Commonwealth of Pennsylvania.

REPORT OF COMMISSION

APPOINTED TO INVESTIGATE THE

WASTE OF COAL MINING,

WITH THE

VIEW TO THE UTILIZING OF THE WASTE.

ORIGINAL COMMISSION.

J. A. Price, Scranton, Pa. Died August 2, 1892.
Peter W. Sheafer, Pottsville, Pa. Died March 26, 1891.
Eckley B. Coxe, Drifton, Pa.

PRESENT COMMISSION.

Eckley B. Coxe, Drifton, Pa.
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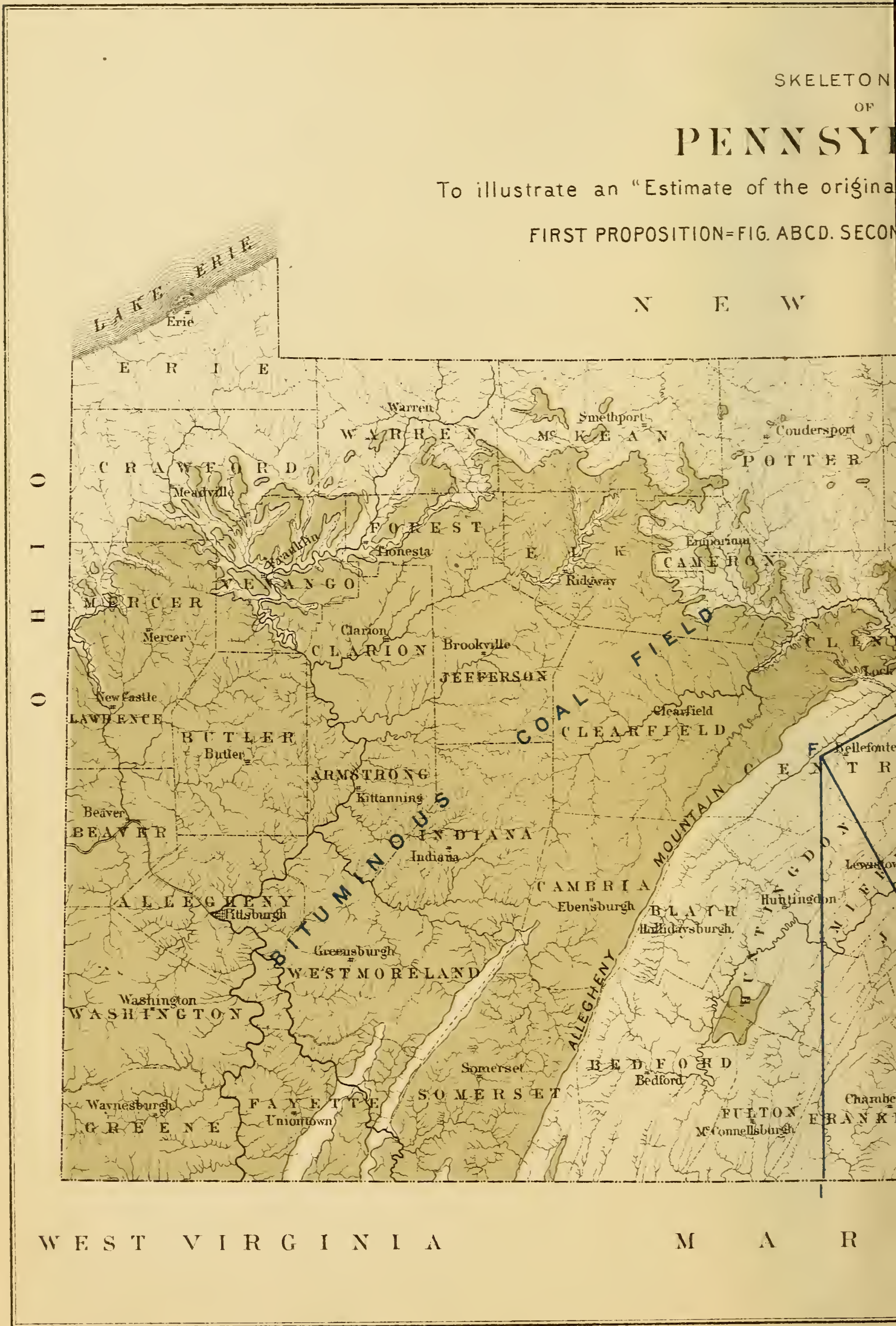
MAY, 1893.

PHILADELPHIA:
Allen, Lane & Scott's Printing House,
229-233 South Fifth Street.
1893.

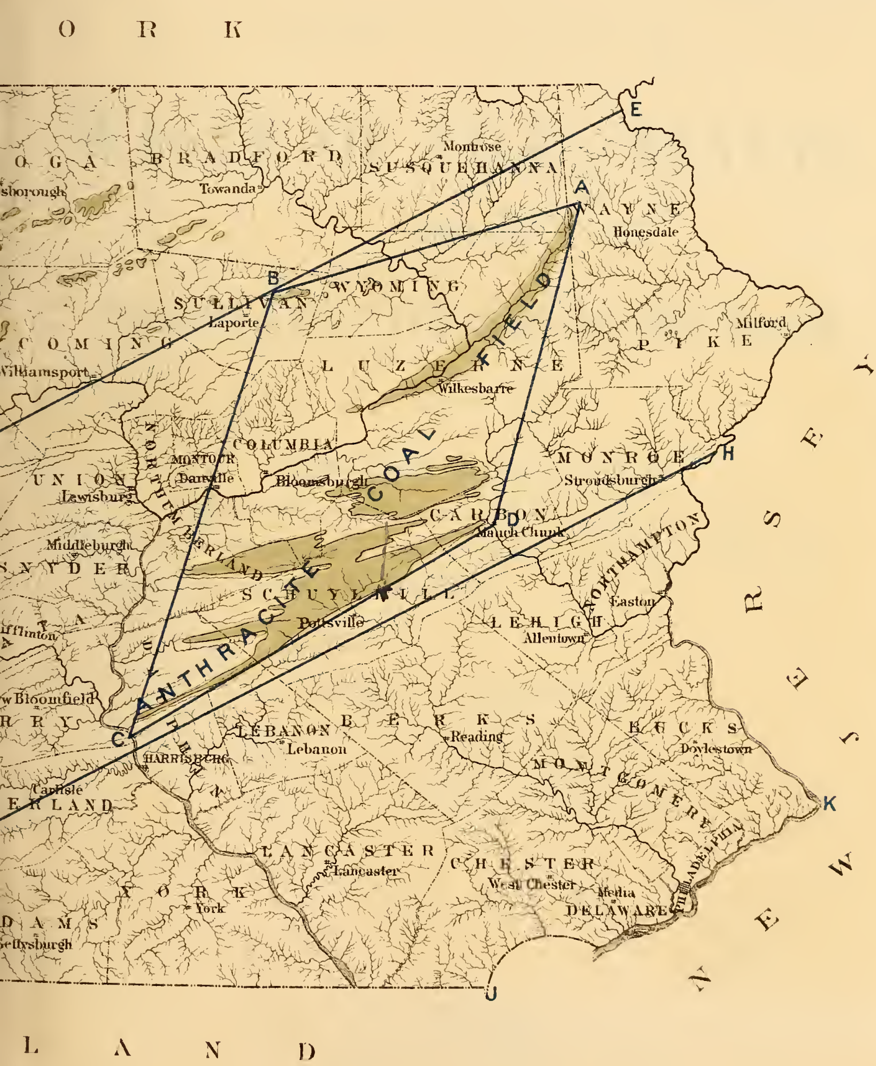


Julius Bien & Co. Lith.

ANIA

sylvania Anthracite Coal Field"

EFGH. THIRD=FIG. EFIJKH.



With the Compliments of

Eckley B. Coxe,

Drifton, Pa.

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APPENDIX A-1.

PHILADELPHIA, PA., May 20th, 1893.

