REPORT

ON THE

MANUFACTURE OF COKE.

BY

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SPECIAL AGENT.

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LETTER OF TRANSMITTAL.

PITTSBURGH, PA., *February* 15, 1883.

Hon. C. W. SEATON,

Superintendent of Census.

SIR: I have the honor to forward you herewith my final report upon the manufacture of coke in the United States in the census year 1880. This report embraces the complete statistics of the production of coke during that year, together with such information regarding the characteristics of the works, materials used, and labor employed as could be obtained. These are supplemented by such statements and explanations as seemed necessary to the correct understanding of the statistics. Considerable attention has also been given to the history of coke, both in this country and in Europe, as well as to such technical information as promised to add to the value of the report.

It should be carefully noted that this report includes only the statistics of that coke which was manufactured as a direct product, and not that produced in connection with the manufacture of gas. There is only one possible exception to this statement, which is noted in its proper place in the report.

The manufacture of coke is so intimately connected with the manufacture of pig-iron that its history is virtually a history of the manufacture of coke pig-iron, while the value of different cokes and of different methods of coking depends largely upon the adaptability of the coke to furnace use. The reason of this will be evident when it is known that more than four-fifths of all the coke manufactured is used in the production of pig-iron. This will explain the constant reference to pig-iron and blast furnaces in this report.

In view of the great variety of coal in this country adapted to the manufacture of coke, some statements regarding the different ovens in use and the results obtained in other countries with various ovens using different kinds of coal have been given, which I trust will be of importance in certain sections of the country. I have also given very full information as to the methods employed in the utilization of the waste products of coking.

In the historical and technical part of this report I have relied for information to some extent upon standard works, as well as upon fragmentary statements scattered through various publications. In most cases I have given in the body of the report the authority for the statements made, but it is no more than just to mention here my especial obligations to *The Iron Age*, of New York, *The Colliery Guardian* and *Engineering*, of London, England, among journals, and Percy's standard work, *Metallurgy*, volume *Fuel*, *Jordan's Album of Metallurgy*, and Mr. Richard Meade's *The Coal and Iron Industries of the United Kingdom*, among standard works. I also desire in a very especial manner to acknowledge my obligations to Mr. John Fulton, mining engineer of the Cambria Iron Company, to whom I am indebted, not only for permission to make use of extracts from the admirable papers published by him in the reports of the second geological survey of Pennsylvania, but also for the revision of certain chapters of this report and for very valuable suggestions and information. My thanks are also due to Major Jed. Hotchkiss, of Staunton, Virginia, Mr. I. Lowthian Bell, Mr. Charles Wheeler, and Mr. Richard Meade, of England, M. Max Goebel, of Belgium, and Dr. Herman Wedding, of Germany, for valuable information.

In the collection and compilation of these statistics I have had the intelligent assistance of Mr. S. C. Armstrong and Miss C. V. Young, of my office.

I am, sir, very respectfully, your obedient servant,

JOS. D. WEEKS,

Special Agent.

PART I.—STATISTICS OF THE MANUFACTURE OF COKE.

SCOPE OF REPORT.

In this report and its accompanying tables the word "coke" is used in a restricted sense, including only that coke made from bituminous coal, in ovens, pits, or "on the ground", and which, for convenience, may be termed "oven coke". "Gas coke" so called, or that which is a residual product of the manufacture of gas, is in no case included. An apparent exception is the coke of the Consolidated Gas Company, of Pittsburgh, which is made in bee-hive ovens, and is, therefore, a true oven coke. The gases escaping during its manufacture, however, are collected and utilized for lighting purposes, instead of being allowed to waste into the air.

By reason of this omission of "gas coke" the total of coke consumed in the United States, as shown by the fuel tables of the census, will not correspond with the total production of coke as shown in this report, the fuel tables showing the consumption of both oven and gas coke.

It is also to be noticed that, though there is a most intimate connection between the mining of coal and its manufacture into coke, this report covers only the latter industry. The coal-mining connected with coke manufacture is regarded as a separate industry, just as the mining of iron ore is an industry distinct from the manufacture of pig-iron. The statistics of such mining are not, therefore, except incidentally, included in this report. The coal is considered as material, and is so tabulated. To this statement there is no exception, not even in reporting concerning those establishments where all the coal mined is manufactured into coke and where the coal mines and coke works are virtually one establishment. The statements of capital, employés, wages, etc., relate only to the coke works. As illustrative, however, of the extent of the coke industry, some facts regarding the coal mines connected with coke works are given, but they are carefully separated from the figures regarding the latter.

In treating of coal as a material for the manufacture of coke it has been thought best to include some general statements regarding the character of our coking coals, but these statements have been for the most part confined to those deposits of coal which were actually used in the manufacture of coke in the census year. No attempt has been made to show the extent of the deposits of coking coal in the United States.

It should also be distinctly understood that from the statements and statistics given in this report it is not possible to ascertain, even approximately, what have been the profits of coke-making in the United States. A series of questions so framed as to show this would probably have received very few answers. All that the tables pretend to show is the cost of labor and materials and the selling price of the coke. The other items that enter into the cost, such as superintendence, insurance, taxes, interest, general office expenses, bad debts, with others that will readily occur to any business man, are not given, and all of these which are not ascertainable must be added to the cost of labor and materials before it would be possible to ascertain what the profit was.

SUMMARY FOR 1880.

There were produced in the United States in the census year, 1879–'80, 2,752,475 tons of coke, valued at $5,359,489, or $1 94+ per ton. In its production 4,360,110 tons of coal, valued at $2,761,657, or 63.3 cents per ton, were used. This would make the yield of the coal in coke 63.1 per cent., or it would require, on an average, 1.58½ tons of coal to produce a ton of coke. The average value of the coal in a ton of coke would therefore be a little over $1.

There were employed in the manufacture of this coke 3,140 (*a*) persons, of whom 3 were women and 71 boys, the total wages paid being $1,198,654, or 43.5 cents per ton of coke produced. There were 10,116 ovens built May 31, 1880, and 2,163 building, making a total of 12,279 built and constructing.

SUMMARY OF STATISTICS FOR 1850, 1860, 1870, AND 1880.

In the tables included in this report will be found the detailed statistical results of the census of the manufacture of coke in the United States for the census year 1880. These results are summarized below, and, as far as possible, are compared with the results obtained at previous censuses.

a In addition there were two watchmen at an idle works.

As will be shown in the historical part of this report, the manufacture of coke in some considerable quantities for use in blast-furnaces began prior to 1840, and as early as 1817 coke was used for refining iron. It is also probable that as early as this, if not earlier, it was used to some extent in melting iron in founderies, in malting, and for other purposes. Coke does not appear, however, under the subdivisions of manufactures until the census of 1850. Prior to this date it was probably returned as coal.

It will also be evident, from considerations that will hereafter be advanced, that the figures prior to the present census are not complete. The comparisons made must therefore be regarded only as approximations, and not as showing the real advance made in the manufacture of coke.

In the following table is given a summary of the totals of the most important items covered by the census of 1880, compared with similar results obtained at the censuses of 1870, 1860, and 1850:

United States.	Total in 1880.	Total in 1870.	Total in 1860.	Total in 1850.	Percentage of increase in 1880 over 1870.	Percentage of increase in 1880 over 1860.	Percentage of increase in 1880 over 1850.
Number of establishments	149	25	21	4	496.00	609.52	3,625.00
Number of persons employed	3,142	528	198	14	495.08	1,486.87	22,342.86
Amount of capital, real and personal	$5,545,058	$1,202,043	$62,300	$3,700	361.30	8,800.57	149,766.43
Wages paid	1,198,654	288,695	61,368	3,444	315.20	1,853.22	34,704.12
Value of all materials used, including coal	2,995,441	615,268	73,552	6,038	386.85	3,972.55	49,509.82
Value of coke produced	5,359,489	1,132,386	169,844	15,250	373.29	2,723.10	35,044.19

This table indicates a most remarkable growth, especially during the past ten years. It must be remembered that coke is both bulky and low-priced, and in proportion to its weight it is one of the lowest, if not the lowest priced of any manufactured article. During the census year the average value of a railroad-car load of coke, containing from 12 to 14 tons, was from $24 to $28 at the ovens. But little of the coke is used where made, the nearest important point of consumption to the Connellsville region (which produced more than 68 per cent. of all the coke made) being Pittsburgh, about 60 miles distant, while hundreds of thousands of tons are carried to points much farther away. The growth of the industry in these years, then, means a growth where the margins of profit must be small and the tonnage handled immense, and the difficulties in the way of its growth, as is always the case with low-priced, heavy articles that must be transported long distances to market, are well-nigh insurmountable. To organize and operate effectively the railroad service in connection with this heavy increase of traffic has been of itself no small undertaking. All things considered, the development of the manufacture of coke during the past ten years must be regarded as one of the marked achievements in our industrial progress.

NUMBER OF ESTABLISHMENTS.

Each separate coke works, with its ovens and other plant, is classified as an establishment. In many instances it was found that an individual or firm operated several works, sometimes contiguous, in other cases widely separated; but notwithstanding this joint ownership each works is regarded as a separate establishment, and is so classified. The number of works and the number of owners are not, therefore, the same. The number of establishments returned at the last four censuses is as follows, there being no returns prior to 1850:

Number of establishments in 1880	149
Number of establishments in 1870	25
Number of establishments in 1860	21
Number of establishments in 1850	4

The increase in the number of establishments between 1870 and 1880 was nearly 500 per cent., assuming that the word "establishment" was used in the same sense at the census of 1870 as at that of 1880, which is probable, as the condition of the coke trade was such at the earlier date that an individual or a firm would hardly have more than one works.

The increase in 1880 over 1860 was about 600 per cent., the increase in the number of establishments in the ten years between 1860 and 1870 being but 4, or about 20 per cent., as will be seen from the table given above. The increase in product, however, was much greater, indicating a very rapid increase in the size and capacity of the works. The number of works returned in 1850 is probably not correct, and is so small as to be hardly worthy of notice. The manufacture of coke at that date was in its infancy in this country, but it was without doubt more of an industry than the returns for 1850 indicate.

WORKS IDLE AND WORKS BUILDING.

In the enumeration of establishments given in Table I are included all works, whether completed or building, that were in existence in the census year 1879–'80. A number of these, however, were idle during the entire year; others were building, and made no coke. In many cases extensive additions were made to old works, some

of which were completed in whole or in part and put in operation during the census year; in other cases construction was going on at the date of this report. It will be necessary, therefore, in order to ascertain what capital, plant, etc., were used in the manufacture of the coke produced in the census year, to distinguish between works which were idle and building and those which were operated in whole or in part.

The following table, condensed from Tables III and IV, gives a statement of all of the works idle or building during the census year 1879–'80. It includes all works at which no coke was made, but does not include any statement of additions made during the census year to works that were completed and operated during any part of the year:

	Number of establishments.	Capital.	NUMBER OF OVENS BUILT.					NUMBER OF OVENS BUILDING.					NO. OF EMPLOYÉS.	Wages paid.	COAL PROPERTY OWNED BY COKE WORKS.	
			Bee-hive.	Belgian.	Other forms.	Pits or mounds.	Total.	Bee-hive.	Belgian.	Other forms.	Pits or mounds.	Total.	Males over 16.		Acres.	Capital.
Works idle	9	$248,700	304	49	.....	.....	353	21	.....	.....	.....	21	2	*$910	1,550	$296,500
Works building	13	526,500	.....	.....	.....	.....	.....	1,287	.....	80	.....	1,367	.....	.....	16,211	1,866,000
Total	22	775,200	304	49	.....	.....	353	1,308	.....	80	.....	1,388	2	910	17,761	2,156,500

* Wages paid watchman at works.

STATISTICS OF ESTABLISHMENTS AT WHICH COKE WAS MADE IN THE CENSUS YEAR 1879–'80.

Comparing the items of this table with the corresponding ones of Table I, and making the necessary deductions, it will be found that the coke made in the United States in the census year 1879–'80 was made in establishments the number and characteristics of which were as follows:

Total number of establishments at which coke was made during census year 1879–'80	127
Total capital invested in the same	$4,769,858
Total number of ovens built at the same May 31, 1880	9,763
Total number of ovens building at the same May 31, 1880	796
Total number of employés at the same May 31, 1880	3,140
Total wages paid at the same	$1,197,744
Total value of materials used at the same	2,995,441
Total tons of coal used at the same	4,360,110
Total value of same	$2,761,657
Total tons of coke produced	2,752,475
Total value of same	$5,359,489
Acres of coal connected with works that make coke	140,922
Capital invested in coal works connected with coke works that made coke in 1879–'80	$10,903,541

LOCALITIES IN WHICH COKE WAS MANUFACTURED.

Though coke was an article of manufacture in this country some years prior to 1850, it is not found enumerated among its manufactures until the census of that year, the very small amount returned being all credited to Pennsylvania. The published volume of statistics of manufactures for that census gives no indication as to the localities in the state where the works making this coke were situated, but an examination of the original returns shows that oven coke was made in Allegheny and Fayette counties. It is very probable that coke was also made in other localities in Pennsylvania, and some in Maryland and Ohio, and possibly in Virginia. The census contains no record of coke so made, and it may have been returned as bituminous coal.

At the census of 1860 coke is returned as made in Allegheny, Cambria, Clarion, and Fayette counties, Pennsylvania. These counties are respectively in the Pittsburgh, Allegheny Mountain, Allegheny River, and Connellsville districts, so that at that date what are now the chief coke-producing regions of Pennsylvania were engaged in its manufacture.

A remark similar to that made concerning the statistics of 1850 is also applicable to those of 1860, as coke was doubtless made in other counties of Pennsylvania than those named. In a work published in Pittsburgh in 1857 (*a*) the statement is made:

> The coke-iron consumed by the manufacturers of Pittsburgh is at present obtained both from a distance and from the neighborhood. The metal of this description made from the fossil ores of the central counties of Pennsylvania is excellent for castings. * * * From the neighboring counties of Fayette, Cambria, Beaver, Mercer, and Lawrence coke metal is now brought to Pittsburgh.

a *Pittsburgh As It Is*, by George H. Thurston (Pittsburgh, 1857), page 103.

This would add Beaver, Mercer, and Lawrence counties to the coke-producing sections of Pennsylvania. The Clinton furnace, at Pittsburgh, working entirely with coke as a fuel, was also blown in during the fall of 1859, and though small, its consumption of coke would have been a considerable proportion of that reported made in the census year 1860. Altogether, the indications are that the returns for 1860 are very incomplete, as they omit many localities at which coke was made, and fail to report much that was made, or do not report it as coke.

In 1870 Ohio for the first time appears in the census as a manufacturer of coke, it being made in Hamilton, Jefferson, and Tuscarawas counties. The coke made in Hamilton county was probably made from the screenings gathered from the different coal-yards. In this year, according to the report, coke was made in Pennsylvania in Allegheny, Armstrong, Cambria, Clarion, and Fayette counties, Armstrong being the only county in which coke was reported as made at the Ninth Census in which it was not reported as made at the Eighth.

In the census of 1880 it will be noticed that coke is reported as being manufactured in nine states: Alabama, Colorado, Georgia, Illinois, Indiana, Ohio, Pennsylvania, Tennessee, and West Virginia. Two establishments for the manufacture of coke are reported in Virginia near Richmond, but no coke was made in this state in the census year 1879–'80. Under the head of "Relative productive rank of the several states and counties" are given the details concerning the several localities at the Tenth Census.

From an inspection of the map accompanying this report and a comparison of the figures given in the tables showing the localities and production it will be seen that the coke-producing belt of the country is the bituminous coal-measures of the Appalachian chain. Beginning very nearly at the extreme northern point of the Allegheny mountains in Pennsylvania, the coke ovens follow this range of the Appalachians nearly to their southern limit, at Huntsville, Alabama. Outside the limit of this region the make of coke in the census year was but 26,600 tons out of a total of 2,752,475, or less than 1 per cent. It will also be noticed that the center of production is the Connellsville region of Pennyslvania.

No doubt coke in considerable quantities will be manufactured in the future in other states. Already there is promise of this in certain sections of Illinois and in Colorado, but for many years it is probable that the bulk of the coke of the country will be produced along the Allegheny Mountain range from the coal-measures of which such a large percentage is now supplied.

CAPITAL.

The capital invested in coke works, including that in ovens and appurtenances, buildings, etc., and employed in the coke business, but not including any of the capital properly belonging to the coal-mining part of coke-making, in the census year 1879–'80 was $5,545,058. This amount, however, does not fairly represent the amount of capital invested in the coke business of the country. Though in this investigation the statistics of the mining of coal for the manufacture of coke have not been included, it is nevertheless true that the capital invested at the mines which supply coal to the coke works is in many instances invested in them solely for the production of coke, and the capital employed at such mines should properly be included with that invested in the manufacture of coke as returned to the special agent. In Fayette and Westmoreland counties, Pennsylvania, the entire product of the mines at the coke works is, with the exception of a small percentage, made into coke. Sales of coal, as coal, are very rare, and are only made under exceptional circumstances, and probably did not equal 1 per cent. of the product in the census year, though it is larger in other years.

In stating the capital invested in the manufacture of coke it would be necessary, therefore, in order to show fairly the total of this capital, to add to that given in the tables of coke manufacture the amount of capital invested in the coal mines at coke works. This was $13,060,041, which would make the total capital invested in the manufacture of coke as follows:

Total capital invested in coal works supplying coal to coke works	$13,060,041
Total capital invested in works for the manufacture of coke	5,545,058
Total invested in the manufacture of coke	18,605,099

A large part of this total is invested in coal lands. There are connected with coal mines that furnish coal for the manufacture of coke 158,683 acres of coal lands, the value of this land varying from $100 or less to $800 an acre, according to its locality.

NUMBER AND KINDS OF OVENS.

The total number of ovens, and the number of each kind built and building in the United States May 31, 1880, was as follows:

	Bee-hive.	Belgian.	Other forms.	Pits and mounds.	Total.
Ovens built May 31, 1880	9,728	316	30	42	10,116
Ovens building May 31, 1880	2,083	.....	80	.....	2,163
Total built and building May 31, 1880	11,811	316	110	42	12,279

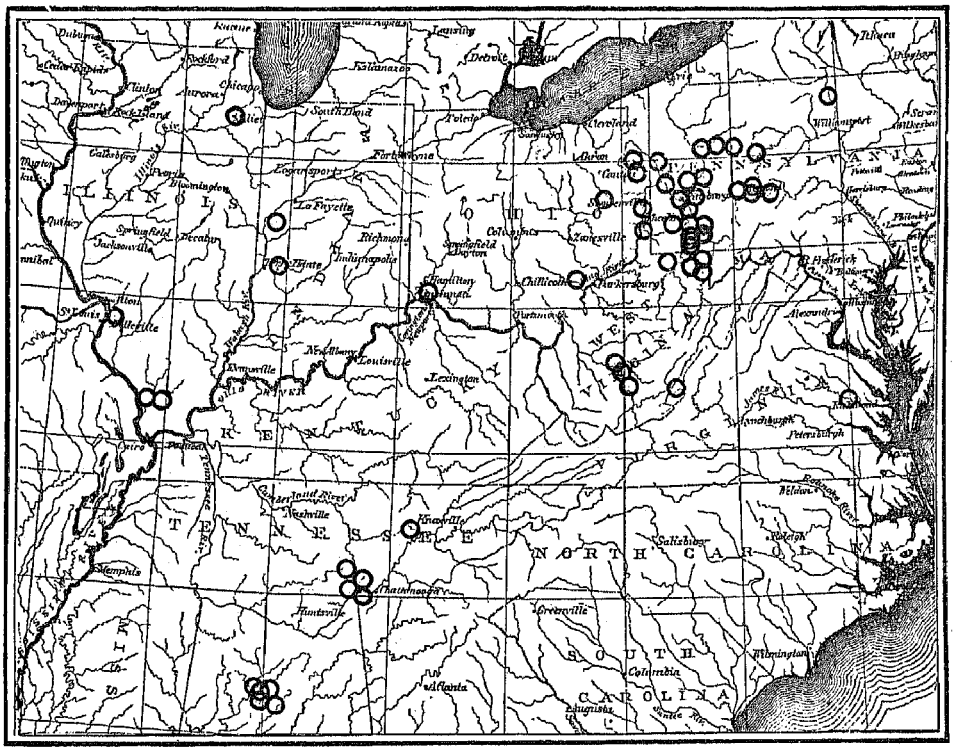

FIG. 1.—THE COKE-PRODUCING BELT.

The 316 Belgian ovens include a number of varieties, but are all constructed on the Belgian plan, with flues in the bottom or sides, or both. The other forms are a modification of the bee-hive, and resemble the oven used in Wales. They are known as the "Tunnel, or English drag".

The report on pits or mounds must necessarily be very unsatisfactory, the number used varying with the demand for coke. In seasons of great demand the number at old works—not only at those where only pits and mounds are used, but sometimes at those where usually all the coke made is burned in ovens—is largely increased, and in addition coke is made in mounds at coal works that do not make coke except at these times of increased demand. With a falling off of demand the number is reduced. As they are so variable in number and are not as permanent as ovens, no satisfactory report can be made of the number in use. Those given in the table may be regarded as the number reported in use May 31, 1880.

There are no statements in the census reports of previous years showing the number of ovens in existence at the dates of the reports, nor are exact data obtainable from other sources. A work published at Pittsburgh in 1870 (*a*) gives the number of coke ovens in Pittsburgh and vicinity in active operation in 1855 as 100. The same work states that—

> In 1870 what are termed city coke ovens number 273. In addition to these there is a number of ovens owned by manufacturers, who consume their own material, or, in other words, mine their own coal and make their own coke.
>
> The Connellsville coke ovens, the product of which is in universal demand throughout the West, number 790. (*b*)

This would give a total of 1,063 reported in the Pittsburgh and Connellsville districts. From other information it would appear that the number of ovens in western Pennsylvania in 1870 was not far from 1,200.

Of the coke reported as manufactured in the census year 1869–'70, 92 per cent. was reported as manufactured in Pennsylvania, all of which was made in western Pennsylvania. Ninety-four per cent. of the persons employed were employed in the same locality, and the relations of capital invested, wages paid, and material used are about the same. All of these facts would lead to the belief that the number of coke ovens in the United States at the census of 1870 did not exceed 1,300, all of which were of the bee-hive pattern. In addition to that made in ovens, some coke was made in pits and mounds in 1870. Much of that produced in the Allegheny Mountain region of Pennsylvania was so burned.

I have not been able to procure any satisfactory information regarding the number of ovens in use in either 1860 or 1850.

PLANT OTHER THAN OVENS.

As before stated, there are connected with the coal mines that furnish coal for the manufacture of coke 158,683 acres of coal land. This does not, however, represent the amount of coal land from which good coking coal can be mined, but only that attached to ovens, or the acreage of the various tracts of coal from which at the close of the last census year supplies of coal for coking were drawn.

Of the plant used at coal mines which supply coal to ovens, the data, for reasons elsewhere given, are not complete enough to justify any statement. There were 4,360,110 tons of coal and slack used in the manufacture of coke. From a comparison of this with the statistics of bituminous coal produced some rough idea of the proportion of the bituminous coal-plant used in the supply of coal to coke works can be obtained. The amount of bituminous coal produced as a regular product in the census year was 41,860,055 tons; the percentage of this used in the manufacture of coke was therefore 10½ per cent. This proportion of the capital, employés, wages paid, material used, and other items entering into the report on bituminous coal should therefore be regarded as employed or paid in connection with the production of bituminous coal for manufacture into coke.

There were in use at 28 coke works 38 coal-washers. Of these 38 washers, 12 are reported as Stutz's patent, 8 as Diescher's, 4 as Endres', 4 as Hybrid, 2 as Plunger—one of which has 4 jigs and the other 2; 2 as Lauders', each with four compartments; 1 as Osterspey's, with 14 jigs, and 1 each of the following: Slush, Common, Bradford, Waverly Coal Company's, and Floating Trough.

There were also in use by coke works 20 locomotives, 1,703 coke cars, and 26.37 miles of railroad track. These are exclusive of locomotives, cars, and track that are properly credited to the coal mines. The coke cars do not include the "larries", or cars in which the coal is run to the ovens, but only the cars used for transporting coke over railroads to consumers.

The ownership of these cars by the works has been found necessary to secure prompt shipment, though only a portion of the coke shipped is forwarded in these private cars, the railroads usually furnishing the necessary rolling-stock. The number of these private cars owned by certain manufacturers is quite large. One firm owns 500, another 222, a third 172, and a fourth 167.

In addition to the above there are at some establishments extensive works for the supply of water used in cooling coke. At those works using Belgian ovens engines are used to discharge the ovens. The number of these was not obtained.

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a Pittsburgh, its Industry and Commerce. Pittsburgh. Barr & Myers: 1870. *b Idem*, page 18.

The statement of washers used and of the number of locomotives, cars, and miles of railroad track is as follows:

States.	Counties.	Number of establishments at which washers were used.	Number of washers.	Kind of washer.	Remarks.
Alabama	Jefferson	1	1	Stutz	Not used.
Colorado	Las Animas	1	2	Stutz	
Illinois	Jackson	1	4 jigs	Plunger	Building.
	Saint Clair	1	14 jigs	Osterspey	Idle.
	Williamson	1	2 jigs	Plunger	
Indiana	Fountain	1	1	Endres	Experimental.
Pennsylvania	Allegheny	8	5	Diescher	
			4	Stutz	
			3	Endres	
			1	Slush	
	Clarion	2	2	Diescher	
			1	Stutz	
	Clearfield	1	2	Stutz	
	Fayette	1	1	Stutz	
	Lawrence	1	1	Lauders	4 compartments.
	Tioga	1	4	Common	
	Westmoreland	4	4	Hybrid	
			2	Diescher	
			1	Lauders	4 compartments.
			1	Waverly Coal Company	
Tennessee	Marion	1	1	Floating Trough	
	Roane	1	1	Stutz	Experimental.
Total		26	58		

STATEMENT OF NUMBER OF COKE CARS, LOCOMOTIVES, AND MILES OF RAILROAD TRACK AT COKE WORKS OF UNITED STATES, MAY 31, 1880.

States.	Counties.	Number of coke cars.	Number of locomotives.	Miles of railroad track owned, not included in statement of coal works.	States.	Counties.	Number of coke cars.	Number of locomotives.	Miles of railroad track owned, not included in statement of coal works.
The United States		1,703	20	26.37	Pennsylvania—c'd	Clearfield			0.37
						Fayette	717	2	4.78
Alabama	Jefferson and Shelby		3			Jefferson	1		
	Jefferson	3	1	0.33		Lawrence	4		
Total		3	4	0.33		Westmoreland	96	3	2.70
					Total		1,376	6	12.78
Georgia	Dade	50	7						
					Tennessee	Grundy	100		
Illinois	Jackson			3.00		Marion	† 53		0.00
						Roane	‡4		6.00
Ohio	Columbiana	12			Total		157		6.00
	Hamilton	2							
	Jefferson	45		1.09	Virginia	Alleghany	2		
	Tuscarawas	3		0.05					
Total		62		1.05	West Virginia	Fayette	7		0.12
						Ohio	2		
Pennsylvania	Allegheny	* 514		1.00		Preston	44	3	3.00
	Blair	44	1	3.75					
	Clarion			0.18	Total		53	3	3.12

* Five hundred cars also used in coal business. † Coke cars, employed in general traffic also. ‡ Iron.

MATERIAL USED.

The material of chief value used in the manufacture of coke is coal, of which 4,360,110 tons, valued at $2,761,657, were used during the census year 1879–'80. This would make the average value of the coal used 63.3 cents per ton. The average price per ton of bituminous coal at the mines for the whole United States during the census year was $1 25 per ton; that for Pennsylvania, in which state most of the coke was made, $1 01 per ton. This would make the average value of the coal used in coking a little more than one-half the average value of all bituminous coal, and about two-thirds the value of bituminous coal in Pennsylvania.

There are several reasons for this great difference. It is not because the coal used is inferior, for economically it is equal to the average of bituminous coal mined; indeed, it is much above the average. The average value of all bituminous coal is probably for screened coal chiefly, while that used in coking includes but little screened coal, but is mostly the "run of the mine", with considerable slack coal. This would reduce the value per ton considerably. As most of the coal used in coking is from mines that are part of the coke works, and as its mining is regarded as only incident to the manufacture of coke, and not as a separate industry, the coal is valued at the cost of production, with a small royalty added, with little or no account of profit. As the coal veins in the Connellsville region of Pennsylvania, where so large a proportion of the coke was made in the census year, are quite thick, the coal soft and easily mined, and the miners are paid for all coal brought out, the wages and consequent labor-cost per ton is much less than in mining for the coal market, where only screened coal is paid for, and for these several reasons the cost value put upon this coal for coke would be low. To indicate how low this might be, it can be stated that Connellsville coke was sold in some instances in 1878, delivered on the cars at the ovens, for 90 cents a ton. As it takes, say, an average of 1½ tons of coal to make a ton of coke, and as the cost of coking must be included, it will be seen that the value of coal at coke works at that time must have been very low, even less than the 63.3 cents a ton shown in this report. Indeed, the value of the coal in a ton of coke in Pennsylvania was only about 87½ cents, or, say, 58⅓ cents a ton of coal.

