right of coal lands, and it shall not be practicable to comply with the requirements of this act in regard to drainage and ventilation, by means of openings on his or their own land, and the same can be done by means of openings on adjacent lands, he or they may apply by petition to the court of quarter sessions of the proper county, after ten days' notice to the owner or owners, their agent or attorney, setting forth the facts under oath or affirmation, particularly describing the place or places where such opening or openings can be made, and that he or they cannot agree with the owner or owners of the land as to the amount to be paid, for the privilege of making such opening or openings; whereupon, the said court shall appoint three disinterested and competent citizens of the county to view the ground designated, and lay out, from the point or points mentioned in such petition, a passage or passages for air and water, not more than sixteen feet in diameter, by the shortest and most convenient route to the coal of such person, firm or corporation, preferring in all cases an opening through the coal strata where the same is practicable; the said viewers shall at the same time assess the damages to be paid by the petitioner or petitioners to the owner or owners of such lands, which damages shall be fully paid before such opening is made. It shall be the duty of the petitioner, or the viewers, to give notice, by at least three written or printed hand-bills posted on the premises at or near the place where such opening is proposed to be made at least five days prior to the time of meeting to attend to the duties of their appointment, setting forth distinctly the time, place and object of their meeting, and also to give personal notice to the owners, their agents or attorneys, if residing in the same county; and the said viewers shall, within thirty days after their appointment, make report of their proceedings to the said court, stating the amount of damages awarded, accompanied by a map or plan of the proposed openings; and if no exceptions be filed to the said report within ten days after notice to the opposite party, his agent or attorney, of the filing of said report, it shall be marked confirmed by the clerk, and the petitioner or petitioners may proceed to make said opening or openings, and shall have the right to use the same for the purpose of ventilation and drainage as aforesaid and as a passage way. The proceedings shall be recorded in the road docket of the proper county, and the pay of viewers shall be the same as in road cases. If exceptions be filed they shall be disposed of by the said court as speedily as possible, and both parties to have the right to take depositions as in road cases. If, however, the petitioner desires to make such opening before the final disposition of such exceptions, he shall have the right to do so, by giving bond to be approved by the court securing the damages as provided by law in the case of lateral railroads.

SEC. 8. *Governor to appoint two mining engineers.*—In the year one thousand eight hundred and eighty-nine, and every four years thereafter, the Governor shall, as hereinafter provided, during the month of February, appoint two mining engineers of good repute and of known experience and practice at the time; he also shall, as hereinafter provided, during the same month and every four years thereafter, notify three president judges of the courts of common pleas of the judicial districts of the State containing bituminous coal mines, whose duty it shall be, each of them, to appoint one reputable miner, of at least five years practical experience in the mining region of Pennsylvania, in practice at least three months prior to his appointment, and a citizen of the Commonwealth not less than five years: *Provided*, That any person having been employed, five months prior to the meeting of the examining board, as Superintendent, State or county officer shall not serve on examining board. The two engineers and the three miners so appointed shall constitute a board of examiners, whose duty it shall be to inquire into the character and qualifications of candidates for the office of inspector of mines, under the provisions of this act. The examining board so constituted shall meet in the city of Pittsburg, on the first Monday of April, and, when called together by the Governor for extra occasions, at such time and place as he may designate, and after being duly organized and having taken and subscribed, before any officer authorized to administer the same, the following oath, namely:

"We, the undersigned, do solemnly swear (or affirm) that we will perform the duties of examiners of applicants for appointment as inspectors of bituminous coal mines to the best of our abilities, and that, in recommending or rejecting said applicants, we will be governed by the evidence of the qualification to fill the position, under the law creating the same and not by any consideration of political or other personal favor, that we will certify all whom we may find qualified according to the true intent and meaning of the act and none others," shall proceed to the examination, which shall be in writing, of those who may represent themselves as candidates for said office; and they shall certify to the Governor the names of all such applicants as they shall find competent to fill the office, under the provisions of this act, which names, with the certificates and their percentage and the oath of the examiner, shall be mailed to the Secretary of the Commonwealth and be filed in his office: *Provided,* That no person shall be returned as competent whose percentage shall be less than ninety per cent., and such certificate shall be valid only when recommended by four of the examining board. The qualification of candidates for said office of inspectors of mines, to be inquired into and certified by said examiners, shall be as follows, namely: They shall be citizens of Pennsylvania, of temperate habits, of good repute as men of personal integrity, shall have attained the age of thirty years, and shall have had at least five years practical experience in the workings of the coal mines of Pennsylvania, and, upon the examination, they shall give evidence of such theoretical as well as practical knowledge, and general intelligence regarding mines and mining and the working thereof, and all noxious gases, as will satisfy the examiners of their capability and fitness for the duties imposed upon inspectors of mines, by the provisions of this act. The board of examiners shall also at their meeting, or when at any time called by the Governor together for an extra meeting, divide the bituminous coal counties of the State into eight inspection districts, as nearly equal to the labor to be performed as is possible, and, at any subsequent calling of the board of examiners, this division may be revised as experience may prove to be advisable; and they shall immediately after the examination furnish each person, who came before said examination board to be examined, all questions, which were given at the examination, on printed slips of paper and to be marked solved right or wrong as the case may be. The board of examiners shall each receive five dollars per day, and all necessary expenses, to be paid out of the State Treasury.

Upon the filing of the certificates of the examining board in the office of the Secretary of the Commonwealth the Governor shall, from the names so certified, commission one person to be inspector of mines for each district, as fixed by the examiners in pursuance of the act, whose commission shall be for a full term of four years to be computed from the fifteenth day of May, one thousand eight hundred and eighty-five: *Always provided however,* The highest candidate or candidates in percentage shall have priority to be commissioned for a full term, or unexpired term, before those candidates of a lower percentage, and in case of a tie in percentage the oldest candidate shall be commissioned. As often as vacancies occur in said offices of inspectors of mines the Governor shall commission, for the unexpired term, from the names on file, the highest in percentage above ninety per centum, in the office of the Secretary of the Commonwealth, until the number shall be exhausted, and, whenever this may occur, the Governor shall cause the aforesaid board of examiners to meet, who shall examine persons who may present themselves for the vacant office of inspector, in the same manner as herein provided, and the board of examiners shall certify to the Governor one person highest in percentage, to be commissioned by him for the office of inspector for the unexpired term; and any vacancies that may occur in the examining board, shall be filled by those or their successors in whose jurisdiction the vacancy occurred.

Each inspector of mines shall receive for his services an annual salary of two thousand dollars and actual traveling expenses, to be paid quarterly by the State treasurer upon warrant of the auditor general; and all mine inspectors hereafter appointed shall make their residence and keep an office in the district for which they are commissioned. Each inspector is hereby authorized to procure such instruments and chemical tests, stationery, and to incur such expense of communication from time to time as may be necessary to the proper discharge of his duties under this act, at the cost of the State, which shall be paid by the State treasurer upon accounts duly certified by him, and audited by the proper department of the State. All instruments, plans, books, memoranda, notes, *et cetera*, pertaining to the office, shall be the property of the State, and shall be delivered to their successors in office. That, in addition to the expenses now allowed by law to the mine inspectors in enforcing the several provisions of this act, to which this is supplementary, they shall be allowed all necessary expenses by them incurred in enforcing the several provisions of said laws in the respective courts of the commonwealth, the same to be paid by the State treasurer on warrants drawn by the auditor general, after auditing the same; all such accounts presented by the mine inspector to the auditor general shall be itemized, and first approved by the court before which the proceedings were instituted.

SEC. 9. *Inspectors to give bond with sureties.*—Each inspector of bituminous coal mines shall, before entering upon the discharge of his duties, give bond in the sum of five thousand dollars, with sureties to be approved by the president judge of the district in which he resides, conditioned for the faithful discharge of his duty, and take an oath (or affirmation) to discharge his duties impartially and with fidelity to the best of his knowledge and ability.

But no person who shall act as a manager or agent of any coal mine, or as a mining engineer, or to be interested in operating any coal mine, shall, at the same time act as an inspector of coal mines under this act.

SEC. 10. *Duties of inspectors.*—The inspector of bituminous coal mines shall each devote the whole of his time to the duties of his office; it shall be his office to examine the mines in his district, as often as possible, which shall not be less than once in three months (and report how often he has visited each mine in the year), to see that all the provisions of this act are observed and strictly carried out; and he shall make record of all examinations of mines showing the condition in which he finds them, especially in reference to ventilation and drainage, the number of mines in his district, the number of persons employed in each mine, the extent to which the law is obeyed, and progress made in the improvement sought to be secured by the passage of this act, the number of accidents and deaths resulting from injuries received in or about the mines, with cause of such accident or death, which record, completed to the thirty-first day of December of each and every year, shall, on or before the first day of February following, be filed in the office of the secretary of internal affairs, to be by him recorded and included in the annual report of his department.

SEC. 11. *Inspectors may enter mines at all times.*—That the inspectors may be enabled to perform the duties herein imposed upon them, they shall have the right at all times to enter any bituminous coal mine, to make examination, or obtain information; they shall notify the owners, operators, lessees, superintendent, or mining bosses, in writing and keep a copy thereof, immediately of the discovery of any violation of this act, and of the penalty imposed thereby for such violation, and in case of such notice being disregarded for the space of five days, they shall institute proceedings against the owner, operator, lessee, superintendent, or mining boss of the mine, under the provisions of section twenty-one of this act; in case, however, where, in the judgment of the inspector of any district, delay may jeopardize life or limb, he shall at once notify one of the inspectors of the other district, whereupon they shall at once proceed to the mine where the danger exists and examine into the matter, and if, after full investigation thereof, they shall be agreed in the opinion that there is immediate danger, they shall apply in the name of the commonwealth to the court of common pleas of the county, or in case the court shall not be in session to a judge of the said court in chambers, in which the mine may be located, for an injunction to suspend all work in and about such mine; whereupon said court or judge shall at once proceed to hear and determine speedily the same, and, if the cause appear to be sufficient after hearing the parties and their evidence as in like cases, shall issue their writ to restrain the working of said mine until all cause of danger is removed; and the costs of said proceedings, including the charges of attorney prosecuting the same, shall be borne by the owner, lessee, or agent of the mine: *Provided,* That no fee exceeding the sum of twenty-five dollars shall be taxed in any one case for the attorney prosecuting such case: *Provided, further,* That if said court shall find the cause not sufficient, then the case shall be dismissed, and the costs shall be borne by the county.

SEC. 12. *Explosions, or other accidents, to be reported to the inspector.*—Whenever by reason of any explosion or other accident, in any bituminous coal mine or the machinery connected therewith, loss of life or serious personal injury shall occur, it shall be the duty of the person having charge of such mine or colliery to give notice thereof forthwith to the inspector of the district, and if any person is killed thereby to the coroner of the county, who shall give due notice of the inquest to be held; if the coroner shall determine to hold an inquest, the mine inspector shall be allowed to testify and offer such testimony as he may deem necessary to thoroughly inform the said inquest of the causes of the death; and the said inspector shall have authority at any time to appear before such coroner and jury and question or cross-question any witness, and in choosing a jury for the purpose of holding such inquest, it shall be the duty of the coroner to impanel a jury no one of whom shall be directly or indirectly interested. It shall be the duty of the inspector, upon being notified as herein provided, to immediately repair to the scene of the accident and make such suggestions as may appear necessary to secure the future safety of the men; and if the results of the explosion or accident do not require an investigation by the coroner he shall proceed to investigate and ascertain the cause of the explosion or accident, and make a record thereof, which he shall file as provided for; and to enable him to make the investigation, he shall have power to compel the attendance of persons to testify, and to administer oaths or affirmations; the cost of such investigation shall be paid by the county in which the accident occurred, in the same manner as costs of inquests held by the coroners or justices of the peace are paid.