Hon. Robert E. Pattison, Executive Chamber, Harrisburg, Pa.

DEAR SIR:—The Commission appointed under

AN ACT

To create a commission to investigate the waste of coal mining, with a view to the utilizing of said waste, and making an appropriation for the expense thereof.

SECTION 1. *Be it enacted, &c.,* That the Governor be and he is hereby authorized to appoint three competent persons to investigate the waste occasioned by the mining and preparing of coal in this Commonwealth, with especial reference to the reduction and utilization of said waste or culm. Said commission shall serve without compensation, but the actual expense of the investigation shall be paid by the Commonwealth, and to provide for the same the sum of $2500, or so much thereof as may be necessary, is hereby appropriated out of any money in the treasury not otherwise appropriated.

Approved the seventh day of May, A. D. 1889,

have the honor to submit their report.

The Commission sends herewith for the use of the Executive and Legislature, one thousand copies of the report which they have had printed, as they found that several of the persons furnishing information would do so only upon the condition that they could see the proof before the report was made public, and much of the other matter had to be revised by a number of people.

The amount expended by the Commission, including the lithographing of the maps and the printing of the one thousand copies of the report, is about $1900.00, or less than the amount of the appropriation. Should the Legislature desire a larger edition it can easily be made, as the type will be kept standing and the stones will be preserved until after the Legislature adjourns.

Yours respectfully,

ECKLEY B. COXE,
HEBER S. THOMPSON,
WILLIAM GRIFFITH,
Commissioners.

REPORT

OF

COAL WASTE COMMISSION.

THE Act creating the Commission was approved on May 7th, 1889, but the Commissioners were not appointed until February 19th, 1890. As originally constituted, the Commission consisted of J. A. Price, of Scranton, chairman; Peter W. Sheafer, of Pottsville, and Eckley B. Coxe, of Drifton.

On account of the business engagements of the different members, the distances they lived from each other, and the ill health of Mr. Sheafer, the Commission was not able to organize until May 21st, 1890, when they met in Mauch Chunk.

After carefully considering the subject, they decided upon a line of investigation which, with a few unimportant exceptions, is practically that set forth in the following report.

As the members of the Commission were all engaged in active business, and lived at some distance from each other, the work was divided into three parts, each member taking up those branches with which he was most familiar, with the understanding that they were to meet from time to time for consultation.

This method of procedure worked well, and matters were progressing very satisfactorily when the Commission had the great misfortune to lose Mr. P. W. Sheafer, who died on March 26th, 1891. He had taken great interest in his part of the work, and, notwithstanding his ill health, had already laid out his plans and gotten together a great deal of very interesting and valuable matter relating to the statistics of the coal trade, to the amount of coal in the culm and dirt banks, and to the size of the latter, at certain collieries, compared with the amount of coal already mined and shipped. Unfortunately, his sudden death left the data in such a condition that only a small amount of it could be utilized, although what he had done was placed by his family at the disposal of the Commission. Mr. Sheafer had been connected with the anthracite coal business for almost half a century, and was a leading authority on all matters connected in any way with the statistics of anthracite. He had for years been specially interested in the question of the utilization of the dirt banks, and in all improvements in mining tending to diminish the loss of coal.

On October 20th, 1891, Mr. Heber S. Thompson, of Pottsville, was appointed to take the place of Mr. Sheafer, and the Commission reorganized and divided up the work anew.

On August 2d, 1892, the Commission again lost one of its members by the death of Mr. J. A. Price, who was one of the first in the Commonwealth to realize fully the importance of utilizing the great accumulations of anthracite culm existing in the coal-fields. For many years he had been a persistent advocate of its value, and did much to bring it into use in many of the industries of the State, particularly in the neighborhood of the city of Scranton. He had studied the subject with a great deal of care, had made many experiments, and was familiar with all its branches. [D–3, No. 3; D–4, No. 26; D–4, No. 30.] By his untimely death the Commission again lost the result of a great deal of valuable work, as many of the papers he left were not in shape to be utilized by others. He was so familiar with the subject that he had not, when his unlooked-for death occurred, written out the results of the greater part of the work that he was engaged in.

On September 22d, 1892, Mr. William Griffith, of Scranton, was appointed to fill the vacancy, and as he had assisted Mr. Price in some of his experiments, and knew him well, he was able to afford valuable aid to the Commission in compiling its report.

After the Commission had organized and carefully examined the question submitted to it, the following conclusions were arrived at:—

First.—That the most important work to be done was to determine the causes of *waste* in its broadest sense, and, after stating them, to give briefly such suggestions as it could as to the lines in which effort should be made to diminish or avoid it.

Second.—That while it is important that attention should as far as possible be called to all the methods, apparatuses, furnaces, &c. (patent or otherwise), by which the smaller, and until recently valueless, sizes of anthracite can be and are gradually being utilized; yet a minute description of any apparatus, or a comparison of rival systems, would be out of place and beyond the powers of the Commission with the limited time and money at its disposal.

Third.—That while the body of the report should be as untechnical as possible, it should give the general results briefly but comprehensively.

Fourth.—That a series of appendixes should be prepared in which information of a more or less technical character, but of value to those wishing to make a closer and more detailed study of any part of the subject, would be given. They are as follows:—

APPENDIX A.

Estimate of the territory probably covered originally by the Pennsylvania anthracite coal-field.

Estimate of the amount of coal in the existing field before mining began.

Estimate of coal actually won at certain collieries.

Amount of coal worked up to January 1st, 1893.

Table of shipments up to January 1st, 1893.

The above were prepared by Mr. A. D W. Smith, of the Pennsylvania Geological Survey.

Diagram showing shipments by regions, by Howell T. Fisher.

Tabular estimate showing the approximate quantity of coal, with past and probable future production, in the several districts of the Northern anthracite coal basin of Pennsylvania, by Mr. William Griffith, a member of the Commission.

APPENDIX B.

Table showing the experience on locomotives with small anthracite of all railroads using the same, and giving such details as to the locomotives, the coal and its use, as could be obtained.

APPENDIX C.

A list as complete as possible of all patents that have any application to the subject, with the exception of patents on ordinary stoves, which are very numerous, and involve so many details that it is almost impossible to decide accurately which of them have reference to the subject.

APPENDIX D.

A list of such literature on the subjects discussed, mostly American, as the Commission thought would be of value to those wishing to investigate more fully any question treated here.

This literature is arranged as follows :—

References to Official Reports.
" " Transactions of Engineering Societies.
" " Private Reports.
" " Technical Journals.
" " Text-Books or Treatises.
" " Circulars from Patentees and Manufacturers.

APPENDIX E.

A list of grates, stokers, and furnaces, classified as follows :—

Inclined grates : Reciprocating, rocking, and stationary.
Horizontal grates : Reciprocating, rocking, and stationary.

Mechanical feeding arrangements: Fuel and air.

Traveling grates.

Circular grates: Horizontal, inclined, and underfeeding.

Rotary grates and grate-bars.

Domestic or stove grates. (A selection of those that seemed of interest.)

These articles are numbered consecutively in each table, and when a reference is made to any of them in the text, the number only will be used. Thus instead of referring to an article by giving the whole title, author's name, name of periodical, volume, &c., we simply give, for example, D–2, No. 3.

WHAT IS COAL WASTE?

The Commission has taken these words in their most comprehensive sense and has discussed the subject with the view of determining, as nearly as possible, what portion of the coal originally deposited has been, or will be, lost to the community, and the causes to which this loss is due, with such suggestions as they were able to make with the view of diminishing the waste in the future.

CAUSES OF WASTE.