It will be noticed in Table I that the coal used is divided into three classes, "coal used," "slack used," and "washed coal used". Under the first class, "coal used," is included all lump coal, and also the coal used at works where the "run of the mine" or the entire product, lump, nut, and slack, is coked. All of these grades of coal, even though the lump may be crushed and washed, are included under the first class. Under "slack used" is included only the screenings of coal. The total of these two columns is the total amount of coal coked. The third class, "washed coal used", shows the total amount of coal washed. Most of this total is made up of slack coal, with a part of lump and the "run of the mine", which have been crushed and washed. All of the slack coal used, however, was not washed. At some coal mines a few ovens are built, in which the slack which cannot be sold for other purposes is coked without washing. Some works also find it injurious to the quality or yield of the coke to wash the slack.

Of the total amount of 4,360,110 tons of coal coked, 3,729,328 tons, or 85.5 per cent., valued at $2,392,449, or 64 cents per ton, was lump coal and "run of the mine"; 630,782 tons, or 14.5 per cent., valued at $358,558, or 56.8 cents per ton, was slack.

It will be noticed that the average value of "slack used", though slack is generally regarded at the mines as a waste product of little value, is very nearly that of "coal used", being only 7.2 cents per ton less. This is due to the fact that a large part of the slack used is not coked at the mines where it is produced, and the freight charges from the mines to the ovens, and the cost of handling, add to its value. On the other hand, the ovens using lump coal and the "run of the mine" are usually at the mouth of the mine. In many cases the ovens are charged from the cars that were loaded in the pit, and all expenses for freight and handling are saved. The value of the slack at some points is also enhanced by a demand for it for purposes other than coking, as at Pittsburgh, where it is used at some of the iron works for making gas.

Of the total amount of coal and slack used, 751,824 tons, or 17.2 per cent., valued at $533,818, or 71 cents per ton, was washed. This makes the value of the "washed coal and slack" greater per ton than the value of either the coal or slack. The crushing and washing of the lump and "run of the mine", before referred to, involve in some cases a cost of 20 cents a ton; this is above the average, however; and the washing of the slack would add from 2 to 12 cents a ton to its value.

No other material enters directly into the coke, the other materials reported being used for repairs and renewals of ovens, and for the tools and appliances used in the manufacture of coke. To arrive at the value of these materials has been the most difficult part of this investigation. In many cases it has been impossible to separate the materials and supplies used in the manufacture of coke from those used in mining the coal; but when it has been possible to make this separation, it has been done. Careful and extensive inquiries have been made, and an average has been taken from the reports of a number of works that have kept their cost of materials very carefully. As a result, it is estimated that the average cost of materials, other than coal, used in the manufacture of coke is about 7½ cents per ton of coke produced. When the value of material has been given it is reported; when statements of material have been omitted, or are imperfect, this average of 7½ cents per ton is used. As a result, it is estimated that the value of all materials used, other than coal, is $233,784.

The value of all materials used in the manufacture of coke in the census year is as follows:

Total value of coal and slack	$2,761,657
Total value of other materials	233,784
Total value of all materials	2,995,441

The chief materials other than coal were fire-brick, red brick, wood, and castings, but no reliable statement of the amount of each could be secured.

WEIGHT OF THE BUSHEL.

The weight of the bushel, which is so frequently employed as the unit of measure in the buying, selling, and using of coal and coke, varies but little in the different states. A bushel of coke is almost uniformly 40 pounds; but in exceptional cases, where the coke is very light, 38, 36, and even 33 pounds are regarded as a bushel. In one return 56 pounds, in four 50 pounds, in one 48 pounds, in one 45 pounds, and in one 42 pounds are given as the weight of the bushel; but in these cases the coke would be quite heavy. These exceptions, however, are so few that 40 pounds may be taken as the uniform weight of a bushel of coke.

The weight of a bushel of coal differs more than this. In Alabama the returns give it as 80 pounds, and the same is returned for Colorado, Georgia, Illinois, Ohio, Tennessee, and West Virginia; but in Pennsylvania it is 76 pounds, and in Indiana 70.

EMPLOYÉS.

Compared with the tonnage produced, the manufacture of coke requires the labor of but a small number of persons, the average number employed at each works that made coke in 1879–'80 being less than 25. There are but four works in the United States that employ over 100 men, and one of these is a works at which the labor is performed by convicts. With other labor a less number of men would have sufficed.

The total number of persons employed directly in the manufacture of coke, as returned at the last census, is 3,140, (*a*) of whom but 3 were women and 71 boys.

The number of employés in coke works at the last four censuses is as follows:

	All.	Males over 16.	Females over 15.	Youths.
Employés at census 1880	3,142	3,068	3	71
Employés at census 1870	528	522	.....	6
Employés at census 1860	198	198	.....	.....
Employés at census 1850	14	14	.....	.....

Most of the employés are unskilled workmen, and would be classed as common labor. The operations connected with the manufacture of coke, for the most part, require only strength and endurance, and at many of the works, especially the smaller ones, even the term "superintendent" does not imply much more than a "labor boss". This is not universally true, however, as at some works the position of superintendent is one of importance and responsibility.

WAGES AND EARNINGS.

The total amount of wages paid during the census year in the manufacture of coke was $1,198,654. (*b*) This, however, does not include any wages paid in the mining of coal, but only the labor-cost, from the delivery of the coal at the ovens until the coke is loaded upon the cars.

As the amount of coke produced during the census year was 2,752,475 tons, and the total of wages paid $1,198,654, the average labor-cost of producing a ton of coke would be 43.5 cents.

Any attempt to deduce from the figures given in these tables the average yearly earnings of each person employed would be futile. The total amount of wages paid ($1,198,654), divided by the number of persons employed (3,142), would give a quotient of $381 50. Though such a quotient is often regarded as the average yearly earnings of each employé, a little consideration will make it evident that it does not represent such earnings, but that it really represents nothing but the result of the division of one number by another. A consideration of the circumstances attending the growth and development of the coke industry during the census year will show that this is especially true in its manufacture. Many of the old works, or those in existence at the beginning of the census year, were idle, in whole or in part, June 1, 1879, and did not resume in full until the census year was well advanced; in other cases additions were made to old works, and in still others entirely new works were built. To operate these various works additional persons were employed, not in place of others, but as an increase in their number, and therefore the number reported May 31, 1880, would be much above the average for the year, and very greatly in excess of the number at work June 1, 1879. These additional persons would, of course, be paid only for the time they were employed in making coke, and in the wages-total only the amount so paid, say, for two, three, or six months, as the case might be, would appear. Now, it would be manifestly misleading under these circumstances to say that the quotient resulting from dividing the entire amount of wages paid during the whole year by the number of persons employed May 31, 1880, some of whom had been at work but a month, would give the average yearly earnings. If there had been no increase in plant or in the number of persons employed during the year, if no persons had been brought into this industry from other industries or from idleness, and if, when the coke works were idle, the men employed at them performed no labor, then such a quotient might represent with some degree of accuracy the average yearly earnings of the persons employed in the coke industry; but when not one of these conditions exists, it is evident that the average yearly earnings of the men employed at the coke works was not $381 50, but more than this—what, we have no data for ascertaining.

a In Table I 3,142 employés are reported, but 2 are watchmen at idle works.

b Of this amount $910 were paid two watchmen at an idle works. The amount is so small, however, that it is not subtracted in the following computations.

A somewhat similar difficulty exists in any attempt to arrive at the average rate of wages paid to persons employed in this industry. This is a most difficult fact to ascertain in connection with this or any other industry. It is very easy to give an average of the different rates of wages paid, but this is more properly termed *the average of rates of wages*, not the *real average rate*. To arrive at the average rate of wages—that is, an average that shall consider not only the several rates paid, but the number of men employed at each rate, as the average rate can only be found by the consideration of both—is very difficult.

In the following statement an attempt has been made to approximate the average rate of wages for a number of classes of employés at a portion of the coke works. These tables show:

1. The range of the rates of wages, or the highest and the lowest rate paid the different classes of labor as given in the schedules returned to this office.

2. The average rates of wages as near as can be ascertained.

These average rates are found by multiplying each rate by the number of persons employed at that rate and dividing the sum of the products by the sum of the multipliers, which represent the number of persons employed at each rate for whom rates of wages are given in the schedules. It will be observed that the tables below do not take into consideration the number of days the men were employed, or, in other words, the regularity of employment, but simply give the range of wages and the average wages, without reference to such regularity of employment:

States.	SUPERINTENDENT.		CLERK.		HAULER.	
	Range of rate of wages per month.	Average rate per month.	Range of rate of wages per day.	Average rate of wages per day.	Range of rate of wages per day.	Average rate of wages per day.
The United States	$35 00 to $125 00	$56 04	$1 50 to $4 17	$1 93	$1 00 to $2 00	$1 55
Alabama	40 00 to 100 00	63 33	.....	.....	1 00 to 1 25	1 17
Colorado	125 00	125 00	.....	.....	2 00	2 00
Illinois	55 00	55 00	.....	.....	.....	.....
Ohio	45 00 to 62 50	50 50	.....	.....	1 20 to 1 50	1 29
Pennsylvania	35 00 to 105 00	53 15	1 50 to 4 17	2 03	1 15 to 1 80	1 62
Tennessee	75 00	75 00	.....	.....	1 40	1 40
West Virginia	50 00	50 00	1 50	1 50	1 00 to 1 10	1 07

States.	COKE-CHARGER.		ENGINEER.		COKE LABORER.	
	Range of rate of wages per day.	Average rate of wages per day.	Range of rate of wages per day.	Average rate of wages per day.	Range of rate of wages per day.	Average rate of wages per day.
The United States	$1 00 to $2 50	$1 49	$1 50 to $2 60	$1 59	$0 78 to $2 00	$1 27
Alabama	1 00 to 1 25	1 08	.....	.....	90 to 1 00	93
Colorado	2 00	2 00	.....	.....	1 50 to 2 00	1 75
Illinois	.....	.....	1 75	1 75	1 35	1 35
Ohio	1 20 to 1 50	1 39	.....	.....	1 00	1 00
Pennsylvania	1 15 to 2 50	1 65	1 50 to 2 60	1 55	78 to 1 56	1 23
Tennessee	1 10 to 1 50	1 34	.....	.....	1 00	1 00
West Virginia	1 00 to 2 25	1 22	1 50	1 50	1 00 to 1 10	1 06

PERIODS OF PAYMENT.

There are returns from 110 establishments showing the frequency with which labor is paid. Of these, 86 pay monthly, 14 every two weeks, 6 every week, 3 every three weeks, and 1 quarterly. This latter is an establishment in Tennessee that employs convict labor, and the state is paid quarterly for such labor. It will thus be seen that the rule as to periods of payment at coke works is monthly.

The following table gives the periods of payment at the coke works of the United States so far as reported:

States.	Total number of establishments.	Quarterly.	Monthly.	Every three weeks.	Every two weeks.	Weekly.
The United States	147	1	86	3	14	6
Alabama	4	.....	4	.....	.....	.....
Colorado	1	.....	1	.....	.....	.....
Georgia	1	.....	1	.....	.....	.....
Illinois	4	.....	1	.....	1	.....
Indiana	2	.....	1	.....	.....	.....
Ohio	15	.....	5	.....	4	2
Pennsylvania	104	.....	62	3	8	3
Tennessee	4	1	1	.....	.....	1
West Virginia	12	.....	10	.....	1	.....

METHODS OF PAYMENT.

Returns from 118 establishments show that at 56 of them there were stores connected with the works for supplying the operatives with goods, and that 62 were without stores. This would indicate that the "truck system" was in use at a little less than half the coke works, while a little more than one-half paid cash in full. What proportion of the wages paid at those works that have stores is in cash and what proportion is "truck" we have no means of knowing.

The following table shows, so far as reports have been received, the establishments in each state that have stores connected with them and those that have not:

States.	Total number of establishments.	Number of establishments from which reports have been received.	Number of establishments that have stores connected with them.	Number of establishments that do not have stores connected with them.
The United States	147	118	56	62
Alabama	4	4	3	1
Colorado	1	1		1
Georgia	1	1	1	
Illinois	4	2	1	1
Indiana	2	1		1
Ohio	15	14	4	10
Pennsylvania	104	80	38	42
Tennessee	4	4	3	1
West Virginia	12	11	6	5

RELATIVE RANK IN PRODUCTION OF THE SEVERAL STATES AND COUNTIES.

The relative rank of the several states and the counties in the same in which coke was produced in the census year 1879-'80 is as follows:

RELATIVE RANK OF STATES.

States.	Tons of coke manufactured.	Percentage of make to total make.
The United States	2,752,475	100.00
1. Pennsylvania	2,317,149	84.18
2. Ohio	109,296	3.97
3. West Virginia	95,720	3.48
4. Tennessee	91,675	3.33
5. Georgia	70,000	2.54
6. Alabama	42,035	1.53
7. Colorado	18,000	0.65
8. Illinois	7,600	0.28
9. Indiana	1,000	0.04

RELATIVE RANK OF COUNTIES, IN ORDER OF PRODUCTION.

Counties.	Tons manufactured.	Percentage of make to total make.	Counties.	Tons manufactured.	Percentage of make to total make.
The United States	2,752,475	100.00	15. Las Animas, Colorado	18,000	0.65
			16. Marion, Tennessee	11,675	0.42
1. Fayette, Pennsylvania	1,260,440	45.79	17. Clarion, Pennsylvania	10,800	0.39
2. Westmoreland, Pennsylvania	753,501	27.38	18. Hamilton, Ohio	9,806	0.36
3. Blair, Pennsylvania	98,154	3.57	19. Williamson, Illinois	7,600	0.28
4. Allegheny, Pennsylvania	95,685	3.48	20. Armstrong, Pennsylvania	7,000	0.25
5. Dade, Georgia	70,000	2.54	21. Lawrence, Pennsylvania	3,941	0.14
6. Grundy, Tennessee	60,000	2.18	22. Marion, West Virginia	2,800	0.10
7. Fayette, West Virginia	57,943	2.10	23. Washington, Pennsylvania	1,200	0.04
8. Jefferson, Ohio	57,684	2.10	24. Ohio, West Virginia	1,200	0.04
9. Cambria, Pennsylvania	51,950	1.89	25. Mahoning, Ohio	1,017	0.04
10. Jefferson, Alabama	42,035	1.53	26. Clay, Indiana	1,000	0.04
11. Columbiana, Ohio	39,424	1.43	27. Tuscarawas, Ohio	800	0.03
12. Preston, West Virginia	33,777	1.23	28. Athens, Ohio	565	0.02
13. Tioga, Pennsylvania	33,572	1.22	29. Beaver, Pennsylvania	506	0.02
14. Roane, Tennessee	20,000	0.73	30. Butler, Pennsylvania	400	0.01

Pennsylvania in 1879–'80 is credited with 84.18 per cent. of the total product of the country. There are no figures of product given at any previous census with which to institute comparisons, but comparing by values Pennsylvania made a little less than 80 per cent. in 1879–'80, 92 per cent. in 1869–'70, and 100 per cent., or all, in both 1859–'60 and 1849–'50. Though there has been a relative decline, the amount and the value of coke actually produced in Pennsylvania have very largely increased, as will be seen from the following statement:

Value of coke produced in Pennsylvania:	
In census year 1849–'50	$15,250
In census year 1859–'60	189,844
In census year 1869–'70	1,048,716
In census year 1879–'80	4,190,136

The increase in value has been as follows:

Increase in value of coke produced in Pennsylvania in 1859–'60 over that produced in 1849–'50	$174,594
In 1869–'70 over 1859–'60	858,872
In 1879–'80 over 1869–'70	3,141,420

Ohio stands in the second rank as a coke-producing state, but far below Pennsylvania, producing but 3.97 per cent. in 1880. Making the same comparison of values with previous censuses as is made above in the case of Pennsylvania, Ohio made in 1879–'80 about 6 per cent.; in 1869–'70, 8 per cent. Prior to this no coke is reported as made in Ohio. Though in Ohio, as well as in Pennsylvania, there has been a decline in the value of product relative to the entire product, there has been an increase in total value. The value of the coke produced in Ohio in 1869–'70 was $83,675; in 1879–'80, $334,546.

None of the other states are reported as making coke at either of the censuses prior to the present. In West Virginia, Tennessee, Georgia, and Alabama, however, deposits of very good coking coal exist, and rapid advances are making in its manufacture—advances that before another census will probably place some, if not all, of these states ahead of Ohio in production, though they will hardly supplant Pennsylvania and reach the first place.

Referring to the table of "counties in order of production", it will be noted that two counties in Pennsylvania, Fayette and Westmoreland, produced, respectively, 45.79 and 27.37 per cent. of all the coke made in the country at the present census, or 73.16 per cent. of the whole. At the census of 1870 Fayette county, Pennsylvania, was the largest producer, returning $516,800 in value, Allegheny, Pennsylvania, following with $243,690, and Cambria, Pennsylvania, with $225,898. Westmoreland, which is now the second county, produced no coke, while Allegheny, formerly the second county, is now the fourth, and Cambria, formerly the third, is now the ninth; Dade county, in Georgia, Grundy, in Tennessee, Fayette, in West Virginia, and Jefferson, in Ohio, surpassing Cambria in amount of product.

YIELD OF COAL IN COKE.

The following table shows the percentage of yield in coke of the coal coked in the several states and the United States:

States.	Tons of coal used.	Tons of coke produced.	Percentage yield of coal.
The United States	4,360,110	2,752,475	63.1
Alabama	67,376	42,035	62.4
Colorado	29,500	18,000	61.0
Georgia	117,000	70,000	59.8
Illinois	15,000	7,600	50.7
Indiana	1,500	1,000	66.7
Ohio	193,848	109,296	56.4
Pennsylvania	3,608,095	2,317,149	64.2
Tennessee	179,311	91,675	51.1
West Virginia	148,480	95,720	64.5

From this table it appears that the coal coked in the United States yielded on an average 63.1 per cent. of coke. The range of the yield in the several states was from 50.7 per cent. in Illinois to 66.7 in Indiana. The high average yield, in view of the range, it being very nearly equal to the highest percentage yield, is due to the high average in Pennsylvania, 64.2 per cent., which produced 84.18 per cent. of all the coke made.

The yield of 66.7 per cent. in Indiana is an estimate. In the schedule return the amount of coke produced was given at 1,000 tons, and the statement was made that the yield was "about 66 per cent." As no record of the coal charged into the ovens was given, this estimated yield was taken, and the amount of coal used was estimated at 1,500 tons.

Neglecting this, then, as only an estimate, and considering the figures of coal used and coke produced actually reported, it will be seen that the next highest yield is in West Virginia and in Pennsylvania, which report essentially

the same yield, there being a difference of only three-tenths of one per cent. As part of the coke made in Pennsylvania is made by the wasteful method of coking in pits, it may be assumed that the present investigation shows that the yield of Pennsylvania coals and that of West Virginia are about equal. This is further confirmed by the following tables. The counties in these two states of the greatest production are Fayette and Westmoreland, Pennsylvania, Fayette and Preston, West Virginia, and the coal used, coke produced, and yield of coal in coke for these four counties, which together produced 76 per cent. of all the coke made, are as follows:

Counties.	States.	Tons of coal used.	Tons of coke produced.	Percentage yield of coal.
Fayette	Pennsylvania	1,910,279	1,260,440	0.66
Westmoreland	do	1,195,824	753,501	0.63
Fayette	West Virginia	88,769	57,943	0.65
Preston	do	53,331	33,777	0.63

The low yield in some of the other states is doubtless due chiefly to two causes: First, wasteful methods of coking; and, secondly, the use of coals not well adapted to coking. It should be stated, however, that yield is not always a measure of the economic value of coal for coking purposes.

AVERAGE SELLING PRICE OF COKE.

The figures in Table I under the caption "Value of product", and in the accompanying table under "Total value", are to be regarded as the total selling price of the coke produced when loaded on cars at the ovens, or, expressed in trade language, "f. o. b. cars at ovens." The "average value" in the table given below is the "average selling price" at the ovens. Coke is rarely stocked at the place of manufacture, but when drawn from the ovens is loaded directly into cars and sent to the place of consumption, where any surplus stock, or an amount necessary to provide against delay in delivery, is stored.

It should be noticed in regard to this selling price that the census year was a period of great fluctuation greater probably than ever before in the history of the coke trade. In July, 1879, coke was selling at from $1 15 to $1 30 per ton (2,000 pounds); but during the latter part of that year it advanced quite rapidly, and sold early in 1880 in some instances as high as $5 a ton. The decline in price was equally rapid, and at the close of the census year, or early in June, 1880, it was selling at from $1 25 to $1 50 per ton.

As an important factor in determining the selling price, it should be noted that a large proportion of the total product is sold to blast-furnaces on contracts running generally for a year. The time of making these contracts in many cases was such that the coke works failed to profit by the very large increase in prices noted above; and for much of the coke supplied to blast-furnaces that were blown in to meet the great demand for iron during the census year, as well as that sold in the course of daily business or on "short-time contracts", very good prices were obtained. These amounts, however, were not sufficient to increase the average materially, and under the combined influence of the contract system and the great fluctuations in prices noted above the average selling price was low. These same influences also had a marked effect upon the relation of cost to the selling price. Contracts taken at low rates had to be filled when cost had materially advanced and coal appreciated in price, and as a result the amount of money made during the census year in proportion to the amount of coke sold was very small.

The average selling price for the census year in each state and in the United States is given in the following table:

AMOUNT AND TOTAL VALUE OF COKE PRODUCED IN EACH STATE IN CENSUS YEAR 1879-'80, AND AVERAGE VALUE OF SAME PER TON.

[Arranged by states, according to average value.]

States.	Total number of tons produced.	Total value.	Average value per ton.
The United States	2,752,475	$5,359,489	$1 95
Colorado	18,000	90,000	5 00
Alabama	42,035	148,026	3 52
Illinois	7,000	24,700	3 25
Ohio	109,296	334,546	3 06
Indiana	1,000	3,000	3 00
Tennessee	91,675	212,493	2 32
West Virginia	95,720	216,588	2 26
Georgia	70,000	140,000	2 00
Pennsylvania	2,317,149	4,190,136	1 81

The selling price, as given, should by no means be regarded as an evidence or even as an indication of the economic value of the cokes of different states. For example, the price of Pennsylvania coke, which is chiefly Connellsville, than which there is no better made in the country, averaged for the year only $1 81 per ton, while the Indiana coke, which is not equal to the Pennsylvania coke, and was indeed only experimental, is rated at $3 per ton. The difference in the selling price of cokes of the different localities is due mainly to its quality, the local demand, the amount made, and the distance from centers of supply. The Connellsville coke, which may be regarded as a typical coke, furnishing the chief fuel for the smelting of iron and other metals west of the Allegheny mountains as well as for use in founderies, virtually fixes the price for all other coke, the price at different points depending chiefly upon that at which Connellsville coke can be delivered at these points.

The very low price at which coke is sold is one of the remarkable features of this industry. To manufacture a ton of coke one and one-half tons of coal are required. This coal was handled at the ovens, burned, drawn from the ovens, and furnished, loaded into cars in the Connellsville region, for $1 81 per ton of coke, or $1 20 per ton of coal.

TABLE I.—STATISTICS OF THE MANUFACTURE OF COKE IN THE UNITED STATES, AT THE CENSUS OF 1880, BY STATES.

States.	Number of establishments.	Capital invested in coke works and employed in coke business.	NUMBER OF OVENS BUILT.					NUMBER OF OVENS BUILDING.					NUMBER OF EMPLOYÉS.					Total wages paid in manufacturing coke.
			Bee-hive.	Belgian.	Other forms.	Pits or mounds.	Total.	Bee-hive.	Belgian.	Other forms.	Pits or mounds.	Total.	Males over 16.	Females over 15.	Males under 16.	Females under 15.	Total.	
The United States.	149	$5,545,058	9,728	316	30	42	10,116	2,083	.....	80	.....	2,163	3,008	3	71	.....	3,142	$1,108,654
Alabama	4	135,500	216	.....	.....	.....	216	206	.....	.....	.....	206	64	.....	.....	.....	64	38,500
Colorado	1	150,000	128	.....	.....	.....	128	72	.....	.....	.....	72	75	.....	.....	.....	75	13,500
Georgia	1	80,000	140	.....	.....	.....	140	.....	.....	.....	.....	.....	107	.....	.....	.....	107	13,837
Illinois	4	205,000	.....	49	30	.....	79	.....	.....	80	.....	80	16	.....	2	.....	18	9,347
Indiana	2	8,000	20	25	.....	.....	45	.....	.....	.....	.....	.....	4	.....	.....	.....	4	300
Ohio	15	144,012	619	.....	.....	.....	619	12	.....	.....	.....	12	150	.....	3	.....	153	51,977
Pennsylvania	104	4,262,525	7,524	242	.....	42	7,808	1,469	.....	.....	.....	1,469	2,379	3	62	.....	2,444	983,431
Tennessee	4	200,021	589	.....	.....	.....	589	152	.....	.....	.....	152	114	.....	.....	.....	114	38,820
Virginia	2	30,000	85	.....	.....	.....	85	21	.....	.....	.....	21	.....	.....	.....	.....	.....	.....
West Virginia	12	330,000	407	.....	.....	.....	407	151	.....	.....	.....	151	150	.....	4	.....	103	48,942

States.	Value of materials other than coal.*	COAL USED.		SLACK USED.		WASHED COAL USED.		TOTAL COAL AND SLACK USED.		COAL PROPERTY.		COKE PRODUCED.	
		Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Acres.	Capital.	Tons.	Value.
The United States.	$233,784	3,729,328	$2,302,449	630,782	$358,558	751,824	$533,818	4,360,110	$2,761,657	158,683	$13,060,041	2,752,475	$5,359,489
Alabama	1,304	66,370	73,814	1,000	1,500	.....	.....	67,370	75,314	35,860	471,000	42,035	148,026
Colorado	600	29,500	22,600	.....	.....	29,500	29,500	29,500	29,500	2,000	1,033,500	18,000	90,000
Georgia	4,900	117,000	120,000	.....	.....	.....	.....	117,000	120,000	15,000	220,000	70,000	140,000
Illinois	420	.....	.....	15,000	11,250	15,000	15,000	15,000	15,000	160	38,000	7,600	24,700
Indiana	200	1,500	2,025	.....	.....	.....	.....	1,500	2,025	260	20,000	1,000	3,000
Ohio	5,399	148,292	181,112	45,556	47,320	.....	.....	193,848	228,432	3,357	432,525	109,296	334,546
Pennsylvania	209,849	3,144,969	1,786,717	463,126	244,588	596,713	426,581	3,608,095	2,031,305	32,272	9,421,450	2,317,149	4,190,136
Tennessee	8,092	80,911	75,137	98,400	49,000	110,611	62,737	179,311	124,137	48,383	570,101	91,675	212,493
Virginia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
West Virginia	3,020	140,780	131,044	7,700	4,900	.....	.....	148,480	135,944	21,391	853,465	95,720	216,588

* See remarks under Materials, page 7.