SEC. 13. *Inspectors may be removed for cause.*—The court of common pleas of any county in the proper district, upon a petition signed by not less than fifteen reputable citizens, who shall be miners, owners, or lessees of mines, and with the affidavit of one or more of said petitioners attached, setting forth that any inspector of mines neglects his duties, or is incompetent, or that he is guilty of a malfeasance in office, shall issue a citation, in the name of the commonwealth, to the said inspector to appear, on not less than fifteen days' notice, upon a day fixed, before said court, at which time the court shall proceed to inquire into and investigate the allegations of the petitioners; if the court find that the said inspector is neglectful of his duties, or is incompetent to perform the duties of his office, or that he is guilty of malfeasance in office, the court shall certify the same to the governor, who shall declare the office of said inspector vacant, and proceed in compliance with the provisions of this act to supply the vacancy; the costs of said investigation shall, if the charges are sustained, be imposed upon the inspector, but if the charges are not sustained, they shall be imposed upon the petitioners.

SEC. 14. *Decisions of the inspector.*—The inspector shall exercise a sound discretion in the enforcement of the provisions of this act, and if the operator, owner, or miners shall not be satisfied with any decision the inspector may arrive at in the discharge of his duties under this act, which said decision shall be in writing signed by the mine inspector, the said owner, operator, miner, or miners shall forthwith appeal from such decision to the court of quarter sessions of the county wherein the mine is located, and said court shall speed ly determine the question involved in said decision and appeal, which said decision shall be binding and conclusive. The court in its discretion may appoint three practical, reputable, competent, and disinterested persons, whose duty it shall be, under instructions of the said court, to forthwith examine such mine, and make report under oath of the facts as they exist, or may have been, together with their opinions thereon. The report of said board shall become absolute, unless exceptions thereto shall be filed within ten days after notice of the filing thereof to the owner, operator, miner or miners, or inspector; and if exceptions are filed, the court shall at once hear and determine the same, and the decision shall be final and conclusive. If the court shall finally sustain the decision of the inspector, then the appellant shall pay all costs of such proceedings, and if the court shall not sustain the decision of the inspector, then such costs shall be paid by the county, or by the appellant and county in such proportion as the court shall determine. That no appeal from any decision made by any mine inspector shall work as a supersedeas to such decision during the pendency of such appeal, but all such decisions shall be in full force until reversed or modified by the proper court.

SEC. 15. *Board to examine candidates for mining boss.*—On the petition of the mine inspector of any district, the courts of common pleas in any county in said district shall, at the first term after the passage of this act, appoint an examining board, consisting of a mine inspector, an operator, and a miner, who are citizens of the United States and shall have at least five years' experience in the bituminous mines of the State, who shall examine any person applying thereto as to his competency and qualifications to discharge the duties of mining boss. The said board of examiners shall meet at the call of the inspector, and they shall grant certificates to all persons whose examination shall disclose their fitness for the duties of mining boss, and such certificates shall be sufficient evidence of the holder's competency and qualifications for the duties of the said office: *Provided*, That any person who shall have been employed as a miner at least five years in the bituminous mines of Pennsylvania, and as a mining boss continuously by the same person or firm for the period of one year next preceding the passage of this act, shall be entitled to a certificate without undergoing said examination, but he shall not be employed by any other person or firm without having undergone such examination. The examining board shall hold their office for the period of four years from the date of their appointment, and shall receive five dollars per day for each day necessarily employed, and mileage at the rate of three cents per mile for each mile necessarily traveled, to be paid by the commonwealth. For each certificate granted the board shall receive the sum of one dollar, which shall be for the use of the commonwealth.

No person shall act as fire boss in any bituminous mine, unless granted a certificate of competency by any of the mine inspectors of the bituminous region of Pennsylvania, and it shall be unlawful for any owner, operator, contractor, superintendent, or agent to employ any person as fire boss who has not obtained such certificate.

After January first, one thousand eight hundred and eighty-six, no owner, operator, contractor, lessee, superintendent, or agent shall employ any mining boss or fire boss, who does not have the certificate of competency or service required by this section.

And if any accident shall occur, in any mine in which a mining boss or fire boss shall be employed, who has no certificate of competency or service as required by this section, by which any miner shall be killed or injured, he or his heirs shall have a right of action against such operator, owner, superintendent, contractor, lessee or agent, and shall recover the full value of the damages sustained.

SEC. 16. *Boys under a certain age, and all girls and women prohibited from being employed.*—No boy, under the age of twelve years, and no woman or girl of any age, shall be employed or permitted to be in any bituminous coal mine for the purpose of employment therein, nor shall any boy under the age of ten years, or any woman or girl of any age, be employed or permitted to be in or about the outside structure or workings of any bituminous mine or colliery, for the purpose of employment: *Provided however*, That this provision shall not affect the employment of a boy or a female of suitable age in an office, or in the performance of clerical work at such mine or colliery.

SEC. 17. *Liability of owners, &c., for damages.*—For any injury to person or property occasioned by any violation of this act, or any wilful failure to comply with its provisions, a right of action against the party at fault shall accrue to the party injured for the direct damage sustained thereby; and in any case of loss of life by reason of such violation or wilful failure, a right of action against the party at fault shall accrue to the widow and lineal heirs of the person whose life shall be lost, for like recovery of damages for the injury they shall have sustained.

SEC. 18. *Stretchers at mouth of the drift, &c.*—It shall be the duty of owners, operators, contractors, superintendents, lessees or agents to keep at the mouth of the drift, shaft, or slope, or at such other place as shall be designated by the mine inspector, stretchers properly constructed for the purpose of carrying away any miner or employé working in or about such mine, who may in any way be injured in and about his employment.

SEC. 19. *Inspector to make report of the condition of mine, and post same.*—It shall be the duty of the mine inspector, on each visit to any mine, to make out a written, or partly written and partly printed, report of the condition in which he finds such mine and post the same in the office at the mine. The said report shall give the date of the visit, the number of visits during the year, the total number of mines in his district, the number of feet of air in circulation and where measured, and such other information as he shall deem necessary; and the said report shall remain posted in the office for one year, and said report may be examined by any miner or person employed in and about such mine.

SEC. 20. *Owners, &c., to report annually to the inspector.*—On or before the fifteenth day of January in each year, the owner, operator, or superintendent of every mine or colliery shall send to the inspector of his district a correct report, specifying, with respect to the year ending the thirty-first of December preceding such report, the name of the owner or operator, and officers of the mine, and the quantity of coal mined; the report shall be in such form and give such information as may be from time to time required and prescribed by the mine inspector of the district. Blank forms for such reports shall be furnished by the Commonwealth.

SEC. 21. *Violation of provisions of this act declared a misdemeanor.*—The neglect or refusal to perform the duties required to be performed by any section of this act, by the parties therein required to perform them, or the violation of any of the provisions or requirements hereof, shall be deemed a misdemeanor, and shall upon conviction be punished by fine of not less than two hundred dollars and not exceeding five hundred dollars, at the discretion of the court. And in default of payment of such fine and costs for the space of ten days, the defendant shall be sentenced to imprisonment in the county jail for a period not exceeding six months.

SEC. 22. The provisions of this act shall not apply to any mine employing less than ten persons in any one period of twenty-four hours.

SEC. 23. All acts, or parts of acts supplied or inconsistent herewith, are hereby repealed.

An act to provide for the health and safety of persons employed in and about the anthracite coal mines of Pennsylvania, and for the protection and preservation of property connected therewith.

ARTICLE I.

SECTION 1. This act shall apply to every anthracite coal mine or colliery in the Commonwealth, provided the said mine or colliery employs more than ten (10) persons.

ARTICLE II.—*Inspectors and inspection districts.*

SECTION 1. *Anthracite coal field divided into seven inspection districts.*—The counties of Sullivan, Susquehana, Wayne, Luzerne, Lackawanna, Carbon, Schuylkill, Northumberland, Columbia, Lebanon, and Dauphin, or so much of them as may be included under the provisions of this act, shall be divided into seven inspection districts, as follows:

First. That portion of the Wyoming coal field included in the counties of Lackawanna, Wayne and Susquehanna.

Second. The county of Sullivan, and that portion of the Wyoming coal field situated in Luzerne county, east of and including Plains and Kingston townships.

Third. The remaining portion of the Wyoming coal field west of Plains and Kingston townships, including the city of Wilkes-Barre and the boroughs of Kingston and Edwardsville.

Fourth. That part of Luzerne county lying south of the Wyoming coal field, together with Carbon county.

Fifth. That part of the Schuylkill coal field in Schuylkill county, lying north of the Broad mountain and east of a meridian line through the centre of the borough of Girardsville.

Sixth. That part of the Schuylkill coal field in Schuylkill county, lying north of the Broad mountain and west of a meridian line through the centre of the borough of Girardville, together with Columbia, Northumberland and Dauphin counties.

Seventh. All that part of the Schuylkill coal field in Schuylkill county lying south of the Mahanoy valley, and the county of Lebanon.

SEC. 2. *Examining boards to be appointed by the court of common pleas.*—In order to fill any vacancy that may occur in the office of inspector of mines by reason of expiration of term, resignation, removal for cause, or from any other reason whatever, the judges of the court of common pleas of the county of Luzerne shall appoint an examining board for the counties of Sullivan, Susquehanna, Wayne, Luzerne, Lackawanna, and Carbon, and the judges of the court of common pleas of the county of Schuylkill shall appoint an examining board for the counties of Schuylkill, Northumberland, Columbia, Lebanon and Dauphin.

SEC. 3. *Qualifications and number of examiners.*—The said board of examiners shall be composed of three reputable coal miners, in actual practice, and two reputable mining engineers, all of whom shall be appointed at the first term of court in each year to hold their places during the year. Any vacancies that may occur in the board of examiners shall be filled by the court as they occur.

SEC. 4. *Public notice to be given of time and place of meeting.*—Whenever candidates for the office of inspector are to be examined, the said examiners shall give public notice of the fact, in not less than two papers published in the county and at least two weeks before the meeting, specifying the time and place when such meeting shall be held. The said examiners shall be sworn to a faithful discharge of their duties, and four of them shall agree in their recommendation of candidates to the Governor, and shall recommend only such applicants as they find qualified for the office.

Should the board of examiners not be able to agree in their selection and recommendation of a candidate, the judges of the court of common pleas shall dissolve the said board and appoint a new board of like qualifications and powers. The said board of examiners shall be permitted to engage the services of a clerk, and they, together with the clerk, shall each receive the sum of five dollars per day, for every day they are actually engaged in the discharge of their duties under this appointment, and mileage, at the rate of six cents per mile, from their home to the place of meeting and return by the nearest practicable railway route.