Geological.—A very small percentage of the coal originally deposited now remains in the coal-fields, by far the larger portion having been carried away by the erosion following the uplifting of the strata by which the present anthracite coal basins were formed, as is more fully set forth in the report of Mr. Smith. Of the coal that remains, quite an appreciable percentage is rendered practically useless by the distortion to which it has been subjected when upturned; for where the dips are steep or overturned a large amount of coal has been twisted, crushed, and sometimes intimately mixed with the slates that occur either above, below, or in the vein, thus destroying or diminishing its value. The coal in those portions of the veins (or beds) which lie close to the surface is often more or less depreciated in quality by the action of the atmosphere, and the close proximity of rivers, creeks, and buried valleys may practically destroy the value of much coal of good quality.

At the request of the Commission, Mr. A. D W. Smith, of the Geological Survey, has prepared a very careful paper, giving, as far as could be obtained, information upon the following points:—

First.—Probable percentage of the coal originally deposited in Eastern Pennsylvania, which was left in the ground when the mining of anthracite first began.

Second.—Estimate of the amount of coal actually contained in each of the four basins when the mining began. A number of very valuable reports, showing percentage of coal obtained in working certain areas of certain veins and the amount of coal probably contained in some of the dirt banks [D–2, No. 14; D–3, No. 4; D–3, No. 5.]. Consideration and estimation of the percentage of coal actually contained in the ground which has been and can be shipped to market or used at the collieries.

Third.—Statistics of the anthracite coal trade up to January 1st, 1893, with a diagram showing the total anthracite shipments and the proportional output of the Schuylkill, Lehigh, and Wyoming regions.

It is not necessary to refer to the details more at length, as they will be found to be thoroughly explained in the report itself.

The Commission, in submitting the report of Mr. Smith, would call attention to the following facts:—

It does not pretend to be absolutely correct. The data for making a correct report do not exist, and will not probably exist for many years. The report is a very careful compilation of the facts now known, and is based on an immense amount of work done partly by the Geological Survey and partly by mining companies, individual operators, and mining engineers.

The estimate of the amount of coal originally in the ground is approximately correct, assuming that the veins will maintain the characteristics which they have near the surface or where they have been worked or opened.

A large portion of the data has been obtained from sections of veins taken from actual mining operations or from explorations, nearly 6000 in number, of which 2500 were in detail, and as the natural tendency is to work the better veins or portions of veins in preference to those less valuable, it is possible and probable that the sections on the whole may represent a somewhat better state of affairs than actually exists on the average. It is impossible to determine how much better the ground actually worked is than the average of what is left, and this fact may have a very important bearing in reducing the actual amount of good coal still unworked.

When we come to consider the amount of coal that can be obtained, the calculations become much more uncertain, for the following reasons: The percentage of coal to be obtained from any vein increases, first, with the smallness of the vein down to a certain point; that is to say, a vein 6 or 8 feet thick will yield a much larger percentage of coal than a vein 20 feet thick, and a vein of 20 feet a much larger than a vein of 40 feet, other things being equal. The nearer the vein is to being horizontal the greater will be the yield of coal; that is to say, a vein on a pitch of 5 degrees will yield more than a vein on a pitch of 30 degrees, and a vein on a pitch of 30 degrees more than a vein on a pitch of 50 degrees; first, because the amount of pillars required to sustain the horizontal roof, including gangway pillars, chain pillars, &c., is less in a horizontal vein; secondly, the pillars can be maintained of a more regular size, and cars can be run in and taken out of the breast so that the gangways can be further from each other, involving less chain pillar [D–1, No. 9], and the pillars in the gangway need not be so large; thirdly, pillars need only be maintained at long distance to retain the water; and, fourthly, when the cars are loaded in flat breasts the coal can be taken out cleaner and not so much left in the gob, and the mining and blasting can be carried out more systematically.

The amount of coal increases with the solidity of the roof. Where the roof is not good the pillars must be made larger, and a large quantity of coal is left in consequence of the roof falling and burying coal under it or cutting off available coal behind it.

The percentage of coal gotten from the vein depends also upon its purity. If the coal is in a single bed, say 6 feet thick, it will yield more than a vein of 8 or 9 feet thick containing the same amount of coal, but having slate through it. If the slate is distributed in the vein in large beds, which part from the coal, it will yield more coal than if the slate is distributed in many layers or attached to the coal or burned in, as the miners say. Should the 2 or 3 feet of refuse be distributed uniformly throughout the vein in the form of small, thin layers attached strongly to the coal the whole vein may be unworkable, as the cost of preparing it in the breaker may render it valueless commercially. This is an important factor in determining the quantity and value of the smaller sizes obtainable from a vein.

The amount of coal we may get from a given vein depends also upon its relation to the veins above or below it. If the vein stands alone with no other vein near it, it may, if the conditions are favorable, be worked very clean, while if there should be a number of other veins below it which have been worked, and the intervening strata is not of a very strong character, the vein, particularly if it is a small one, may be made unworkable by the caving in of the lower veins, or if worked at all may yield but a small percentage of the coal contained in it.

When working deep basins where the pitches are steep and where there are a number of veins, a large amount of coal may be lost in this way. It is possible also that in some of the basins the infiltration of water, due to overlying workings where considerable breaking up of the strata has occurred, may be so great that it would take all the coal that you could get from the vein to pump out the water. The existence of large creeks and rivers such as the Susquehanna, which covers a large portion of the Wilkes-Barre region, may also diminish the quantity of coal that can be taken from the veins.

The great buried valley referred to by Mr. Smith presents some very serious problems. It is also possible that in some of the deep basins there may be at the bottom more or less twisting of the strata, &c. In fact, the miner may at any time find a vein in fault and unworkable when he enters new ground.

In regard to the specific gravity of the coal, we are of the opinion that, while individual specimens selected for the purpose of determining the specific gravity may have given the figures used in Mr. Smith's report and taken from the reports of Mr. McCreath, of the Geological Survey, yet a number of experiments made lately by Mr. E. B. Coxe in his laboratory leads him to the conclusion that the average specific gravity of the pure coal in all the regions is probably less than those used in the tables. This is important, as a variation of 1 per cent. in the specific gravity would reduce the total number of tons of coal in the ground 195,000,000.

Mr. Coxe's determinations were made by obtaining samples from a large number of tons of prepared coal as it came from the breaker, selecting them by the method usually adopted for sampling ores, that is, by quartering down.

For the above reasons the Commission is of the opinion, in which Mr. Smith concurs, that the amount of coal that will be obtained finally may fall short, and in some localities far short, of the estimates given in this report.

The Commission also reprint, with the consent of the author, from the May, 1892, number of the *Colliery Engineer*, of Scranton, Pa., at the end of Mr. Smith's report, a tabular estimate showing the approximate quantity, past and future production of coal in the several districts of the Northern anthracite coal basin of Pennsylvania. This was prepared on April 20th, 1892, by Mr. William Griffith, now one of the Commission, but before he was appointed. This estimate was prepared from other data and upon a plan different from that adopted by Mr. Smith, neither gentleman being influenced by the other's figures in reaching his result.

Mr. Smith's figures are	5,697,380,784 tons.
Mr. Griffith's figures are	5,057,808,560 tons.
	639,572,224 tons.

A difference of about 12 per cent.

At the foot of Mr. Griffith's table will be found a clear statement of the method adopted by him in preparing it.

In reaching these results Mr. Griffith, in estimating, used 1.5 as the specific gravity, while Mr. Smith used 1.55. Mr. Griffith estimated the percentage of waste to be $23\frac{4}{10}$, while Mr. Smith estimated it at $18\frac{2}{10}$. These two differences account for a part of the variation in the estimates.

Waste by the Mining of the Available Coal left in the Ground.—This may be considered under two heads:—

First.—That which is absolutely necessary and cannot be avoided.

Second.—That which may be diminished or done away with by better methods of mining.