TABLE II.—STATISTICS OF THE MANUFACTURE OF COKE IN THE

	States and counties.	Number of establishments.	Capital invested in coke works and employed in coke business.	NUMBER OF OVENS BUILT.					NUMBER OF OVENS BUILDING.					NUMBER OF EMPLOYÉS.					Total wages paid in manufacturing coke.
				Bee-hive.	Belgian.	Other forms.	Pits or mounds.	Total.	Bee-hive.	Belgian.	Other forms.	Pits or mounds.	Total.	Males over 16.	Females over 15.	Males under 16.	Females under 15.	Total.	
	The United States.	149	$5,545,058	9,728	316	30	42	10,116	2,083	.....	80	.....	2,163	3,068	3	71	.....	3,142	$1,198,654
	ALABAMA.																		
1	Jefferson	3	135,500	216	.....	.....	.....	216	206	.....	.....	.....	206	64	.....	.....	.....	64	38,500
2	Shelby *	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Total	4	135,500	216	.....	.....	.....	216	206	.....	.....	.....	206	64	.....	.....	.....	64	38,500
	COLORADO.																		
1	Las Animas	1	150,000	128	.....	.....	.....	128	72	.....	.....	.....	72	75	.....	.....	.....	75	13,500
	GEORGIA.																		
1	Dade	1	80,000	140	.....	.....	.....	140	.....	.....	.....	.....	.....	107	.....	.....	.....	107	13,837
	ILLINOIS.																		
1	Jackson	1	75,000	.....	.....	.....	.....	.....	.....	.....	80	.....	80	.....	.....	.....	.....	.....	.....
2	Saint Clair	1	100,000	.....	24	.....	.....	24	.....	.....	.....	.....	.....	2	.....	.....	.....	2	910
3	Will†	1	.....	.....	25	.....	.....	25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	Williamson	1	30,000	.....	.....	30	.....	30	.....	.....	.....	.....	.....	14	.....	2	.....	16	8,437
	Total	4	205,000	.....	49	30	.....	79	.....	.....	80	.....	80	16	.....	2	.....	18	9,347
	INDIANA.																		
1	Clay	1	8,000	20	.....	.....	.....	20	.....	.....	.....	.....	.....	4	.....	.....	.....	4	300
2	Fountain‡	1	.....	.....	25	.....	.....	25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Total	2	8,000	20	25	.....	.....	45	.....	.....	.....	.....	.....	4	.....	.....	.....	4	300
	OHIO.																		
1	Athens	1	2,000	8	.....	.....	.....	8	12	.....	.....	.....	12	7	.....	.....	.....	7	375
2	Columbiana	2	57,500	195	.....	.....	.....	195	.....	.....	.....	.....	.....	27	.....	.....	.....	27	11,965
3	Hamilton	3	14,000	22	.....	.....	.....	22	.....	.....	.....	.....	.....	13	.....	.....	.....	13	4,012
4	Jefferson	6	61,512	344	.....	.....	.....	344	.....	.....	.....	.....	.....	96	.....	3	.....	99	34,645
5	Mahoning	2	2,000	10	.....	.....	.....	10	.....	.....	.....	.....	.....	3	.....	.....	.....	3	480
6	Tuscarawas	1	7,000	40	.....	.....	.....	40	.....	.....	.....	.....	.....	4	.....	.....	.....	4	500
	Total	15	144,012	619	.....	.....	.....	619	12	.....	.....	.....	12	150	.....	3	.....	153	51,977
	PENNSYLVANIA.																		
1	Allegheny	17	325,150	336	140	.....	.....	476	20	.....	.....	.....	20	169	.....	2	.....	171	59,485
2	Armstrong	2	30,000	.....	.....	.....	20	20	66	.....	.....	.....	66	10	.....	.....	.....	10	4,000
3	Beaver	1	400	2	.....	.....	.....	2	.....	.....	.....	.....	.....	1	.....	.....	.....	1	280
4	Blair	4	110,000	171	.....	.....	19	190	.....	.....	.....	.....	.....	97	.....	10	.....	107	38,704
5	Butler	1	200	7	.....	.....	.....	7	.....	.....	.....	.....	.....	3	.....	.....	.....	3	500
6	Cambria	3	106,000	17	102	.....	.....	119	.....	.....	.....	.....	.....	45	.....	.....	.....	45	10,870
7	Clarion	2	30,200	60	.....	.....	.....	60	.....	.....	.....	.....	.....	14	.....	1	.....	15	7,200
8	Clearfield	1	25,000	.....	.....	.....	.....	.....	60	.....	.....	.....	60	.....	.....	.....	.....	.....	.....
9	Fayette	44	1,956,450	4,185	.....	.....	3	4,188	1,082	.....	.....	.....	1,082	1,067	3	5	.....	1,075	493,332
10	Jefferson	1	10,000	.....	.....	.....	.....	.....	31	.....	.....	.....	31	.....	.....	.....	.....	.....	.....
11	Lawrence	2	38,500	98	.....	.....	.....	98	.....	.....	.....	.....	.....	19	.....	3	.....	22	3,004
12	Tioga	1	50,000	152	.....	.....	.....	152	.....	.....	.....	.....	.....	69	.....	4	.....	73	25,321
13	Washington	1	2,000	8	.....	.....	.....	8	.....	.....	.....	.....	.....	4	.....	.....	.....	4	600
14	Westmoreland	24	1,578,625	2,488	.....	.....	.....	2,488	210	.....	.....	.....	210	881	.....	37	.....	918	331,075
	Total	104	4,202,525	7,524	242	.....	42	7,808	1,469	.....	.....	.....	1,469	2,379	3	62	.....	2,444	983,431
	TENNESSEE.																		
1	Grundy	1	125,000	404	.....	.....	.....	404	102	.....	.....	.....	102	79	.....	.....	.....	79	24,000
2	Marion	2	56,021	118	.....	.....	.....	118	30	.....	.....	.....	30	18	.....	.....	.....	18	7,820
3	Roane	1	19,000	67	.....	.....	.....	67	20	.....	.....	.....	20	17	.....	.....	.....	17	7,000
	Total	4	200,021	589	.....	.....	.....	589	152	.....	.....	.....	152	114	.....	.....	.....	114	38,820
	VIRGINIA.																		
1	Allegheny	1	30,000	83	.....	.....	.....	83	21	.....	.....	.....	21	.....	.....	.....	.....	.....	.....
2	Henrico	1	.....	2	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Total	2	30,000	85	.....	.....	.....	85	21	.....	.....	.....	21	.....	.....	.....	.....	.....	.....
	WEST VIRGINIA.																		
1	Fayette	6	239,000	238	.....	.....	.....	238	134	.....	.....	.....	134	98	.....	1	.....	99	27,612
2	Marion	1	14,000	36	.....	.....	.....	36	.....	.....	.....	.....	.....	5	.....	.....	.....	5	2,000
3	Ohio	1	3,000	3	.....	.....	.....	3	1	.....	.....	.....	1	2	.....	.....	.....	2	480
4	Preston	4	74,000	130	.....	.....	.....	130	16	.....	.....	.....	16	54	.....	3	.....	57	18,850
	Total	12	330,000	407	.....	.....	.....	407	151	.....	.....	.....	151	159	.....	4	.....	163	48,942

* The report of this works is included with those in Jefferson county.

† Manufacture of coke abandoned and capital regarded as sunk.

‡ Works experimental; no returns of capital, etc.

UNITED STATES AT THE CENSUS OF 1880, BY STATES AND COUNTIES.

Value of materials other than coal.	COAL USED.		SLACK USED.		WASHED COAL USED.		TOTAL COAL AND SLACK USED.		COAL PROPERTY.		COKE PRODUCED.		
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Acres.	Capital.	Tons.	Value.	
$233,784	3,729,328	$2,392,449	630,782	$358,558	751,824	$533,818	4,360,110	$2,761,057	158,683	$13,060,041	2,752,475	$5,350,489	
1,304	66,376	73,814	1,000	1,500	.....	.....	67,376	75,314	35,860	471,000	42,035	148,026	1
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
1,304	66,376	73,814	1,000	1,500	.....	.....	67,376	75,314	35,860	471,000	42,035	148,026	
600	29,500	22,600	.....	.....	29,500	29,500	29,500	29,500	2,000	1,033,500	18,000	90,000	1
4,000	117,000	120,000	.....	.....	.....	.....	117,000	120,000	15,000	220,000	70,000	140,000	1
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3
420	.....	.....	15,000	11,256	15,000	15,000	15,000	15,000	160	38,000	7,600	24,700	4
420	.....	.....	15,000	11,250	15,000	15,000	15,000	15,000	160	38,000	7,600	24,700	
200	1,500	2,025	.....	.....	.....	.....	1,500	2,025	260	20,000	1,000	3,000	1
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
200	1,500	2,625	.....	.....	.....	.....	1,500	2,025	260	20,000	1,000	3,000	
.....	400	640	730	320	.....	.....	1,130	960	287	41,525	505	2,097	1
1,588	67,646	101,469	.....	.....	.....	.....	67,646	101,469	1,530	169,000	39,424	125,052	2
735	.....	.....	14,922	16,471	.....	.....	14,922	16,471	.....	.....	9,806	42,887	3
2,992	77,285	74,024	29,904	30,529	.....	.....	107,189	104,553	1,280	183,900	57,084	156,902	4
84	1,361	1,779	.....	.....	.....	.....	1,361	1,779	180	22,000	1,017	3,806	5
.....	1,000	3,200	.....	.....	.....	.....	1,000	3,200	80	17,000	800	3,200	6
5,399	148,202	181,112	45,556	47,320	.....	.....	193,848	228,432	3,357	432,525	109,236	334,546	
7,276	10,618	20,273	156,082	99,445	127,201	86,891	166,700	119,718	.....	.....	95,685	235,915	1
400	13,400	6,700	.....	.....	.....	.....	13,400	6,700	.....	.....	7,000	13,000	2
2	.....	.....	1,012	253	.....	.....	1,012	253	.....	.....	500	936	3
5,366	155,453	142,318	.....	.....	.....	.....	155,453	142,318	2,345	470,000	98,154	212,102	4
30	.....	.....	750	100	.....	.....	750	100	443	15,000	400	1,200	5
11,000	85,000	78,500	.....	.....	.....	.....	85,000	78,500	400	34,500	51,950	110,864	6
810	.....	.....	16,200	4,050	16,200	4,050	16,200	4,050	300	26,000	10,800	13,500	7
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8
127,807	1,907,999	935,654	2,280	1,140	.....	.....	1,910,279	936,794	20,856	5,780,450	1,260,440	2,007,870	9
.....	.....	.....	.....	.....	.....	.....	.....	.....	175	25,000	.....	.....	10
296	.....	.....	7,500	3,750	7,500	3,750	7,500	3,750	.....	.....	3,941	20,651	11
1,190	.....	.....	53,777	67,221	53,777	67,221	53,777	67,221	.....	.....	33,572	100,716	12
100	.....	.....	2,200	550	.....	.....	2,200	550	.....	.....	1,200	2,400	13
55,512	972,499	603,272	223,325	98,079	391,975	264,669	1,195,824	671,351	7,763	3,111,500	753,501	1,410,946	14
209,849	3,144,969	1,786,717	463,126	244,588	596,718	426,581	3,608,695	2,031,305	32,272	9,421,450	2,317,149	4,190,136	
4,500	21,600	7,200	98,400	49,000	98,400	49,000	120,000	56,200	4,000	240,000	60,000	120,000	1
2,092	19,311	27,937	.....	.....	12,211	13,737	19,311	27,937	39,383	120,101	11,675	42,493	2
1,500	40,000	40,000	.....	.....	.....	.....	40,000	40,000	5,000	210,000	20,000	50,000	3
8,092	80,911	75,137	98,400	49,000	110,611	62,737	179,311	124,137	48,383	570,101	91,675	212,493	
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
1,320	88,769	84,444	.....	.....	.....	.....	88,769	84,444	16,000	519,715	57,943	127,588	1
160	.....	.....	4,200	2,100	.....	.....	4,200	2,100	.....	.....	2,800	4,000	2
90	2,180	2,000	.....	.....	.....	.....	2,180	2,000	66	13,750	1,200	3,000	3
1,450	49,681	44,600	3,500	2,800	.....	.....	53,331	47,400	5,330	320,000	33,777	82,000	4
3,020	140,780	131,044	7,700	4,900	.....	.....	148,480	135,944	21,391	853,465	95,720	216,588	

TABLE III.—STATISTICS OF THE COKE WORKS OF THE

	States and counties.	Number of establishments.	Capital invested in coke works and employed in coke business.	NUMBER OF OVENS BUILT.					NUMBER OF OVENS BUILDING.					NUMBER OF EMPLOYÉS.					Total wages paid in manufacturing coke.
				Bee-hive.	Belgian.	Other forms.	Pits or mounds.	Total.	Bee-hive.	Belgian.	Other forms.	Pits or mounds.	Total.	Males over 16.	Females over 15.	Males under 16.	Females under 15.	Total.	
	The United States.	9	$248,700	304	49	.....	.....	353	21	.....	.....	.....	21	2	.....	.....	.....	2	$910
	ILLINOIS.																		
1	Saint Clair	1	100,000	.....	24	.....	.....	24	.....	.....	.....	.....	.....	2	.....	.....	.....	2	910
	INDIANA.																		
1	Fountain	1	.....	.....	25	.....	.....	25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	PENNSYLVANIA.																		
1	Allegheny	1	20,000	24	.....	.....	.....	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2	Clarion	1	21,200	30	.....	.....	.....	30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	Fayette	1	65,000	127	.....	.....	.....	127	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	Lawrence	1	2,500	18	.....	.....	.....	18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
5	Westmoreland	1	10,000	20	.....	.....	.....	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Total	5	118,700	219	.....	.....	.....	219	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	VIRGINIA.																		
1	Alleghany	1	30,000	83	.....	.....	.....	83	21	.....	.....	.....	21	.....	.....	.....	.....	.....	.....
2	Henrico	1	.....	2	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Total	2	30,000	85	.....	.....	.....	85	21	.....	.....	.....	21	.....	.....	.....	.....	.....	.....

TABLE IV.—STATISTICS OF THE COKE WORKS OF THE

	States and counties.	Number of establishments.	Capital invested in coke works and employed in coke business.	NUMBER OF OVENS BUILT.					NUMBER OF OVENS BUILDING.					NUMBER OF EMPLOYÉS.					Total wages paid in manufacturing coke.
				Bee-hive.	Belgian.	Other forms.	Pits or mounds.	Total.	Bee-hive.	Belgian.	Other forms.	Pits or mounds.	Total.	Males over 16.	Females over 15.	Males under 16.	Females under 15.	Total.	
	The United States.	13	$526,500	.....	.....	.....	.....	.....	1,287	.....	80	.....	1,367	.....	.....	.....	.....	.....	.....
	ALABAMA.																		
1	Jefferson	1	29,000	.....	.....	.....	.....	.....	100	.....	.....	.....	100	.....	.....	.....	.....	.....	.....
	ILLINOIS.																		
1	Jackson	1	75,000	.....	.....	.....	.....	.....	.....	.....	80	.....	80	.....	.....	.....	.....	.....	.....
	PENNSYLVANIA.																		
1	Allegheny	1	14,500	.....	.....	.....	.....	.....	20	.....	.....	.....	20	.....	.....	.....	.....	.....	.....
2	Armstrong	1	25,000	.....	.....	.....	.....	.....	66	.....	.....	.....	66	.....	.....	.....	.....	.....	.....
3	Clearfield	1	25,000	.....	.....	.....	.....	.....	60	.....	.....	.....	60	.....	.....	.....	.....	.....	.....
4	Fayette	4	230,000	.....	.....	.....	.....	.....	800	.....	.....	.....	800	.....	.....	.....	.....	.....	.....
5	Jefferson	1	10,000	.....	.....	.....	.....	.....	31	.....	.....	.....	31	.....	.....	.....	.....	.....	.....
6	Westmoreland	2	80,000	.....	.....	.....	.....	.....	150	.....	.....	.....	150	.....	.....	.....	.....	.....	.....
	Total	10	384,500	.....	.....	.....	.....	.....	1,127	.....	.....	.....	1,127	.....	.....	.....	.....	.....	.....
	WEST VIRGINIA.																		
1	Fayette	1	38,000	.....	.....	.....	.....	.....	60	.....	.....	.....	60	.....	.....	.....	.....	.....	.....

UNITED STATES IDLE AT THE CENSUS OF 1880.

Value of materials other than coal.	COAL USED.		SLACK USED.		WASHED COAL USED.		TOTAL COAL AND SLACK USED.		COAL PROPERTY.		COKE PRODUCED.		
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Acres.	Capital.	Tons.	Value.	
									1,550	$296,500			
													1
													1
													1
									300	26,000			2
									400	55,500			3
													4
									850	215,000			5
									1,550	296,500			
													1
													2

UNITED STATES BUILDING AT THE CENSUS OF 1880.

Value of materials other than coal.	COAL USED.		SLACK USED.		WASHED COAL USED.		TOTAL COAL AND SLACK USED.		COAL PROPERTY.		COKE PRODUCED.		
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Acres.	Capital.	Tons.	Value.	
									16,211	$1,860,000			
									4,000	40,000			1
													1
													1
													2
													3
									10,823	1,600,000			4
									175	25,000			5
									213	95,000			6
									11,211	1,720,000			
									1,000	100,000			1

RELATION OF COST OF COKE TO SELLING PRICE.

In the accompanying table will be found the average selling price of coke per ton in the United States and in each state, and the value of the different elements of cost so far as the data for the same have been collected and are ascertainable:

States.	COKE PRODUCED.		Value of coal used.	Total wages paid.	Value of materials used other than coal.	SELLING PRICE OF COKE.		WAGES PER TON OF COKE.		Value of coal required to make a ton of coke.	Value of materials other than coal per ton of coke.
	Tons.	Value.				Average per ton.	Range of prices per ton.	Average per ton.	Range per ton.		
The United States...	2,752,475	$5,359,489	$2,701,057	$1,198,654	$233,784	$1 95	$1 00 to $5 24	$0 44	$0 20 to $1 30	$1 00	$0 08
Alabama	42,035	148,026	75,314	38,500	1,304	3 52	3 50 to 4 00	92	56 to 93	1 79	03
Colorado	18,000	90,000	29,500	13,500	600	5 00	5 00	75	75	1 64	03
Georgia	70,000	140,000	120,000	13,837	4,900	2 00	2 00	20	20	1 71	07
Illinois	7,000	24,700	15,000	9,347	420	3 25	3 25	1 23	1 24	1 97	06
Indiana	1,000	3,000	2,025	300	200	3 00	3 00	30	30	2 03	20
Ohio	109,206	334,546	228,432	51,977	5,399	3 06	1 75 to 4 00	48	30 to 1 20	2 01	05
Pennsylvania	2,317,149	4,190,136	2,031,305	983,431	209,849	1 81	1 00 to 5 24	42	23 to 1 30	88	09
Tennessee	91,675	212,493	124,137	38,820	8,092	2 32	2 00 to 4 74	42	35 to 77	1 35	09
West Virginia	95,720	216,588	135,944	48,942	3,020	2 26	1 50 to 4 00	51	37 to 71	1 42	03

In considering these figures it should be most carefully noted that all the elements of the cost of coke are not given. No attempt was made to ascertain all these items, and my experience in other positions convinces me that any such attempt would have been an utter failure. The average business man will not give to his competitors, much less to the whole world, all the details of the cost of manufacture, nor indeed such details as will enable others to approximate, with any degree of accuracy, his cost, and therefore how much or how little profit he is making. This should not be expected.

The only elements of cost given are wages and material. Among the elements of cost of a ton of coke which are not given are interest, taxes, insurance, collections, postage, rents, general office expenses, expense of selling, bad debts, and many other items, and in most cases the hauling of coal from the pit to the ovens, washing, profit chargeable on coal, etc.

With these considerations in mind the following table should not be misleading:

States.	Average selling price of ton of coke.	AVERAGE COST OF LABOR AND MATERIAL TO TON OF COKE.			
		Coal.	Other material.	Wages.	Total.
The United States	$1 95	$1 00	$0 08	$0 44	$1 52
Alabama	3 52	1 79	03	92	2 74
Colorado	5 00	1 64	03	75	2 42
Georgia	2 00	1 71	07	20	1 98
Illinois	3 25	1 97	06	1 23	3 26
Indiana	3 00	2 03	20	30	2 53
Ohio	3 06	2 01	05	48	2 54
Pennsylvania	1 81	88	09	42	1 39
Tennessee	2 32	1 35	09	42	1 86
West Virginia	2 26	1 42	03	51	1 96

PART II.—COKING IN THE UNITED STATES.

THE COAL-FIELDS AND COAL OF THE UNITED STATES IN THEIR RELATION TO THE MANUFACTURE OF COKE IN THE CENSUS YEAR.

A discussion at any length of the geological features of the several coal-basins of the United States, or even of the geology of the coking coal, does not lie within the scope of this report, nor will an attempt be made to establish the correlation of the different seams of coal used in coking in the several states. All of these subjects belong more properly to the report on coal, and will be referred to and discussed in this report only incidentally. Neither will it fall within the plan adopted to show, save in the most general way, the extent of the deposits of coking coal nor the character of these deposits, except of such as furnished coal for the manufacture of coke during the census year.

The coal used in the manufacture of coke at the census of 1880 represented three of the great coal-basins or coal-fields of the country, the Appalachian, the Illinois, and the Colorado. By far the larger part was derived from the measures of the great Appalachian field, less than 1 per cent. of the total coming from the Illinois and Colorado basins.

This Appalachian basin is at present the most important of the coal-fields of America. Beginning near the northern boundary of Pennsylvania, it extends for a distance of over 750 miles in a southwesterly direction, following the western line of the Allegheny mountains with a course nearly parallel to the Atlantic ocean coast line, through western Pennsylvania, West Virginia, Kentucky, Tennessee, Georgia, and Alabama, to Tuscaloosa, Alabama, where it ends. The average breadth of the field is from 80 to 90 miles, the area being fully 70,000 square miles.

The eastern escarpment of the Allegheny mountains formed, and still forms, the eastern border of this basin, while the great Cincinnati anticlinal hemmed it in on the west and separated it from the measures of the Illinois basin. The eastern line of this field is comparatively regular, following the trend of the mountains; but the western is very irregular, the basin being quite broad in its northern area, contracting through Tennessee and northern Alabama and expanding considerably at its termination in Alabama, though by no means so broad as in Pennsylvania, Ohio, and West Virginia.

In the northern part of this basin the coal is found in numerous isolated patches, the chief of which are the Blossburg, McIntyre, and Barclay. Between the eastern edge and the ocean other detached fields are found, such as the anthracite coal-fields of northeastern Pennsylvania, the Broad Top semi-bituminous coal-field of middle Pennsylvania, and the Cumberland coal-basin of Maryland. These patches are all that have been left by the denuding agencies which have swept away so much of the Devonian and Silurian rocks and cut so deeply and sharply, and at the same time so destructively, into these measures in this belt of country.

Along nearly the entire length of this great field, from Blossburg, Pennsylvania, on the north, to Birmingham, Alabama, on the south, the coke industry has been established. The ovens, following the zone of best coking coal, are generally found near the eastern limits of the field, hugging the mountains, the coal in the middle or western part of the basin being, as a rule, not so well adapted to coking as that in the eastern.

The greatest development in the manufacture of coke is in the Connellsville region of western Pennsylvania, a small trough 50 or 60 miles long by 3 miles wide. The Connellsville coke is regarded as the typical coke of this country, as the Durham is of England. Some other regions in this field may produce a coke equal to the Connellsville, but as a blast-furnace fuel especially, which is the purpose to which most coke is put, it is so well adapted, its use is so extensive, and its characteristics so well known, that it fully deserves the designation "typical". Coke is made at other points in Pennsylvania, especially in the Allegheny Mountain region, in the Ligonier valley, and near Pittsburgh. As a rule, none of these cokes equal the Connellsville. In some cases the cokes are lower in ash but inferior in physical structure, while in others washing is necessary to produce a fuel for blast-furnace uses.

In West Virginia the New River coal furnishes the most and also the best coke. Analysis shows it to be lower in ash than the Connellsville, and its producers assert that it is fully equal to it as a blast-furnace fuel; but this is by no means conceded. The Preston County beds, which are regarded as the equivalent of the Ligonier Valley coal of Pennsylvania, are also used to a considerable extent, but the coke is not equal to the New River coke.

In Ohio most of the coals are coking coals, but the deposits are much thinner than in either Pennsylvania or West Virginia, and generally, though not always, contain an objectionable amount of sulphur. The coals are coked only to a limited extent, and the manufacture of coke is not increasing as rapidly as in Pennsylvania, West Virginia, and Alabama.

In Tennessee the Sewanee seam furnishes most of the coke, while in Alabama coals from both the Warrior and the Cahaba fields were coked, furnishing a most excellent fuel. The extreme eastern outcrop of the Appalachian basin cuts the northwestern corner of the state of Georgia, furnishing a small patch of coking coal, from which some coke was made in the census year.

Two important facts regarding the character of the coal in this Appalachian field have been pointed out. These are the debituminization eastwardly of the coal and the similarity of the composition of the coals in the same basin. These laws are of considerable importance in connection with the coke industry, the one indicating generally the location of the seams of best coking coal, the other bearing on the future supply of this coal. (*a*)

The fact of the debituminization of the coals eastwardly has been pointed out by Professor Rogers. Whether this has been accomplished by the heat evolved by the dynamic crust-flexing force or by conditions in the coal flora is immaterial in this connection. Certain it is that the most abnormal condition of the coal is found in the extreme eastward coal-fields, in the natural coke or anthracite coal. From this anthracite range westward the bituminous element in the coal-beds increases gradually until the zone of full pitchy or gaseous coal is reached in the vicinity of Pittsburgh.

The following analyses exhibit these extremes:

	Per cent. of bituminous.	Per cent. of anthracite.
Fixed carbon, (MM, p. 17, No. 180) (*b*)	48.769	89.06
Volatile matter	40.995	3.45
Ash	7.020	5.81
Sulphur	2.206	0.30
Phosphorus	------	0.024
Moisture	1.010	1.35

The following table shows the increase westwardly of volatile or hydrogenous matter in the Upper Coal-Measures (McCreath):

Coal-fields.	Moisture.	Carbon.	Volatile matter.	Ash.	Sulphur.	Reports Pennsylvania Second Geological Survey.
Anthracite	1.35	89.06	3.45	5.81	0.30	L, p. 133.
Cumberland	0.893	74.289	15.522	9.296	0.714	H 3, p. 101.
Salisbury	1.665	68.774	22.35	5.965	1.246	
Connellsville	1.26	59.52	30.11	8.23	0.78	
Greensburgh	1.02	61.34	33.50	3.28	0.86	MM, pp. 23, 24.
Irwin	1.41	54.44	37.66	5.86	0.64	MM, p. 22.

This table leaves a gap of 30 miles between Salisbury and Connellsville without analysis of the great Pittsburgh bed, the Upper Coal-Measures, including the great Pittsburgh bed, having been swept away with the exception of the Salisbury and Fairfield basins, from a belt of 35 miles broad, west of the Allegheny mountains.

The following table shows the character of the Lower Coal Series in the Allegheny field (McCreath):

Coal-fields.	Moisture.	Carbon.	Volatile matter.	Ash.	Sulphur.	Reports Pennsylvania Second Geological Survey.
Anthracite	1.35	89.06	3.45	5.81	0.30	
Broad Top	0.77	73.34	18.18	6.69	1.02	
Bennington	1.40	61.84	27.23	6.93	2.60	
Johnstown	1.18	74.46	16.54	5.96	1.86	
Blairsville	0.92	62.22	24.36	7.59	4.92	H 4.
Armstrong County	0.96	52.03	38.20	5.14	3.66	M 3, p. 56.

The gradual increase of volatile matter from the Broad Top coal-field of the east to Armstrong county in the west, a distance of about 75 miles, is very marked, showing an increase of 0.267 per mile. Making a comparison of coals from the second bed in the Lower Coal-Measures, bed "B" of the *Second Geological Survey of Pennsylvania*, we find that this bed at Bennington contains 27.23 per cent. of volatile matter, which exceeds its legitimate richness westward 2.38 per cent. At Johnstown, in the second sub-basin, this bed "B" contains 16.54 per cent. of volatile matter, or 10.98 per cent. less than its westward position should afford. This is a remarkable exception to the law of general bituminization of coals westward.

So far as determinations have been made on coals in this second sub-basin north and south of Johnstown, this condition of "dryness" in the coal-bed has been found extended and uniform. How far it may reach northeast and southwest has not been determined.

Blairsville, 55 miles west from Broad Top, has coal containing 24.36 per cent. of volatile matter. This is 8.50 per cent. under its normal richness, showing the broad range of the operation of the causes that have produced exceptional results. In fact, this Blairsville coal is lower in volatile matter than the coal at Bennington, 30 miles eastward.

a For the following statement I am indebted to Mr. John Fulton, M. E.

b These letters refer to the various reports of the *Second Geological Survey of Pennsylvania.*

Armstrong County coal attains a mature condition, and is constituted with its full share of volatile matter, 38.20 per cent. This last result unfolds a truth that has been clearly pointed out by Professor J. P. Lesley: the similarity of the elements of coals in beds in a common basin. Taking the Salisbury coal as an illustration, and its congener, the Berlin bed, below, in the same geological range, they are constituted as follows:

	Salisbury (Pittsburgh). (HHH, p. 78.) Per cent.	Berlin bed. (HHH, p. 34.) Per cent.
Moisture	1.385	2.010
Fixed carbon	69.352	68.321
Volatile matter	21.470	20.535
Ash	7.030	8.390
Sulphur	0.763	0.744

The slight increase of volatile matter in the higher beds of Salisbury and Johnstown sub-basins has been observed.