Upon the recommendation of the board of examiners as aforesaid, the Governor shall appoint such person to fill the office of inspector of mines under this act and shall issue to him a commission for the term of five years, subject however to removal for neglect of duty or malfeasance in office, as hereafter provided for.

SEC. 5. *Qualifications of inspector of mines.*—The person so appointed must be a citizen of Pennsylvania and shall have attained the age of thirty years. He must have a knowledge of the different systems of working coal mines, and have been practically connected with the anthracite coal mines of Pennsylvania for a period of not less than five years, and he must also have had experience in the working and ventilation of coal mines where noxious and explosive gases are evolved. Before entering upon the duties of his office, he shall take an oath, or affirmation, before an officer properly qualified to administer the same, that he will perform his duties with fidelity and impartiality, which oath or affirmation shall be filed in the office of the prothonotary of the county.

He shall also provide himself with the most modern instruments and appliances for carrying out the intentions of this act.

SEC. 6. *Salary of inspectors.*—The salary of each of the said inspectors shall be three thousand dollars per annum, which salary, together with the expenses incurred in carrying into effect the provisions of this act, shall be paid by the State treasurer out of the treasury of the Commonwealth upon the warrant of the Auditor-General.

SEC. 7. *Residence and duties.*—Each of the said inspectors shall reside in the district for which he is appointed, and shall give his whole time and attention to the duties of the office. He shall examine all the collieries in his district as often as his duties will permit, not less than four times a year, or oftener, if the exigencies of the case or the condition of the mines require it, see that every necessary precaution is taken to secure the safety of the workmen, and that the provisions of this act are observed and obeyed, attend every inquest held by the coroner or his deputy upon the bodies of persons killed in or about the collieries in his district, visit the scene of the accident for the purpose of making an examination into the particulars of the same whenever loss of life or serious personal injury occurs, as elsewhere herein provided for, and make an annual report of his proceedings to the Secretary of Internal Affairs of the Commonwealth at the close of every year, enumerating all the accidents in and about the collieries of his district, marking in tabular form those accidents causing death or serious personal injury, the condition of the workings of the said mines with regard to the safety of the workmen therein and the ventilation thereof, and the result of his labors generally shall be fully set forth.

SEC. 8. *On approval of the court, districts may be readjusted.*—The board of examiners as hereinbefore provided for, in order to divide more equitably among the several mine inspectors the labor to be performed and the territory to be covered by them in the performance of the duties of the office, may, at any time when they shall deem it desirable or necessary, readjust the several districts by the creation of new boundary lines, thereby adding to or taking from, as the case may be, the districts as at present bounded and described, if the court approve the same.

SEC. 9. *Inspectors to enter, inspect, and examine all mines.*—The mine inspector shall have the right, and it is hereby made his duty, to enter, inspect, and examine any mine or colliery in his district and the workings and machinery belonging thereto at all reasonable times, either by day or night, but not so as to impede or obstruct the working of the colliery, and shall have the power to take one or more of his fellow inspectors into or around any mine or colliery in the district for which he is appointed, for the purpose of consultation or examination.

He shall also have the right, and it is hereby made his duty to make inquiry into the condition of such mine or colliery, workings, machinery, ventilation, drainage, method of lighting or using lights, and into all other matters and things connected with or relating to, as well as to make suggestions providing for, the health and safety of persons employed in or about the same, and especially to make inquiry whether the provisions of this act have been complied with.

The owner, operator, or superintendent of such mine or colliery is hereby required to furnish the means necessary for such entry, inspection, examination, inquiry, and exit.

The inspector shall make a record of the visit, noting the time and material circumstances of the inspection.

SEC. 10. *Certain persons disqualified from holding the office of inspector of mines.*—No person, who shall act or practice as a land agent, or as the manager, or agent of any coal mine or colliery, or as a mining engineer, or who is pecuniarily interested in operating any coal mine or colliery in his district, shall at the same time hold the office of inspector of mines under this act.

SEC. 11. *Inspectors may be removed on cause shown.*—Whenever a petition, signed by fifteen or more reputable coal operators or miners or both, setting forth that any inspector of mines neglects his duties, or is incompetent, or is guilty of malfeasance in office, it shall be the duty of the court of common pleas of the proper county to issue a citation in the name of the Commonwealth to the said inspector to appear, at not less than fifteen days' notice, on a day fixed, before said court, and the court shall then proceed to inquire into and investigate the allegations of the petitioners; if the court find that the said inspector is neglectful of his duties, or that he is incompetent to perform the duties of the office for any cause that existed previous to his appointment, or that has arisen since his appointment, or that he is guilty of malfeasance in office, the court shall certify the same to the Governor of the Commonwealth, who shall declare the office of inspector for the district vacant, and proceed in compliance with the provisions of this act to appoint a properly qualified person to fill the office. The cost of said investigation shall be borne by the removed inspector, but if the allegations in the petition are not sustained the costs shall be paid by the petitioners.

SEC. 12. *Property, custody, arrangement, and disposition of maps, plans, &c.*—The maps and plans of the mines and the records thereof, together with all the papers relating thereto, shall be kept by the inspector properly arranged and preserved in a convenient place in the district for which each inspector has been appointed, and shall be transferred by him, with any other property of the Commonwealth that may be in his possession, to his successor in office.

SEC. 13. The persons, who at the time this act goes into effect are acting as inspectors of mines under the acts hereby repealed shall continue to act in the same manner, as if they had been appointed under this act, and until the term for which they were appointed has expired.

ARTICLE III.—*Surveys, maps, and plans.*

SECTION 1. The owner, operator or superintendent of every coal mine or colliery shall make or cause to be made an accurate map or plan of the workings or excavations of such coal mine or colliery, on a scale of one hundred feet to the inch, which map or plan shall exhibit the workings or excavation in each and every seam of coal, and the tunnels and passages connecting with such workings or excavations; it shall state, in degrees, the general inclination of the strata, with any material deflection therein, in said workings or excavations, and shall also state the tidal elevations of the bottom of each and every shaft, slope, tunnel, and gangway and of any other point in the mine or on the surface, where such elevation shall be deemed necessary by the inspector. The map or plan shall show the number of the last survey station, and date of each survey, on the gangways or the most advanced workings; it shall also accurately show the boundary lines of the lands of the said coal mine or colliery, and the proximity of the workings thereto; a true copy of which map or plan, the said owner, operator, or superintendent shall deposit with the inspector of mines for the district in which the said coal mine or colliery is situated, showing the workings of each seam, if so desired by the inspector, on a separate sheet of tracing muslin. One copy of the said map or plan shall be kept at the colliery.

SEC. 2. *Progress of work to be noted on inspector's map at least once every six months.*—The said owner, operator, or superintendent shall, as often as once in every six months, place or cause to be placed, on the said inspector's map or plan of said coal mine or colliery, the plan of the extensions made in such coal mine or colliery during the preceding six months. The said extensions shall be placed on the inspector's map and the map returned to the inspector within two months from the date of the last survey.

SEC. 3. *Abandonment of mine.*—When any coal mine or colliery is worked out preparatory to being abandoned, or when any lift thereof is about to be abandoned, the owner, operator or superintendent of such coal mine or colliery shall have the maps or plans thereof extended to include all the excavations, as far as practicable, and such portions thereof, as the case may require, shall be carefully verified.

SEC. 4. *Failure of owner to furnish to inspector such map or plan.*—Whenever the owner, operator, or superintendent of any coal mine or colliery shall neglect or refuse, or, from any cause not satisfactory to the inspector, shall fail for a period of three months to furnish to the inspector the map or plan of said colliery, or of the extensions thereto as provided for in this act, the inspector is hereby authorized to cause an accurate map or plan of such coal mine or colliery to be made at the expense of the owner thereof, which cost shall be recoverable from said owner as other debts are by law recoverable.

SEC. 5. *When map is believed to be inaccurate, on petition of inspector, court of common pleas may order correct map to be made.*—If the inspector finds, or has reason to believe that any map or plan of any coal mine or colliery, furnished under the provisions of this act, is materially inaccurate or imperfect, it shall be his duty to make application to the court of common pleas of the county in which such colliery is situated for an order to have an accurate map or plan of said colliery prepared, and if such survey shall prove that the map furnished was materially inaccurate or imperfect such owner, operator, or superintendent shall be liable for the expense incurred in making the same.

SEC. 6. *When the State shall pay for such map.*—If it shall be found that the map or plan furnished by the owner, operator or superintendent was not materially inaccurate or imperfect, the Commonwealth shall be held liable for the expense incurred in making said test survey.

SEC. 7. If it shall be shown that the said owner, operator or superintendent has knowingly and designedly caused or allowed such map or plan when furnished to be incorrect or false, such owner, operator or superintendent thus offending shall be guilty of a misdemeanor, and, upon conviction thereof, shall be punished by a fine not exceeding five hundred dollars, or imprisonment not exceeding three months at the discretion of the court.

SEC. 8. The maps or plans of the several coal mines or collieries in each district and which are placed in the custody of the inspector shall be the property of the Commonwealth, and shall remain in the care of the inspector of the district in which the said collieries are situated, to be transferred by him to his successor in office, and in no case shall any copy of the same be made without the consent of the owner, operator or superintendent.

SEC. 9. The inspector's map or plan of any particular colliery shall be open to the inspection, (in the presence of the inspector,) of any miner of that colliery, whenever said miner shall have cause to fear that his working place is becoming dangerous by reason of its proximity to other workings, which may be supposed to contain water or dangerous gases, but only to the miner working in such supposed dangerous place.

ARTICLE IV.—*Shafts, slopes, openings and outlets.*

SECTION 1. *Two outlets to each seam of coal.*—It shall not be lawful for the owner, operator or superintendent of any mine to employ any person or persons in such mine, or permit any person or persons to be in such mine for the purpose of working therein, unless they are in connection with every seam or stratum of coal, and from every lift thereof worked in such mine, not less than two openings or outlets, separated by a strata of not less than sixty (60) feet in breadth under ground and one hundred and fifty (150) feet in breadth at the surface, at which openings or outlets safe and distinct means of ingress and egress are at all times available for the person or persons employed in the said mine; but it shall not be necessary for the said two openings to belong to the same mine, if the persons employed therein have safe, ready and available means of ingress and egress by not less than two openings. This section shall not apply to opening a new mine, or to opening any new lift of a mine while being worked for the purpose of making communication between said two outlets, so long as not more than twenty persons are employed at any one time in such mine or new lift of a mine, neither shall it apply to any mine or part of a mine in which the second outlet has been rendered unavailable, by reason of the final robbing of pillars previous to abandonment, so long as not more than twenty persons are employed therein at any one time. The cage or cages and other means of egress shall at all times be available for the persons employed where there is no second outlet.