Unavoidable Waste by Mining.—It is evident that, except in very special cases, it is not possible to remove all the coal. A certain amount must be left in order to maintain the slopes, shafts, gangways, air-ways, &c., and in some cases to support the surface, as, for instance, under railroads, streets, houses, streams of water, &c. A thorough study of each area to be worked will enable the mining engineer to reduce this, but it will never be possible to take out all the coal, except by stripping. In thin veins, where the long-wall system [D–4, Nos. 33, 34, 35] of working is used, a very large percentage of the coal can be taken out, and where the method of gobbing up is used, as is very commonly the case in France (*méthode par remblais*), a very large percentage of the coal can be obtained. The possibility of adopting the latter method, however, depends very largely on the rate of wages paid in the district and the price of coal. The nature of the roof or of the floor of the vein may often be an insuperable obstacle to getting out all the coal. The proximity of the veins to each other is also a difficulty. In strata where there is a good deal of water it may be necessary to sacrifice coal in order to prevent the water from reaching the lower levels, and thereby causing too great an expense for pumping, including, as it may do, a great consumption of coal, so that it may be better mining to leave larger pillars. Where the pitch of the veins is great, it is often necessary near the bottom of the basins to leave considerable coal to prevent the whole superincumbent strata from crushing in the mine. In other words, to keep the mine safe and in such a condition that maximum quantity of coal can be worked economically out of the openings, a certain part of the coal must always be sacrificed. Where the mine generates large quantities of fire-damp, it may be necessary for safety to leave large pillars between the air courses, and it may not be possible to rob as closely as it would be were the mines free from gas.

It is one of the best evidences of engineering skill when the coal that must be sacrificed is determined and deliberately set apart for that purpose at the time the colliery is opened out, or very soon thereafter.

Avoidable Waste by Mining.—When any given territory is to be worked a much larger percentage of coal can be gotten out if the conditions in which the coal occurs are carefully studied, and a general system of working decided upon and thoroughly carried out from the beginning. One of the most important points is to leave large pillars more than sufficient to sustain the workings and to take no more coal than is commercially necessary until the boundary of the colliery is reached, and then to rob back carefully in sections, so that whatever caving-in occurs is back of the main body of the coal still to be worked. The gangways and other openings should be driven through the faults wherever it is necessary to properly open up the workings, and the coal should be mined regularly instead of taking only the better coal first, and leaving the inferior for future operations. One of the great causes of loss of coal is the tendency to leave too small pillars which are not sufficient to sustain the pressure or crushing, thus closing off much coal that could otherwise be gotten out. In order to avoid leaving in the ground much coal that is fit for market, the breakers should be prepared to take anything the mine may send to them, and the miners should not be required to leave coal inside because it contains more slate than the breaker is able to handle without cutting down its capacity. In many cases where veins contain bands of slate they are either not worked or only those portions of the veins which are pure are taken out; that is to say, in many cases a vein containing 10 feet of coal, interstratified with slate, will not yield more than a vein of clean coal 4 or 5 feet thick.

Waste Due to Preparation.—As is well known, anthracite coal is not sold in the same way as bituminous. The latter is generally sold "run of mine;" that is to say, the large, small, and dust are usually shipped together just as the coal comes from the mine, and, at the most, only 2 or 3 sizes are made. This cannot be done with anthracite, as in order to have a good economical combustion the pieces used in a fire should be as far as possible of about the same size. The sizes are known in the market, beginning with largest, as lump, steamboat, broken, egg, stove, chestnut, pea, buckwheat, No. 2 buckwheat or rice, and No. 3 buckwheat. Screenings made at shipping points are sold as "pea and dust," and there has already developed a large trade in what is known as culm, which is made at the mines, and includes some of the finer coals mixed with the dust.

As a general thing, much more lump, steamboat, broken, and egg are produced naturally than can be sold, and less stove and chestnut. This involves the breaking up by mechanical means of the surplus of the larger sizes. Pea, buckwheat, and the finer sizes must be sold as they are made, and it is impossible to diminish the quantity below a certain amount, dependent upon the quantity of coal broken and the method used for breaking it. These smaller sizes must therefore be sold at what they will bring, stocked, or thrown upon the dirt banks.

It is possible to make a certain quantity of any size of coal that is desired, but consumers who wish, for their own convenience, to use special sizes of which the production is limited, must pay not only the actual cost of making them, but also the loss of coal caused by the breakage. This breaking down of the coal is one of the great causes of waste. When pieces of coal coming from the mine are of such peculiar shapes that they cannot be burned with economy or convenience they must be broken into smaller sizes. In many mines large quantities of flat or abnormally long pieces occur which consumers will not take. A still larger portion of the coal must be broken, because it has attached to it pieces of slate or bone which renders it unfit for market. By breaking it down the objectionable parts can be removed in the preparation and a large amount of good marketable coal obtained.

Breaking up, of course, causes much loss, as the percentage of the smaller sizes, which are of much less value, and the percentage of dust, which is of no value at present, are greatly increased. Great attention should be given to the breaking of the coal. It seems to be pretty well demonstrated that less waste is caused when the coal is broken down by degrees, that is, when lump is broken to steamboat, steamboat to broken, broken to egg, &c., than when an effort is made to break down lump or steamboat directly into stove and chestnut. Careful study should in all cases be made of the way in which the particular coal breaks, and we should try to adapt the machinery to the nature of the coal. The ordinary method of breaking is by what is known as rolls. Great improvements have of late years been made in their construction. They were formerly merely cast-iron cylinders, with more or less rude cast-iron teeth upon them, but now they are constructed with much greater care. They are made of cast-iron cylinders carefully turned, with cast-steel teeth inserted in them very accurately, and great attention is paid to the form, construction, tempering, sharpening, and insertion of the teeth. They are so arranged that whenever a tooth becomes dull or breaks it can be taken out. Some use fluted cast-iron cylinders [D–2, No. 27]; that is to say, cylinders in which the teeth are continuous from one end to the other, the coal being broken very much as a man breaks a piece of chalk or a slate pencil with his two hands.

At Bernice, where the coal is very brittle, it is broken by means of chisels inserted in a head, which has an up and down motion very much like the hammer part of the steam-hammer, the coal passing under it. [D–1, No. 3.] A modification of the Blake rock breaker has been used, and also a breaker constructed very much like a coffee-mill; that is, there is a funnel-shaped cavity with teeth on it in which a cone covered with teeth moves. The shaft of this cone at the lower end is in a step, or ball and socket joint, while the upper end describes a circle, so that the axis of the shaft of the cone describes a conical surface.

At every colliery careful experiments should be made to determine whether the coal breaks with little or much waste. For example, the waste in breaking a ton of broken coal from one colliery may be two or three times as much as in breaking a ton from another colliery. Where this waste is much above the average, greater efforts should be made to sell the large sizes even at a lower price; or where several collieries belong to one company the orders for large coal should be given to the colliery making most waste in breaking.

Another great cause of waste is the screening. If the screens are overcrowded the pieces of coal abraid each other in passing through the screen. This may be diminished by making the screens shorter, taking the larger sizes out at the end, and dropping the smaller soon after the coal enters the screen. By putting two sizes of jackets upon the screen so as to make two sizes in each screen, and placing several screens under one another, each taking coal from the preceding one, waste of this kind may be diminished. In a number of collieries gyrating screens [D–2, No. 27] are used, in which the coal does not remain for any length of time upon the screen, and it is almost impossible for one lump to ride upon another.

In the construction of breakers the waste can be very appreciably diminished by arranging the chutes in such a way that the coal does not rush down them, and that there are no drops in the chutes or into the pockets. This also applies to the running of the coal into the screens. The coal should be allowed to enter the screens as gently as possible.

A certain amount of waste is made in loading cars which is very difficult to avoid, as the cars are at present of so many different sizes. If you have arranged to load a high car economically, there is waste in loading a low one, and if you arrange to load a low car economically you cannot load the high cars at all.

What has been said about the loading of the cars applies with great force to the unloading of the coal at the shipping points and loading it into vessels there. There is undoubtedly a great waste in this way. Attention is being called to this point, and better methods of loading and unloading are being adopted, although there is a wide field for invention and improvement here.