The coals in the lower and upper series in the western counties of the state show as follows:

	Pittsburgh bed (M3, p. 56). Per cent.	Kittanning coal. Per cent.
Water	0.800	0.96
Volatile matter	36.900	38.20
Fixed carbon	50.230	52.03
Sulphur	3.040	3.66
Ash	9.030	5.14

These results confirm the view of the uniformity in elementary matter in coal-beds in the same basins, with slight variations.

The importance of this law will appear when the future supply of coking coals shall be considered.

The coal-measures of the Illinois basin very nearly equal in area those of the Appalachian basin, covering about 47,188 square miles, (*a*) but they by no means equal the latter in the character of their coking coal. This basin occupies the larger part of the state of Illinois, the southwestern portion of Indiana, and the western part of Kentucky. Its eastern limit is the rocks of the Cincinnati axis, which separate it from the Appalachian basin, while its western margin is formed by the bed of the Mississippi river, which has been excavated through it and separates it from the Missouri basin. The beds of coal in the Illinois field are not as thick as in either the Appalachian or the Missouri basin, though their number is about the same as in the former. "The coals themselves are more apt to be impure," (*b*) being high in sulphur and ash. This is not uniformly the case, however, as will be evident from an inspection of the analyses of the Big Muddy and Cartersville coals of southwestern Illinois. The character of the coals of this basin, and the difficulty of adapting them to the manufacture of coke, is shown in the fact that but 8,600 tons of coke were made from them in the census year. At present (1880) the successful manufacture of coke in the Illinois basin is confined to the two localities in southwestern Illinois mentioned above: Mount Carbon and Cartersville.

In Indiana the coals of the "eastern zone" of Professor Cox's reports, or the lower measures, are non-coking, being the well-known block coal of the state, which can be used raw in smelting iron. The "western zone", or upper measures, which are much more extensiv ethan the lower, contain deposits of good coking coal, generally, however, so far as they have been tried for making coke, high in ash and sulphur.

The coals of the northern part of this basin in Illinois are too sulphurous to make good coke, but in the southwestern part of the state there are several small deposits of quite pure coal, which, although dry-burning, makes a very good coke when crushed, washed, and charged wet. The portion of this field lying in Kentucky, like that part of the Appalachian field lying in the same state, has not been utilized for the manufacture of coke.

But little is known of the extent of the coking coal in what I have termed, for want of a better name, the Colorado basin; but from the coal mines of the Trinidad region, which are the highest above the sea-level worked in the country, some coke was made in the census year. For many years it was believed that all the coals of this section were lignites or brown coal; and speaking as late as 1875 Professor Hayden says of this region:

> According to Dana's classification, I should term these coals *caking or binding bituminous coal*. The term *lignite* is generally used, but speaking from the strict standpoint of a mineralogist this name is not applicable.

The term "lignite" applied to these coals has no doubt given a widespread but erroneous idea as to their character, which the success of the Colorado Coal and Iron Company in coking them has entirely removed. There are other extensive beds of coking coal in this region, but little is known of them except of the most general character.

Of the adaptability of the coals of the other basins of the country to the manufacture of coke, our information, so far as relates to actual attempts on a commercial scale, is very limited. The coal of the Rhode Island basin is anthracite, and is a natural coke. In the Missouri basin some coke has been made in Iowa, and it is rumored that

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a Statistical Atlas of the United States, page 12. Some authorities make this 68,000. *b Ibid.*, page 13.

some ovens have been built to test the coal of this basin in Missouri. The coals of the Michigan basin are reported as not being adapted to coking. No trials have been made of the coals of the Texas basin, and but little is known of them. A number of trials have been made with Utah coal, and there is said to be a number of deposits of good coking coal in that territory.

In the following table will be found analyses of a number of the most important coking coals of the United States, and the oven cokes made from the same. These all appear in the remarks regarding coking in the different states, and are brought together here for convenience of reference and comparison. The cokes are supposed to be industrial cokes, unless it is stated otherwise:

Districts or localities.	Mine or seam.	COAL.					COKE.					Authorities or chemists.
		Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Moisture.	Carbon.	Ash.	Sulphur.	Moisture.	Volatile matter.	
PENNSYLVANIA.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Connellsville	Broad Ford	30.107	59.616	8.233	0.784	1.260	89.576	9.113	0.821	0.030	0.460	McCreath.
Do	Coketon*	21.850	65.720	11.710	0.700	.....	89.150	9.650	1.200	.....	.....	B. Crowther.
Irwin's	Penn Gas Coal†	38.130	54.880	6.980	0.060	.....	88.240	9.414	0.962	.....	1.384	Carnegie Bros. & Co.
Allegheny Mountain	Bennington "B"	27.225	61.843	6.930	2.002	1.400	87.580	11.360	1.060	.....	.....	McCreath.
Do	Lilly's Station "E"	22.250	70.518	5.058	1.459	0.715	.....	.....	.....	.....	.....	Do.
Blossburg	Arnot, Seymour vein‡	21.586	71.574	4.753	0.007	1.180	84.760	13.345	0.998	0.175	0.722	Do.
Allegheny River	Lower Freeport†	35.825	54.223	7.340	1.312	1.300	85.777	11.463	2.107	0.330	0.623	Do.
Beaver county	Hulmes & Bro.‡	38.110	54.619	4.080	0.791	2.400	84.727	12.636	1.994	0.100	0.633	Do.
WEST VIRGINIA.												
New River	Quinnimont	18.190	75.890	4.680	0.300	0.940	93.850	5.850	0.300	.....	.....	J. B. Britton,
Do	Fire Creek	22.340	75.020	1.470	0.560	0.610	92.180	6.680	0.618	0.110	.....	Coal, Dr. Ricketts; coke, J. B. Britton.
Do	Longdale	21.380	72.320	5.270	0.270	1.030	93.000	6.730	0.270	.....	.....	C. E. Dwight.
Do	Nuttallburg	29.590	69.000	1.070	0.780	0.340	92.220	7.530	0.910	.....	.....	Do.
OHIO.												
Leetonia	Washingtonville	39.600	56.040	1.800	0.530	2.560	93.750	5.380	0.870	.....	.....	Professor Wormley.
Steubenville	Shaft Coal	30.900	65.900	1.800	0.980	1.400	90.630	8.380	0.270	.....	.....	Coal, Professor Wormley; coke, Dr. Wuth.
TENNESSEE.												
Tracy City	Sewanee	29.300	61.000	7.800	Trace	1.600	83.364	15.440	0.142	.....	.....	Coal, Robertson; coke. Land.
Whiteside	Kelly	21.100	74.200	2.700	0.700	1.300	94.560	4.650	0.790	.....	.....	Coal, Professor Shale; coke, Etna Coal Company.
Rockwood	Roane Iron Company's	26.020	63.740	7.820	0.330	1.490	84.187	14.141	0.182	.....	.....	Land.
ALABAMA.												
Warrior Field	Pratt seam	31.480	61.600	5.416	0.918	1.508	88.224	11.315	0.563	0.362	0.990	Professor McCalley.
Cahaba	Helena	34.370	59.580	6.050	0.660	.....	84.035	15.216	0.445	0.083	0.660	Coal, Eureka Iron Company; coke, Professor McCalley.
ILLINOIS.												
Big Muddy	Mount Carbon	31.930	59.130	1.810	0.760	6.370	88.180	10.070	0.610	.....	0.930	Coal, Robertson; coke, Thos. M. Williamson.
COLORADO.												
El Moro	El Moro	38.230	55.860	3.590	.....	1.320	87.470	10.680	0.850	1.850		
Crested Buttes	Crested Buttes	23.200	72.600	3.100	.....	1.100	92.030	6.620	.....	1.350		

* Average of top and bottom of vein.
† Analysis is of washed slack and coke from same.
‡ The coal is "run of mine"; the coke is made from washed slack.

HISTORY OF THE MANUFACTURE OF COKE IN THE UNITED STATES.

The first date I have been able to find at which it is claimed that coke was used in this country is that given in French's history of the iron trade, (*a*) which states that coke was employed a few years before the Revolution in the manufacture of pig- and refined bar-iron.

While this is possible, it is hardly probable that coke was used in the blast-furnaces and refineries of this country at this early date. It was not until 1735 (*b*) that Darby used coke successfully at Coalbrookdale, in Shropshire, England, and it was not until 1750 that it came into anything like general use in that country as a blast-furnace fuel. The repeal by the British parliament in 1750 of the import duty on pig-iron from the American colonies stimulated its production in this country, but it was the scarcity of wood for fuel in Great Britain that led to this action, and as charcoal pig-iron, not coke pig, to supply the demand of English iron works, that was sought for export. It

(*a*) *History of the Rise and Progress of the Iron Trade of the United States*, by B. F. French (New York, 1858), page 58.
(*b*) See chapter on "History of Coke in England" for difference among authorities as to this date.

is hardly probable that there would be any demand for foreign coke-iron in England at that time, especially at the price at which it could be made in America and transported to the British iron works. Even charcoal pig-iron could hardly have been exported with profit were it not for its comparatively high price in England, caused by the scarcity of wood fuel. The great abundance of wood in this country—large tracts being burned for the ashes—and the fact that coal suitable for coking, if it existed at all, was found only to a limited extent in that portion of the country in which iron was made prior to the Revolution, would seem to preclude the idea that coke was used for the manufacture of pig-iron, as stated by French. When, in addition to this, we recall the imperfect knowledge of the method of manufacture and use of coke in this country, the difficulties of transportation, and the prejudice in favor of charcoal iron, it would seem, in the absence of other and more definite information, that French's statement must be wrong.

With the close of the Revolution and the subsequent emigration from England numbers of skilled iron workers found their way to this country notwithstanding the stringent laws against such emigration and the heavy penalties imposed upon those discovered in the attempt to emigrate. Among these workers were doubtless some skilled in the manufacture and the use of coke. This supposition is borne out by an advertisement which appeared in the Pittsburgh *Mercury* of May 27, 1813, in which one of these emigrants offers his services to instruct blast-furnace managers in the method of manufacturing coal into coke. The advertisement was as follows:

To proprietors of blast-furnaces:

John Beal, lately from England, being informed that all the blast-furnaces are in the habit of melting iron ore with charcoal, and knowing the great disadvantage it is to proprietors, is induced to offer his services to instruct them in the method of converting stone coal into *coak*. The advantage of using coak will be so great that it cannot fail becoming general if put to practice. He flatters himself that he has had all the experience that is necessary in the above branch to give satisfaction to those who feel inclined to alter their mode of melting their ore. JOHN BEAL, *Iron Founder.*

N. B.—A line directed to the subscriber, postpaid, will be duly attended to.

I have been unable to learn whether Mr. Beal's proposition was accepted.

Shortly after this, however, in 1816–'17, Colonel Isaac Meason built the first rolling-mill erected west of the Allegheny mountains, to puddle iron and roll iron bars, at Plumsock, in Fayette county, Pennsylvania. At this mill, which went into operation September, 1817, coke was used in the refinery. This is the first definite statement that I have been able to find of the use of coke in this country. It is an interesting fact that it was made on Redstone creek, about midway between Connellsville and Brownsville, in Fayette county, the county that produced the largest number of tons of coke in the last census year.

This mill was built under the direction of Mr. Thomas C. Lewis, one of the English emigrant iron-workers before referred to. The next notice I have been able to find of the use of coke was at a blast-furnace built under his management, the Bear Creek furnace, situated in Armstrong county, Pennsylvania, one mile from Lawrenceburg, the present Parker's Landing. This furnace was built to use coke, and went into operation in 1819. It was unsuccessful, however, the blast being too weak, and the furnace chilled after making two or three tons of iron, and the attempt to use coke was probably abandoned.

The rapid disappearance of the forests of Pennsylvania and the abundant deposits of bituminous coal caused widespread attention to be given to the use of coke in the manufacture of pig-iron, and during the next few years attempts were made in the western part of that state to utilize bituminous coal for this purpose. In 1825 the acting committee of the Pennsylvania Society for the Promotion of Internal Improvement sent Mr. William Strickland to England as their agent to study various subjects relating to internal improvements, and also charged him with investigating the methods employed in the manufacture of iron, allowing him £100 for expenses of the iron investigation.

In their letter of instruction to Mr. Strickland the committee say: (*a*)

Attempts of the most costly kind have been made to use the coal of the western part of our state in the production of iron. Furnaces have been constructed according to the plan said to be adopted in Wales and elsewhere; persons claiming experience in the business have been employed, but all has been unsuccessful. In large sections of our state ore of the finest quality, coal in the utmost abundance, limestone of the best kind, lie in immediate contiguity, and water-power is within the shortest distance of these mines of future wealth. The prices which are obtained for iron on the western waters are double those of England, the demand is always greater than the supply, and thus nothing but knowledge of the art of using these rich possessions is wanted.

We desire your attention to the following inquiries on the subject of the manufacture of iron:

1. What is the most approved and frequent process for coking coal, and what is the expense of the process per ton or caldron?

2. In what manner are the arrangements or buildings, if any, constructed for the coking of coal, obtaining drawings and profiles thereof?

3. Are there different modes for coking coal; and if they have any differences in principle, what are they?

4. In what manner are the most approved furnaces for the smelting of ore constructed? Drawings and sections of the same to accompany the information which may be obtained upon this inquiry.

5. The mode of drawing off the pigs, the plan adopted for keeping supply of ores, if peculiar or superior to that used in this country?

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a The First Annual Report of the Acting Committee of the Society for the Promotion of Internal Improvement in the Commonwealth of Pennsylvania (Philadelphia, 1826), pages 37, 38.

The report was signed by Matthew Carey and others, who were well acquainted with the state of the iron industry at that time, and indicates that before 1825 coke had been used in the blast-furnaces of western Pennsylvania, as the reference in the first paragraph could hardly have been to the use of raw coal. This probability is strengthened by a passage referring to the investigations of their agent. In 1825 Mr. Strickland forwarded a complete statement as to the method of making coke in England. In the first annual report, before quoted, occurs the following on this subject: (*a*)

> The next report received from Mr. Strickland was dated the 16th of June, 1825, which, as far as its contents are connected with railways, may be considered as a supplement to the first report. It contains "a description of the Duke of Portland's tram-road", and a very particular account of the mode of coking bituminous coal and of making cast and blister steel. The drawings, which form a part of this report, exhibit in detail the processes which are in successful use in England for the production and manufacture of the articles mentioned. To those sections of our country where bituminous coal abounds, and where no method of coking it for the purposes of smelting iron has yet been in successful operation, the plans of the ovens, by which this process is accomplished, may be essentially important; and the information communicated upon this grand desideratum in the making of iron in western Pennsylvania may be employed to remove the difficulties which have hitherto baffled all the efforts of those who have endeavored to use that coal in their smelting-furnaces.

This certainly indicates that attempts to use coke in smelting iron in western Pennsylvania had certainly been made prior to 1825, and gives color of probability to the statements made in the *History of Fayette County.*

There can be no doubt that these reports of Mr. Strickland had much to do with the experiments that shortly after their publication began to be made in the use of coke in blast-furnaces in various parts of Pennsylvania, and its advantage as a fuel for iron-smelting at last attracted the attention of the legislature of the state. In a report on coal made by a committee of the Pennsylvania senate, of which the Hon. S. J. Packer was chairman, and read in the senate March 4, 1834, it was stated that—

> The coking process is now understood, and our bituminous coal is quite as susceptible of this preparation and produces as good coke as that of Great Britain. It is now used to a considerable extent by our iron manufacturers in Centre county and elsewhere.

I have not been able to learn any of the details of the use of coke in the furnaces referred to by Mr. Packer. Mr. James M. Swank (*b*), in his report on iron and steel, expresses the opinion that at the time Mr. Packer wrote his report coke could not have been used in blast-furnaces in any other way than as a mixture with charcoal, and then only experimentally; but it is probable, in view of the attention that had been given to the subject and the publication of Mr. Strickland's report, that attempts had been made to use coke alone. (*c*)

In 1835 the Franklin Institute of Pennsylvania offered a premium of a gold medal to "the person who shall manufacture in the United States the greatest quantity of iron from the ore during the year, using no other fuel than bituminous coal or coke, the quantity to be not less than 20 tons". The phraseology of this offer would lead to the belief that coke had before this been used in the manufacture of iron, as Mr. Packer states; but the best results obtained had been in connection with other fuels, as the offer of the Institute is for "iron made by the use of no other fuel than bituminous coal or coke". This would also seem to indicate that in the experiments made, if they had been made with coke only as a fuel, even so small a quantity as 20 tons of pig-iron had never been made with this fuel.

In the same year that this offer was made Mr. William Firmstone was successful in making good gray forge iron for about one month at the Mary Ann furnace, in Huntingdon county, Pennsylvania, with coke made from Broad Top coal.

Mr. Isaac Fisher, of Lewiston, Pennsylvania, who states in a pamphlet published in April, 1836, that "successful experiments have lately been tried in Pennsylvania in making pig-iron of coke", probably had Mr. Firmstone's experiment in mind. Mr. Firmstone is doubtless entitled to the honor of having been the first successful manufacturer in this country of coke pig-iron. It is also interesting to note that his blast was just one hundred years after the date usually assigned to Darby's successful use of coke in England.

In 1836 or 1837 F. H. Oliphant made at his Fairchance furnace, near Uniontown, Fayette county, Pennsylvania, a considerable quantity of coke-iron, probably more than 100 tons, and in a letter to the Franklin Institute, dated October 3, 1837, Mr. Oliphant suggests that possibly he was entitled to the premium offered by them. Accompanying his letter was a piece of pig-iron and samples of the raw material from which it was made. Mr. Oliphant, however, did not continue the manufacture of iron with coke, but returned to the use of charcoal as a fuel.

Between 1836 and 1839 other attempts were made to use coke at Pennsylvania furnaces, but they were unsuccessful or unfortunate. (*d*) The legislature of Pennsylvania, June 16, 1836, passed an act to encourage the manufacture of iron with coke or mineral coal, which gave the governor authority to charter companies, with ample

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a The First Annual Report of the Acting Committee of the Society for the Promotion of Internal Improvement in the Commonwealth of Pennsylvania, page 20.

b Statistics of the Iron and Steel Production of the United States, James M. Swank (Tenth Census), p. 143.

c The History of Fayette County, Pennsylvania, page 242, states that coke was made and used at the Allegheny furnace, Blair county, Pennsylvania, in 1811, and speaks of this as authenticated. If this is correct, it was an earlier use of coke than that mentioned at the Plumsock refinery. The same work also states that the Howard furnace, in Blair county, put in operation in 1830, and the Elizabeth furnace, built in the same county in 1832, were constructed with a view to the use of coke, and furnaces in Clearfield, Clinton, Lycoming, and Armstrong counties, Pennsylvania, erected between 1835 and 1838, made repeated attempts at the manufacture of coke-iron, all of which resulted in failure, from the fact that cold blast was used and at a very low pressure. I have not been able to verify these statements, and give them solely on the authority of the work referred to.

d Attempts were also made in Ohio, which will be spoken of in another part of this chapter.

powers for the purpose of prosecuting this branch of industry. At Farrandsville, in Clinton county, coke was used to a considerable extent from 1837 to 1839, about 3,500 tons of pig-iron being made. The manufacture was abandoned, however, owing to the impurity of the coal and the difficulty of transportation. At Karthaus, in Clearfield county, Mr. Peter Ritner succeeded in using coke in making pig-iron as early as 1838, if not in 1834 (*a*). Coke was also used in 1839 in this furnace, but at the close of that year the enterprise was abandoned, owing to the lack of transportation facilities. In Mather's second report of the *Geology of Ohio*, published in 1838, the following statement regarding this furnace is given:

Through the enterprise and perseverance of Mr. Peter Ritner, of Karthaus, Clearfield county, Pennsylvania, the same practice has been introduced into this country, and at the last information was in most successful operation. His experiments were made in a common charcoal stack, 45 feet from the hearth to the trundle-head; diameter at the top, 6 feet; at the boshes, 13 feet; hearth 2 feet 6 inches square. Coke from Phillipsburg was used in the operation, the details of which, relative to consumption, blast, product, etc., have been freely and unreservedly given me by Mr. Ritner:

Bushels of charcoal necessary to make a ton of pig, 200; bushels of coke, 75; charge of coke, 10 bushels, weight 45 pounds per bushel; burden, about one-fourth the charge in weight; blast, 4,000 to 6,000 cubic feet per minute, under a pressure of 2¼ to 2½ pounds to the square inch; yield of furnace, 65 to 70 tons per week; ordinary yield of charcoal stack, 23 to 27. Mr. R. says, under date of August 23, 1838: "As to quality, there can be no doubt of its being as good as that made from coke in any part of the world. It has been tested by the committee appointed by the treasury department to try the strength of boiler-iron, and bore 68,869 pounds to the square inch. We have also caused it to be rolled into bars and plates, and find it an excellent article. Finished bar-iron can be made in this region at a cost not exceeding $35 per ton, and I hope to see the time when it will be.

I am informed of another furnace at Kittanning, Armstrong county, Pennsylvania, now in operation with coke as a fuel.

A furnace at Frozen Run, in Lycoming county, made some coke pig-iron in 1838, but returned to the use of charcoal in 1839.

It was in Maryland, however, that coke was first successfully used for any considerable length of time in blast-furnaces in this country. In 1837 the George's Creek Coal Company built the Lonaconing furnace, 8 miles northwest of Frostburg, Maryland, to use coke, and in June, 1839, according to Johnson, (*b*) it was making about 70 tons per week of good foundery coke-iron. This furnace was 50 feet high by 14½ in the boshes. Its highest yield in a campaign of four months was 92 tons per week; the lowest, 62. In 1840 two large blast-furnaces were built by the Mount Savage Company to use the same fuel. These furnaces were for several years successfully operated with coke. Their success, no doubt, was due to their having been constructed with sufficient blast-power and hot blasts, especially for using coke. The coke made at these furnaces was from the seam of coal known as the Mount Savage fawn-ash coal, containing about 78 per cent. of fixed carbon and 7 per cent. of ash. It also carried quite a large percentage of sulphuret of iron, which greatly injured its value both for furnace and foundery purposes. The coke was made in open pits, as was all the coke produced in Maryland so far as I have been able to learn. Both the rectangular pit and the circular mound were used. The coke produced was hard, bright, and carried a good burden in the furnace, making, it is claimed, a ton of iron with a ton and a quarter of coke. The pressure of blast used in this furnace was from 2¾ to 3½ pounds, and the temperature about the melting point of lead, 612° F. The furnaces were 14 feet boshes by 45 to 50 feet high. No doubt the success of these furnaces in making long blasts was due to their great blowing power, the greatest in the country at the time, and to their hot-blast capacity. Most of the attempts to use coke prior to this had been with the weak blasts of charcoal furnaces, blowing the air into the furnaces cold. The yield of the coal in coke was about 52 per cent. From 1840 to 1850 between 50,000 and 75,000 tons of coke were made at the Mount Savage works, most of which was used at the furnace, but some of it was used at founderies. In the next decade a portion of the coke used was from what is known as the big vein of Alleghany county, but the coke was unsatisfactory. From 1860 to 1870 all the coke made was from another portion of the big vein, which produced a good coke. These furnaces have not been in blast for some years.

In 1845 the Antietam furnace, which was built about 1730 as a charcoal furnace, and which had been several times rebuilt, was again rebuilt and blown in with half coke and half charcoal, running in this way until 1848, when all coke was used. From this time until 1857 short blasts were made, using coke entirely, the coke being chiefly from the Frostburg Coal Company's and the Cumberland Coal and Iron Company's mines, though in the last three or four years part of the coke was made at the furnace. From 1857 to 1867 there was but one short blast, when the present proprietor bought it. From this time until 1879 the coke used was made at the furnace. At its last blast, beginning in 1879, Connellsville coke was used.

As I have indicated, all of the coke made in Maryland was burned in open-air pits, and I have not been able to find the record of the existence of a single oven. During the last few years coke has only been used to utilize the fine coal from the dumps. The last company making coke at Cumberland was the Cumberland Coal and Iron Company, which made some as late as 1878 and 1879, and these were the only parties producing any for a number of years. So far as I have been able to learn, no coke is now made in Maryland.

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a Mr. John Irwin, jr., of Bellefonte, Pennsylvania, writes me that "in the year 1834 Loy & Ritner made some coke-iron at this furnace. The coke was made in pits from a superior vein of bituminous coal, six feet in thickness. I do not remember anything in regard to the quality of the coke. They, however, succeeded in making some pig-iron, but not having means to carry on the business, and being dependent altogether on the uncertain river (Susquehanna) channel to reach a market, they soon abandoned the business".

b See *Anthracite Iron*, by Walter R. Johnson, pages 7 and 8.

While these experiments were in progress in Pennsylvania and Maryland similar ones were being conducted in Ohio. In the *First Annual Report of the Geological Survey of Ohio*, page 18, published in 1838, but submitted at the close of 1837, Professor Mather says:

Coke is now manufactured in Ohio from several of the coal-beds. Hon. Daniel Upson, of Portage county, makes a coke of excellent quality from a coal of his mine in Tallmadge. Mixed with charcoal, it is used in the high furnace at Akron, in the smelting of iron ore. Mr. Ford, of Akron, by mixing 40 bushels of coke per day with the charcoal, is stated to have increased the quantity of iron smelted 33⅓ per cent. The coal-bed is from 3 to 5 feet thick, and from 2 to 3 feet of the coal make excellent coke, which is found to be a perfect substitute for anthracite coal in the cupola furnaces.

An analysis of this coal and coke is given in the second report, page 35. (*a*)

In this same report (*b*) Professor Mather, after stating that most of the pig-iron produced in Ohio was smelted with charcoal, notwithstanding the inexhaustible supplies of coal fitted for the manufacture of "coke, or the charcoal of bituminous coal", says:

In my first annual report to this legislature I mentioned that coke was beginning to be used in three of our furnaces. Whether it has increased during the past season I have not been informed, but it is now extensively used for melting iron for castings. Anthracite coal was formerly brought to various parts of this state from Pennsylvania for this purpose; but in consequence of the great expense, coke has been substituted, and is equally effective. One ton of coke will melt from 5 to 10 tons of iron, but 7 tons is considered an average. This variation is due to the greater or less purity of the coal. The coal may be used raw in the furnace, where it cokes itself, or it may be previously coked in a coke oven, or in a heap in the open air. By coking it loses about one-half its weight, but increases about one-fourth its bulk.

In this second report, Mr. Whittlesey, after constantly referring to the possibility of coking the coals of Ohio, showing that the thought of this use was an ever present one, says: (*c*)

The Tallmage coal undergoes this process in the open air without any covering, but it is more economical to use close ovens, in which the refuse and inferior coal may be reduced.

Coke is already in general use in the cupolas throughout the northeastern part of the state; but the great demand for this article must soon come from the manufacture of pig-metal.

Coke, however, did not come into favor rapidly as a furnace fuel. In 1849 there was not a coke-furnace in blast in Pennsylvania. In 1856, however, according to Lesley's *Iron Manufacturers' Guide*, there were 21 furnaces in Pennsylvania and 3 in Maryland using coke, which made in that year: Pennsylvania, 39,953 tons; Maryland, 4,528 tons. The Pennsylvania furnaces were chiefly in what is known in this report as the Allegheny Mountain region. There was not a furnace using Connellsville coke unless the Valley C furnace near Ligonier is regarded as in the Connellsville region. Lesley also mentions a coke-furnace called the Potomac, at Point of Rocks, Virginia, which used charcoal until 1848, that made 60 tons a week. Coke seems also to have been used at the Clay furnaces, in Mercer county, Ohio, in the latter part of 1845, in connection with charcoal, but coke was rapidly supplanted in this section by raw coal.

It was not, however, until the development of the Connellsville region, Pennsylvania, that the use of coke as a blast-furnace fuel or the manufacture of coke itself in this country assumed any importance.

The history of the early attempts to make coke in this region are involved in considerable obscurity, though some of the parties are still living who helped build the first Connellsville coke oven. As early as 1817, as has already been stated, Colonel Meason used coke at his Plumsock refinery. It is also stated that some attempts were made in 1819 to use this coke in the blast-furnaces of the neighborhood. This early coke was all made "on the ground", and it is probable that up to 1841 no coke was made in ovens.