SEC. 2. *Authority to make an additional shaft, slope, or outlet upon intervening lands.*—The owner, operator or superintendent of any mine, to which there is only one shaft, slope, or outlet, may petition the court of common pleas in and for the county in which such mine is situated, which said court is hereby empowered to act in the premises, setting forth that in consequence of intervening lands between the working of his mine and the most practicable point, or the only practicable point, as the case may be, at which to make or bring to the surface from the working of his mine, he is unable to make an additional shaft, slope or outlet, in accordance with the requirements of this act; whereupon the court may make an order of reference, and appoint three disinterested persons, residents of the county, viewers, one or more of whom shall be a practical mining engineer, all of whom, after being sworn to a faithful discharge of their duties, shall view and examine the premises, and determine as to whether the owner should have the privilege of making an additional outlet through or upon any intervening lands as the case may require, and report in writing to the term of court, which report shall be entered and filed of record; if the finding of the viewers, or any two of them, is in favor of the owner of such coal mine or colliery, he may make an additional shaft, slope or outlet, under, through or upon intervening lands, as may be determined upon and provided for by the award; if the finding of the viewers is against the owner, or if no award be made by reason of any default or neglect on the part of the owner, he shall be bound to comply with the provisions of this act in the same manner as if this section had not been enacted; in case the said owner, operator or superintendent desires to, and claims that he ought to make an additional opening under, through, or upon any adjoining or intervening lands, to meet the requirements of this act, for the ingress and egress of the men employed in his or their mine, he or they shall make a statement of the facts in the petition, with a survey setting forth the point of commencement and the point of termination of the proposed outlet, which, he or they, their engineers, agents, or employés may enter upon said intervening lands and survey and mark, as he or they shall find it proper to adopt, for such additional outlet, doing as little damage as possible to the property explored; and the viewers shall state in their report what damage will be sustained by the owner or owners of the intervening lands by the opening, constructing, and using of the outlet; and if the report is not appealed from, it shall be confirmed or rejected by said court, as to right and justice shall appertain; and any further and all proceedings in relation thereto shall be in conformity with like proceedings, as in the case of a lateral railroad across or under intervening lands, under the act in relation to lateral railroads, approved the fifth day of May, Anno Domini one thousand eight hundred and thirty-two, and the supplements thereto, so far as the provisions of the same are applicable hereto; and the notices, to the owner of intervening lands, of the intention to apply for the privilege of making an outlet, and meeting of the viewers, shall be given, and the costs of the case shall be paid, as provided in the said act of fifth day of May, anno Domini one thousand eight hundred and thirty-two, and the supplements thereto.

SEC. 3. *Escapements, &c.*—The escapements, shafts, or slopes shall be fitted with safe and available appliances, by which the persons employed in the mine may readily escape in case an accident occurs deranging the hoisting machinery at the main outlets.

SEC. 4. *Certain slopes to be provided with separate traveling ways, &c.*—In slopes, where the angle of inclination is fifteen degrees (15°) or less, there must be provided a separate traveling way, which shall be maintained in a safe condition for travel, and kept free from steam and dangerous gases.

SEC. 5. *Erection of inflammable buildings over openings prohibited.*—From and after the passage of this act, no inflammable structure, other than a frame to sustain pulleys or sheaves, shall be erected over the entrance of any opening connecting the surface with the underground workings of any mine, and no "breaker" or other inflammable structure for the preparation or storage of coal shall be erected nearer than two hundred (200) feet to any such opening, but this act shall not be construed to prohibit the erection of a fan drift for the purpose of ventilation, or of a trestle for the transportation of cars from any slope to such breaker or structure, neither shall it apply to any shaft or slope until the same has been driven to its proposed limit, or until the work of development and shipment of coal has commenced: *Provided*, That this section shall not apply to breakers that are now erected, or that are in course of erection.

SEC. 6. *Top of shaft, &c., to be fenced off, &c.*—The top of each shaft, and also of each slope, if dangerous, or any intermediate lift thereof, shall be securely fenced off by railing or by vertical or flat gates.

SEC. 7. *Abandoned slopes to be fenced.*—Every abandoned slope, shaft, air-hole and drift shall be properly fenced around or across its entrance.

SEC. 8. *Underground entrances to be guarded.*—All underground entrances to any places not in actual course of working or extension shall be properly fenced across the whole width of such entrances, so as to prevent persons from inadvertently entering the same.

SEC. 9. *Signals.*—The owner, operator, or superintendent of any coal mine or colliery, which is worked by shaft or slope, shall provide and maintain a suitable appliance by or through which conversation can be held by and between persons at the bottom and at the top of the shaft or slope, and also an efficient means of signaling from the bottom of such shaft or slope to the engineer in charge of the hoisting engine.

SEC. 10. *Hand-rails, &c., on every cage.*—Hand-rails and efficient safety catches shall be attached to, and a sufficient cover overhead shall be provided on every cage used for lowering or hoisting persons in any shaft.

SEC. 11. *Cages, etc., to be provided with protectors.*—Wherever practicable, every cage or gunboat, used for lowering or hoisting persons in any slope, shall be provided with a proper protector so constructed, that persons, while on such cage or gunboat, shall not be struck by anything which may fall or roll down said slope.

SEC. 12. *Main link, chain, etc., to be made of the best quality of iron.*—The main link and chain, connecting the rope to the cage, gunboat or car in any shaft or slope, shall be made of the best quality of iron. Bridle chains, made of the same quality of iron, shall be attached to the main link, rope or rope socket from the cross head of the cage or gunboat, when persons are being lowered or hoisted thereon.

SEC. 13. *Ropes, etc., to be examined daily.*—The ropes, safety catches, links and chains shall be carefully examined every day they are used, by a competent person delegated for that purpose, and any defects therein found, by which life and limb may been (*sic*) endangered, shall be immediately remedied.

SEC. 14. *Brakes.*—An efficient brake shall be attached to every drum that is used for lowering or raising persons or material in any mine.

SEC. 15. *Flanges or horns to be attached to the drum.*—Flanges or horns, of sufficient dimensions to prevent the rope from slipping off the said drum, shall be provided and properly attached to the drum, and all machines used for lowering or hoisting persons in mines shall be provided with an indicator to show the position of the cage, car or gunboat in the shaft or slope.

SEC. 16. *Structures to sustain the pulleys to be erected.*—Over all shafts, which are being sunk or shall hereafter be sunk, a safe and substantial structure shall be erected to sustain the sheaves or pulleys, at a height of not less than twenty (20) feet above the tipping place, and the top of such shaft shall be arranged in such manner that no material can fall into the shaft while the bucket is being emptied.

SEC. 17. *When such structure to be erected.*—The said structure shall be erected as soon as a substantial foundation is obtained, and in no case shall a shaft be sunk to a depth of more than fifty (50) feet without such structure.

SEC. 18. *Construction of truck.*—If provision is made to land the bucket upon a truck, the said truck shall be constructed in such manner that material cannot fall into the shaft.

SEC. 19. *Rock and coal from shafts to be raised in bucket or cage.*—All rock and coal from shafts as they are being sunk shall not be raised, except in a bucket or on a cage, and such bucket or cage must be connected to the rope or chain by a safety hook, clevis, or other safe attachment.

SEC. 20. *Guides and guide attachments.*—Such shafts shall be provided with guides and guide attachments, applied in such a manner as to prevent the bucket from swinging while descending or ascending therein, and such guides and guide attachments shall be maintained at a distance of not more than seventy-five (75) feet from the bottom of such shaft, until its sinking shall have been completed, but this section shall not apply to shafts one hundred (100) feet or less in depth.

SEC. 21. Where the strata are not safe, every shaft shall be securely cased, lined or otherwise made secure.

SEC. 22. *Rules.*—The following rules shall be observed, as far as practicable, in every shaft to which this act applies:

First. After each and every blast, the chargeman must see that all loose material is swept down from the timbers, before the workmen descend to their work.

Second. After a suspension of work, and also after firing a blast in a shaft where explosive gases are evolved, the person in charge must have the said shaft examined and tested with a safety lamp, before the workmen are allowed to descend.

Third. Not more than four persons shall be lowered or hoisted in any shaft on a bucket at the same time, and no person shall ride on a loaded bucket.

Fourth. Whenever persons are employed on platforms, in shafts, the person in charge must see that the said platforms are properly and safely constructed.

Fifth. While shafts are being sunk, all blasts therein must be exploded by an electric battery.

Sixth. Every person, who fails to comply with, or who violates the provisions of this article, shall be guilty of an offense against this act.

ARTICLE V.—*Boilers and connections, machinery, et cetera.*

SECTION 1. All boilers used for generating steam in and about mines and collieries shall be kept in good order, and the owner, operator or superintendent shall have them examined and inspected by a competent boilermaker, or other well qualified person, as often as once in six months, and oftener if needed. The result of such examination, under oath, shall be certified in writing to the inspector for the district, within thirty (30) days thereafter.

SEC. 2. From and after the passage of this act it shall not be lawful to place any boiler or boilers for the purpose of generating steam under, nor nearer than one hundred (100) feet to, any coal breaker or other structure, in which persons are employed in the preparation of coal: *Provided*, That this section shall not apply to breakers already erected, or that are in course of erection.

SEC. 3. *Safety-valves, etc.*—Each nest of boilers shall be provided with a safety-valve, of sufficient area for the steam to escape, and with weights or springs properly adjusted.

SEC. 4. *Steam gauges.*—Every boiler-house shall be provided with a steam-gauge properly connected with the boilers, to indicate the steam pressure; and another steam-gauge shall be attached to the steam pipe in the engine house, and placed in such position, that the engineer or fireman can readily examine them and see what pressure is carried. Such steam-gauges shall be kept in good order, tested and adjusted as often as once in every six months, and their condition reported to the inspector in the same manner as the report of boiler inspection.

SEC. 5. *Machinery to be protected.*—All machinery used in or around the mines and collieries, and especially in breakers, such as engines, wheels, screens, shafting and belting, shall be protected by covering or railing, so as to prevent persons from inadvertently walking against or falling upon the same. The sides of stairs, trestles and dangerous plank walks, in and around the collieries, shall be provided with hand and guard-railing to prevent persons from falling over the sides. This section shall not forbid the temporary removal of a fence, guard-rail or covering for the purpose of repairs or other operation, if proper precautions are used and the fence, guard-rail or covering is replaced immediately thereafter.

SEC. 6. *Engineer for breaker engine.*—A sober and competent person, not under eighteen (18) years of age, shall be engaged to run the breaker engine, and he shall attend to said engine while the machinery is in motion.

SEC. 7. A signal apparatus shall be established at important points in every breaker, so that in case of an accident, the engineer can be promptly notified to stop the machinery.

SEC. 8. No person under fifteen (15) years of age shall be appointed to oil the machinery, and no person shall oil dangerous parts of such machinery while it is in motion.

SEC. 9. No person shall play with, loiter around or interfere with any machinery in or about any mine or colliery.

SEC. 10. Failure to comply with the provisions of this article shall be deemed an offense against this act.

ARTICLE VI.—*Wash houses.*

SECTION 1. *Convenient wash house to be provided, on request of inspector.*—It shall be the duty of the owner, operator or superintendent of each mine or colliery, at the request in writing of the inspector of mines, to provide a suitable building, not an engine or boiler house, which shall be convenient to the principal entrance of such mine, for the use of the persons employed therein for the purpose of washing themselves and changing their clothes when entering the mine and returning therefrom. The said building shall be maintained in good order, be properly lighted and heated, and supplied with pure cold and warm water, and shall be provided with facilities for persons to wash. If any person or persons shall neglect or fail to comply with the provisions of this article, or maliciously injure, or destroy, or cause to be injured or destroyed, the said building or any part thereof, or any of the appliances, or fittings used for supplying light, heat and water therein, or doing any act tending to the injury or destruction thereof, he or they shall be deemed guilty of an offense against this act.