The demand for certain sizes of coal varies with the season, and there are times when more coal is produced than can be marketed, at other times more coal is burned than is mined; this is especially the case in the West, to which it is shipped largely by water, and where the coal is needed principally in the winter. In consequence of this condition of affairs large amounts of coal must be stocked in the dull season and picked up afterwards. Enormous storage plants have been erected all over the country, and much waste is occasioned by the handling of the coal in them, particularly with the older and more primitive plants. The loss on large sizes shipped by the lakes to Chicago, Milwaukee, Duluth, &c., and reshipped in cars there, amounts to from 5 to 11 per cent.; that is, there is that much pea, buckwheat, and dust made in handling the coal after it leaves the mines. Stocking coal should therefore be avoided as much as possible, and every mechanical device to reduce the breakage should be employed.

A large portion of the coal coming from the mine is either what we may call slate-coal or bony coal. By slate-coal is meant coal which has pieces of slate of greater or less size attached to it, which can be separated by breaking the coal into smaller pieces and subjecting it to preparation. Bony coal is coal in which the impurities are so intermingled with the coal that it is impossible to break the coal in such small pieces as to separate the impurities. Sometimes bony coal is merely coal with such a high percentage of ash as to interfere seriously with its burning. Until a comparatively recent date slate-coal and bony coal were practically wasted. They were either left in the mines by not working the veins containing any large quantity of them, or by not loading anything that was of this character. Of course this involved leaving behind much good coal, as it was very difficult for the miner with his poor light to separate them from the good coal. If brought out they were generally thrown on the dirt bank, except such portions as were sent to the consumer against his will.

To such a great extent was this carried on that many of the old coal banks are being worked with profit yielding as high as 75 per cent. of good coal. Already some of the collieries are putting a portion of their old dirt banks through the breakers with the fresh mined coal, where they have better facilities for cleaning it.

The above remarks apply, but with not so great force, to what is known as slippy [or crushed] coal.

In many collieries the coal thus lost was a very large percentage of what was actually won. We are not now discussing coal that was thrown away because it was too small. We are only referring to coal wasted because it was not marketable in the shape it came from the mines, and the breaker was not in condition to prepare it economically. It was considered that the coal that might be obtained would cost more than it would bring if an effort was made to save it.

The great difficulty was the want of proper facilities for preparation. The breakers as then constructed could not clean the coal properly. Much of the machinery now used in preparing anthracite, although to a certain extent known abroad, was not in use here. Reference has already been made to the improvements in rolls. The range of coal which it was possible to prepare has been much increased, and the cost of preparation diminished, by the adoption of apparatuses for separating the coal from slate by mechanical means. Among the most important of these are what are known as jigs [D–2, No. 27], of which there are several types used for the larger coals, and the Feldspar jigs, which are used for the smaller coals; the automatic slate pickers [D–2, No. 27], which enable the operator to remove a larger quantity of slate from the coal at a comparatively small cost when it is done on a large scale. The great advantage of these types of apparatus is, that the cost of preparation does not depend to so large an extent upon the amount of slate in the coal as it does where it is picked out by hand. In other words, coal containing more slate can be brought to a marketable condition with less expense.

When we come to the smaller sizes, bony coal is not so detrimental as it is in the large sizes. The bony coal, when ignited in large pieces, becomes coated with ashes and does not burn on the inside, leaving large masses of partially consumed material which goes out and eventually deadens the fire.

There have also been great improvements in the construction of the screens which are now made of much larger capacity, allowing a much better classification of coal. A great improvement in the screening of small sizes is the substitution of punched steel, copper, or bronze plates for wire screens and cast-iron screens. The openings are generally made circular and maintain their original dimensions better. The coal produced is of a more uniform size, and the jackets do not wear out as soon.

This saving of the impure coal is a matter of great importance. It tends to diminish the cost of production, because by utilizing the impure coal you increase the product of a mine without increasing either the cost of the plant, the driving of gangways, pumping, opening breasts, and the major part of the general expenses, and in addition the labor of the miner necessary to produce a ton of coal is decreased, as he does not have to spend his time separating the pure coal from the slate coal, and much good coal which in the old method was left with the refuse will be brought to the breaker. Of course it involves a much larger investment in building the breaker, which must be supplied with a large quantity of more or less costly machinery, every additional machine increasing materially the cost of the breaker.

Where the quantity of impure coal is large the labor account on the breaker, notwithstanding the saving due to machinery, is greater. It is probable, however, that in many cases the saving inside will at least make up for the additional cost outside. When this method of saving coal is adopted the yield per acre is very much greater. By far the most important saving of waste, however, that has been accomplished is due to the better utilization of the smaller sizes.

They were first used at the mines for making steam, and little if any care was paid to their preparation, but as the market for them began to increase more attention was given to it. It is very important that they should be properly sized; that is to say, that each kind of small coal should be as nearly as possible of uniform size. Pea coal should contain but little buckwheat, buckwheat should contain but little No. 2 buckwheat or rice, &c. This cannot be done absolutely, but the more perfect the sizing the more satisfactory will be the burning of the coal. These small coals vary very much in purity. If they are made exclusively by breaking up larger lumps of pure coal they will be a very desirable fuel; but if they are made from the dirty or crushed coal coming from the mine, particularly where the breasts are steep and much small slate is mixed with it, they may contain a very large quantity of impurities.

The coal must then be carefully jigged, otherwise the amount of clinker, ash, and refuse will be so great as to materially interfere with its use and value.

It is very important that the chemical composition of the coals should be studied; that is, they should be analyzed from time to time so as to determine the amount of ash and slate contained in them.

Bony coal when broken up does not do as much damage to the smaller coals as it does to the larger, although the purer the coal the better the results obtained will be.

A number of experiments were made in the testing laboratory of Coxe Bros. & Co., by Mr. John R. Wagner, in burning small coals, from which the following conclusions were arrived at:—

A series of careful experiments were made with a forced draught, obtained in one case by a fan and in the other by a steam jet, which showed:—

First.—That the ashes produced by a steam jet were never as low in carbon as those produced by the fan; that is, an appreciably larger per cent. of the carbon was utilized by the fan-blast. This appears to be due to the fact that when the carbon in the ash over the grate is reduced to a certain point the steam dampens it somewhat, and it ceases to burn sooner than it does when dry air only is blown through it.

Second.—That with the fan-blast the rate of combustion per square foot per hour is greater than with the steam jet.

Third.—It was found that where a bed of coal was ignited and burned out, the percentage of carbon in the ash is much less than where coal is successively added to the burning mass. In practice it is not generally possible to allow the bed to burn out sufficiently before adding the cold, unignited coal; the result is a damping down of the fire, which causes the ash to cease burning sooner than it would do if there were no reduction of temperature and checking of the draught due to the adding of the coal.

Fourth.—There seems to be no doubt that the introduction of steam into the ash-pit decreases very materially the tendency of the coal to clinker on the grate in comparison with the fan-blast or natural draught. It also changes the color, volume, and character of the flame and increases the distance that the flame extends beyond the bridge-wall. In many cases it is not practical, or at least it is very difficult, to burn the smaller sizes of coal without the steam jet on account of the clinkering. This effect of steam on clinkering is probably due to the fact that the steam, to a certain extent, moistens the ash close to the grate and prevents the ash from reaching there as high a temperature as it would with dry air. It is also probable that the decomposition of the steam into carbonic oxide and hydrogen, which takes place to a certain extent, and which, of course, is accompanied by a reduction of temperature, tends to prevent clinkering. The decomposition of the steam, accompanied by the formation of carbonic oxide and hydrogen, will probably account for the difference in the flame referred to. [D–2, No. 5.]

Fifth.—A careful study of the burning of culm, that is, the burning of small coals with more or less dust in them, in these and other experiments, seemed to show that in almost all cases it is accompanied by a very high percentage of carbon in the ash, which analysis showed, in some cases, reached 58 per cent. Unless special precautions are taken to prevent it, a large portion of the fine coal runs down through the grate. When the culm gets red hot it acts almost like dry sand and works its way into the ash-pit, thus increasing largely the percentage of carbon. Where coal has to be transported any distance, the value of the culm at the mines being very small, it is probable, from the investigations made, that it would be cheaper to remove the dust and transport only the larger coal.