It was in this year, 1841, that two carpenters, Provance McCormick and James Campbell, overheard an Englishman, so the story runs, commenting on the rich deposits of coal at Connellsville and their fitness for making coke, as well as the value of coke for foundery purposes, and they determined to enter upon its manufacture. Mr. McCormick, who is still living, an old man of eighty-four, has given me an account from memory of this enterprise, which I quote:

James Campbell and myself heard, in some way that I do not now recollect, that the manufacturing of coke might be made a good business. Mr. John Taylor, a stone-mason, who owned the farm on which the Fayette coke works now stand, and who was mining coal in a small way, was spoken to regarding our enterprise, and proposed a partnership—he to build the ovens and make the coke, and Mr. Campbell and myself to build a boat and take the coke to Cincinnati, where we heard there was a good demand. This was in 1841. Mr.

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a The following is a recapitulation of the items determined in the composition of coal from D. Upson's mine, Tallmadge Portage county, Ohio:

	Per cent.
Coke containing the earthy and metallic matter of the coal	55.425
Bitumen=39.505 volatile matter—0.274 sulphur=	39.231
Sulphur volatilized with the bitumen	0.274
Hygrometric water	5.067
Loss	0.003

The coke in the above recapitulation is composed as follows:

Composition of coke of Hon. D. Upson's mine:	Per cent.
Carbon	96.355
Protosulphuret of iron	1.375
Earthy matter	2.270

Some of the determinations in this analysis having been made by differences, they necessarily show no loss, although a small loss was undoubtedly sustained.

b Second Annual Report of the Geological Survey of Ohio, page 11. This was submitted late in 1838.

c Idem, page 62.

Taylor built two ovens. I think they were about 10 feet in diameter. My recollection is that the charge was 80 bushels. The ovens were built in the same style as those now used, but had no iron ring at the top to prevent the brick from falling in when filling the oven with coal, nor had we any iron frames at the mouth where the coke was drawn. The top and mouth had to be repaired when they fell in.

In the spring of 1842 enough coke had been made to fill two boats 90 feet long—about 800 bushels each—and we took them to Cincinnati, down the Youghiogheny, Monongahela, and Ohio, but when we got there we could not sell. Mr. Campbell, who went with the boats, lay at the landing some two or three weeks, retailing out one boat-load and part of the other in small lots at about 8 cents a bushel. Miles Greenwood, a founderyman of that city, offered to take the balance if he would take a small patent flour-mill at $125 in pay, which Mr. Campbell did. He had it shipped here. We tried it, but it was no good, and we sold it to a man in the mountains for $30, and thus ended our coke business.

These gentlemen lost heavily in their venture. Mr. Greenwood sent part of his coke to Dayton, to Judge Gebhart, who was formerly a resident of Connellsville, and who owned a foundery at Dayton. He was so much pleased with the fuel that he visited Connellsville, and, as Mr. McCormick states—

Wanted us to continue to make coke, and he would take two boat-loads a year, delivered at Cincinnati, and pay the cash on delivery; also that he would insure us sale for all the coke we could make and deliver at Cincinnati at 8 cents per bushel; but we had gone into other business, and refused to do anything more with the coke.

This was the beginning of the coke business in the Connellsville region. (*a*) For some years but little coke was made, though a few ovens were built, and that knowledge acquired which was necessary for the coming development of the trade. In 1843 the ovens built by Taylor were leased to three gentlemen named Cochran, a name that from that time to the present has been connected with coke-making in this region. They made 13,000 bushels and floated it down to Cincinnati, where it was sold to Miles Greenwood, at 7 cents a bushel. Between this date and 1850 three or four ovens were built by Stewart Strickler, who sold his product to the Cochrans. In 1851 improved ovens were built, and the trade increased somewhat, but in 1855 it is stated there were but 26 coke ovens above Pittsburgh. It was not until the Baltimore and Ohio railroad was completed to Pittsburgh, and Connellsville coke had been used successfully in the Clinton furnace of Graff, Bennett & Co., at Pittsburgh, that its value as a furnace fuel was thoroughly demonstrated and the foundation laid for the demand that has resulted in such a development of coke manufacture in the Connellsville region. This furnace was blown in in the fall of 1859, to make pig-iron from coke. The coke was at first made from Pittsburgh coal near the furnace on the south side of the Monongahela river, nearly opposite the Point, at Pittsburgh. The furnace was run for about three months, when, the coke made in this way not proving satisfactory, it was blown out, and arrangements made to secure a supply from the Connellsville region. The furnace blew in again early in the spring of 1860, the coke used being from the Fayette coke works on the Baltimore and Ohio railroad, made at first on the ground in pits. The result was so satisfactory that 30 ovens were built in 1860 and arrangements were made to secure a continued supply. When it is remembered that this was only twenty years ago, the development of this industry, as shown in this report, is remarkable.

Though there have been many attempts to coke Indiana coals, some of which were at quite an early date, this industry has never prospered in this state. Before the building of railroads made it possible to procure coke from Pennsylvania at a reasonable cost Indiana founderies were compelled to depend for their supplies upon the coal of the state, and at a number of coal-banks coke was made in small quantities for melting iron. In the *Report of the Geological Survey of Indiana for* 1872 (page 364) is the following statement, which assigns the earliest date to the manufacture of coke in this state I have been able to find: "Coke Oven Hollow is named from the business conducted in it by William G. Coffin about thirty-five years ago. He had a foundery at Mount Etna, near by, and procured his pig-iron from Cincinnati, Hanging Rock, and Pittsburgh. It was transported by wagons from Cincinnati, and in order to have loading economically both ways he mined and coked coal in this hollow, which reaches Sugar Creek just below the Feeder Dam, and would make sale of it either in Indianapolis, Richmond, or Cincinnati."

If this statement is correct, it would appear that coke was made in Indiana as early as 1837, only two years after Firmstone's successful experiments in Huntingdon county, Pennsylvania, and four years before the first coke oven was built in the Connellsville region.

The *Geological Report* for 1870 (page 224) refers to the production of coke in Sullivan county as early as 1845, for the supply of the Terre Haute founderies. Some fragments of the coke were found in 1870 by Professor Collett "after an exposure to the elements of a quarter of a century as bright and lustrous as if fresh from the oven". Some time prior to 1873 further attempts were made to coke the Sullivan county coals, a bee-hive oven being erected by Mr. Charles R. Peddle, at the instance of Mr. Chauncey Rose, to test the adaptability of the coal to coke-making. Mr. Peddle writes regarding this attempt:

I built the oven and coked some of the coal, and, though it came out of the oven all right in appearance, there was evidently more or less sulphur or some other ingredient that hardened the iron and rendered the coke unfit for foundery purposes. The coke was lighter than Connellsville, weighing about 37 pounds to the bushel. The founderyman who tried it reported that it required 561 pounds of Connellsville coke to melt 3,000 pounds of iron and 609 pounds of the Shelburn coke to do the same work. The coke did not swell in burning, so that the bulk of the coke was about the same as of the coal charged.

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a In the *History of Fayette County*, elsewhere mentioned, a statement is made that some coke ovens were built between 1830 and 1836, at or near the mouth of Furnace run. While making the statement and indorsing the credibility of the informant, the *History* seems to imply that there may be a mistake of dates.

Some time about 1849, so Mr. W. B. Seward, of Bloomington, Indiana, writes me, his father built two coke ovens at Arney's coal-bank, in Owen county, Indiana, and one at Bloomington for the purpose of coking the Arney coal, for use in his foundery at Bloomington. These ovens he describes as being "very much like the old Dutch bake-oven", evidently "bee-hive ovens". For a number of years, and until the building of a railroad to Bloomington enabled him to procure it from Pennsylvania, all the coke used in Mr. Seward's foundery was made in these ovens. In speaking of the coke Mr. Seward writes:

> With proper care in managing the ovens a good article of coke was made, but it was not equal in quality to that made from what is known here as "Pittsburgh coal". The Arney coal runs together better than any other Indiana coal I have seen, but not enough to make large coke from fine coal. We always used the large lumps for coking. It was as free from sulphur as Pittsburgh coke, and, when properly made, melted iron about as well. We discontinued its use some twenty years since, when we got a railroad, as we had to transport the Arney coke 30 miles in wagons. I have examined all the specimens of Indiana coal I have been able to procure from time to time with a view to testing their coking qualities, but have not as yet found any that is superior to the Arney coal.

In 1868 Wilson, Ostrander & Co. began the manufacture of coke in mounds at Washington, Daviess county, and made some 25,000 or 30,000 bushels, but they were so far from market that it was difficult to dispose of it, and its manufacture was abandoned. In 1879 Cabel Wilson & Co., the successors of the before-mentioned firm, erected two ovens to make coke out of slack, but as no arrangements were made to wash the slack the enterprise was a failure.

Coke has also been made in other counties. Of the Fountain county attempt some account is given in another part of this report. Some years since coke was made in Parke county, near Clinton, by the Indiana Furnace Company, but with what success has not been learned. A number of attempts have also been made in Clay and other counties, but I have received no details of importance concerning them.

But little has been learned regarding the history of coke in other states, and that of a most fragmentary character. The location of the coal mines and the slight preparation and expense necessary in experimental coking in pits or "on the ground" are not conducive to the preservation of the records of early trials, and it is not until ovens are built that a permanent record is made. Even then in many cases the location of these ovens is such that information about them is only found in the books of the coke-maker or in his memory.

In Virginia coke was made many years ago at the mines in the neighborhood of Richmond, but it was not of a very good quality, and during the war of the rebellion coke was also made for use in the founderies of the state. In the northwestern part of the state some furnaces were run on coke between 1840 and 1850, but it is supposed the fuel came from Maryland.

In West Virginia the first ovens in the New River region were built in 1874. In this year the Quinnimont furnace was put in blast, using, with most gratifying success, the New River coke. The opening of the Chesapeake and Ohio railroad through this region in 1873 aided largely in its development, and made it possible to bring the coke and iron ores along its route together and furnish an outlet for the product. As is elsewhere stated, the development of this section since this date has been very rapid.

Coke to some extent was made in Alabama during the late war, being mainly used in the manufacture of cannon at the Selma (Alabama) foundery of the confederate government, and many openings were made along the veins in the immediate vicinity of the Cahaba river. On Pine Island branch, on what is known as the Gholson seam, coke was made in the open air, and was hauled over the hills to the railroad for shipment to Selma. Considerable quantities were also made at the opening in township 22 of sections 12 and 13, known as the "coke seam", and at various other places in the Cahaba coal-field. Some time in 1866 or 1867 the Glasgow Coal Company opened a mine on what is known as the Gould-seam and made some coke, but after a while the work was discontinued, partly on account of the small demand for the coal and coke. In the Coosa fields some coke was made in 1863 and 1864 by Captain Schultz for the confederate army, and was floated down the river.

Though no coke was made in Kentucky in the census year, (*a*) some years ago attempts were made to run a number of charcoal furnaces in this state on coke, in some instances using coke entirely, and in others part charcoal and part coke. The old Airdrie was thus run, and in volume one, new series, *Kentucky Geological Survey*, page 147, is an analysis of coke made at this furnace, which has been weathered sixteen years. This analysis shows 82.90 per cent. fixed carbon, 5.40 per cent. ash, 11.70 per cent. moisture and volatile matter. I am also informed that some ovens were erected in Carter county for testing the Coalton coal, but the percentage of sulphur was too high at the particular trial made, being 2.026 per cent.

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a I am informed while this report is going through the press that good coke is made at Earlington, Hopkins county, Kentucky, by the Saint Bernard Coal Company. Recent investigations show the existence of a coal in southeastern Kentucky remarkable for thickness, purity, and its high percentage of carbon, which has been named by Mr. John R. Proctor, the director of the Kentucky geological survey, to whom I am indebted for the information, the "Elk horncoking coal". These coals were coked by officers of the geological survey by building ricks on the ground, and were also sent to coke ovens at Cincinnati and in Connellsville, Pennsylvania. Analyses of these cokes by Dr. Peter gives the following results, selecting those highest and lowest in carbons:

	Per cent.	Per cent.
Moisture	0.06	2.86
Fixed carbon	94.34	88.44
Ash	5.60	8.70
Sulphur	0.788	0.844

The cokes are firm, bright, and, as will be seen, quite pure.

As to the early history of coke in the other states, the information in my possession is given in connection with the paragraphs on the coke industries of these states.

THE COKE INDUSTRY IN PENNSYLVANIA.

In any statement concerning the coke industry of this country Pennsylvania must occupy the first place. It was in this state, so far as the record remains, that coke was first manufactured, and it is here that the development of this industry has been the greatest, its production being largely in excess of that of any other state.

Coke was produced in western Pennsylvania commercially at least sixty years ago, but it has only been within the last decade that its manufacture has attained to a magnitude and an importance that entitle it to separate consideration. Its magnitude is shown in the statistical tables of this report, and its importance is evidenced by the fact that not only has it built up a large pig-iron industry in a section where there are no ores, but it is used in the smelting of much of the iron ore of the country from the Hudson to the Mississippi. Indeed, the commercial success attained in the smelting of these ores west of the Allegheny mountains with mineral fuel is due to this coke. In addition to the ores of iron, it smelts most of the ores of the precious metals of the Rocky Mountain region, its value for this purpose being so great that it is carried to points where the freight in many cases exceeds the cost of the coke at the oven 1,000 per cent.

There were produced in Pennsylvania in the census year 2,317,149 tons of coke, all west of the Allegheny mountains. This was valued at $4,190,136, or $1 80 per ton. In its manufacture 3,608,095 tons of coal, valued at $2,031,305, or 56.3 cents a ton, were consumed. This would make the yield 64.2 per cent. At the close of the census year there were 7,808 ovens built, of which 7,524 were bee-hive. In addition to this 1,469 were building June 1, 1880, all bee-hive; 2,444 persons were employed in its manufacture, to whom $983,431 wages were paid.

The following table, condensed from Table I, will show the chief statistical items concerning the manufacture of this coke:

Counties.	No. of establishments.	Capital.	OVENS.		Number of employés.	Wages paid.	COAL.		COKE.	
			Number built.	Number building.			Tons used.	Value.	Tons produced.	Value.
Total	104	$4,262,525	7,808	1,469	2,444	$983,431	3,608,095	$2,031,305	2,317,149	$4,193,136
Allegheny	17	325,150	476	20	171	59,485	166,700	119,718	95,685	235,915
Armstrong	2	30,000	20	66	10	4,000	13,400	6,700	7,000	13,000
Beaver	1	400	2	.....	1	280	1,012	253	506	936
Blair	4	110,000	190	.....	107	38,764	155,453	142,318	98,154	212,102
Butler	1	200	7	.....	3	500	750	100	400	1,200
Cambria	3	106,000	119	.....	45	19,870	85,000	78,500	51,950	110,894
Clarion	2	30,200	60	.....	15	7,200	16,200	4,050	10,800	13,500
Clearfield*	1	25,000	.....	60	.....	.....	.....	.....	.....	.....
Fayette	44	1,956,450	4,188	1,082	1,075	493,332	1,910,279	936,794	1,260,440	2,067,876
Jefferson*	1	10,000	.....	31	.....	.....	.....	.....	.....	.....
Lawrence	2	38,500	98	.....	22	3,004	7,500	3,750	3,941	20,651
Tioga	1	50,000	152	.....	73	25,321	53,777	67,221	33,572	100,716
Washington	1	2,000	8	.....	4	000	2,200	550	1,200	2,400
Westmoreland	24	1,578,625	2,488	210	918	331,075	1,195,824	671,351	753,501	1,410,946

*Building, and not in operation during any part of the census year.

The bituminous coal regions of western Pennsylvania were divided by Professor Rogers, in his report of the *First Geological Survey of Pennsylvania*, into six principal basins, numbered from the Allegheny mountains on the east to the Ohio river on the west. Five great anticlinal waves of remarkable persistence and regularity separate these basins, one of these, the anticlinal that bounds the Connellsville basin on the west, running from the Virginia state line to Elk county, a distance of 100 miles, in an absolutely straight line. (*a*) Some of these basins coincide with the physical division of the surface. The first basin, for example, lies between Laurel Hill and the Allegheny mountains, and the second between Chestnut Ridge and Laurel Hill. Other basins, however, are only geological, and have no strongly marked corresponding surface depressions. (*b*)

In all of these basins coke was made during the census year. The bulk of the product, however, was from the Allegheny Mountain and the Connellsville regions. Most of the coke was made from the coal of the great Pittsburgh seam, which is, on the whole, the most extensive and economically important coal-bed in the Appalachian basin. It is the main seam worked at Pittsburgh, on the Monongahela and Youghiogheny rivers, at Connellsville, Wheeling, and many other places, and is estimated to underlie, in the states of Pennsylvania, Ohio, and West Virginia, 14,000 square miles. In southwestern Pennsylvania Professor Lesley estimates that this bed, after all the erosion it has

a See Report H, *Second Geological Survey of Pennsylvania*, page 16.

b For a discussion of these basins, their extent and subdivision, more thorough than can be given here, the reader is referred to the different publications of the *Second Geological Survey of Pennsylvania*, particularly reports H and KK. It will of course be understood that in this report we are speaking only in general terms regarding these basins.

undergone, is found over an area of somewhat less than 3,000 square miles, so situated that every square yard of it can be reached. He also states that the present British coal trade could be supplied for twenty centuries from this single coal-bed, as developed in western Pennsylvania. (*a*) This bed does not everywhere show the same thickness as in western Pennsylvania, where it is generally about 8 feet, gradually increasing eastwardly to the Cumberland (Maryland) region, where it is 14 feet; nor does it always make as good a coke as that of the Connellsville region, where it is seen at its best.

This Connellsville region, or basin, the great coke-producing center of the country, is situated in the southwestern part of the state of Pennsylvania, in the counties of Westmoreland and Fayette, 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 near Latrobe, on the Pennsylvania railroad, in a southwesterly direction, to the Virginia state 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 through the remainder of Westmoreland county, and through Indiana and Clearfield counties, but the Connellsville region is regarded as extending no farther north than the vicinity of Latrobe. The coal in the northern part is inferior as a coking material to that in the southern part, though both physically and chemically the coal of this basin on the Conemaugh seems the same as that on the Youghiogheny. The latter, however, produces the typical Connellsville coke, compact, silvery, and lustrous, while the coke from the coal on the Conemaugh, or in any locality north from the Pennsylvania railroad, is tender, dull, and soon loses what little luster it has. Even in some portions of what is known as the Connellsville region proper the coal and coke is not of equal value. Coal at Coketon, in the northern part of the immediate Connellsville basin, just south of the Pennsylvania railroad, produced wretched coke when coked as it came from the mines, but when washed it produced a coke regarded as fully equal to the Connellsville. The coal at Latrobe and at Loyalhanna, in the same locality, must also be washed before coking to produce the best results.

As showing the character of the coal in this part of the Connellsville basin and the coke made from it I give the following analyses, which have been furnished by Mr. Benj. Crowther, of the Isabella Furnace Company:

ANALYSES OF COKETON (PENNSYLVANIA) COAL.

	Top of vein. Per cent.	Bottom of vein. Per cent.
Bituminous matter	25.52	18.18
Fixed carbon	70.91	60.57
Ash	3.34	20.08
Sulphur	0.23	1.17

ANALYSES OF COKETON (PENNSYLVANIA) COKE.

Constituents.	Unwashed.	WASHED.	
		No. 1.	No. 2.
	Per cent.	*Per cent.*	*Per cent.*
Moisture and volatile matter	1.26	.....	.....
Fixed carbon	86.58	89.15	83.93
Ash	10.67	9.65	14.80
Sulphur	1.49	1.20	1.27
Silica in ash	.....	4.67	6.12

Mr. Crowther states that No. 1 coke from washed coal is about the average result when the washer is working right.

A comparison of the above analyses with those of the Connellsville coal and coke from the neighborhood of Broad Ford will show the difference in the character of the coal and the similarity of the coke from the washed coal.

This variation in the Connellsville coal seems to have been discovered at an early day in the history of coke manufacture, for the coke-making area is confined to that portion of the trough which lies south from Sewickley creek, and the works are by no means important until one comes near to Jacob's creek. Thence southward to near Uniontown, in Fayette county, the eastern outcrop of the bed is lined with coke ovens. There appears to be prejudice in favor of the eastern outcrop; and although several manufacturers have told me that the coal on the western outcrop is somewhat inferior, facts do not seem to justify this prejudice. The extensive coke works near Dawson, on the Youghiogheny river, are upon the extreme western outcrop, but the coke made there is not inferior to any made along the eastern outcrop from Mount Pleasant to Lemont furnace. (*b*)

Regarding the Connellsville region proper as including all the ovens in the basin from Latrobe and vicinity south, there were built in this region at the close of the census year, May 31, 1880, 6,264 ovens, all of which were of the bee-hive pattern. There were also three pits or mounds. At the same time there were actually 1,242 ovens.

a *Atlas of Pennsylvania*, with description (Philadelphia, 1872), page 17.
b *Second Geological Survey*, Report KKK, by J. J. Stevenson, page 200.

in process of construction in this region, all bee-hive. Deducting from the totals for Fayette and Westmoreland counties, as given in the table on page 29, the totals for those establishments that cannot properly be regarded as in the Connellsville basin, we have the following statistics for the Connellsville region:

Counties.	No. of establishments.	Capital.	OVENS.		Number of employés.	Wages paid.	COAL.		COKE.	
			Number built.	Number building.			Tons used.	Value.	Tons produced.	Value.
Fayette	42	$1,939,450	4,109	1,082	1,030	$489,882	1,898,799	$926,454	1,253,743	$2,051,126
Westmoreland	19	1,295,500	2,158	160	826	284,573	984,499	606,872	639,457	1,149,772
Total	61	3,234,950	6,267	1,242	1,856	774,455	2,883,298	1,533,326	1,893,200	3,200,898

From this table it appears that about 62 per cent. of all the ovens in the United States at the close of the census year were in the Connellsville region, and that 69 per cent. of all the coke made that year was made in the same district. Of the extensions in progress June 1, 1880, judging by the number of ovens building, about 58 per cent. were in the Connellsville region. Since the census year its development has been remarkable, large tracts of land, in which the coal lies at a considerable depth below the surface, being now utilized, and the number of ovens has increased, until it is estimated that there are now 9,000. The accompanying map, showing the extent of the Connellsville region, the localities of the ovens, and their relation to Pittsburgh, is based on a map furnished by H. C. Frick & Co.

The coal-bed from which all the so-called Connellsville coke is made is the Pittsburgh bed of Professor Rogers' report of the *First Geological Survey of Pennsylvania of* 1842, and is described in the second volume of the final report of 1858. The continuation of the Pittsburgh area of this bed with the Connellsville area is broken off by the Youghiogheny river, the bed taking an upward course and descending again, the intermediate portion being swept away. This has led to a popular belief that the bed at Connellsville is different from that at Pittsburgh, but careful surveys have established their identity. It is a fact, however, that at Pittsburgh this bed is not in its best condition, while at Connellsville it is at its greatest thickness and is of the finest quality. It is also true that the coke made from the bed at Pittsburgh is not as good as that made at Connellsville. In the Connellsville basin the coal ranges from 8 to 11 feet in thickness, with one small slate parting, the "bearing-in slate", (*a*) 18 inches above the floor. The roof is only passable; the rooms can only be run 12 feet wide, and the pillars will average 10 feet, a large amount of which is lost in drawing. The floor is even and quiet, the coal is of a remarkably good and uniform character, and is soft and easily mined. On wagers, 23 wagons (57,684 pounds) have been dug and loaded inside of 10 hours by a man and a boy. The greater portion of this work is to shovel the coal into wagons, the digging or mining being the easiest part. Very little outside labor is required, and the average output per man per day is from 8 to 10 wagons, the cost of digging being about 25 cents per ton.

It is this ease of mining which, next to its chemical and physical characteristics, gives the Connellsville coal so much value as a material for coke, and has enabled the latter to compete in such distant markets with other cokes and fuels. Mr. Fulton has pointed out in a letter that this ease of mining is also a distinguishing peculiarity in the Connellsville basin. East or west from this narrow strip the cost of mining increases; westward the coal hardens, eastward the beds become thinner.

The coal is bituminous, with generally a dull, resinous luster, alternating with seams of bright, shining, crystalline coal, coated with a yellowish silt. It contains numerous particles of slate and some crystals of pyrites; is compact, with a tendency to break up into cubes; is a very tender coal, and is ill adapted for shipping. Such a coal from the mines of the H. C. Frick Coke Company, at Broad Ford, is taken by the Pennsylvania geological survey as the typical coal of the Connellsville basin. Its analysis, as determined by Mr. McCreath, chemist of the survey, is:

	Per cent.
Water	1.260
Volatile matter	30.107
Fixed carbon	59.616
Sulphur	0.784
Ash	8.233

Color of ash, reddish gray; coke, per cent., 68.633; sulphur left in coke, 0.512.

	Per cent.
Percentage of sulphur in coke	0.746
Percentage of ash in coke	11.995
Percentage of carbon in coke	87.25

The coke from this region is of silvery luster, cellular, with a metallic ring, tenacious, comparatively free from impurities, and is capable of bearing a heavy burden in the furnace. Its porosity and ability to "stand up" in the

a The present or *Second Geological Survey* is devoting a great deal of labor to this coal-field, and the reports that have been published contain much valuable information. I am greatly indebted to these reports, especially reports L and KK, for data.

furnace are what have given it such a reputation as a blast-furnace fuel, and have created such a demand for it for mixing with anthracite and bituminous coal in the east and west, especially where an open iron, such as is used in the Bessemer process, is needed. Mr. John Fulton has conducted a series of very elaborate and ingenious experiments on the physical properties of coke for furnace use, embracing the typical coking coals of Pennsylvania. Some of these results are given in a table in connection with the remarks on the Allegheny Mountain region, and will be referred to at further length in the chapter on "Coke as a Blast-furnace Fuel".

In coking the Connellsville coal, the bee-hive oven is in universal use in the Connellsville region, these ovens varying at the different works from 11 to 12 feet in diameter, and from 5 to 6 feet in height. (*a*) The working is very simple. The coal is dumped through an opening in the crown of the furnace and spread evenly on the floor to the average depth of 2 feet for 48-hour coke and 2½ feet for 72-hour. The front opening, through which the coke is discharged, is at first nearly closed with brick, luted with loam. The heat of the oven from the previous coking fires the charge, and as the coking progresses the air is more and more shut off by luting the openings and finally closing the roof openings. The average charge is 100 bushels (76 pounds each) of coal, and the yield in coke is from 63 per cent. to 65 per cent. The average time of coking is 48 hours, with 72 hours for that burned over Sunday; 24-hour coke is sometimes made. The 72-hour coke is a firmer coke than either of the others, but it is questionable whether it is a better furnace coke. When the coke is thoroughly burned, the door is removed, and the coke is cooled by water, thrown in from a hose, and then drawn.

We have given an analysis of what was regarded as the typical coal from this region from the mines of the H. C. Frick Coke Company at Broad Ford. The analysis also gave the results of coke in the laboratory. A sample of the coke from these mines made in the ovens of the firm, analyzed by Mr. McCreath, gave the following results. This coke is exceedingly coherent and compact, with a silvery luster, and contains some slate:

	Per cent.
Water	0.030
Volatile matter	0.460
Fixed carbon	89.576
Sulphur	0.821
Ash	9.113

Mr. Platt, of the Pennsylvania geological survey, in his report on coke, takes this as the typical coke, "as being thoroughly burned and as well made as can be produced in the Connellsville basin." Probably the most thorough analyses of the coke from this region were made by Mr. J. Blodgett Britton, of Philadelphia. It is the average of a large number of analyses of all sorts of Connellsville coke, and cannot, therefore, be regarded as a fair analyses of good coke:

	Per cent.
Moisture	0.490
Ash	11.332
Sulphur	0.693
Phosphoric acid	0.029
Carbon, by difference	87.456

Mr. E. C. Pechin gives a typical verified analysis of this coke as follows:

	Per cent.
Volatile matter	1.296
Carbon, hydrogen, and nitrogen	89.147
Ash	9.523
Water	0.032
Sulphur	0.084
Ash ignited:	
Silica	5.413
Alumina	3.262
Sesquioxide	0.479
Lime	0.243
Magnesia	0.007
Phosphoric acid	0.912
Potash and soda	traces.

In commenting on this analysis, Mr. Pechin, who has had considerable experience with Connellsville coke, says:

A large number of analyses of Connellsville coke have been made, showing less carbon and more sulphur. As regards carbon, I have had a number of analyses made at different times out of different lots, showing somewhat more carbon than the above.