ARTICLE VII.—*Ambulances and stretchers.*

SECTION 1. *Ambulance and stretchers for each colliery.*—The owner, operator or superintendent of every mine or colliery, except as hereinafter provided, shall provide and keep at such mine or colliery an ambulance and also at least two (2) stretchers for the purpose of conveying to their places of abode any person or persons, who may be injured while in the discharge of his or their work at such mine or colliery.

SEC. 2. *How ambulance shall be constructed and furnished.*—The said ambulance shall be constructed upon good, substantial and easy springs; it shall be covered and closed, and shall have windows on the sides or ends; it shall be of sufficient size to convey at least two injured persons, with two attendants, at one time, and shall be provided with spring mattresses, or other comfortable bedding, to be placed on roller frames, together with sufficient covering for the comfort and protection and convenient moving of the injured; it shall also be provided with seats for the attendants.

The stretchers shall be constructed of such material and in such manner as to afford the greatest ease and comfort in the carriage of the injured person.

SEC. 3. *Injured persons to be removed to their homes or hospitals.*—Whenever any person or persons employed in or about a mine or colliery shall receive such injury, by accident or otherwise, while so employed, as would render him or them unable to walk to his or their place of abode, the owner, operator or superintendent of such mine or colliery shall immediately cause such person or persons to be removed to his or their place of abode, or to a hospital, as the case may require.

SEC. 4. *When ambulance need not be provided.*—It is provided, however, that the owner, operator or superintendent of any mine or colliery shall be excepted from the requirement of an ambulance as aforesaid, if the places of abode of all the workmen at such mine or colliery be within a radius of a half mile from the principal entrance to such mine.

SEC. 5. *When one ambulance may serve two or more mines.*—It is provided further that where two or more mines or collieries are located within one mile of each other, or the ambulance is located within one mile of each colliery, but one ambulance as aforesaid shall be required, if the said mines or collieries have ready and quick means of communication one with the other by telegraph or telephone.

SEC. 6. An ambulance as aforesaid shall not be required at any mine or colliery at which less than twenty (20) persons are employed.

SEC. 7. *When railway may be used instead of ambulance.*—In case the distance from any mine or colliery, to the place of abode of the person injured, is such as to permit his conveyance to his home, or to an hospital, more quickly and conveniently by railway, such mode of conveyance shall be permitted, but in such case the conveyance must be under cover and the comfort of the injured person must be provid cofor.

ARTICLE VIII.—*Certified mine foreman.*

SECTION 1. *Mine foremen to be registered.*—From and after the first day of July, one thousand eight hundred and eighty six, no person shall be permitted to act as mine foreman, unless he is registered as a holder of a certificate under this act.

SEC. 2. *Certificates of qualification.*—Certificates of qualification to mine foreman shall be granted by the Secretary of Internal Affairs to every applicant, who may be reported by the examiners, as hereinafter provided, as having passed a satisfactory examination, and as having given satisfactory evidence of at least five years practical experience, and of good conduct, capability and sobriety.

The certificate shall be in manner and form as shall be prescribed by the Secretary of Internal Affairs, and a record of all certificates issued shall be kept in his department.

SEC. 3. *Board of examiners to be appointed in each district.*—For the purpose of examination of candidates for such certificates, a board of examiners shall be appointed in each of the inspection districts provided for by this act. The said board shall consist of the district inspector of mines, a practical miner and one owner, operator or superintendent of a mine. The said inspector shall act *ex-officio*, and the said engineer and owner, operator or superintendent shall be appointed in like manner, and at the same time, as the boards of examiners for candidates for mine inspectorship under this act are now appointed. The said board shall act as such for the period of one year from the date of their appointment. Meetings of the board may be held at any time, and they may make such rules and conduct such examinations as in their judgment, may seem proper for the purpose of such examinations. The said board shall report their action to the Secretary of Internal Affairs, and at least two of the members thereof shall certify to the qualification of each candidate, who has passed such examination. The traveling expenses of the members of such board to and from their place of meeting, together with the sum of five dollars per day each to the said practical miner and owner, operator or superintendent, members of such board, for each day they are actually engaged therein, not exceeding ten (10) days in all during the year, shall be paid by the Commonwealth, on an order of the Auditor General drawn on the State Treasurer, upon the certificate of the mine inspector, member of such board.

SEC. 4. *Certificates of service.*—Certificates of service, which shall have the same effect for the purposes of this act as certificates of qualification, shall be granted by the Secretary of Internal Affairs, on the report of the examining board, to each person who, for at least one year prior to the first day of July, one thousand eight hundred and eighty-six, has acted at any mine under this act as mine foreman. Certificates of qualification and certificates of service shall contain the full name, age and place of birth of the applicant, as also the length and nature of his previous service in or about mines.

SEC. 5. *Fees for certificates.*—Before certificates as aforesaid shall be granted, applicants for same shall pay to the Secretary of Internal Affairs the following fees, namely: For examination one dollar, for registration of certificate one dollar, for certificate one dollar. All fees so received shall be covered into the treasury of the Commonwealth.

SEC. 6. *Mines not to be operated without foremen.*—No mine shall be operated for a longer period than thirty (30) days without the supervision of a mine foreman: *Provided however*, That any mine employing ordinarily less than ten (10) persons under ground, or one whose daily output is less than fifty (50) tons of coal, shall be exempt from the operations of this section.

SEC. 7. *Penalty.*—In case any mine, except as hereinafter excepted, is worked a longer period than thirty (30) days without such certificated mine foreman, the owner, operator or superintendent thereof shall be subject to a penalty of twenty dollars per day, for each day over the said thirty (30) days during which the said mine is worked, unless it shall be clearly shown that the said owner, operator or superintendent has used all reasonable means for the enforcement of this article and to prevent the mine from being worked contrary to this act: *And provided further*, That in case no suitable or satisfactory certificated mine foreman may at the time be obtained, some suitable person may be appointed to act as mine foreman for the space of three months, or until such person can obtain the proper certificate under this act.

SEC. 8. *When copy of certificate may be issued.*—In case of the loss or destruction of a certificate, the Secretary of Internal Affairs may supply a copy thereof to the person losing the same, upon the payment of the sum of fifty cents: *Provided*, It shall be shown to the satisfaction of the Secretary that the loss has actually occurred.

SEC. 9. *Forging, &c., of a certificate declared a misdemeanor.*—If any person or persons shall forge or counterfeit a certificate, or knowingly make or cause to be made any false statement in any certificate under this act, or in any official copy of the same, or shall urge others to do so, or shall utter or use any such forged or false certificate or unofficial copy thereof, or shall make, give, utter, produce or make use of any false declaration, representation or statement in any such certificate, or copy thereof, or any document containing the same, he or they shall be guilty of a misdemeanor, and upon conviction thereof shall be fined two hundred dollars, or imprisoned for a term not exceeding one year, or both at the discretion of the court trying the case.

ARTICLE IX.—*Employment of boys and females.*

SECTION 1. *Boys under a certain age, and all females not to be employed about mines.*—No boy under the age of fourteen years, and no woman or girl of any age, shall be employed or permitted to be in any mine for the purpose of employment therein; nor shall a boy under the age of twelve years, or a woman, or girl of any age, be employed or permitted to be in or about the outside structures or workings of a colliery for the purpose of employment, but it is provided, however, that this prohibition shall not affect the employment of a boy or female of suitable age in an office, or in the performance of clerical work at a colliery.

SEC. 2. *How age of applicant is to be determined.*—When an employer is in doubt as to the age of any boy or youth applying for employment in or about a mine or colliery, he shall demand and receive proof of the said lawful employment age of such boy or youth by certificate from the parent or guardian, before said boy or youth shall be employed.

SEC. 3. *Penalty.*—If any person or persons contravene, or fail to comply with the provisions of this act in respect to the employment of boys, young male persons, or females, or if he or they shall connive with, or permit others to contravene or fail to comply with said provisions, or if a parent or guardian of a boy or young male person, make or give a false certificate of the age of such boy or young male person, or knowingly do or perform any other act for the purpose of securing employment for a boy or young male person under the lawful employment age and in contravention of the provisions of this act, he or they shall be guilty of an offense against this act.

ARTICLE X.—*Ventilation.*

SECTION 1.—The owner, operator or superintendent of every mine shall provide and maintain an adequate supply of pure air for the same, as hereinafter provided.

SEC. 2. *Furnaces prohibited in certain mines.*—At the expiration of one year from and after the passage of this act, it shall not be lawful to use a furnace for the purpose of ventilating any mine wherein explosive gases are generated.

SEC. 3.—*Minimum quantity of air.*—The minimum quantity of air thus produced shall not be less than two hundred (200) cubic feet per minute, for each and every person employed in any mine, and as much more as the circumstances may require.

SEC. 4. *How ventilating currents are to be conducted, &c.*—The ventilating currents shall be conducted and circulated to and along the face of each and every working place throughout the entire mine, in sufficient quantities to dilute, render harmless and sweep away smoke and noxious or dangerous gases, to such an extent that all working places and traveling roads shall be in a safe and fit state to work and travel therein.

SEC. 5. *Abandoned mines to be kept free of gases.*—All worked out or abandoned parts of a mine, so far as practicable, shall be kept free of dangerous bodies of gases.

SEC. 6. *When mines are to be divided into districts.*—One year after the passage of this act, every mine employing more than seventy-five (75) persons must be divided into two or more districts; each district shall be provided with a separate split of pure air, and the ventilation shall be so arranged that no more than seventy-five (75) persons shall be employed at the same time in any one current or split of air.

The inlet and return air passages for any particular district must be separated by a pillar of coal or stone, if the thickness and dip of the vein will permit, except where it is necessary to cut through said dividing pillar for the purpose of ventilation, traffic or drainage.

SEC. 7. *Area of air passages.*—All the air passages shall be of a sufficient area to allow the free passage of not less than two hundred (200) cubic feet of air per minute for every person working therein, and in no case, in mines generating explosive gases, shall the velocity exceed four hundred and fifty (450) lineal feet per minute in any opening, through which the air currents pass, if gauze safety lamps are used, except in the main inlet or outlet airways.

SEC. 8. *Cross cuts to be closed.*—All cross cuts, connecting the main inlet and outlet air passages of every district, when it becomes necessary to close them permanently, shall be substantially closed with brick or other suitable building material, laid in mortar, or cement wherever practicable, but in no case shall said air stoppings be constructed of plank, except for temporary purposes, or as above provided.

SEC. 9. *Doors.*—All doors used in assisting or in any way affecting the ventilation shall be so hung and adjusted, that they will close of their own accord and cannot stand open.

SEC. 10. All main doors shall have an attendant, whose constant duty it shall be to open them for transportation and travel and prevent them from standing open, longer than is necessary for persons or cars to pass through.

SEC. 11. All main doors shall be so placed that when one door is open, another, which has the same effect upon the same current, shall be and remain closed, and thus prevent any temporary stoppage of the air current.

SEC. 12. An extra main door shall be placed and kept standing open so as to be out of reach of accident, and so fixed that it can be at once closed in the event of an accident to the doors in use.

SEC. 13. The frame work of such main doors shall be substantially secured in stone or brick laid in mortar or cement, unless otherwise permitted in writing by the inspector.

SEC. 14. *Air bridges.*—All permanent air bridges shall be substantially built of such material and of such strength as the circumstances may require.