Sixth.—It has been found that the percentage of iron pyrites, which occurs to a greater or less extent in all coals, increases very rapidly with the smallness of the coal. This is due to the fact that the iron pyrites occur generally in thin layers or incrustations on the coal. These thin layers are broken off and pulverized in the preparation and handling of the coal, and are therefore found to a much greater extent in the very small coal. It is, of course, well known that the presence of iron pyrites in fuel is very undesirable, as it generates sulphurous acid and has a tendency to destroy the grates or other iron work around the boilers, besides in many cases increasing the tendency to clinker.

Seventh.—That while the fan-blast produces the best ash and gives a more perfect rate of combustion, yet in many cases it is more advantageous to use the steam-blower on account of the clinkering, which may cause very serious trouble. In certain localities, particularly in cities, the noise of the steam-blower is sometimes a disadvantage.

Eighth.—While it is not positively demonstrated, it is thought that the question of mixing small coals from different veins or different localities is a matter of importance. It would appear that sometimes two coals, each of which, when burned separately, give reasonably satisfactory results, when mixed together clinker and give trouble, probably because the ash of the combined coals forms a much more fusible silicate than either of the ashes separately.

Ninth.—It would seem that the combustion of the small anthracite is more perfect when the coal remains undisturbed, or as nearly as possible in the condition in which it was put in the fire, instead of being turned over, so that the partially consumed and the unconsumed coal are mixed together.

COMMERCIAL CAUSES OF WASTE.

Up to this point the report has been confined to the consideration of the questions which concerned principally those engaged in the mining of the coal. We now come to the consideration of another series of problems, which are important to the general public, and in which their co-operation is more or less necessary in order to obtain more satisfactory results.

The first point is the effect that the rates of transportation have upon the utilization of the smaller sizes of anthracite.

Until a comparatively recent period the rates paid for all sizes of anthracite were the same, and as the smaller sizes came largely in competition with cheap fuels of all kinds, particularly bituminous coal, the higher rates of transportation charged had a tendency to restrict the market, in consequence of which all the buckwheats, and even some of the pea coal, were in many cases thrown upon the dirt banks.

The lower the relative value of any coal the less expense of transportation it can bear. For example: If two fuels, one worth 25 cents per ton and the other $2 per ton at the mines, were used at the mines, a saving of $15 per day would be made if 20 tons of the cheaper fuel would do the work of 10 tons of the more expensive; but if they should be carried to a point where the rate of transportation was $2 per ton, the 10 tons of the dearer fuel would then cost $40, while the 20 tons of the cheaper fuel would cost $45, thus causing a loss of $5 per day, assuming the cost of firing, &c., to be the same in both cases; therefore, in order to allow the cheaper fuel to compete, a less rate of transportation would have to be charged on it than on the more expensive fuel.

This point has been thoroughly recognized by the transportation companies, and of late years pea coal has been carried at a less rate than the larger sizes, and buckwheat at a less rate than pea, in consequence of which a very great increase in the use of the smaller sizes has been brought about. Of course, this development is not entirely due to the rate of tolls, but also to a better acquaintance of the public with the value of these fuels, and the invention of special furnaces, &c., to utilize them.

In order to make a market for any product it must be worth what it costs the consumer, and in addition must be known by or be made known to him.

It is now proposed to call attention, briefly, to the different methods by which the smaller sizes of anthracite are now utilized, as well as to those others which have been tried with more or less success, or which are in process of trial.

The sizes of coal generally classed under the head of small anthracites are pea, No. 1 buckwheat, No. 2 buckwheat, sometimes called rice, No. 3 buckwheat, and culm. The list below will give a clear idea of the degree of fineness of each, and represents all the different meshes used in the trade as far as the Commission could obtain data in regard to them.

Pea coal is made :—

Through $\frac{7}{8}$ inch square and over $\frac{5}{8}$ inch square ;
Through $\frac{7}{8}$ square and over $\frac{1}{2}$ square ;
Or through $\frac{13}{16}$ round punched and over $\frac{9}{16}$ round punched ;
Or through $\frac{3}{4}$ square wire and over $\frac{1}{2}$ square wire ;
Through $\frac{3}{4}$ square wire and over $\frac{3}{8}$ square wire ;
Or through $\frac{3}{4}$ square punched and over $\frac{1}{2}$ square punched ;
Or through $\frac{3}{4}$ square cast and over $\frac{1}{2}$ square cast ;
Or through $\frac{3}{4}$ to $\frac{5}{8}$ square wire and over $\frac{1}{2}$ to $\frac{3}{8}$ punched plate ;
Or through $\frac{3}{4}$ round punched and over $\frac{1}{2}$ round punched ;
Or through $\frac{3}{4}$ square wire and over $\frac{3}{8}$ square wire ;
Or through $\frac{3}{4}$ and over $\frac{7}{16}$;
Through $\frac{5}{8}$ and over $\frac{1}{2}$ round and square ;
Through $\frac{9}{16}$ and over $\frac{5}{16}$ round punched.

Buckwheat No. 1 is made :—

Through $\frac{5}{8}$ square and over $\frac{3}{8}$ square ;
Through $\frac{5}{8}$ square and over $\frac{1}{4}$ square ;
Through $\frac{9}{16}$ round punched and over $\frac{5}{16}$ round punched ;
Or through $\frac{1}{2}$ square wire and over $\frac{3}{8}$ square wire ;
Or through $\frac{1}{2}$ square and round wire and punched and over $\frac{5}{16}$ round punched plate ;
Or through $\frac{9}{16}$ round punched and over $\frac{3}{8}$ round punched ;

Or through $\frac{1}{2}$ square wire and over $\frac{1}{4}$ square wire;
Or through $\frac{1}{2}$ square cast and over $\frac{1}{4}$ square cast;
Or through $\frac{1}{2}$ square punched and over $\frac{1}{4}$ square punched;
Or through $\frac{1}{2}$ square wire and over $\frac{5}{16}$ round punched.
Or through $\frac{1}{2}$ square punched and square wire and over $\frac{1}{4}$ by $1\frac{1}{4}$ punched, and $\frac{1}{4}$ round punched and $\frac{1}{4}$ square wire;
Or through $\frac{1}{2}$ square wire and over $\frac{3}{8}$ square wire.
Or through $\frac{1}{2}$ square wire and square punched and over $\frac{1}{4}$ square wire and square punched;
Or through $\frac{1}{2}$ round punched and over $\frac{1}{4}$ round punched;
Or through $\frac{3}{8}$ square wire and over $\frac{1}{4}$ square wire;
Through $\frac{3}{8}$ round punched and over $\frac{3}{16}$ round punched;
Or through $\frac{1}{2}$ and $\frac{3}{8}$ punched plate and over $\frac{1}{4}$ and $\frac{3}{16}$ punched plate;
Or through $\frac{7}{16}$ square and over $\frac{3}{8}$ round;
Through $\frac{5}{16}$ round punched and over $\frac{3}{16}$ round punched.