It will be noted that Mr. Pechin's analysis corresponds very closely with that given above from the Pennsylvania geological survey, and from the best evidence I have been able to obtain I regard these two as fairly representing the average of good Connellsville coke. At the Edgar Thomson steel works, near Pittsburgh, a large amount of coke is used from the works of the H. C. Frick Coke Company, and frequent analyses for ash are made. The average of a large number of these analyses, covering the deliveries of 150,000 tons, extending from May 25 to November 18, 1882, gives 9.75 per cent. of ash, the range being from 9.11 to 10.91 per cent.; 9.75 may therefore be regarded as the average ash in good Connellsville coke.

a Drawings of these ovens are given in the chapter on "Bee-hive Ovens".

It is almost impossible to arrive at the average detailed cost of making coke in this region, as the mines and facilities for manufacture greatly differ.

When engaging in the manufacture of coke, no one should have less than 200 acres of coal to 100 ovens. Coal advantageously located cannot on the average be had for less than $400 per acre, and the ovens, with all the necessary plant, cannot be built for less than $40,000. Then we have:

200 acres of coal, at $400 per acre	$80,000
100 ovens complete	40,000
Total cost	120,000

At least 8 per cent. per annum interest should be expected on an investment of this character, which gives us:

Interest	$9,600
100 ovens use per annum fully 7 acres of coal, $400	2,800
Total cost	12,400

So it will be seen that at least $12,400 should be first made yearly out of an investment of this kind to pay interest and make up depleted capital. It is not possible to make on an average more than 39,000 tons of 2,000 pounds each of good coke yearly with 100 ovens, and by the above figures it will be seen that it will require about 32 cents per ton to cover interest and replace capital.

At the best arranged works in the Connellsville region, and at the present prices of labor, the cost of manufacturing a ton of 2,000 pounds of coke is about as follows:

Mining coal for 1 ton of coke	$0 38
Drawing coke	25
Loading, hauling, and incidentals	10
Repairs	10
Total	83

For the total we have:

Interest on capital, and allowance for coal used, per ton, say	$0 32
Cost of manufacture, per ton	83
Total, per ton	1 15

The above calculation is, if anything, too low, as the investment in ovens, etc., is lost when the coal is all gone, and the cost of manufacture will increase as the front coal is used up. This calculation is based on coal that will drain itself, as the cost will exceed this when drainage is added. Until recently most of the coal was brought out through entries, but now a number of shafts are employed, the great increase of ovens necessitating the mining of coal at points where the coal-measures are from 300 to 500 feet below the surface.

A statement furnished by Mr. John Fulton as to the cost of a plant of 400 ovens erected by the Cambria Iron Company at Morrell, Pennsylvania, and also as to the cost of producing coke, differs considerably from that given above. The cost of the plant at Morrell was as follows:

Water-works	$29,113 80
Houses	30,598 48
Slope	50,000 00
400 ovens	118,673 46
Total	228,385 74

This would make the cost of a hundred ovens $57,096 43½. Taking the cost of workmen's houses, $30,598 48, from the above, the cost of the 400 ovens, not including such houses, would be $197,787 26, and of 100 ovens $49,446 81½, or very nearly $50,000. This Mr. Fulton regards as the cost of 100 ovens where the coal is worked by slope or shaft, the estimate being based on a slope 2,000 feet long or a shaft 300 feet deep. Of course when a simple adit is run the expense would be less, but adits are exceptional. This is 25 per cent. less than the estimate above given, but is based on the actual cost of a bank of 400 ovens recently built.

The actual cost of making coke at the works of the Cambria Iron Company, at Morrell and Wheeler, near Connellsville, is given on page 34, the mining of coal being based on 25 cents per ton for mining the room coal and 32 cents per ton (2,000 pounds) for heading coal.

MINING COAL.

Mining coal, per ton (2,000 pounds)	$0 27.6
Hauling	07.3
Hoisting and dumping	03.8
Superintendent, foreman, and clerk	01.6
Lumber, ties, and props	02.9
Repairs and supplies	06.8
Cost of coal per ton, delivered at ovens	50.0

COKING.

1.6 tons of coal, at 50 cents	$0 80.0
Labor (drawing, loading, charging, superintendent, and clerk)	41.2
Supplies	02.6
Repairs	05.2
Cost of coke per ton	1 29.0

It is estimated that at these works 20 cents per ton on all coke made should be added to this to pay for real estate and interest on improvements. This would make:

Cost of improvements and allowance for coal used per ton of coke	$0 20
Cost of manufacturing coke per ton	1 29
Total	1 49

It will be noted that this estimate of the cost of manufacturing coke is considerably in excess of that first given. These two estimates, from two reliable manufacturers, are given for the purpose of showing how difficult it is to arrive at exact figures.

The result of a careful survey lately made puts the amount of coal yet remaining in this region at 72,000 acres. As each acre furnishes 5,500 tons of coke, this would furnish, say, 400,000,000 tons, which will supply the present output, say, 200 years. This only applies to the Pittsburgh bed. Other seams in this same field not now worked will no doubt, when needed, furnish a supply of coking coal.

Before speaking of the Allegheny Mountain region, the next most important coking district in western Pennsylvania, it may be well to refer to those coke works in Fayette and Westmoreland counties not properly belonging to the Connellsville region. In these counties are two coal-basins, or, more properly, sub-basins or troughs, in addition to the Connellsville, one the Greensburgh, of small extent and lying only in Westmoreland county, the other the Lisbon or Irwin, which is much larger than the Connellsville, extending from near the northern boundary of Westmoreland county in a southwesterly direction, through Fayette and Greene counties, into West Virginia. In both of these troughs the Pittsburgh bed remains, from which considerable coke was made in the census year, mainly from slack.

Following the line of the Pennsylvania railroad, the first of these troughs (the Greensburgh) lies west of the northern extremity of the Connellsville basin, and some five or six miles from Latrobe. It is of but little importance as a coking-field, only 4,154 tons of coke from unwashed slack being made in its limits in the census year.

The second of these troughs, still following the line of the Pennsylvania railroad westward, the Irwin, is less than 10 miles distant from the Greensburgh, and includes the mines of the Penn Gas Coal Company and the Westmoreland Coal Company, so well known for the production of coal of excellent gas-making qualities. The coal from the Pittsburgh bed in this portion of the Irwin trough makes an excellent coke, and contains, except in very rare cases, but little sulphur and a very low percentage of ash. The coal, however, is much harder than the Connellsville, and will bear shipping, which the Connellsville, as a rule, will not, being too friable. The coal of this trough also contains a large proportion of volatile combustible matter, and consequently the percentage of coke per ton of coal is much less than in the Connellsville region. For these two reasons, and to utilize what would otherwise be not only a waste product but one very inconvenient to dispose of, but little lump coal is used in coking, most of the coke being made from slack, 9,200 tons only out of 215,045 tons used being lump coal or "run of the mine".

The largest works in this trough is that of Carnegie Brothers & Co., limited, who have a large number of ovens, with necessary washers, near Larimer station, on the Pennsylvania railroad, washed slack chiefly from the mines of the Westmoreland Coal Company and the Penn Gas Coal Company being used. This coke is of good quality, in some respects equal to the Connellsville and lower in ash, and has been used in Pittsburgh furnaces with good results. An average of three analyses of the Penn Gas Company's coal, made by Mr. A. S. McCreath, chemist of the Pennsylvania geological survey, is as follows:

	Per cent.
Water	1.427
Volatile matter	37.980
Fixed carbon	54.598
Sulphur	0.638
Ash	5.357

From Messrs. Carnegie Brothers & Co., limited, we have the following analyses of the slack, both washed and unwashed, and the coke made from the same. It will be noted, on comparing the analysis of the unwashed slack

with that of the coal above given, that the amount of sulphur and ash are both very much higher in the unwashed slack than in the coal, while the volatile matter is somewhat lower. By washing, the slack is made to very nearly equal in purity and contents the unwashed coal:

Constitutents.	SLACK.		Coke.
	Unwashed coal.	Washed coal.	
	Per cent.	*Per cent.*	*Per cent.*
Fixed carbon	56.57	54.88	88.240
Volatile matter	31.68	38.13	1.384
Ash	11.08	6.98	9.414
Sulphur	1.26	0.96	0.962

Southwesterly from the Pennsylvania railroad, on the Youghiogheny and Monongahela rivers, several banks of ovens have been erected to utilize the slack from various mines. This slack, however, contains, when unwashed, fragments of slate, which interfere with the reputation and the use of coke made from it. At Cat's run, on the Monongahela, near the Virginia state line, where ovens and washers have been erected, an analysis of the coal is as follows:

Water	1.040
Volatile matter	32.815
Fixed carbon	60.214
Sulphur	1.249
Ash	4.655

The slates of this coal are somewhat thicker than in the Connellsville basin, and the coke is not apt to find a ready market, owing to the injury caused by projecting bits of slack.

We give below a statement showing the manufacture of coke in these two counties outside of the Connellsville region:

Troughs.	No. of establishments.	Capital.	OVENS.		Number of employés.	Wages paid.	COAL.		COKE.	
			Number built.	Number building.			Tons used.	Value.	Tons produced.	Value.
Greensburgh	1	$3,125	10	.....	4	$1,653	7,750	$3,410	4,154	$6,231
Irwin	6	297,000	399	50	133	48,299	215,055	71,409	116,590	271,693
Total	7	300,125	409	50	137	49,952	222,805	74,819	120,744	277,924

The most important coking district in western Pennsylvania, next to the Connellsville, is the Allegheny Mountain, which district includes that part of Blair and Cambria counties that lie in the first bituminous basin along the sides and near the summit of the Allegheny mountains. This basin extends both north and south of these counties, but the coke made from its coal in the census year was all made in the counties named.

The coal in the different sub-basins of this district differs widely in its coking qualities. In the eastern portion of the region, on the eastern slope of the mountains, near the summit, it cokes readily in the bee-hive oven, forming a hard, silvery coke, but little, if any, inferior to the Connellsville; but west of the summit, on the slope, bee-hive ovens are also used, and the coke, which is from a different bed of coal, is not as good as that at Bennington and other localities in Blair county. Still west of this a few miles, at East Conemaugh, pits were used and a good coke made, while a short distance farther west the coal is so dry-burning that the Belgian oven is employed. This distance, say, from Altoona to Johnstown, less than 40 miles, thus becomes one of the most interesting coking districts in the country. The coal varies from a true coking coal, making in the bee-hive oven an admirable blast-furnace coke, to a dry-burning coal that cannot be coked to advantage in the bee-hive oven, requiring the heat of the Belgian to coke it properly. In this same district could be studied in the census year the three typical methods of coking: in pits, in bee-hive ovens, and in Belgian ovens. The experiments made for the Cambria Iron Company by Mr. John Fulton, their mining engineer, in the use of different coals and methods of coking, as well as those relating to the value of cokes, have been the most careful and thorough of any made in this country. They have already been of great value, and must be of increasing importance.

The coal most extensively used for coke, as well as that making the best coke in the district, is bed "B" of the geological survey. An analysis of this coal as it is mined at Bennington, in Blair county, where it is called the Miller seam, and the coke from it, is as follows: (*a*)

	Coal. Per cent.	Coke. Per cent.
Water	1.400	.....
Volatile matter	27.225	.....
Fixed carbon	61.843	87.58
Ash	6.930	11.36
Sulphur	2.602	1.06

a From *Report Second Pennsylvania Geological Survey*, HH, page 16.

This coal is semi-bituminous, and has a shining luster, contains considerable pyrites, and in the vicinity of Bennington the bed is about 3½ feet thick. All of the coke made in Blair county (bee-hive ovens being used) is from this seam, and closely resembles the Connellsville, is sonorous, cellular, and tenacious, reasonably pure, and has great calorific vigor.

On the western side of the summit of the Alleghenies, at Lilly's station, in Cambria county, coal from bed E, commonly known as the Upper Freeport bed, is coked. An average analysis of this coal at this point is as follows: (*a*)

	Per cent.
Water	0.715
Volatile matter	22.250
Fixed carbon	70.518
Sulphur	1.459
Ash	5.058

This coal has a bright, shining luster, is rather friable, and contains numerous thin partings of mineral charcoal and pyrites. Coke was made from this coal in open ricks until December, 1879, when some bee-hive ovens were put in operation.

The Lilly's Station mine is in the Wilmot sub-basin of the first bituminous basin. A short distance west an anticlinal rises, which separates this sub-basin from the Johnstown sub-basin, where bed E is again used at the East Conemaugh ovens. This coal is reasonably pure, is low in ash but high in sulphur, and makes a dense coke. It is also low in volatile matter.

Though this coal was coked in open ricks during the census year, Belgian ovens are now (1882) being erected to use it.

At Johnstown, bed E, or the Upper Freeport, the same bed as is coked at Lilly's station and East Conemaugh, is coked in Belgian ovens. An analysis of this coal by T. T. Morrell, chemist, is as follows:

	Per cent.
Moisture	0.160
Volatile matter	18.630
Fixed carbon	74.950
Ash	4.860
Sulphur	1.400
Phosphorus	0.011

Mr. John Fulton has prepared for this report the following statement as to the coals and cokes of this region: The Allegheny section affords three types of coking coals: Connellsville, Allegheny-Bennington, and Portage.

Connellsville and Bennington types are coked in bee-hive ovens, and make excellent coke.

The dry coals approaching Johnstown basin would require to be coked in Belgian ovens, as they do not inherit sufficient pitchy matter to fuse in the slow heat of a bee-hive oven.

The following table exhibits the typical coals of the Allegheny region for coking:

Constituents.	Connellsville (Pittsburgh coal).	Bennington (Miller, bed B).	Portage (Upper Freeport, bed E).
	Per cent.	*Per cent.*	*Per cent.*
Moisture	1.260	1.400	.....
Volatile matter	30.107	27.225	22.24
Fixed carbon	59.616	61.843	68.94
Ash	8.233	6.930	8.82
Sulphur	0.784	2.602	.....

These three types of coking coals embrace the main supply of the eastern section of the Allegheny region.

The Connellsville (Pittsburgh bed) is 8 feet thick, with soft, easily-mined coal; Bennington (Miller bed B) 3 feet thick, affording also a soft coal, and the Lemon bed, or Upper Freeport (bed E), 4 feet thick, gives a very desirable coal for coking.

The detached Broad Top coal-field in Huntingdon and Bedford counties affords coking coal which produces a hard, bright, cellular coke, second only to Connellsville. The Kemble Coal and Iron Company coke for two blast-furnaces at Riddlesburg from the Kelly or "E" bed in bee-hive ovens. Robert Hare Powell, esq., is coking the "A" or Fulton bed in Belgian ovens.

The East Broad Top Railroad and Coal and Iron Company coke a dry coal in Belgian ovens with indifferent success.

The three types submitted, which embrace Broad Top and Clearfield coals, can be coked to good advantage, and the cokes take a first rank for metallurgical uses. Outside of these there are two extremes that will require special treatment to produce a moderate quality of coke: the very dry coals of the east, holding from 16 to 18 per cent. of hydrogenous matter, and the very fat coals of the west, holding from 30 to 50 per cent. of volatile matter. The first requires to be charged into a hot oven to fix its small percentage of fusing matter; the latter requires to be coked slowly under pressure to repress an excessive cell development.

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a Report of the Pennsylvania Geological Survey, HH, page 33 (McCreath).

The following table exhibits the physical character of the cokes of the Allegheny border, taking the Connellsville as a standard:

Localities.	GRAMS IN ONE CUBIC INCH.		POUNDS IN ONE CUBIC FOOT.		PERCENTAGE.		Compressive strength per cubic inch (4) ultimate strength.	Height of furnace charge supported without crushing.	Order in cellular space.	Hardness.	Specific gravity.	CHEMICAL ANALYSIS.						Remarks.
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Fixed carbon.	Moisture.	Ash.	Sulphur.	Phosphorus.	Volatile matter.	
												Pr. ct.	*Pr. ct.*	*Pr. ct.*	*P. ct.*	*Pr. ct.*	*Pr. ct.*	
Standard coke, Connellsville.	12.46	20.25	47.47	77.15	61.53	38.47	284	114	1	3.5	1.500	87.46	0.490	11.32	0.69	0.029	0.011	
No. 1 big vein, Salisbury.	12.98	23.33	49.52	89.01	56.07	44.93	162	65	1	3.25	1.501	89.31	0.420	9.45	0.82	0.019	.....	Almost equal to Connellsville.
No. 2, over big vein.	12.73	22.94	48.50	87.39	55.49	44.51	171	69	1	3.00	1.645	84.42	0.030	12.02	1.63	0.100	.....	Little high in sulphur and phosphorus.
No. 3, under big vein.	12.05	22.78	45.92	86.05	52.49	47.51	127	51	1	3.00	1.644	86.27	0.010	11.68	2.02	0.020	.....	Little high in sulphur.
No. 4, under big vein.	13.71	22.35	85.15	85.15	60.88	39.12	167	67	1	2.75	1.546	91.59	0.150	7.08	1.16	0.020	.....	Very good coke.
Blair Coal and Iron Co., Bennington.	13.19	20.80	50.25	79.25	63.41	36.59	.....	.....	1	3.30	.....	87.58	.....	11.36	1.06	.....	.....	
Kemble Coal and Iron Co., Broad Top.	11.76	20.18	44.81	76.88	58.27	41.73	240	96	1	3.20	.....	89.28	.....	9.66	1.06	.....	.....	Washed coal.
Clearfield Coal Co., Clearfield.	14.79	19.80	56.35	76.09	74.43	25.57	319	128	1	3.60	1.560	89.87	0.005	9.41	.....	.....	0.667	T. T. Morrell, chemist.
Munson coke, Clearfield.	14.09	19.37	53.71	72.30	72.23	27.77	180	70	1½	3.00	1.186	84.30	0.520	13.74	1.41	0.022	.....	Do.
Hon. Hy. Rawle, Butler county.	13.35	21.11	50.66	80.46	58.68	41.32	266	107	1	3.30	1.300	92.04	.....	7.18	0.78	.....	.....	Do.

From the above table it will be seen that the Allegheny coal region affords a wide area for coke-making, and it is remarkable that, so far as disclosed in the practice hitherto, economy of production and good quality of coke are closely allied. It also affords a wide field for the application of ovens adapted to the peculiar wants of each family of coking coals.

It may be urged that the Connellsville and Allegheny Mountain belts may become exhausted. To this it may be shown that the law of similarity of composition of coals in each basin would afford a large additional supply of coking coal. The lower productive coal-measures in the Connellsville basin must produce at least twice as much coking coal as the great upper bed, and the belt of coals between the Johnstown sub-basin and the Connellsville basin should also afford a very extensive supply of coking coals. It would appear, therefore, that the present demands the utilization of the best coking coals with the utmost economy in the production of coke.

Though no coke was made in Somerset county in the census year, I am informed that there are 30 bee-hive ovens at Ursina, built about 1868 or 1870, but as the coal failed to make a marketable coke these ovens were abandoned, and have not been in operation for some years. The company has recently been reorganized, and the ovens will be repaired and put in operation. Coking is also now being done at other places in this county.

The Appalachian coal-field, at its northern extremity, breaks into a number of small detached coal-basins. From the coal of one of these, the Blossburg, in Tioga county, 33,572 tons of coke were made in the census year, all from washed slack, 53,777 tons being consumed. Slack both from the Bloss bed (Upper Kittanning) and the Seymour bed, which lies some 150 feet above, is used, but the Seymour-bed slack furnishes much the larger proportion. This bed is from 3 to 3½ feet thick. The coal is semi-bituminous, bright and shining, and is very tender, carrying numerous thin partings of iron pyrites and a large amount of mineral charcoal. An average specimen of the coal from this bed, as analyzed by A. S. McCreath, gave the following result:

	Per cent.
Water	1.180
Volatile matter	21.586
Fixed carbon	71.574
Sulphur	0.907
Ash	4.753

I have no analysis of the slack, washed or unwashed, but an analysis of the washed coke is given in report MM of the *Pennsylvania Geological Survey*, page 110, as follows:

	Per cent.
Water	0.175
Volatile matter	0.722
Fixed carbon	84.760
Sulphur	0.998
Ash	13.345

The screenings are thoroughly washed and coked in bee-hive ovens, the yield being about 62 per cent. of the washed slack. The ovens are burned from 48 to 72 hours, and the coke is watered in the oven. When properly burned, it is an open, porous, cellular, ringing, and strongly coherent coke, and its physical structure is very good. From its location the manufacture of coke at this point is commercially of considerable importance, a large portion of New York state being supplied with this fuel. Two ovens were erected at McIntyre, in Lycoming county, during the census year, and experiments looking to the utilization of this so-called McIntyre coal were made.

But little coke is made from the coal of the Pittsburgh bed at or near Pittsburgh. There are two reasons for this. In the first place the coal does not make as good a coke for smelting iron as that from the same bed at Connellsville, which is only some 60 miles distant. While the coke is as pure, indeed somewhat purer, the coal contains so much volatile matter that the coke is generally too porous for blast-furnace purposes when the lump or run of the mine is used. In addition to this, the coal at Pittsburgh is more valuable for other purposes than for coke, and by using an oven adapted to coking this coal, good coke could be made, but under present circumstances it would not pay.

Notwithstanding these facts, Allegheny county ranked fourth in order of production among the counties of Pennsylvania in the census year. It also made more coke than any of the states except Pennsylvania, Ohio, and West Virginia, its production being only 35 tons less than that of the latter state. There were produced in this county 95,685 tons of coke from 166,700 tons of coal, all but 10,618 tons of which were slack. Most of the slack was washed. It will be noted that while the larger number of ovens were bee-hive, 140 were Belgian, nearly half of those in the United States. Considerable success has been reached in coking Pittsburgh slack in this oven, and it is a curious fact that in western Pennsylvania, where the bee-hive oven is used so extensively, and, indeed, where it is the best oven for most of the coal now coked, the Belgian oven has also been used the most successfully, these Pittsburgh ovens and those at Johnstown showing the best results of any flue ovens in this country. It is also worthy of note that the coke is watered inside the Belgian ovens at Pittsburgh. Probably this practice obtains nowhere else.

A noticeable feature of the manufacture of coke in Pittsburgh and vicinity is that it is chiefly to utilize what would otherwise be a waste product. Slack is used in other sections, but nowhere to the extent that it is used at Pittsburgh. In what is sometimes called the Pittsburgh district, which includes Allegheny county and those portions of Fayette and Westmoreland counties outside of the Connellsville region, in which 216,429 tons of coke were made in the census year from 389,505 tons of coal used, only about 25,000 tons, or 6 per cent. of the whole amount, was lump coal or run of the mine, and more than half of this was used, as has already been explained, in bee-hive ovens for the purpose of manufacturing gas, the coke being a by-product, so that of the entire amount of coal used in this Pittsburgh district directly for the manufacture of coke about 2½ per cent. only was lump coal.

The following table gives the chief statistical items concerning the make of coke in Allegheny county in the census year:

County.	No. of establishments.	Capital.	OVENS.		Number of employés.	Wages paid.	COAL.		COKE.	
			Number built.	Number building.			Tons used.	Value.	Tons produced.	Value.
Allegheny	17	$325,150	470	20	171	$59,485	166,700	$119,718	95,685	$235,915

Outside of the districts already mentioned the manufacture of coke in the state of Pennsylvania was of comparatively small importance, although the total make of these counties is much greater than the entire make of a number of the states. The coke, however, is either produced for the purpose of utilizing screenings, which would otherwise be wasted, or to supply some local blast-furnace with fuel.

In the Allegheny River region, which may be regarded as including the ovens in the valleys of the Allegheny and Redbank rivers above Pittsburgh, coke was made in Armstrong, Butler, and Clarion counties in the census year. But 7,000 tons were made in Armstrong county, all in pits or mounds. This coke was made from Upper Freeport coal, Mr. McCreath's analysis of a fair average specimen being as follows:

	Per cent.
Water	1.700
Volatile matter	35.520
Fixed carbon	55.545
Sulphur	0.835
Ash	6.630
Yield of coal in coke	63.0100
Phosphorus in coal	0.0684
Phosphorus in coke	0.1085

The coking is badly done in open-air ricks, requiring from 8 to 10 days in the operation, according to the state of the weather. The coke is very tender, and is an inferior fuel; crushing and washing the coal before coking would improve it. It is used in a local blast-furnace. Another works was in course of construction. (*a*)

a At this works, which is now (1882) in operation, the coal is washed, and a very good blast-furnace fuel is made.

In Butler county coke (400 tons) was made at one small works for the purpose of utilizing slack from the mine.

In Clarion county there are two coke works, but one of which was in operation in the census year. The idle works, when in operation, supply coke to a blast-furnace which was idle during the entire year. The coke made is from the Upper Freeport coal, the bed ranging from 2 feet 6 inches to 4 feet 3 inches, the coke showing the following analysis:

Water	0.230
Volatile matter	1.106
Fixed carbon	88.360
Sulphur	1.076
Ash	9.228

At the works which were in operation in this county coke was only made for the utilization of slack, the coal in this case being the Lower Freeport, and the yield in coke being 67 per cent. The coal is from 5½ to 6½ feet thick. The slack is mixed with considerable slate and fire-clay, necessitating careful washing, which is done by a Stutz washer. The following analyses show the effect of washing on the coal and coke:

	Unwashed slack. Per cent.	Washed slack. Per cent.
Water	1.260	1.300
Volatile matter	35.130	35.825
Fixed carbon	51.397	54.223
Sulphur	1.988	1.312
Ash	10.225	7.340

COKE FROM WASHED SLACK.

Water	0.033
Volatile matter	0.623
Fixed carbon	85.777
Sulphur	2.107
Ash	11.463

The cost of washing is about 12 cents a ton, but on a large scale it would be somewhat less. The coke is bright, silvery, of rather an open structure, with small masses of slate included.

In Washington county 1,200 tons of coke were made in the census year; but like most of the other coke made on the Pan-Handle railroad near Pittsburgh, it was only made to utilize a portion of the slack at the mine, as at times it is more profitable to sell the slack.

In Beaver county there was one small works, making altogether but 506 tons of coke from slack produced at a small mine. The coal used is from the Kittanning bed. This bed is in two benches, the upper a hard, dull, open-burning coal, with some pyrites, and the lower a bright, oily, soft coking coal. Much of the lower part comes out as slack and nut coal, and is coked. The coke is firm and porous, has a bright silvery luster, and is used in the steel cutlery and other works at Beaver Falls. The analysis of this coal and coke is as follows:

	Coal. Per cent.	Coke. Per cent.
Water	2.400	0.010
Volatile matter	38.110	0.633
Fixed carbon	54.619	84.727
Sulphur	0.791	1.994
Ash	4.080	12.636

It is evident that the coal is a picked specimen, and that the slack from which the coke was made contained a larger proportion of slate than coal.

In Lawrence county 3,941 tons of coke were made in the census year, washed slack from the mines in the vicinity of New Castle being used. These works had been idle for some years, but owing to the increased demand for coke that sprung up in the census year the works were repaired and run. There are also some coke-ovens connected with the Wampum furnace, but these were idle the entire year. When running, they make coke from the Darlington or Upper Kittanning coal. The coke is mixed with Connellsville and is used in the furnace.

THE COKE INDUSTRY IN WEST VIRGINIA.

Coke to the amount of 95,720 tons was made in four counties of West Virginia in the census year. The following table, condensed from Table I of this report, gives the chief statistical items concerning its manufacture:

Counties.	No. of establishments.	Capital.	Ovens.		Number of employés.	Wages paid.	Coal.		Coke.	
			Number built.	Number building.			Tons used.	Value.	Tons produced.	Value.
Fayette	6	$289,000	238	134	99	$27,612	88,769	$84,444	57,943	$127,588
Marion	1	14,000	36	.....	5	2,000	4,200	2,100	2,800	4,000
Ohio	1	3,000	3	1	2	480	2,180	2,000	1,200	3,000
Preston	4	74,000	130	16	57	18,850	53,331	47,400	33,777	82,000
Total	12	330,000	407	151	163	48,942	148,480	135,944	95,720	216,588

In order of production West Virginia ranked third among the states, producing 3.48 per cent. of the entire make. In yield of coal in coke the returns contained in the table on page 11 show that Indiana coal surpassed that of West Virginia; and, disregarding the Indiana manufacture as little more than experimental, West Virginia, in this respect, stands first, closely followed by Pennsylvania. Indeed, the yield in coke of the coal of these two states may be regarded as the same.

The most important, as well as the best known, of the coking coal-fields of this state is the New River field, which lies principally in Fayette and Raleigh counties, extending along the course of the New river (*a*) and its tributaries about 40 miles. Reports of recent investigations include the Flat Top coal-field in the New River district, which would extend this district to Mercer county, and make its total length 80 miles. The relations of these fields to the New river and the Chesapeake and Ohio railway and the Norfolk and Western railroad will be seen by an inspection of the accompanying map, prepared specially for this report, by Major Jed. Hotchkiss.