SEC. 15. *Air measurements.*—The quantities of air in circulation shall be ascertained with an anemometer, or other efficient instrument. Such measurements shall be made by the inside foreman, or his assistant, once every week at the inlet and outlet airways, also at or near the face of each gangway, and shall be entered in the colliery report book.

SEC. 16. *Copies to be sent to the inspector.*—A copy of these air measurements shall be sent to the inspector, before the twelfth (12) day of each month for the preceding month, together with a statement of the number of persons employed in each district.

SEC. 17. *Recording instruments.*—All ventilators, used at mines generating explosive gases, shall be provided with recording instruments by which the number of revolutions of the fan shall be registered for each hour, and such data shall be taken and reported in the colliery report book.

SEC. 18. *Penalty.*—Any person or persons, who shall neglect or fail to comply with the provisions of this article, or who shall knowingly make any false report in regard to air measurements, shall be guilty of an offense against this act.

ARTICLE XI.—*Props and timbers.*

SECTION 1. *Props and timbers to be furnished the miners at their request.*—It shall be the duty of the owner, operator, superintendent, or mine foreman of every mine to furnish to the miners, at their request, all props and timbers necessary for the safe mining of coal and for the protection of the lives of the workmen. Such props and timbers shall be suitably prepared and shall be delivered to the workmen, as near to their working places as they can be conveyed in ordinary mine cars, free of charge.

SEC. 2. *Mine foreman to be so notified.*—Every workman in want of props or timbers shall notify the mine foreman, or his assistant, of the fact, at least one day in advance, giving the length of the props or timber required, and in case of danger from loose roof or sides, he shall not continue to cut or load coal, until the said props and timber have been properly furnished and the place made secure.

SEC. 3. *Penalty.*—A failure to comply with the provisions of this article shall be deemed an offense against this act, and shall be taken to be negligence *per se* on the part of the owner, operator, superintendent or mine foreman as the case may be, of such mine, in action for the recovery of damages for accidents resulting from the insufficient propping of such mine through failure to furnish the necessary props or timbers.

ARTICLE XII.—*General rules.*

The following general rules shall be observed in every mine to which this act applies:

Rule 1. *Mine foreman.*—The owner, operator or superintendent of a mine or colliery shall place the underground workings thereof and all that is related to the same under the charge and daily supervision of a competent person, who shall be called "mine foreman."

Rule 2. *Assistants.*—Whenever a mine foreman cannot personally carry out the provisions of this act so far as they pertain to him, the owner, operator or superintendent shall authorize him to employ a sufficient number of competent persons to act as his assistants, who shall be subject to his orders.

Rule 3. *Charge of ventilation.*—The mine foreman shall have charge of all matters pertaining to ventilation, and the speed of the ventilators shall be particularly under his charge and direction.

Rule 4. *Abandoned mines to be examined.*—All accessible parts of an abandoned portion of a mine, in which explosive gases have been found, shall be carefully examined by the mine foreman, or his assistants, at least once every week, and all danger found existing therein shall be immediately removed. A report of said examination shall be recorded in a book kept at the colliery for that purpose and signed by the person making the same.

Rule 5. *Examination of mines generating gases.*—In mines generating explosive gases, the mine foreman or his assistants shall make a careful examination every morning of all working places and traveling roads before the workmen shall enter the mine, and such examination shall be made with a safety lamp within three hours at most before time for commencing work, and a workman shall not enter the mine or his working place until the said mine or part thereof and working place are reported to be safe. Every report shall be recorded without delay in a book, which shall be kept at the colliery for the purpose, and shall be signed by the person making the examination.

Rule 6. *Proof to be marked.*—The person who makes said examination shall establish proof of the same by marking plainly the date thereof at the face of each working place.

Rule 7. *Stations to be established.*—A station or stations shall be established at the entrance to each mine, or different parts of each mine as the case may require, and a workman shall not pass beyond any such station, until the mine or part of the mine beyond the same has been inspected and reported to be safe.

Rule 8. *When noxious gases are found, workmen to be withdrawn.*—If at any time it is found by the person for the time being in charge of the mine, or any part thereof, that, by reason of noxious gases prevailing in such mine, or such part thereof, or of any cause whatever, the mine or the said part is dangerous, every workman, except such persons as may be required to remove the danger, shall be withdrawn from the mine, or such part thereof as is so found dangerous, until the said mine, or said part thereof, is examined by a competent person and reported by him to be safe.

Rule 9. *Safety lamps.*—In every working approaching any place where there is likely to be an accumulation of explosive gases, or in any working in which danger is imminent from explosive gases, no light or fire, other than a locked safety lamp, shall be allowed or used. Whenever safety lamps are required in any mine, they shall be the property of the owner of said mine, and a competent person, who shall be appointed for the purpose, shall examine every safety lamp immediately before it is taken into the workings for use and ascertain it to be clean, safe and securely locked, and safety lamps shall not be used until they have been so examined and found safe, clean and securely locked, unless permission be first given by the mine foreman to have the lamps used unlocked.

Rule 10. *Keys.*—No one, except a duly authorized person, shall have in his possession a key, or any other contrivance, for the purpose of unlocking any safety lamp in any mine where locked safety lamps are used. No lucifer matches or any other apparatus for striking light shall be taken into said mine or parts thereof.

Rule 11. *Blasts.*—No blast shall be fired in any mine where locked safety lamps are used, except by permission of the mine foreman or his assistant, and before a blast is fired, the person in charge must examine the place and adjoining places and satisfy himself that it is safe to fire such blast before such permission is given.

Rule 12. *Visitations of mines.*—The mine foreman, or his assistant, shall visit and examine every working place in the mine at least once every alternate day, while the men of such place are or should be at work, and shall direct that each and every working place is properly secured by props or timber, and that safety in all respects is assured by directing that all loose coal or rock shall be pulled down or secured, and that no person shall be permitted to work in an unsafe place, unless it be for the purpose of making it secure.

Rule 13. *Examination of slopes, &c.*—The mine foreman, or some other competent person or persons to be designated by him, shall examine at least once every day all slopes, shafts, main roads, traveling ways, signal apparatus, pulleys and timbering and see that they are in safe and efficient working condition.

Rule 14. *Roofs and sides to be secured.*—Any person having charge of a working place in any mine shall keep the roof and sides thereof properly secured by timber, or otherwise, so as to prevent such roof and sides from falling, and he shall not do any work or permit any work to be done under loose or dangerous material, except for the purpose of securing the same.

Rule 15. *Danger from water.*—Whenever a place is likely to contain a dangerous accumulation of water, the working approaching such place shall not exceed twelve (12) feet in width, and there shall be constantly kept, at a distance of not less than twenty (20) feet in advance, at least one bore hole near the center of the working and sufficient flank bore holes on each side.

Rule 16. *Riding on loaded cars.*—No person shall ride upon or against any loaded car, cage or gunboat in any shaft, slope or plane in or about a mine or colliery.

Rule 17. *Number of persons to be hoisted or lowered at one time.*—Not more than ten (10) persons shall be hoisted or lowered at any one time in any shaft or slope, and whenever ten persons shall arrive at the bottom of any shaft or slope in which persons are regularly hoisted or lowered, they shall be furnished with an empty car or cage and be hoisted, except however in mines where there is provided a traveling way having an average pitch of fifteen degrees (15°) or less and not more than one thousand feet in length.

Rule 18. *Qualifications of engineer.*—An engineer placed in charge of an engine, whereby persons are hoisted or lowered in any mine, shall be a sober and competent person of not less than twenty-one (21) years of age.

Rule 19. *Working of engine.*—Every engineer shall work his engine slowly and with great care when any person is being lowered or hoisted in a shaft or slope, and no one shall interfere with or intimidate him while in the discharge of his duties.

Rule 20. *Duty of the engineer in charge of the hoisting machinery.*—An engineer, who has charge of the hoisting machinery by which persons are lowered or hoisted in a mine, shall be in constant attendance for that purpose during the whole time any person or persons are below ground, and he shall not allow any person or persons, except such as may be deputed by the owner, operator or superintendent, to handle or meddle with the engine under his charge or any part of its machinery.

Rule 21. *Signals.*—When any person is about to descend or ascend a shaft or slope, the headman or footman, as the case may be, shall inform the engineer by signal or otherwise of the fact, and the engineer shall return a signal before moving or starting the engine. In the absence of a headman or footman, the person or persons about to descend or ascend shall give and receive the signals in the same manner.

Rule 22. *Outside foreman.*—The owner, operator or superintendent of a colliery shall place a competent person, to be called outside foreman, in charge of the breaker and the outside work of such colliery, and who shall direct, and, as far as practicable, see that the provisions of this act are complied with in respect to the breaker, outside machinery, ropes, cages and all other things pertaining to the outside work, unless otherwise provided for in this act.

Rule 23. *Dirt in coal breakers.*—In all coal breakers, where the coal dust is so dense as to be injurious to the health of persons employed therein, the owner, operator or superintendent of said breaker shall, upon the request of the inspector, immediately adopt measures for the removal of the dust, as far as practicable.

Rule 24. *Injuries to ventilating current, roof, &c., to be reported.*—Any miner, or other workman, who shall discover anything wrong with the ventilating current, or with the condition of the roof, sides, timber or roadway, or with any other part of the mine, in general, such as would lead him to suspect danger to himself, or to his fellow-workmen, or to the property of his employer, shall immediately report the same to the mine foreman, or other person for the time being in charge of that portion of the mine.

Rule 25. *Wilful damage to mine or equipments thereof.*—Any person or persons who shall knowingly or willfully damage, or without proper authority remove, or render useless any fencing, means of signaling, apparatus, instrument or machine, or shall throw open or obstruct any airway, or open a ventilating door and not have the same closed, or enter a place in or about a mine against caution, or carry fire, open lights or matches in places where safety lamps are used, or handle without authority, or disturb any machinery or cars, or do any other act or thing, whereby the lives or health of persons, or the security of the property in or about a mine or colliery are endangered, shall be guilty of an offense against this act.

Rule 26. *Explosives.*—Gunpowder, or any other explosive, shall not be stored in a mine, and a workman shall not have at any one time in any one place more than one keg or box containing twenty-five (25) pounds, unless more is necessary for a person to accomplish one day's work.

Rule 27. *How to be kept.*—Every person who has gunpowder, or other explosive in a mine, shall keep it in a wooden or metallic box securely locked, and such box shall be kept at least ten feet from the tracks, in all cases where room at such distance is available.

Rule 28.—Whenever a workman shall open a box containing explosives, or while in any manner handling the same, he shall first place his lamp not less than five feet from such explosive and in such a position that the air current can not convey sparks to it, and a workman shall not approach nearer than five feet to an open box containing powder, with a lighted lamp, lighted pipe, or any other thing containing fire.

Rule 29. *Storage.*—When high explosives, other than gunpowder, are used in any mine, the manner of storing, keeping, moving, charging, and firing, or in any manner using such explosives, shall be in accordance with special rules, as furnished by the manufacturers of the same. The said rules shall be indorsed with his or their official signature, and shall be approved by the owner, operator or superintendent of the mine in which such explosives are used.

Rule 30. *Needle.*—In charging holes for blasting in slate or rock in any mine, no iron or steel-pointed needle shall be used, and a tight cartridge shall not be rammed into a hole in coal, slate or rock with an iron or steel tamping bar, unless the end of the tamping bar is tipped with at least six (6) inches of copper, or other soft metal.