Buckwheat No. 2 is made:—

Through $\frac{3}{8}$ square and over $\frac{3}{16}$ round;
Through $\frac{3}{8}$ round punched and over $\frac{5}{16}$ round punched;
Through $\frac{3}{8}$ round and over $\frac{1}{4}$ round;
Through $\frac{3}{8}$ round punched and over $\frac{3}{16}$ round punched (manganese bronze);
Through $\frac{5}{16}$ round punched and over $\frac{1}{8}$ round punched;
Through $\frac{1}{4}$ square wire and over $\frac{1}{8}$ by $1\frac{1}{2}$ punched;
Through $\frac{1}{4}$ square wire and over $\frac{1}{8}$ by $1\frac{1}{4}$ punched;
Through $\frac{1}{4}$ square wire and over $\frac{1}{8}$ square wire;
Through $\frac{1}{4}$ square wire and punched and over $\frac{1}{8}$ square wire and round punched;
Through $\frac{1}{4}$ square and round punched and wire and $\frac{3}{8}$ round punched, and over $\frac{1}{8}$ round punched;
Through $\frac{1}{4}$ square wire and over $\frac{3}{32}$ square wire;
Through $\frac{1}{4}$ square cast and over $\frac{1}{8}$ square cast;
Through $\frac{1}{4}$ square cast and over $\frac{1}{8}$ round punched;
Through $\frac{1}{4}$ square cast and over $\frac{3}{32}$ round punched;
Through $\frac{1}{4}$ square punched and over $\frac{3}{16}$ round punched;
Through $\frac{1}{4}$ square and over $\frac{1}{8}$ square;
Through $\frac{1}{4}$ round and over $\frac{3}{16}$ by $1\frac{1}{2}$ punched.

Buckwheat No. 3 is made:—

Through $\frac{5}{16}$ round punched and over $\frac{1}{4}$ round punched;
Through $\frac{3}{16}$ round punched and over $\frac{3}{32}$ and $\frac{1}{16}$ round punched (both manganese bronze);
Through $\frac{1}{8}$ square cast and over $\frac{3}{32}$ round;
Through $\frac{1}{8}$ square and over $\frac{3}{32}$ square;
Through $\frac{1}{8}$ and over $\frac{1}{16}$.

Culm or waste is made :—

Through $\frac{3}{8}$ square wire ;
Through $\frac{5}{16}$ round punched ;
Through $\frac{1}{4}$ by $1\frac{1}{4}$, $\frac{1}{4}$ square wire and $\frac{1}{4}$ round punched ;
Through $\frac{1}{4}$ oblong ;
Through $\frac{1}{4}$ square wire ;
Through $\frac{1}{4}$ square ;
Through $\frac{1}{4}$ round punched ;
Through $\frac{3}{16}$ by $1\frac{1}{4}$ punched ;
Through $\frac{3}{16}$ round punched plate (manganese bronze) ;
Through $\frac{1}{8}$ square wire ;
Through $\frac{1}{8}$ by $1\frac{1}{4}$ punched ;
Through $\frac{1}{8}$ round punched ;
Through $\frac{3}{32}$ square wire ;
Through $\frac{3}{32}$ round punched ;
Through $\frac{1}{16}$ round punched (manganese bronze) ;
Through $\frac{1}{16}$ round.

The small anthracites are used :—

1. *For Domestic Purposes.*—Pea coal is used successfully for heaters or furnaces, sometimes alone, and sometimes with large coal to reduce the intensity of the fire. Many people put pea coal on their furnaces at night, which keeps up a moderate fire, burning slowly and economically at a time when only a gentle heat is wanted. Pea coal is also used in ranges and stoves for cooking with excellent results and economy, when those using it understand how to handle it. Those accustomed to its use are perfectly satisfied with it. It is also an excellent fuel for low-down grates, where an intense heat is not desired. It is one of the best fuels for base burners when they are properly constructed.

It is probable that before many years most of the pea coal will be used for domestic purposes, and that it will take rank with stove and chestnut as a domestic size.

Buckwheat coal is used in large and growing quantities in towns for generating steam, which is supplied to private houses for heating and other purposes. The boilers are generally located near the railroad, and the steam is carried in pipes laid in the street just as gas pipes are. This is also done in large private houses and institutions.

The smaller buckwheats might also be used for this purpose. Any institution or private person heating a building with steam or hot water can use these sizes.

2. *Use for Generating Steam and for Manufacturing Purposes.* In this section we will only consider those cases where the coal is used as it is shipped from the breaker; the question of mixing it with other combustibles will be considered further on.

For many years pea coal has been used on a large scale for making steam on land and water. It is a favorite fuel for steamboats where cleanliness is desired. It is easy to handle, and can be burned on almost any kind of grate, or at least on grates that are much more simple than those required for the still smaller sizes. It can also be burned with natural draught, as the pieces are large enough to allow the air to pass freely through the interstices between them when the bed of coal is thick enough to make a good fire. Where the item of expense is not of the first importance, it is one of the best fuels in the world for manufacturing purposes and for steam vessels, and it is also used to a moderate extent for forging. It is sold through Pennsylvania, New Jersey, New York, Connecticut, Massachusetts, Maine, New Hampshire, Vermont, and Rhode Island, but is not much used in the South and West. It is used also for burning lime. It is seldom if ever used mixed with bituminous coal. It is probable that, as the demand for pea coal increases for domestic purposes, it will gradually be replaced as a manufacturing fuel by buckwheat coal.

Buckwheat coal is largely used for making steam. It is gradually taking the place of pea coal for that purpose. It is used for burning lime, and has a promising future for use in gas producers.

No. 2 buckwheat is just beginning to be used, principally for steam, either alone or mixed with bituminous coal and sometimes with sawdust and shavings. It has a large future in plants properly constructed for generating steam, especially for electric light and electric railway plants, as it is cheap, clean, and makes no smoke.

No. 3 buckwheat is used for steam, and it and dust are used by brick-makers to mix with the clay. Its use for generating steam offers a promising field to investigators.

3. *For Locomotives.*—One of the most important uses of small anthracite is as a locomotive fuel. [D–2, No. 1 and No. 13.] The following-named railroads use it to a considerable extent, with entirely satisfactory results in most cases, and effect a great saving in cost of fuel thereby, viz.: Philadelphia and Reading, Central Railroad of New Jersey, Delaware, Lackawanna and Western, Delaware and Hudson Canal Company, Erie and Wyoming Valley (Pennsylvania Coal Company), New York, Ontario and Western, and Delaware, Susquehanna and Schuylkill. The general tendency seems to be towards an increase in the number of locomotives burning small anthracite. Buckwheat is the size generally used on freight trains and pea on passenger trains.

The accompanying table (Appendix B) shows the results of the experience of the principal roads using the small sizes of anthracite as locomotive fuel. The data contained therein have been given by those in authority on the different roads, and their names will be found in the table. It was the aim of the Commission, in compiling this table, to give such locomotive dimensions as have a direct bearing on the burning of the fuel, as well as some comparative data as to the use and value of different kinds of locomotive fuels; and, also, information relating to the properties and preparation of the smaller sizes of anthracite coal used.

There seems to be no question as to the value of small anthracite on all but very fast trains. The sharp exhaust of the steam, when a locomotive is running at a very high speed, has a tendency to "turn up" the fire of small-sized anthracite, and also to draw a considerable amount of the smaller pieces out through the stack, which, in addition to being unpleasant to the passengers on the trains, is a loss of fuel.

It is probable, as Mr. Paxson states (in the table), that by using compound locomotives, the exhaust nozzles of which are larger, the exhaust consequently less sharp and the amount of steam required to run less than on simple locomotives, small anthracite may be used as fuel on even the fastest trains. In this connection attention is called to the statement in the Philadelphia and Reading (Main Line and Williamsport Divisions) column of the table that all locomotives built in future shall have fire-boxes suited for burning small anthracite, and also to the test of compound engine No. 229, on passenger service, in the Central Railroad of New Jersey column.

To burn small anthracite on locomotives a much larger grate surface is required than on those burning large anthracite or bituminous, as well as a special form of grate bar. Somewhat more skill is required in their use, as light and judicious firing is necessary with the small anthracite.

A strong argument in favor of small anthracite as locomotive fuel is, that a number of railroads now using such fuel are replacing the old fire-boxes for burning larger sized fuels by others suited for burning small sizes of anthracite in engines taken into their shops for general overhauling and repairs.

The Commission would therefore call attention to the value of small anthracite as locomotive fuel, particularly in cities and for suburban passenger traffic, where a not too expensive but smokeless fuel is desirable. For such use it will undoubtedly prove valuable, even at a considerable distance from market.