Along the sides of the escarpment of these mountains, fronting on the cañon of New river and its many tributaries, the outcroppings of several veins of bituminous and semi-bituminous coal are exposed, varying in thickness from a few inches to over seven feet, (*b*) five of them being workable, containing 3 feet of coal and upward. The coking property of these coals, in view of their relations to extensive deposits of iron ore, makes them very valuable, the coke made from them being an admirable blast-furnace fuel, second to none in the country. It "stands up" well in the furnace, has a high percentage of carbon and low percentage of ash, sulphur, and phosphorus, and in the practical test of furnace work has shown results that have not been surpassed by any other coke in the country. At the Longdale furnace, with 72-hour coke and an ore with 50 per cent. metallic iron, 5 per cent. silica, and of an aluminous nature, a ton of pig-iron has been made with a ton of coke, and this not for a day at a time, but for some weeks in succession. The average consumption for the entire blast would be in excess of this. As a result of this excellent character, coke is rapidly coming into use in the iron furnaces of Virginia and the Ohio valley, and the number of ovens has largely increased since the census year. (*c*)

The bee-hive oven was the only form of oven used in this region in the census year, but ovens on the Coppée system are being constructed in Virginia to coke the New River coal. The charge of coal to each oven is three tons; the time of coking is 48 hours, except on Fridays and Saturdays, when the charge is increased and the coking continued for 72 hours. The coal yields about 64 per cent. of coke. This is to be understood as the average, not the uniform yield. The yield at Sewell in 1879 was 65⅝ per cent.; at Quinnimont, for five months, 66.7 per cent. The chief points in New River region at which coke was manufactured during the census year, following the line of the Chesapeake and Ohio railway, are Quinnimont, Fire Creek, Sewell (Longdale Iron Company), Nuttallburg, and Hawk's Nest. Below we give analyses of the coals of this region, and the furnace cokes made from them:

Constituents.	QUINNIMONT COAL.			FIRE CREEK COAL.		Longdale coal.§	NUTTALLBURG COAL.		Hawk's Nest coal.‖	Anstead coal.
	No. 1.*	No. 2, lump coal.†	No. 3, slack.†	No. 1.‡	No. 2.		No. 1.§	No. 2.†		
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Fixed carbon	75.89	79.26	79.40	75.02	75.499	72.32	69.00	70.67	75.37	63.10
Volatile matter	18.19	18.65	17.57	22.34	22.425	21.38	29.59	25.35	21.83	32.61
Ash	4.68	1.11	1.92	1.47	0.805	5.27	1.07	2.10	1.87	2.15
Sulphur	0.30	0.23	0.28	0.56	0.536	0.27	0.78	0.57	0.26	0.74
Water	0.94	0.76	0.83	0.61	0.735	1.03	0.34	1.35	0.93	1.40
Phosphorus								0.08		
Total	100.00	100.01	100.00	100.00	100.000	100.27	100.78	100.12	100.26	100.00

*Analyst: J. B. Britton. †Analyst: Professor Egleston. ‡Analyst: Dr. Ricketts. §Analyst: C. E. Dwight. ‖Analyst: J. W. Mallet.

As the Flat Top coal is now (1882) included in the New River region, and is rapidly assuming importance as a coking coal, we give the following analysis by A. S. McCreath:

	Per cent.
Water	0.932
Volatile matter	20.738
Fixed carbon	73.728
Sulphur	0.618
Ash	3.984
Laboratory coke	78.3300
Phosphorus	0.0013

a The upper part of the Kanawha is called the New river.

b Four feet is the generally-stated maximum thickness of any of these seams, but a letter from Major Hotchkiss puts it at 12 feet. This probably refers to the Flat Top region, and not to that section where coke was produced in the census year. In Professor McCreath's section of this coal at Pocahontas, published in *Mineral Wealth of Virginia*, 4 feet 8 inches of the 11 feet 8 inches is described as "coal with irregular thin slate streaks". With such a coal, if it is included, an analysis showing but 3.984 per cent. of ash is remarkable.

c Mr. Jed. Hotchkiss, in the October (1882) number of his journal, *The Virginias*, published at Staunton, Virginia, gives the number of coke ovens in operation on the line of the Chesapeake and Ohio railway as 731, very nearly double the entire number of ovens in the state in 1879–'80, and more than three times the number in the New River region at that date.

The following are analyses of industrial coke made from New River coals:

Constituents.	QUINNIMONT.		FIRE CREEK.		Longdale.‡	Nuttallburg.‡
	No. 1.*	No. 2.†	No. 1.*	No. 2.		
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Volatile matter	.....	.....	.....	0.492	.....	.....
Carbon	93.85	93.11	92.180	91.940	93.00	92.22
Ash	5.85	5.94	6.080	6.928	6.73	7.53
Sulphur	0.30	0.82	0.618	0.538	0.27	0.92
Moisture	.....	.....	0.110	0.102	.....	.....
Total	100.00	99.87	99.588	100.00	100.00	100.67

* Analyst: J. B. Britton. † Analyst: Professor Egleston. ‡ Analyst: C. E. Dwight.

The relation between the ash in the coals and cokes of which analyses are given will not fail to be noted. In but two of these analyses (Quinnimont No. 1. and Longdale) is the per cent. of ash in the coal and coke near what it should be theoretically. In all of the others the ash in the coke is much in excess of that which should be found in cokes made from coals of which the analyses are given. The ash in these cokes, however, is very low, but the cokes could not have been made from coal containing no more ash than the analyses show.

There are now (December, 1882) 200 coke ovens in the Flat Top region in process of construction. The coal-beds are reached at railway level, so that no inclines are needed. Of the large vein opened at Pocahontas Major Hotchkiss writes:

> I have been into it over half a mile, and have had it fully proved for miles to the northeast, along the Bluestone slope of Flat Top. The New River coal-beds begin to thicken as soon as you cross New river from the Chesapeake and Ohio railway, and, from what we now know, attain their greatest thickness in the Flat Top region. No coal was coked from this particular bed during the census year.

The only other county in which coke was made to any considerable amount in the census year was Preston, all in bee-hive ovens, and most, if not all of it, for use in the local blast-furnaces, generally by the owners or lessees of the furnaces. Professor Maury, in *The Resources of West Virginia*, describes the Preston County coal-basin as bounded on the east by the Briery mountains, on the west by Laurel ridge, and is the southerly continuation of the Ligonier valley of the Pennsylvania survey. At the Irondale furnace a seam 4 feet thick is worked, giving a coke, which is used in the furnace, with the following analysis:

	Per cent.
Fixed carbon	89.30
Volatile matter	0.54
Moisture	0.16
Sulphur	0.70
Ash	9.30

The coke made in Marion and Ohio counties is commercially of but little importance, that of the former county being only made to utilize the waste coal from a gas-coal mine. The ovens were operated but seven months, and during that time sometimes 5 and at other times 10 of the 36 ovens were operated, and at no one time were more than 15 ovens burning. The Ohio County ovens were run to supply a glass-works with coke, Wheeling coal being used.

THE COKE INDUSTRY IN VIRGINIA.

During the census year no coke was made in Virginia. A number of attempts have been made to coke the coal from the mines near Richmond, and some coke was made in this vicinity during the recent war for cupola use, but it was very poor stuff, and could only be used under the exceptional circumstances then existing. At the present time Virginia coke cannot compete in quality with that from New river or from Connellsville; indeed there is little or no coal in Virginia that has as yet been developed that can be adapted to the manufacture of coke. The Lowmoor Iron Company, at Lowmoor, Virginia, were building ovens during the census year, but made no coke. Their supplies of coal are to be drawn from the New river, in West Virginia. The Iron and Steel Works Company of Virginia, limited, have since the census year begun the building of 80 Coppée ovens at Goshen Bridge, Virginia, but in this case also the coal will be brought from the New River region of West Virginia.

THE COKE INDUSTRY IN OHIO.

Ohio held the second rank among the states in the production of coke in the census year, producing 109,296 tons, or 3.98 per cent. of the entire amount. The following table, condensed from Table I of this report, gives the chief statistical items concerning its manufacture:

Counties.	No. of establishments.	Capital.	OVENS.		Number of employés.	Wages paid.	COAL.		COKE.	
			Number built.	Number building.			Tons used.	Value.	Tons produced.	Value.
Athens	1	$2,000	8	12	7	$375	1,130	$960	565	$2,097
Columbiana	2	57,500	195	.....	27	11,965	67,046	101,469	39,424	125,652
Hamilton	3	14,000	22	.....	13	4,012	14,922	16,471	9,806	42,887
Jefferson	6	61,512	344	.....	99	34,645	197,189	104,553	57,084	156,902
Mahoning	2	2,000	10	.....	3	480	1,361	1,779	1,017	3,808
Tuscarawas	1	7,000	40	.....	4	500	1,600	3,200	800	3,200
Total	15	144,012	619	12	153	51,977	193,848	228,432	109,296	334,546

While much of the coal of this state is excellent for many purposes, there is but little as well adapted to the manufacture of coke as some of the coals of Pennsylvania, West Virginia, and Alabama, though most of the seams of coking coal are geologically the same as those of the former. They appear, however, at their best as they approach the mountains. Much of the coal used in Ohio gives a coke that is soft and brittle, and often high in sulphur and ash. This is not true of all the cokes, however, some being remarkably pure. The yield in coke is not as great as that of the coal of the same seams in the states mentioned above, being on an average only 58.64 per cent., one of the lowest yields in the country, Tennessee and Illinois only showing a lower yield.

The chief localities in which coke was made in Ohio in the census year were Columbiana and Jefferson counties, which produced 97,108 tons of the 109,296 tons made in the state, or about 89 per cent. Most, if not all, of this was consumed in the blast-furnaces located at or near the ovens, the Columbiana coke being used at the Leetonia furnaces and the Jefferson County coke at the Steubenville furnaces.

Of the coal from which the Columbiana County coke is made Professor Newberry says: "It is remarkably pure, and makes a coke of superior quality."(a) A portion of the coke reported as made in Columbiana county was made in Mahoning county, the Cherry Valley iron works, which are situated in the former, having ovens in the latter and finding it impossible to separate the product of the two. Mr. J. C. Chamberlain, of this works, writes me regarding their coal and coke as follows:

We have a mine and coke ovens on the Mahoning county side, another mine and coke ovens on the Columbiana county side, and a mile and a half south, at Leetonia, we have still another mine and coke ovens. All three of these mines are working the same seam of coal; this is positive, and there is no material difference in the coke; if anything the middle mine produces coal a little freer from sulphur. It is from this mine that the "Washingtonville coke" received its name. We call all our coke by that name. The coal is, according to Professor Newberry's classification, "No. 4," but further and later examinations will place it one if not two veins higher in the series. The greatest thickness of the seam is 3 feet, the average is 30 inches, of which from 4 to 6 inches of the top of the seam we do not coke, but use in the furnace in its raw state. This upper 6 inches is very hard and a little slaty. The bottom 2 feet we coke, using slack and lump coal or slack only, just as circumstances require. Generally we run the coal over a 2-inch screen and sell or use the lump coal at the furnace or rolling-mill, coking only the screenings. The coal is remarkably pure, is free from sulphur, and has a very low per cent. of ash.

The following is an analysis of No. 4 seam coal, Leetonia, Ohio, thickness 2 feet 6 inches:

	Per cent.
Water	2.56
Volatile combustible matter	39.60
Fixed carbon	56.04
Ash	1.80
Sulphur	0.53
Specific gravity	1.213

Coke compact; ash white.

Two analyses of oven coke made at Leetonia are as follows:

	Per cent.	Per cent.
Carbon	93.75	95.50
Ash	5.38	3.30
Sulphur	0.87	1.20
Silica in ash		3.02

Mr. Chamberlain writes me that the analysis of 1.20 of sulphur is the only one he has ever seen of this coke that showed over 1 per cent. This coke is not so compact as that at Connellsville, and will not stand transportation so well, but it is used in the Leetonia furnace, and is regarded as better than Connellsville for the native ores. It is also claimed that it will carry as much burden by weight as Connellsville coke.

This coal, when coked in bee-hive ovens, yields from 55 to 58 per cent. in coke, and is mined, paying for slack and "top" coal at 69 cents per ton of 2,100 pounds. The miners keep the top coal separate.

An analysis of picked samples of the coal used for coking at Steubenville, Jefferson county, shows a very pure coal, containing less than 2 per cent of ash. As this coal is somewhat slaty, the samples from which the analysis was made must have been a very good selection. Mr. William H. Wallace, president of the Jefferson iron works at Steubenville, which was the largest producer of coke in Ohio in the census year, writes regarding Steubenville coke as follows:

In reply to your inquiries in regard to Steubenville coke I would say: It is soft and brittle; it breaks very easily, and a large proportion of it becomes fine and like dust, even in transporting it from the ovens to our blast-furnaces, a few hundred yards distant. As compared with Connellsville coke, it is difficult to give more than an approximate statement. We have not used the Connellsville coke alone, but usually in the proportion of one-half Connellsville and one-half Steubenville coke. We find that it not only increases the output of the furnaces from 25 to 35 per cent. when used in this way, but the amount consumed per ton of pig-iron is less, being 85 to 90 bushels of Steubenville, and but 77½ bushels when mixed half and half. The Connellsville coke does not improve the quality of the iron when mixed with the Steubenville coke, and our forge manager, a practical boiler of many years' experience, has said that the iron is deteriorated in quality by the admixture. As we use a large proportion of good lump coal in making our coke, it costs us not far from 4½ cents per bushel, or $2 25 per ton. The Connellsville coke costs us from $1 25 to $1 75 per ton at the ovens; freight to Pittsburgh $1 16⅔. and freight from Pittsburgh to Steubenville $1; making it cost here from $3 41⅔ to $3 91⅔ per ton. If we could get the

a *Geology of Ohio*, vol. iii, page 124.

Connellsville coke at $2 75 per ton it would not pay us to make our own coke, as the superior quality of the Connellsville coke would overcome the difference in the cost. Our coal contains considerable slate, to which is ascribed, by some, the brittle character of the coke; but it also contains a large amount of charcoal, and it is believed that in crushing and washing the coal to remove the slate this charcoal would be wasted. We use the bee-hive oven, and the views above expressed are the result of opinions formed from experience with coke made in this way. What difference a different process for its manufacture would make, and what improvement in quality might result therefrom, we have no means of ascertaining at present.

The seams of coal at Steubenville are from 3 feet 9 inches to 5 feet thick. The following analyses by Wormley are of shaft coal No. 6 and of coke made from the same in the Steubenville Furnace and Iron Company's ovens:

	Per cent.
Fixed carbon	65.90
Volatile combustible matter	30.90
Ash	1.80
Sulphur	0.98
Water	1.40
Specific gravity	1.308

Coke from this coal analyzed by Wuth as follows:

	Per cent.
Fixed carbon	90.63
Ash	8.38
Sulphur	0.27
Hydrogen	0.72

All of the ovens used at Steubenville are of the bee-hive pattern, and vary somewhat in their dimensions, some being 11 feet in diameter by 5 feet high in the clear, and arched from the bottom, others 10½ feet in diameter with 36-inch spring of arch above wall, 5½ feet high in the clear. In some cases, with a charge of 100 bushels of coal, 72-hour coke is made, and in others, with 75 bushels of coal to the charge, 48-hour coke.

But little coke was made in the great Hocking Valley coal-field during the census year, the single establishment reported as in existence having been built during the year and operated from March only. While much of the coal in this region is adapted to use in the blast-furnace raw, and therefore does not need to be coked, other coals are well adapted to the manufacture of coke. Dr. T. Sterry Hunt (*a*) thinks that coal No. 7 will yield a good coke, while the lower four feet of the great Pittsburgh seam, so fully developed in Big Run, gives a coke of superior appearance. Mr. E. C. Pechin, whose long experience in the manufacture of iron in the Connellsville region gives his views special weight, says: (*b*)

In coal No. 7 the district possesses a coal for making an admirable coke which will shortly play a most important part in the metallurgical operations of the district.

Mr. Pechin, in the same article, refers to a peculiar product of one of the coals of this valley, which he calls "charred coal", which has many of the properties and can be put to many of the uses to which coke is put. He says:

I inspected the oven at XX furnace, which had been experimenting on various coals. The attempt at coking the small coal and slack was not successful, as the heat of the oven was not sufficient to agglutinate the slack; but in charging the slack several large pieces of the coal had gone in with it and had been drawn unbroken. They had retained their original shape, and were extremely hard, resonant, and lustrous. The use of this charred coal will prove of special importance in those districts where coal No. 7 is either not found or becomes too impure for smelting purposes.

But little coke is reported as made in Mahoning county. A part of that reported in Columbiana county, however, was made in that county, and all information received is to the effect that some very good seams of exceedingly pure coking coal exist there. At Washingtonville there is one of the purest coals in the state, containing very little sulphur and not more that 2 per cent. of ash. The vein is 2½ feet thick, and some little coke was made from it at this point. The coke made in Columbiana county was nearly, if not quite, all from the same seam. Formerly this Washingtonville seam is reported to have been extensively coked, and to have furnished a fuel regarded as excellent for blast-furnace purposes. One reason probably why this coal has not been more extensively used is that Mahoning county furnishes the well-known Brier Hill or Mahoning coal, called locally "block coal", used largely for iron-smelting. Though this coal has more bitumen and less carbon than well-known coking coals, it is non-coking, and can be used raw in the furnace.

It will also be noticed from the table on page 41 that some little coke was made in Tuscarawas county; but though this county contains some coal fairly well adapted to coking, and though many attempts have been made to establish the manufacture of coke on a commercial scale within its limits, they have up to this time been unsuccessful, the failures arising chiefly from unskillful management and the necessity of thoroughly washing the coal to remove the ash and sulphur. There is no doubt that some of the coals of Tuscarawas county, especially coal No. 5 and coal No. 6 of the geological survey, by proper washing will give good coke. That already made is generally strong, adhesive, has a high heating power, and is capable of bearing a heavy burden; but its high percentage of ash and sulphur precludes its use unless thoroughly and carefully washed, which has not yet been done.

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a *Coal and Iron of Southern Ohio*, T. Sterry Hunt, Salem, Massachusetts, 1874, page 78.

b *Metallurgical Review*, vol. i, page 107.

The attempts to use the coal of Tuscarawas county at the Glasgow-Port Washington furnaces resulted in the loss of large amounts of capital invested in iron and coal land plant and operations by a company of Scotch capitalists. (*a*)

All of the coke in Hamilton county was made from the screenings of Pittsburgh and other coals gathered from the coal-boats and coal-yards.

Some attempts have also been made to use the Vinton County coals, and others of the Hanging Rock region, for the manufacture of coke, but with little success so far, though with proper methods and care a fair coke can no doubt be produced. A block of Belgian ovens are standing at the Vinton furnace, but they have been idle for some years, and there was no coke made in the census year.

THE COKE INDUSTRY IN TENNESSEE.

Coke to the amount of 91,675 tons was made in Tennessee in the census year at four works located in three counties. The following statement, condensed from Table I, will give the chief statistical items concerning its manufacture:

Counties.	No. of establishments.	Capital.	OVENS.		Number of employés.	Wages paid.	COAL.		COKE.	
			Number built.	Number building.			Tons used.	Value.	Tons produced.	Value.
Grundy	1	$125,000	404	102	79	$24,000	120,000	$56,200	60,000	$120,000
Marion	2	56,021	118	30	18	7,820	19,311	27,937	11,675	42,493
Roane	1	19,000	67	20	17	7,000	40,000	40,000	20,000	50,000
Total	4	200,021	589	152	114	38,820	179,311	124,137	91,675	212,493

As a coke-producing state Tennessee holds the fourth rank, supplying 3.33 per cent. of the entire product. In no other state, however, was the average output so great as in Tennessee, the average for each of the four works being 22,919 tons, Pennsylvania, which was the next, averaging 22,280 tons.

The coal-fields of Tennessee, which are a continuation of the great bituminous deposits of western Pennsylvania and West Virginia, are computed to cover an area of 5,100 square miles. These fields extend through the state from northeast to southwest, are coextensive with the Cumberland table, about one-half the area being in middle Tennessee and the other in eastern Tennessee, and form an irregular quadrilateral, 71 miles wide at the northern border and 50 at the southern. In the southern portion of the field, on the eastern side, is a deep gorge, canoe-shaped, with sharp escarpments rising from 800 to 2,000 feet above the valley, through which the Sequatchie river flows. The Sequatchie valley or trough thus formed is 160 miles long, the Tennessee part being 60 and the Alabama 100 miles in length. It was in this valley, and that of its feeder, the Little Sequatchie, that most of the coke produced in the census year was burned.

The most important as well as the best known of the coke-producing localities of Tennessee are the Sewanee mines, in Grundy county, in the Little Sequatchie coal-field, sometimes called the Tracy City mines. This coal-seam is in the Upper Measures, is supposed to correspond to bed B of the Pennsylvania geological survey, and is to the state of Tennessee what the Pittsburgh seam is to the state of Pennsylvania. It will average 4½ feet in thickness, its largest development being 10 feet 4 inches, its smallest 2 feet, and varies somewhat in its characteristics and constituents in different localities. The Sewanee coal, as mined at Tracy City, is semi-bituminous, conchoidal in fracture, reasonably low in ash, and almost wanting in sulphur. The cohesion of this coke is slight, having the same tendency to disintegrate on exposure to the atmosphere that the Connellsville coke has. For this reason, and from the fact that it is an excellent coking coal, it is more largely used for coke than it otherwise would be. The coke is made in part from the slack, which contains, of course, a larger amount of slate than the coal, and accounts for the large percentage of ash in the coke as compared with the ash in the coal. Analyses of the Sewanee coal and coke are as follows:

ANALYSIS OF THE SEWANEE (TENNESSEE) COAL.

Constituents.	No. 1.*	No. 2.†	No. 3.‡
	Per cent.	*Per cent.*	*Per cent.*
Water	.....	.....	1.6
Volatile matter	29.9	29.0	29.3
Fixed carbon	63.5	65.5	61.0
Ash	6.6	5.5	7.8
Sulphur	Trace.	.....	Trace.

* Analyst: H. T. Yaran. † Analyst: F. Zwicke. ‡ Analyst: Robertson.

a Report for 1882 of Mr. Andrew Roy, mine inspector of Ohio.

ANALYSIS OF SEWANEE (TENNESSEE) COKE.

[Analyst, W. S. Land.]

	Per cent.
Fixed carbon	83.364
Ash	15.440
Sulphur	0.142
Undetermined	1.054

The coke made at Tracy City was all burned in bee-hive ovens, of which 404 were built at the close of the census year and 102 were being built. The ovens at these works vary in size and shape, the old ones of the regular bee-hive pattern being 10 feet in diameter and 4½ feet high inside, while the latest built are 11 feet in diameter and 8 feet high. The larger ovens seem to work the best, making the most compact and the densest coke. From 100 to 120 bushels of coal are charged into each of these ovens, and the coke is burned 48 hours. The yield is about 58 per cent. At the Rattlesnake mines of this company the ovens are oval or egg-shaped, 9½ by 14 feet and 5½ feet high inside; eighty bushels are charged. The labor at these mines and works is largely done by convicts, 306 convicts and 300 free hands being employed at the close of 1880.

In Marion county, which joins Grundy county, there were two coke works in the census year, the Etna and the Southern States Coal and Iron Company. At the Etna works two veins, called the Kelly and the Oak Hill, are worked. From the Kelly mine a coke is made for foundery use exclusively, while from the Oak Hill coke for blast-furnace use is made. The Kelly seam is frequently regarded as the equivalent of the Sewanee at Tracy City, and J. B. Killebrew, the commissioner of mines of Tennessee, shares in this opinion. It is asserted, however, by the Etna Coal Company, who mine the Kelly coal, that in appearance and general characteristics these coals are as different as two coals of the same formation can well be, and samples of both seem to bear out this claim. In Professor Safford's *Geology of Tennessee* (pages 369–382) the difference between the two measures can be readily distinguished. The impression as to the identity of these two coals probably arises from the fact that both lie in the upper plateau of their respective regions. The Etna Coal Company claim, however, that the "Kelly", the "Oak Hill", and the "Slate" veins do not appear at any other point in this region. At Tracy City only eight veins are shown, while the Etna Coal Company claim eleven at their mines. A section at the Kelly mines shows two conglomerates, while at the Sewanee mines there is only one.

About one-fourth of the product of the mines is coked, all in bee-hive ovens. The coke from the Kelly seam is sent all over the South, where it has an especially enviable reputation for foundery purposes, commanding at the present time for this use $6 25 per ton on cars at the mines. This coal is not washed before coking. Below will be found analyses of the Kelly coal and of the Kelly and the Oak Hill cokes:

ANALYSIS OF KELLY COAL.

[Analyst, Professor Shale, New York.]

	Per cent.
Water	1.30
Volatile matter	21.10
Fixed carbon	74.20
Ash	2.70
Sulphur	0.70

ANALYSIS OF KELLY AND OAK HILL COKES.

Constituents.	Kelly.*	Oak Hill.*
	Per cent.	*Per cent.*
Fixed carbon	94.56	83.05
Ash	4.65	16.95
Sulphur	0.79	.....

*Analyst: William Manthey.

The coke at these works is made in bee-hive ovens ranging from 9 feet in diameter and 5 feet high to 11 feet in diameter and 6 feet high. In the smaller ovens 80 bushels of coal are charged, and in the larger from 100 to 120 bushels. The Oak Hill (blast-furnace) coke is burned from 48 to 60 hours, and the Kelly (foundery) coke 72 hours.

The other works in Marion county is that of the Southern States Coal and Iron Company. The coal from these mines resembles the Sewanee in structure, but contains a large quantity of sulphur in balls and plates from the size of a pea to pieces 8 or 10 inches long and from 1 to 1½ inches thick. For manufacture into coke it is therefore all crushed and washed. The ovens are of the usual bee-hive pattern, and are from 10 to 11 feet in diameter and 6 feet high to the crown of the arch.

In Roane county, toward the eastern part of the coal-field, the Roane Iron Company makes coke for its blast-furnaces from a seam of coal nearly identical with the Sewanee vein. The average thickness of this seam is about 5 feet. The coal is easily mined, and makes a dense and valuable coke. Nearly the entire product is converted into coke and used at the works of the company at Rockwood, where the mines and furnaces are located. On page 46 will be found and analysis of the coal and coke at Rockwood.

ANALYSIS OF ROCKWOOD COAL.

[Chemist, W. S. Land.]

	Per cent.
Moisture	1.49
Sulphur	0.33
Volatile matter	26.62
Fixed carbon	63.74
Ash	7.82

ANALYSIS OF ROCKWOOD COKE.

[Chemist, W. S. Land.]

	Per cent.
Fixed carbon	84.187
Ash	14.141
Sulphur	.182
Undetermined	1.490

The coke at these works is made in the ordinary bee-hive oven, from 9 to 11 feet in diameter and from 4½ to 6 feet in height. Forty-eight hours are allowed for coking. The coke is taken in bogies hot directly to the furnaces, which are situated contiguous to the ovens. Since the close of the census year the works at this point have been largely increased.

THE COKE INDUSTRY IN ALABAMA.

Alabama possesses three distinct coal-fields or basins, in all of which coking coal is found in abundance. These are the Coosa, which is the most easterly, containing some 300 square miles; (*a*) the Cahaba, with some 230 square miles; and the Warrior, which is the southern end of the great Appalachian coal-field, and which is much the largest of the Alabama basins, covering nearly 4,700 square miles. As in other states, these basins are divided into a number of sub-basins, but little is known of them, owing to the incompleteness of the geological survey, except of a most general character. It is estimated, however, that the Alabama coal-fields underlie more than 5,000 square miles, divided as stated.

The coke made from some of the seams of coal in these fields, especially in the Warrior and the Cahaba fields, the Coosa not being so well known, is an excellent fuel for blast-furnace and foundery purposes, and was largely used by the confederate government at their cannon foundery at Selma, one of the officers pronouncing it "to equal the very best English cokes". Its value has become so manifest that large investments have been made, both during and since the census year, in iron and coal properties, and several blast-furnaces to use coke are either building or have recently been completed.

Alabama ranked sixth as a coke-producing state during the census year, producing 42,035 tons, or 1.53 per cent. of the entire amount, from 67,376 tons of coal, a yield of 62.1 per cent. All of this was made in bee-hive ovens, of which there were 216 built May 31, 1880, and 206 were building. The capital invested in coke works was $135,500; 64 persons were employed, to whom $38,500 of wages were paid.