Rule 31. *Missed charge.*—A charge of powder, or any other explosive, in slate or rock, which has missed fire, shall not be withdrawn or the hole reopened.

Rule 32. *Match.*—A miner, or other person who is about to explode a blast by the use of a patent, or other squibs, or matches, shall not shorten the match, nor saturate it with mineral oil, nor turn it down when placed in the hole, nor ignite it except at its extreme end, nor do anything tending to shorten the time the match will burn.

Rule 33. *Notice of blast.*—When a workman is about to fire a blast, he shall be careful to notify all persons who may be in danger therefrom, and shall give sufficient alarm, so that any person or persons who may be approaching, shall be warned of the danger.

Rule 34. *Examinations after each blast.*—Before commencing work, and also after the firing of every blast, the miner, working a breast or any other place in a mine, shall enter such breast or place to examine and ascertain its condition, and his laborer or assistant shall not go to the face of such breast or place until the miner has examined the same and found it to be safe.

Rule 35. *Qualifications of blaster.*—No person shall be employed to blast coal or rock, unless the mine foreman is satisfied that such person is qualified by experience and judgment to perform the work with ordinary safety.

Rule 36.—A person who is not a practical miner shall not charge or fire a blast in the absence of an experienced miner, unless he has given satisfactory evidence of his ability to do so with safety and has obtained permission from the mine foreman or person in charge.

Rule 37. *Accumulation of gas.*—An accumulation of gas in mines shall not be removed by brushing, where it is practicable to remove it by brattice.

Rule 38. *Ignited gas to be extinguished.*—When gas is ignited by blast or otherwise, the person igniting the same shall immediately extinguish it, if possible, and notify the mine foreman or his assistant of the fact, and workmen must see that no gas blowers are left burning upon leaving their working places.

Rule 39. *Duties of fireman in charge of boilers.*—Every fireman in charge of a boiler or boilers for the generation of steam shall keep a constant watch of the same; he shall see that the steam pressure does not at any time exceed the limit allowed by the outside foreman or superintendent; he shall frequently try the safety valve and shall not increase the weight on the same; he shall maintain a proper depth of water in each boiler, and if anything should happen to prevent this, he shall report the same without delay to the foreman for the time being in charge, and take such other action as may, under the particular circumstances, be necessary for the protection of life and preservation of property.

Rule 40. *Headman and footman.*—At every shaft or slope, in which provision is made in this act for lowering and hoisting persons, a headman and footman shall be designated by the superintendent or foreman to be at their proper places from the time that persons begin to descend until all the persons, who may be at the bottom of said shaft or slope when quitting work, shall be hoisted. Such headman and footman shall personally attend to the signals, and see that the provisions of this act, in respect to lowering and hoisting persons in shafts or slopes, shall be complied with.

Rule 41. *Jumping on cars prohibited.*—No person, except the man giving the signal, shall jump on a car, cage or gunboat after the signal to start has been given, and if any person should enter a car, cage or gunboat in excess of the lawful number, the headman or footman shall notify him of the fact and request him to get off, which request must be immediately complied with. Any violation of this rule must be reported promptly to the mine foreman.

Rule 42. *Construction of passage ways.*—Every passage way, used by persons in any mine and also used for transportation of coal or other material, shall be made of sufficient width to permit persons to pass moving cars with safety, but if found impracticable to make any passage way of sufficient width, then safety holes of ample dimensions and not more than one hundred and fifty feet apart shall be made on one side of said passage way. The said passage way and safety holes shall be kept free from obstructions and shall be well drained, the roof and sides of the same shall be made secure.

Rule 43. *Speed of locomotives.*—When locomotives are used in any mine their speed shall not exceed six miles per hour, and an efficient alarm shall be provided and attached to the front end of every train of cars pushed by a locomotive in any mine or part of a mine.

Rule 44. *Use of locomotives in certain passage ways prohibited.*—Locomotives propelled by steam, if using fire, shall not be used in any passage way, which is also used as an in-take airway to any mine or part of a mine where persons are employed, unless there be a sufficient quantity of air circulating therein to maintain a healthy atmosphere.

Rule 45. *Coupling of cars.*—No person, except the driver and helper, shall couple or uncouple loaded or empty cars while the same are in motion.

Rule 46. *Cars for gravity roads.*—When cars are run on gravity roads by brakes or sprags, the runner shall ride only on the rear end of the last car; and when said cars are run by sprags, a space of not less than two feet from the body of the car shall be made on one or both sides of the track, whenever it may be necessary for the runner to pass along the side of the moving car or cars, and said space or passage way shall always be kept free from obstruction.

Rule 47. *Runners, and their qualifications.*—No person shall run cars on gravity roads, or act as a driver or runner, or sprag any mine car after it has been started from the face of a chamber, unless he is authorized to do so by the mine foreman or his assistant, and all runners engaged in any mine or part of a mine must have attained the age of fifteen (15) years.

Rule 48. *Safety holes.*—When deemed necessary by the mine inspector and upon his request in writing to the owner, operator, or superintendent, safety holes shall be made at the bottom of all slopes and planes, and shall be kept free from obstruction, to enable the footman to escape readily in case of danger.

Rule 49. *Safety blocks.*—Safety blocks, or some other device for the purpose of preventing cars from falling into a shaft, or running away on a slope or plane, shall be placed at or near the head of every shaft, slope or plane, and said safety blocks or other device must be maintained in good working order.

Rule 50. *Travel on gravity roads prohibited.*—No person shall travel on any gravity plane while cars are being hoisted or lowered thereon. Whenever ten persons arrive at the bottom or top of any plane on which it is necessary for men to travel, traffic thereon shall be suspended for a period of time long enough to permit them to reach the top or bottom of said plane.

Rule 51. *Construction of mine cars.*—From and after the passage of this act, no mine car shall be built or reconstructed for use in any mine, unless the bumpers are of sufficient length and width to keep the bodies of said cars separated by not less than twelve (12) inches when the cars stand on a straight level road and the bumpers touch each other, and five years after the passage of this act no mine car shall be used in any mine unless it complies with the above conditions.

Rule 52. *Penalty.*—Every person who willfully or negligently acts in contravention of, or fails to comply with, any of the foregoing rules, or any of the provisions of this article, shall be guilty of an offense against this act.

ARTICLE XIII.—*Provision for special rules.*

SECTION 1. There shall be established in every mine or colliery, to which this act applies, such rules for the conduct and guidance of the persons acting in the management of such mine or colliery, or employed in or about the same, as under the particular state and circumstances of such mine or colliery may appear best calculated to prevent dangerous accidents and to provide for the safety and proper discipline of the persons employed in and about the mine or colliery; and such special rules when established shall be signed by the inspector, who is the inspector of the district at the time such rules are established, and shall also be approved by the court of the county in which the mine or colliery is located, and after having been so signed and approved, the said special rules shall be observed in and about every such mine or colliery in the same manner as if they were enacted in this act.

SEC. 2. *Penalty.*—If any person, who is bound to observe the special rules established for any mine or colliery, acts in contravention of, or fails to comply with, any of such special rules, he shall be guilty of an offense against this act, and the owner, operator, or superintendent of such mine shall also be guilty of an offense against this act, unless he proves that he had taken all reasonable means, by publishing and to the best of his power enforcing the said rules as regulations for the working of the mine or colliery, so as to prevent such contravention or non-compliance.

SEC. 3. *Copy of special rules to be forwarded to the inspector.*—The owner, operator or superintendent of every mine or colliery, to which this act applies, shall forward to the inspector of his district, for his approval, a copy of the proposed special rules for such mine or colliery within three months after the commencement of this act, or within three months after the commencement of any work for the purpose of opening a new mine, or renewing the work of an old mine. The proposed special rules, together with a printed notice specifying that any objection to such rules on the ground of anything contained therein or omitted therefrom, may be sent by any of the persons employed in the mine to the inspector of the district, at his address stated in such notice, shall, during not less than two weeks before such rules are transmitted to the inspector, be posted up in like manner as is provided in this act respecting the publication of special rules for the information of persons employed in the mine, and a certificate that such rules and notice have been so posted up shall be sent to the inspector with the rules signed by the person sending the same.

If the rules are not objected to by the inspector or by the court within thirty (30) days after their receipt by him, they shall be established.

If the inspector is of the opinion that the proposed special rules, or any of them, do not sufficiently provide for the prevention of dangerous accidents in the mine or colliery, or for the safety of the persons employed in or about the mine or colliery, or are unreasonable, he may, within thirty (30) days after the receipt of the rules, object to them and propose to the owner, operator or superintendent, in writing, any modifications in the rules by way of omission, alteration, substitution or addition.

If the owner, operator or superintendent does not, within twenty days after the receipt of the proposed modifications, object to them in writing, the proposed special rules, with such modifications, shall be established.

If the owner, operator or superintendent sends his objections in writing within the said twenty days, the matter shall be referred to arbitration, and the rules shall be established as settled by an award or arbitration.

SEC. 4. *New special rules or amendments may be adopted.*—After special rules have been established under this act in any mine or colliery, the owner, operator or superintendent of such mine or colliery may, from time to time, propose in writing to the inspector, or the inspector may, from time to time, propose in writing to the owner, operator or superintendent of the mine or colliery, any new special rules, or any amendment to the special rules, and the provisions of this act with respect to the original special rules shall apply to all such amendments and new rules in like manner, as near as may be, as they apply to the original rules.

SEC. 5. *Special rules to be promulgated.*—For the purpose of making known the special rules and the provisions of this act to all persons employed in or about such mine or colliery, to which this act applies, an abstract of the act, together with the special rules, shall be posted up, in legible characters, in some conspicuous place or places at or near the mine or colliery, where they may be conveniently read by the persons employed, and so often as the same becomes defaced, obliterated or destroyed, the owner, operator or superintendent shall cause them to be renewed with all reasonable despatch.

Every person who pulls down, injures or defaces any abstract or special rules, when posted up in pursuance to the provisions of this act, shall be guilty of an offense against this act.

ARTICLE XIV.—*Inquests.*

SECTION 1. *Inspectors to be promptly notified of any loss of life.*—Whenever loss of life to a miner or other employé occurs in or about a mine or colliery, notice thereof shall be given promptly to the inspector of mines for the district in which the accident occurred by the mine foreman or outside foreman, or other person having immediate charge of the work at the time of the accident, and when death results from personal injury, such notice shall be given promptly after the knowledge of the death comes to the said foreman or person in charge.

SEC. 2. *Inspector to visit scene of accident.*—Whenever loss of life occurs, or whenever the lives of persons employed in a mine or at a colliery are in danger from any accident, the inspector of mines shall visit the scene of the accident as soon as possible thereafter, and offer such suggestions as in his judgment shall be necessary to protect the lives and secure the safety of the persons employed. In case of death from such accident and after examination he finds it necessary that a coroner's inquest shall be held, he shall notify the coroner to hold such inquest without delay, and if no such inquest be held by the coroner within twenty-four (24) hours after such notice, the inspector shall institute a further and fuller examination of such accident, and for this purpose he shall have power to compel the attendance of witnesses at such examination and to administer oaths and affirmations to persons testifying thereat. The inspector shall make a record of all such investigations and accidents, which record shall be preserved in his office. The costs of such investigations shall be paid by the county in which the accident occurred, in like manner as costs of inquests held by coroners or justices of the peace are now paid.

SEC. 3. *Duty of coroner when inspector is not present.*—An inquest, held by the coroner upon the body of a person killed by explosion or other accident, shall be adjourned by the coroner, if the inspector of mines be not present to watch the proceedings, and the coroner in such case shall notify the inspector in writing of such adjourned inquest and the time and place of holding the same, at least three days previous thereto.

SEC. 4. *Notice of inquest.*—Due notice of an intended inquest to be held by the coroner shall be given by the coroner to the inspector, and at any such inquest, the inspector shall have the right to examine witnesses.

SEC. 5. *When cause of accident shall be certified by the coroner to the inspector.*—If at any inquest, held over the body or bodies of persons whose death was caused by an accident in or about a mine or colliery, the inspector be not present, and it is shown by the evidence given at the inquest that the accident was caused by neglect or by any defect in or about the mine or colliery, which in the judgment of the jury requires a remedy, the coroner shall send notice in writing to said inspector of such neglect or default.

SEC. 6. *Qualifications of jurors.*—No person who is interested personally, nor a person employed in the mine or at a colliery in or at which loss of life has occurred by accident, shall be qualified to serve on a jury empanelled on the inquest, and a constable or other officer shall not summon such a person so disqualified as juror, but the coroner shall empanel a majority of the jury from persons who are qualified to judge of the nature of the accident. Every person who fails to comply with the provisions of this article shall be guilty of an offense against this act.

ARTICLE XV.—*Returns, notices, etc.*

SECTION 1. *Notices of deaths, &c., to be sent to inspector.*—Notices of deaths, or serious injuries resulting from accident in or about mines or collieries, shall be made to the inspector of mines in writing, and shall specify the name, age and occupation of the person killed or injured, and also the nature and character of the accident and of the injury caused thereby.

SEC. 2. *Other notices to be given.*—The owner, operator or superintendent of a mine or colliery shall, within two weeks, give notice to the inspector of the district in which said mine or colliery is situated in any or all of the following cases:

First. When any working is commenced for the purpose of opening a new shaft, slope or mine to which this act applies.

Second. Where any mine is abandoned, or the working thereof discontinued.

Third. Where the working of any mine is re-commenced after any abandonment or discontinuance for a period exceeding three months.

Fourth. Where any new coal breaker is completed and work commenced therein for the purpose of preparing coal for market.

Fifth. Where the pillars of a mine are about to be removed or robbed.

Sixth. Where a squeeze, or crush, or any other cause, or change may seem to affect the safety of persons employed in any mine, or where fire occurs, or a dangerous body of gas is found in any mine.

SEC. 3. *Annual report to be made to inspector by owner.*—On or before the first day of February, in each year, the owner, operator or superintendent of every mine or colliery, shall send to the inspector of the district a correct report specifying with respect to the year ending December thirty-first (31st), previously, the name of the operator and officials of the mine, the quantity of coal mined, the amount of powder consumed, the number of persons employed, above and below ground, in or about such colliery, classifying the persons so employed. The report shall be in such form as may be from time to time prescribed by the inspector of the district. Blank forms for said reports shall be furnished by the Commonwealth.

ARTICLE XVI.—*Injunctions.*

SECTION 1. *Courts may restrain the working of mines.*—Upon application of the inspector of mines of the proper district acting in behalf of the Commonwealth, any of the courts of law or equity having jurisdiction where the mine or colliery proceeded against is situated, whether any proceedings have or have not been taken, shall prohibit by injunction, or otherwise, the working of any mine or colliery, in which any person is employed, or is permitted to be for the purpose of working in contravention of the provisions of this act, and may award such costs in the matter of the injunction, or other proceedings, as the court may think just, but this section shall be without prejudice to any other remedy permitted by law for enforcing the provisions of this act. Written notice of the intention to apply for such injunction in respect to any mine or colliery shall be made to the owner, operator or superintendent of such mine or colliery, not less than five (5) days before the application is made.

ARTICLE XVII.—*Arbitration.*

SECTION 1. Whenever an inspector finds any mine or colliery, or part thereof, or any matter, thing or practice connected with such mine, which, in any respect thereof, is not covered by or provided against by any provision of this act, or by any special rule, to be dangerous or defective, or in his judgment tends to bodily injury to a person, he shall give notice thereof in writing to the owner, operator or superintendent of such mine or colliery, stating in such notice the particular matter or defect requiring remedy, and may demand that the same be remedied, but the owner, operator or superintendent of said mine or colliery shall have the right to refer the demand of the inspector to a board of arbitration, and the matter shall then be arbitrated within forty-eight (48) hours of the time such complaint or demand be made. The said board of arbitration shall be composed of three persons, one of whom shall be chosen by the inspector, one by the said owner, operator or superintendent, and the third by the two thus selected, and the decision of a majority of such board shall be final and binding in the matter.

ARTICLE XVIII.—*Penalties.*

SECTION 1. *Upon affidavit of inspector, judge of court of quarter sessions authorized to hear and determine complaint.*—Any judge of the court of quarter sessions of the peace of the county in which the mine or colliery, at which the offense, act, or omission as hereinafter stated has occurred, is situated, is hereby authorized and required, upon the presentation to him of the affidavit of the mine inspector of the district setting forth that the owner, operator, superintendent, or any other person employed in or about such mine or colliery, had been willfully or negligently guilty of any offense against the provisions of this act, whereby a dangerous accident had resulted, or might have resulted, to any person or persons employed in such mine or colliery, to issue a warrant to the sheriff of said county directing him to cause such person or persons to be arrested and brought before said judge, who shall hear and determine the guilt or innocence of the person or persons so charged, and if convicted he or they shall be sentenced to pay a fine not exceeding fifty dollars in all cases not otherwise provided for in this act, or an imprisonment in the county jail for a period not exceeding three months, or both, at the discretion of the court: *Provided*, That any defendant may waive a trial before a judge as herein provided, and, at any time at or before the time of such trial, demand a trial by a jury in the court of quarter sessions, in which case he may enter into a recognizance, before said judge, with such surety or sureties and in such sum as said judge may approve, conditioned for his appearance at the next court of quarter sessions to answer the charge against him and abide the orders of the court in the premises, meanwhile to be of good behavior and keep the peace, or in default of such recognizance to be committed to the county jail to await such trial.

SEC. 2. *When appeal may be had from the sentence of the judge.*—If any person shall feel himself aggrieved by such conviction and sentence before a judge as aforesaid, he may appeal therefrom subject to the following conditions, namely: The appellant shall within seven days after the decree has been made give notice to the prosecutor of his intention to appeal, and within the same time enter into a recognizance with such surety or sureties and in such sum as shall be approved by said judge, conditioned to appear and try such appeal before the next court of quarter sessions of the peace, and to abide the judgment of the court thereon, and to pay all such costs and penalties as may be there awarded, and upon the compliance with such conditions, the judge shall release the appellant from custody pending the appeal.

SEC. 3. *Trial before judge not a bar to indictment, etc.*—Nothing in this act shall prevent any person from being indicted, or liable under any other act to any higher penalty or punishment than is herein provided, and if the court, before whom any such proceedings is had, shall be of the opinion that proceedings ought to be taken against such persons, under any other act or otherwise, he may adjourn the case to enable the proceedings to be taken.

SEC. 4. *Offenses under this act declared misdemeanors, and penalties prescribed.*—All offenses under this act are declared to be misdemeanors, and in default of payment of any penalty or costs by the party or parties sentenced to pay the same, he or they may be imprisoned for a period not exceeding three months and not less than thirty days.

SEC. 5. *Penalty on violation of act by any inspector.*—If any mine inspector shall be notified in writing of any violation of this act, as above provided, with the names of witnesses, who can prove the fact and with the name of the person giving the information subscribed thereto, and he shall willfully and corruptly neglect or refuse to make complaint to the judge as herein provided, he shall be guilty of a misdemeanor, and upon conviction shall pay a fine not exceeding five hundred dollars, and be removed and discharged from his said office by the sentence of the court; such neglect or refusal in the absence of any just or reasonable cause or ground therefor shall be deemed corrupt.

SEC. 6. *Disposition of fines imposed.*—All fines imposed under this act shall be paid into the county treasury, and shall, if the judge trying the cause so order, be payable to the person or persons injured by an accident resulting from the commission of the offenses for which such fines were imposed, or to their families in case of death: *Provided*, That the same shall not be payable to the person or persons who caused or contributed to such accident. If the judge before whom the cause is tried shall find the person or persons against whom the complaint is made not guilty of any offense he shall decree that the county shall pay the costs, unless he shall be of the opinion that the complaint was wantonly or maliciously brought or made, in which case the costs shall be imposed upon the inspector or informer, or both, at the discretion of the court.

SEC. 7. *Conviction or acquittal not to be evidence in civil actions.*—No conviction or acquittal under this act in any complaint shall be received in evidence upon the tria of any action for damages arising from the negligence of any owner, operator, or superintendent, or employé in any mine or colliery.

SEC. 8. *Damages for injuries, &c.*—That for any injury to persons or property occasioned by any violation of this act, or any willful failure to comply with its provisions, by any owner, operator, or superintendent of any coal mine or colliery, or any other person, a right of action shall accrue to the party injured for any direct damages he may have sustained thereby, and, in case of loss of life by reason of such willful neglect or failure aforesaid, a right of action shall accrue to the widow and lineal heirs of the person whose life shall be lost for like recovery of damages for the injury they shall have sustained.

ARTICLE XIX.—*Definition of terms.*

In this act, unless the context otherwise requires, the term "coal mine or colliery" includes every operation and work, both under ground and above ground, used or to be used for the purpose of mining and preparing coal.

The term "workings" includes all the excavated parts of a mine, those abandoned as well as the places actually at work.

The term "mine" includes all underground workings and excavations and shafts, tunnels, and other ways and opening; also all such shafts, slopes, tunnels and other openings in the course of being sunk or driven, together with all roads, appliances, machinery and materials connected with the same below the surface.

The term "shaft" means a vertical opening through the strata, and which is or may be used for the purpose of ventilation, or drainage, or for hoisting men or material in connection with the mining of coal.

The term "slope" means any inclined way or opening used for the same purpose as a shaft.

The term "breaker" means the structure containing the machinery used for the preparation of coal.

The term "owners" and "operators" means any person or body corporate, who is the immediate proprietor, or lessee, or occupier of any coal mine or colliery, or any part thereof. The term "owner" does not include a person, or body corporate, who merely receives a royalty, rent or fine from a coal mine or colliery, or part thereof, or is merely the proprietor of a mine, subject to any lease, grant or license for the working or operating thereof, or is merely the owner of the soil and not interested in the minerals of the mine, or any part thereof. But any "contractor," for the working or operating of a mine or colliery, or of any part, or district thereof, shall be subject to this act as an operator or owner, in like manner as if he was the owner.

The term "superintendent" means the person, who shall have, on behalf of the owner, general supervision of one or more mines or collieries.

ARTICLE XX.

All laws, or parts of laws, inconsistent or in conflict with the provisions of this act, are hereby repealed.

Approved the 30th day of June, A. D. 1885.

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