The coke made during the census year was made in the Warrior and the Cahaba fields. These coal-fields lie very near each other. Below Birmingham, in the vicinity of which are situated the blast-furnaces which consume most of the coke made, they are never more than 7 or 8 miles apart. In the Warrior field coke was made at the Pratt mines and at New Castle, and in the Cahaba field at Helena, by the same company that operates the ovens at the Pratt mines. Both at Pratt and at Helena the works are quite extensive, but at New Castle but little is made.

The Pratt seam is economically the most important of the coals of Alabama, supplying not only a large proportion of the coal used for railroads, mills, and for all general purposes, but nearly all of the coal made into coke. (*b*) The Pratt Company coke a large amount in its own ovens, and sell a still larger amount to furnaces, to be coked at the furnace ovens. The seam at the Pratt mines is 4½ feet thick. The coke is made from unwashed screenings from a 3-inch screen, which accounts for the large amount of ash in the coke as compared with that in the coal, as shown in the analyses.

At New Castle, in this same (Warrior) field, as is stated, but little coke was made, the ovens having been built to use up the slack from the mines at this point. The coke was too high in sulphur for use in smelting iron. A small vein, called the Black Creek, in the Warrior field, has also been used to some extent in coking, and it is stated the coke was superior as a blast-furnace fuel to any other made in the state. The vein, however, is so small, only 2 feet, that it cannot be worked economically.

The first coke made for blast-furnace use in Alabama was from coal of the Cahaba field at Helena, and a portion of the coke used at the blast-furnaces in the state in the census year was supplied from this field, but it is so high in ash, due probably to careless mining, that the Pratt coke is now used in its stead. The only veins in

a I am informed by Prof. Cook, state geologist, that recent investigations make this field some 300 square miles in extent, but 100 square miles will probably include the productive portion of the field.

b At the present time (December, 1882) most of the coke used in the blast-furnaces of Alabama is made from the coal of this seam as mined by the Pratt Coal and Coke Company. This seam has also been opened at another point, at which some coke is now being made.

this Cahaba field that have been used for coke are the Wadsworth and the Helena. Both make a fair coke, but that from the Pratt seam is so much better that it has entirely displaced the Helena for furnace use.

Attempts have been made to use the "Black Shale" seam, of which an analysis is given below, but it was found to have some iron pyrites which carried arsenic, and though its analysis showed it to be a "pure" coal, low in sulphur and ash, it would not make satisfactory metal in the furnace.

Below is given analyses of the coals used in coking in this state, with cokes made from the same:

ANALYSES OF COALS USED IN COKING IN THE WARRIOR FIELD.

Constituents.	PRATT SEAM.		NEW CASTLE OR MILNER SEAM.		BLACK CREEK.	
	No. 1.*	No. 2.†	No. 1.‡	No. 2.‖	No. 1.	No. 2.§
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Specific gravity	1.300	1.29	1.38	1.30	1.36	.....
Fixed carbon	61.600	64.30	59.69	55.18	71.64	63.12
Volatile matter	31.480	32.08	28.24	36.17	28.24	31.25
Sulphur	0.918	0.47	0.64	1.38	0.64	0.89
Ash	5.416	2.08	10.92	7.83	2.63	5.63
Water	1.508	1.07	0.50	1.12	0.12	.....
Yield of coal in coke	.....	.....	.....	.....	73.67	68.75

* Analyst: Professor McCalley. † Analyst: N. T. Lupton. ‡ Analyst: Otto Wuth. § Analyst: Eureka Iron Company.

ANALYSES OF COKES MADE FROM COALS OF THE WARRIOR FIELD.

Constituents.	FROM PRATT COAL.						
	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.*
Fixed carbon	93.01	88.15	86.090	83.27	85.81	88.224	84.653
Volatile matter	0.16	0.60	0.910	0.93	0.78	0.990	1.329
Ash	6.83	11.25	13.000	15.00	12.80	11.315	13.317
Sulphur	.....	0.70	0.721	0.74	0.61	0.563	0.897
Water	.....	.....	.....	.....	.....	0.362	0.671

* Analyst: Fred. P. Dewey. † Analyst: Eureka Iron Company. ‡ Analyst: Professor McCalley.

The analyses No. 2 of Pratt coal and No. 1 of coke were furnished by the Pratt Coal and Coke Company.

ANALYSES OF COALS USED IN COKING IN THE CAHABA FIELD.

Constituents.	HELENA SEAM.			Wadsworth.‡	Black Shale.‡
	No. 1.*	No. 2.†	No. 3.‡		
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Specific gravity	1.12	1.32	.....	.....	.....
Fixed carbon	66.81	58.69	59.59	60.53	70.00
Volatile matter	12.44	35.48	34.37	34.60	27.01
Sulphur	.....	0.90	0.66	0.68	0.79
Ash	1.21	3.82	6.05	4.87	2.99
Water	2.54	1.74	.....	.....	.....
Yield in coke	.....	.....	65.63	65.40	.....

* Analyst: R. P. Rothwell. † Analyst: Lupton. ‡ Analyst: Eureka Iron Company.

ANALYSES OF COKES MADE FROM THE COALS OF THE CAHABA FIELD.

Constituents.	Helena.*	Wadsworth.*	Not stated.†
	Per cent.	*Per cent.*	*Per cent.*
Specific gravity	1.659	1.693	.....
Fixed carbon	84.035	88.903	93.252
Volatile matter	0.066	0.413	0.730
Sulphur	0.445	0.342	0.601
Ash	15.216	10.144	5.380
Water	0.689	0.540	0.300

* Analyst: Professor McCalley. † Analyst: Professor McCreath.

The first ovens built in this state for furnace-coke were Belgian, on the Coppée system, but they were not successful, and were abandoned and bee-hive ovens were erected in their stead, and since that time no others have been used.

THE COKE INDUSTRY IN GEORGIA.

But one coke works was reported in existence in Georgia in the census year, at which 70,000 tons of coke were made from 117,000 tons of coal, a yield of 59.8 per cent. No information has been received as to the extent of the coal-fields or the character of the coal or the coke made from the same. All of the labor at these ovens, of which there were 140, was performed by convicts, the superintendent, mining overseer, and the guards being the only labor not convict. Most of the coke is used at the Rising Fawn furnace, in the same county, and gives fairly good satisfaction. It has considerable ash, but it is thought to be more economical to flux this out in the furnace than to wash it out before coking. (*a*)

THE COKE INDUSTRY IN INDIANA.

Though the *Geological Survey of Indiana* reports that "the seams of coking coal in Indiana are locally not less than fifteen in number", (*b*) some of which are 7 or 8 feet thick, the manufacture of coke can hardly be said to have existed as an industry in this state in the census year, but 1,000 tons being made. The coking coals of this state, according to the various reports of the geological survey, are found in fourteen counties, and some of the seams are said to be "rich-looking and pure". The percentage yield of coke in the laboratory ranges from 52 to 64.50 per cent., and the ash from 0.50 to 7. (*c*)

Notwithstanding this asserted abundance of coking coals and their purity, the manufacture of coke up to and during the census year had not been, in a commercial sense, a success, though repeated attempts to make it so are recorded. Possibly one reason has been that Indiana has not been a large iron-producing state, and for the little iron ore that has been smelted the block coal furnished an excellent fuel. It is also possible that the physical constitution of the coke made from Indiana coals is not such to justify its use as a blast-furnace fuel. Professor Cox, in the *Report of the Indiana Geological Survey*, published in 1879, page 12, states:

> The coking coals of Indiana swell and fuse to a pasty mass when burning, but the coke which is made from them is not strong, and is filled with large cells, that give it a sort of honey-comb appearance.

Probably the most thorough and careful attempt yet made to coke Indiana coal was that of the North Chicago Rolling Mill Company, made since the census year. The coal used was screenings of Coal Creek coal from Fountain county. These screenings contained from 15 to 20 per cent. of ash, which was reduced by washing, so that the coke contained only from 10 to 12 per cent. The sulphur, however, was from $\frac{3}{4}$ to $1\frac{1}{4}$ per cent. Belgian ovens with Endres' modifications were used. The coke, beside being high in sulphur, was spongy and soft, and would not carry a burden in the furnace; but when mixed in the proportion of from 10 to 15 per cent. with Connellsville coke fairly good results were obtained. Mr. O. W. Potter, president of the company making the experiments, writes:

> We are not sure but further experiments in using lump and nut coal and crushing to remove the slate may give us better results than we have had up to this time.

Some attention has been given to charring or coking the block coal of this state. (*d*) The block coal found at Brazil differs but little in chemical composition from the coking coals of western Pennsylvania. The physical difference is, however, quite marked, the latter having a cuboid structure made up of bituminous particles lying against each other, so that, under the action of heat, fusion throughout the mass readily takes place, while block coal is formed of alternate layers of rich bituminous matter and a charcoal-like substance, which is not only very slow of combustion, but so retards the transmission of heat that agglutination is prevented and the coal burns away, layer by layer, retaining its form until consumed. The experiments in charring the coke above referred to arose out of a failure to coke the slack. The lumps as they came from the mine were charged into a hot bee-hive oven, and after a proper interval were drawn, not materially changed in size or shape, but greatly changed in character, being hard, compact, and silvery, like coke. This product was charged into the furnace instead of Connellsville coke (350 pounds of charred coal in the place of 385 pounds of Connellsville coke) with the most satisfactory results, the quantity of iron produced remaining about the same, but of a somewhat higher grade.

Professor Cox has also made some extended experiments on coking Indiana coals under pressure, and is of the opinion that the dry-burning or block coals of Indiana can be made under pressure into a remarkably strong and dense coke.

THE COKE INDUSTRY IN ILLINOIS.

Of the four coke works reported in existence in Illinois in the census year, but one was in operation during any part of the time, and this made 7,600 tons of coke, the entire production of the state, from washed slack. One of the works resumed operations June 1, 1880, one of the others is still idle, and the ovens and machinery at the fourth have been wrecked and a portion of the materials and machinery removed to another point in the state. (*e*)

Much of the coal of Illinois is coking coal, but its chemical and physical nature is such that as yet no coke has

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a The company, in December, 1882, were constructing 140 additional ovens.

b *Seventh Annual Report of the Geological Survey of Indiana*, Professor E. T. Cox (Indianapolis, Indiana, 1876), page 11.

c *Second Annual Report Geological Survey*, (Indianapolis, 1871), page 180.

d In vol. iv, page 99, *Transactions of the American Institute of Mining Engineers*, will be found a paper on "Coking Indiana Block Coal", contributed by Mr. John Alexander.

e Since the census year, however, two of the existing works have been enlarged and others built, and the product of coke at present (1882) in this state is much greater than during the time covered by this report.

been made from it equal to the Connellsville as a furnace fuel. The deposits, however, are so large and so near the rich and abundant iron-ore fields of Missouri and lake Superior that the efforts to utilize Illinois coal for the manufacture of coke for metallurgical purposes have been unceasing during the past ten years. Much of this experimenting has been to ascertain what form of oven was best adapted to coking. The bee-hive has not answered the purpose, and not one was in use in the state in the census year. The coals that are low in sulphur and ash are, as a rule, too dry-burning, and the bee-hive is too cold an oven for them. Modifications of the bee-hive, similar in plan to the Welsh ovens, have to a considerable extent been used with fairly good results in southwestern Illinois, though equally good results are obtained with the Big Muddy coal in bee-hive ovens that have been erected as a trial plant. The tendency, however, is to the use of some form of the Belgian oven, and from the results of experiments with the different forms it is manifest that this oven is not in all cases a corrective of all the evils that gather about coke-making in Illinois.

Many of the Illinois coals which are not dry-burning are high in sulphur and ash, that of the northern part of the state being especially sulphurous, and for this evil even the Belgian oven is not a cure. It requires careful and thorough washing, and even then, in many cases, the result is not satisfactory. In one case the washing was so thorough that 60 per cent. of the coal was washed away, and still there was an excess of ash and sulphur in the coke. Some of the coals also show no tendency to coke until crushed and washed, and a washing plant is generally a necessary part of a coking plant in this state.

The coal of the Big Muddy region, in the southwestern part of the state, is a marked exception in purity to most Illinois coal, the coke from it being reasonably low in sulphur and ash. Previous to 1876, at which time the furnaces were torn down, the Grand Tower Mining, Manufacturing and Transportation Company made Bessemer pig from Iron mountain and Missouri hematite ores, using four-fifths raw Big Muddy coal and one-fifth coke made from washed screenings of the same in small Welsh ovens. The furnace was 16 by 72 feet. The iron exhibited at the Centennial was awarded the medal for purity and structure. This field, or pocket, occupies an area of about 4,000 acres, of which 250 have been worked out. The coal is not as well adapted to coking as that of the fields that bound it on the north and east, but these latter coals are too high in sulphur to produce a coke for smelting iron, with the exception of a pocket of limited extent at Cartersville. The Big Muddy seam lies almost horizontal, with a slight dip to the north, and varies from 5 to 7 feet in thickness, with a thin slate between the bottom and top coal. The coal is a hard, semi-bituminous, free-burning fuel, showing no inclination to run together, even under extreme heat, unless ground fine and wet. The following analyses of the coal and coke, with the exception of No. 3 coke, are furnished by Mr. Thomas M. Williamson, the superintendent of the Saint Louis Ore and Steel Company's works at Grand Tower and vicinity, where they coke this coal:

ANALYSIS OF MOUNT CARBON BIG MUDDY COAL.

	Per cent.	Per cent.
Water	6.37	6.02
Volatile matter	31.93	33.71
Fixed carbon	59.13	57.06
Ash	1.81	3.21
Sulphur (separately determined)	0.76	1.19

ANALYSIS OF MOUNT CARBON BIG MUDDY COKE.

Constituents.	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Hydroscopic moisture	.....	.....	0.28
Volatile matter	0.83	0.93	1.46
Fixed carbon	87.32	88.18	88.74
Ash	11.85	10.07	9.71
Sulphur (separately determined)	1.08	0.61	0.97
Silica in ash	.....	.....	47.00

Another analysis shows 1.17 per cent. hydroscopic moisture and 46.33 silica in ash.

As has been stated, this coal is much too dry-burning to allow of the successful use of the ordinary bee-hive oven. The Saint Louis Ore and Steel Company coke it in ovens known as the "English drag". This oven is 36 feet long, 7 feet wide, and 3½ feet high, with a capacity of 300 bushels of coal. It is a solid wall oven, discharged by a drag laid on the oven floor prior to the beginning of the operation, the drag being operated by a windlass. The coal is crushed as fine as beans, the screenings also being crushed, and both are washed. The charge of each oven is 11 tons; the time of burning, 96 hours. The yield is only about 55 per cent., as much of the carbon is necessarily wasted in furnishing the heat necessary to coke the coal. These ovens have not worked entirely satisfactorily, though they have been in use for some years, and the company expect to erect Belgian ovens.

The Carbondale Coal and Coke Company, at Cartersville, produced the only coke made in this state in the census year from one of the comparatively pure coals of southwestern Illinois, found near the Big Muddy deposit,

before described. This coal is slightly more bituminuous than the Big Muddy, and contains more sulphur and ash, and the seam is 9 feet thick. I have no analysis of the coal, but an analysis of the coke is as follows:

ANALYSIS OF CARBONDALE COKE.

[Analyst, Chauvenet.]

	Per cent.	Per cent.
Water	2.48	.....
Volatile matter	2.42	1.58
Fixed carbon	86.79	80.14
Ash	8.31	18.28
Sulphur	0.88	2.03

The coal is washed before being coked, and the ovens used are called "tunnel ovens", and are of the same general plan as those used at Mount Carbon, except that they are smaller, being only 15 feet long, 7 feet wide, and 32 inches deep below the arch, and 3½ feet from the bottom of oven to top of arch. The charge is 6 tons, and the time of burning 72 hours, and the yield of coke was 50.7 per cent.

At East Saint Louis the Meir Iron Company have made careful and expensive experiments in using the slack and nut of the Belleville coal, which is high in sulphur and ash, for the manufacture of coke. The analysis of this nut and slack is as follows:

	No. 1. Per cent.	No. 2. Per cent.
Moisture and gas	15.35	15.09
Condensed volatile matter	10.59	15.74
Fixed carbon	53.62	52.62
Ash	20.44	16.55

These represent the slacks; the coals are much better. No. 1 was slack of ordinary quality; No. 2 slack from Duquoin. The slacks used when these works were in operation contained from 16.55 to 23.35 per cent. of ash, but by careful washing and preparation the ash in the coal was reduced to 6 per cent., and in the coke to 10 or 11 per cent. In the ovens used, which were Belgian of the old François pattern, modified by the Messrs. Meir, washed slack yielded 65 per cent. of coke. Mr. Adolphus Meir, who has been so persistent in his efforts to utilize this coal for coking, writes me: "Good coke has been, and will be, made from Illinois coals. A strong prejudice exists against such coke, but we have proof of melting from 7 to 8½ pounds of iron per pound of our coke in cupola furnaces in Saint Louis."

In northern Illinois all attempts to utilize the coal for coke have so far ended in failure, for while it contains more bituminous matter than that of the Big Muddy region, and is a truer coking coal, it is, however, very sulphurous and high in ash. Washing has reduced the percentage both of ash and sulphur somewhat, but not sufficiently low, in view of other characteristics, to make it desirable as a metallurgical fuel. In the experiments at the Joliet steel works, the ovens used being Belgian or a modification of the Belgian, the resulting coke, while not exceedingly high in ash or sulphur, was too porous for the blast-furnace.

Mr. H. S. Smith, the general superintendent of the Joliet Steel Company, at my request, and in view of the fact that the record of a failure is often as valuable as of a success, has furnished a statement of the experiments at these works, from which the following facts are derived.

The first experiments made were in 1872. The ovens used, of which there were twenty, were known as Belgian, and were 22 feet long and 20 inches wide on the inside, and 8 feet high to the top of the arch. The flues in the sides were horizontal, and from a pencil sketch accompanying Mr. Smith's letter I should judge they were either Smet or Dulait ovens; at least they were the earlier forms of the Belgian, and not the latter, like the Coppée or Appolt. These ovens were charged through openings on the top, and the gases escaped through short chimneys. The ovens were discharged by a ram, and the coke was watered outside. The coal used was chiefly slack from the northern Illinois mines, which was crushed and washed to reduce the percentage of ash and sulphur, which was quite large. The experiments were quite extensive, several thousand tons of coke being made, and the results were the same in all cases. The sulphur was reduced so much that, considering its content of sulphur alone, the coke could have been used for smelting iron, but it was still too high in ash and was too porous and weak to carry a proper burden in the furnace.

In 1879 still further experiments were made, Mr. J. J. Endres' modification of the Belgian oven being adopted, the width of the old ovens reduced to 16 inches, and flues put in the walls and bottom approaching the later Belgian ovens in plan. This experiment was a most thorough one, and was participated in by the steel company, the mines, and railroads. It was continued several months, the coal being carefully and thoroughly washed, and was then coked under Mr. Endres' supervision, but the result was no better than before. The washing removed considerable of the ash and a large percentage of the sulphur. In some cases the sulphur and ash were low enough to make a good coke, that from the Diamond mine having but 7.05 per cent. of ash and 1 per cent. of sulphur, but the coke was weak and porous, and was not adapted to carrying the burden in a furnace. Mr. Smith has kindly furnished a table (see page 51) showing the percentage of ash and sulphur in the coal, washed coal, and coke from a number of mines.

CHEMICAL RESULTS OF EXPERIMENTS ON COKING ILLINOIS COAL MADE BY MR. ENDRES IN 1879.

Name of coal.	PERCENTAGE OF ASH.			PERCENTAGE OF SULPHUR.		
	Crushed coal.	Washed coal.	Coke.	Crushed coal.	Washed coal.	Coke.
H shaft	.....	.....	8.11	.....	.....	1.10
G shaft	10.95	4.51	7.21	3.06	2.16	1.11
Diamond	5.51	4.57	7.05	1.70	1.71	1.00
Coal City	8.22	5.67	8.96	2.37	2.23	1.26
Eureka	7.27	4.99	8.60	2.83	1.93	1.21
Do	6.95	4.83	7.75	2.27	1.67	1.05
Streator	9.07	7.32	12.68	4.42	3.59	2.55
Do	8.23	5.77	9.42	4.70	2.62	1.32
Pontiac	.....	12.71	21.01	.....	2.25	1.27
Braidwood	7.10	6.20	8.11	3.12	2.55	1.30
Springfield	11.53	9.96	16.10	3.56	3.22	1.90
Indiana	10.21	8.02	13.34	2.37	1.77	1.33
Grape Creek	6.66	4.49	.....	1.08	0.84	.....

These experiments have been entirely abandoned, the ovens wrecked, and a portion of the machinery was used in building another bank of ovens in another section of the state; and the Joliet Steel Company have erected ovens in the Connellsville region. The result of these experiments, however, was to indicate that certain of the coals tried might, with proper manipulation, make a fair coke, and ovens are being erected to test these coals still further.

The Illinois Central Iron and Coal Mining Company have erected at Saint John's since the census year a number of Thomas Pettral ovens for using the Paradise coal, which they mine. The following table, for which I am indebted to Mr. M. C. Wright, of the Saint John's coke works, gives the physical and chemical properties of certain Illinois coal:

TABLE EXHIBITING PHYSICAL AND CHEMICAL PROPERTIES OF CERTAIN ILLINOIS COAL.

[Chemist, T. T. Morrell.]

	GRAMS IN ONE CUBIC INCH.		POUNDS IN ONE CUBIC FOOT.		PERCENTAGE.		Compressive strength per cubic inch (2), ultimate strength.	Height of furnace charge supported without crushing.	Order in cellular space.	Hardness.	Specific gravity.	CHEMICAL ANALYSIS.					
	Dry.	Wet.	Dry.	Wet.	Coke.	Cells.						Fixed carbon.	Moisture.	Ash.	Sulphur.	Phosphorus.	Volatile matter.
												Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Paradise	11.00	17.86	41.91	68.15	61.59	38.41	204	78	1	3.0	.....	90.44	.....	8.76	0.80	0.01	.....
Jackson	12.80	21.10	48.77	80.39	60.66	39.34	206	81	1½	3.0	.....	80.68	.....	9.38	0.94	0.067	.....
Do	10.39	16.25	39.59	61.91	63.93	36.06	130	52	1	2.0	.....	87.56	.....	11.30	1.14	0.014	.....
Saline	10.99	19.14	41.87	72.92	57.41	42.59	129	51	1	2.5	.....	81.63	.....	16.02	2.35	0.01	.....
Jackson	11.80	18.49	44.96	70.44	63.87	36.13	150	62	1	3.0	.....	81.98	.....	15.78	2.24	0.011	.....

THE COKE INDUSTRY IN COLORADO.

The manufacture of coke in Colorado, which has been but recently undertaken on a commercial scale, has been of the utmost importance to the industries and the development of that state, and has made possible the utilization of its valuable iron resources. The production of pig-iron from native ores has been successfully established, one furnace being in blast and another building, and with this has come the manufacture of nails and Bessemer steel rails. In addition to this, much of the coke used for smelting the ores of the precious metals in this region is now produced in the state, and the long and expensive transportation from the Connellsville region of Pennsylvania is avoided.

The only point at which coke is reported as made during the census year is some 6 miles south of El Moro, in Las Animas county, near the boundary-line of New Mexico, in what is known as the Trinidad or El Moro coal-field. The coke was made from the coal of one of a number of small and isolated basins into which this field is divided. The El Moro field lies along the eastern foot of the Rocky mountains, beginning at the Huerfano river, south of Pueblo, in Colorado, and extending southward into New Mexico as far as the Cimarron river, the basin being about 80 miles long and perhaps 10 miles broad. The beds are Upper Cretaceous or Lower Tertiary. The field is worked near its northern extremity by the Colorado Coal and Iron Company at Walsenburg, on the main line of the Denver and Rio Grande railroad. At this point there are three beds, respectively 4, 7, and 6 feet thick, producing a very good quality of steam coal, which, however, does not coke. These beds are distinctly traceable to the southern boundary of Colorado. From a thickness of 4 feet at Walsenburg, they increase to 11 feet in the neighborhood of Trinidad, the quality changing from a non-coking coal to an excellent coking coal. South of El Moro, in Las Animas county, at the Colorado Coal and Iron Company's works, where the coke made in the census year was produced, a horizontal vein 10 to 12 feet thick is worked, and at Starkville, in the same county, the Trinidad Coal and Coking Company is mining coal, both companies making coke. (*a*) Some 25 miles farther south, in New Mexico, near Raton, the field is worked by the Raton Coal and Coking Company, the veins being from 5 to 7 feet thick. The coal at this point is an excellent steam coal, and will coke, but there is made from it.

a There are now (1882) 250 coke ovens near El Moro, and between 40 and 50 at Starkville.

The seam from which coke was made during the census year is, according to Professor W. H. Chandler, who made an examination in 1877, 14 feet 2 inches thick, with 12 feet 9 inches of coal, the coal being separated by three small layers of slate from 2 inches to 1 foot thick. Analyses of these four strata of coal are given as follows:

Constituents.	No. 1.	No. 2.	No. 3.	No. 4.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Water	1.32	1.36	1.34	1.66
Volatile matter	38.23	36.77	35.79	34.48
Fixed carbon	55.86	56.37	54.75	60.08
Ash	3.59	5.50	8.12	3.78

In Hayden's *Report of the Geological Survey of Colorado* for 1875 an analysis of this coal is given, which is as follows:

	Per cent.
Water	0.26
Volatile matter	29.66
Fixed carbon	65.76
Ash	4.32
Sulphur	0.85

These analyses show the coal to be quite pure, but on coking it from 16 to 23 per cent. of ash was found, the large percentage of ash being due to the presence of a large amount of bony coal, which did not show in the coal analysis. A car-load of the same coal was sent to Pennsylvania to be crushed, washed, and coked, and the coke produced, after being thus treated, analyzed as follows:

	Per cent.
Water and volatile matter	1.85
Fixed carbon	87.47
Ash	10.65
Sulphur	0.85

This indicated the necessity of a crushing and washing apparatus, and machinery designed by Mr. S. Stutz, of Pittsburgh, was erected. The result is a coke answering all the purposes of a metallurgical fuel, being cellular, of a silvery appearance, and having a physical structure to fit it for furnace use. Its content of ash is from 2 to 3 per cent. more than that in Connellsville coke. The coke is made in bee-hive ovens, only 70 of which were completed at the beginning of the census year, but at its close there were 128, with 72 more in process of construction. The El Moro mines are worked through drifts, and the coal is of a remarkably uniform character. The price paid for digging in 1881 was 50 cents per ton of 2,240 pounds, and the actual cost of the coal loaded on the cars at the mines 73 cents. The product of coke in the census year was but 18,000 tons; in 1881 it was 47,186 tons.

Though no coke was made at any other locality in the census year, there are other deposits of excellent coking coal that have since been utilized for this purpose, and still others at which preparations are in progress for its manufacture. At Crested Buttes, north of Gunnison, on the Denver and Rio Grande railroad, some coke of a most excellent quality, very low in ash, was made in 1881 in open pits from two seams of coal 5 and 6 feet respectively. Analyses of this coal and coke are as follows:

ANALYSES OF CRESTED BUTTES (COLORADO) BITUMINOUS COAL.

	Per cent.	Per cent.
Water	1.10	0.44
Volatile matter	23.20	24.17
Fixed carbon	72.60	72.30
Ash	3.10	3.09
Theoretical yield of coke	75.70	75.39

ANALYSES OF CRESTED BUTTES (COLORADO) COKE.

	Per cent.	Per cent.	Per cent.
Water and volatile matter	1.35	0.42	0.41
Fixed carbon	92.03	90.71	92.44
Ash	6.62	8.87	7.15
Sulphur		0.58	0.37

At the close of 1881, 484 tons of coke only had been made, but yards were being prepared for making 200 tons per day. All the slack and fine coal which passes through the shute-screens is used in the coke-yards, and the coke made is of good quality and runs low in ash. This coke commands $7 per ton on cars at the works.

THE COKE INDUSTRY IN UTAH.

There have been for some time past in the Sanpete district, in Utah, a number of coke ovens, but no coke has been made in them recently. Most of the coke used in Utah comes either from Connellsville, Pennsylvania, or from England, the English coke being delivered at San Francisco, or some point on the Pacific coast, and sent by rail to Utah. A line of railroad is now building from Salt Lake City to connect with the Denver and Rio Grande railroad, which will enable El Moro and Gunnison coke to be delivered at the Utah smelting works.

THE COKE INDUSTRY IN NEW MEXICO.

In central New Mexico, 9 miles east from San Antonio station, on the Atchison, Topeka and Santa Fé railroad, is the San Pedro coal-mine, where there is a bed of coking coal 6 feet thick.(*a*)

a Ovens are now (1882) being erected at San Antonio station, on the Rio Grande river, for coking this coal.