4. *Use in Gas Producers.*—After a period of trial which at first was not successful, pea coal, No. 1 buckwheat, and to a certain extent No. 2 buckwheat, are now being used successfully in gas producers for a great number of purposes, as is seen by the accompanying table. The two producers which are used at present are known as the Taylor and the Swindell. The improvement in the preparation of the buckwheat coals due to more perfect sizing and jigging, by

means of which latter the percentage of ash is reduced, opens a field for these fuels, which is constantly growing and promises to be very extensive. The following table shows the vast range of uses to which the gas obtained is applicable:—

Partial List of Uses of the small sizes of Anthracite with Gas Producers.

Sizes of Anthracite.	Number of Producers.	Kind of Producer used.	Kind of Work.
Buckwheat, Nos. 1 & 2	2	Taylor.	Firing biscuit and decorating kilns in pottery in Trenton, N. J.
Buckwheat, Nos. 1 & 2	6	"	Firing bone-black char-kilns in sugar refinery, Brooklyn, N. Y.
Buckwheat, No. 1 . .	2	"	Burning lime in Texas, Md.
Pea coal . . .	1	"	Drying steel ladles and converter bottoms, Steelton, Pa.
Buckwheat, Nos. 1 & 2	6	"	Tempering and annealing steel at South Bethlehem, Pa.
Buckwheat, No. 1 . .	13	"	Drying and roasting in soda-ash manufactory at Syracuse, N. Y.
Buckwheat, No. 1 . .	2	"	Roasting magnetic and sulphurous ore at Emaus, Pa.
Buckwheat, No. 1 . .	2	"	Roasting magnetic and sulphurous ore at Midvale, N. J.
Buckwheat, No. 1 . .	1	"	Running Otto gas-engine in Philadelphia, Pa.
Buckwheat, No. 1 . .	11	"	Firing spelter furnaces and revolving furnaces for deoxidizing zinc ore at South Bethlehem, Pa.
Pea & buckwheat, No. 1	2	"	Firing copper heating and annealing furnace at Ansonia, Conn.
Buckwheat, No. 1 . .	2	"	Drying moulds and cores in pipe foundry at Florence, N. J.
Buckwheat, No. 1 . .	1	"	Manufacture of Portland cement and sulphuric acid from gypsum at Buffalo, N. Y.
Buckwheat, No. 1 . .	6	Swindell.	Heating furnaces for heating muck bar at Oxford, N. J.

5. *The Manufacturing of Coke.*—A number of efforts have been made to utilize the anthracite dust by mixing it either with highly bituminous coal (such as gas-coal) or bitumen, and then coking it. The Pennsylvania Second Geological Survey made a number of valuable experiments

which are described at length in their reports. [D–1, No. 1 and No. 2.]

The late J. A. Price (originally chairman of the Commission) made a series of experiments at the gas-works in Carbondale, with the view of determining the possibility of making a coke by mixing anthracite culm with bituminous slack.

The following table shows the numbers of the experiments, weight of the bituminous, weight of anthracite, &c., as well as the analysis of the product obtained. The coke thus obtained gave the following results :—

Experiments in the Manufacture of Conglomerate Coke, made by William Griffith and Mr. Moon at Carbondale, May 20th, 1892.

No. of Test.	Weight of Bituminous Slack and Anthracite Culm.	Character.	Time Coked.	Moisture.	Volatile Comb. Matter.	Ash.		Carbon.	Sulphur.	Weight of Coke Drawn Wet.	REMARKS.
						Color.	Pr.cent.				
A	Bit. slack—100 lbs. . Anth. culm—100 lbs.	Coarse . . . Coarse . . .	$4\frac{3}{4}$ hours.	2.00	5.59	Red	11.67	80.73	.908		
B	Bit. slack—100 lbs. . Anth. culm—100 lbs.	Screened fine Screened fine	5 hours.	2.19	6.01	Red	12.16	79.64	1.088		
1	Bit. slack—80 lbs. . Anth. culm—120 lbs.	Fine . . . . Screened fine	$8\frac{1}{2}$ hours.	1.57	6.74	Light Red	12.10	79.59	.913	195 lbs. wet.	Coke loose and very friable. Much fine culm dust, absorbed much water.
2	Bit. slack—100 lbs. . Anth. culm—100 lbs.	Coarse . . . Coarse . . .	$8\frac{3}{4}$ hours.	1.95	5.25	Red	11.15	81.63	1.282	176 lbs. wet.	Coke quite strong, but friable, hard to get out of retort.
3	Bit. slack—100 lbs. . Anth. culm—100 lbs.	Fine . . . . Screened fine	$10\frac{1}{2}$ hours.	1.55	6.15	Light Red	12.40	79.90	.810	172 lbs. wet.	Coke quite firm, not thoroughly coked in the centre, friable.
4	Bit. slack—120 lbs. . Anth. culm—80 lbs .	Fine . . . . Screened fine	$10\frac{3}{4}$ hours.	2.12	4.02	Light Red	11.77	82.09	.735	182 lbs. wet.	Coke quite strong, and not so friable as previous test.

Analysis made in Coxe Bros. & Co.'s Laboratory.

When making coke in retorts from pure bituminous coal, the coke breaks into prisms and is not difficult to get out. When, however, the coke is made of a mixture of anthracite and bituminous as described here, the mass does not break up and is difficult to remove from the retorts. To do this without difficulty it would be necessary to have the retort much wider at the opening than at the other end.

In considering the above table it is necessary to note that the empty box in which the coke was weighed was 11 pounds heavier after than before the tests, having absorbed 11 pounds of water.

In each case the coke formed in one large firm mass which was very hard to break and get out of the retort, and the retort was, it was thought, smaller at the front end than at the back.

The bituminous slack used was furnished by the Hendricks Manufacturing Company from their stock of blacksmith coal, and was purchased from Berwind, White & Co. It was probably from the "Crown Freeport" seam of Jefferson County, Pa.

The anthracite was from the screenings of the local retail coal chutes and was probably mined by the D. & H. C. Co. in the vicinity.

In making the tests the coal was first weighed, and then carefully mixed by hand and charged into the gas retort, the gas plant at Carbondale being of the old style for manufacturing illuminating gas from bituminous coal. The coke was cooled after being drawn from the retorts by drenching with water, of which it absorbed quite a quantity, as is shown by the weight of the wet coke.

Mr. J. W. Pittinos also experimented in the same line and obtained a patent for the process (patent No. 279,796).

While it seems to be demonstrated that reasonably good coke can be manufactured as above described, yet the commercial conditions are such that there does not appear, except in special cases, any large field for the use of the culm and dust in this way. (See remarks in "MM" of the Geological Survey of Pennsylvania.) It might be done with profit at points where gas-works are located when a supply of cheap culm could be obtained, although it would probably require more retorts to produce the same number of cubic feet of gas per day.

6. *Mixed with Bituminous Coal.*—A large amount of culm and buckwheat is now being used throughout New York State and in some other localites by mixing it with a certain percentage of bituminous coal. It is very common in the large cities to buy the "pea and dust" made by screening the domestic sizes in the retail yards and use it in this way. Large quantities of culm are shipped from the Northern fields into New York State for a similar purpose. It is somewhat difficult to get exact data on this subject. One of the most satisfactory examples that the Commission has been able to obtain is a case in New York City, where ordinary yard "pea and dust" is burned for heating a large building. Ten parts of the "pea and dust" is mixed with one part of the bituminous coal, care being taken to break the lumps of bituminous and to mix the material thoroughly before firing. This combination of coals produces no smoke from a chimney 100 feet high, except occasionally a slight puff. In this case natural draught only is used. The application of small coal in this way depends upon the relative cost of "pea and dust" and bituminous coal, and it is probable that a large amount can be thus utilized.

Another test was made at the New York steam-heating plant on Cortlandt Street, the report of which, while not giving full details, contains information of value. Twenty-five hundred tons of culm which passed through $\frac{1}{4}$-inch mesh was shipped by the Old Forge Coal Company, of Pittston, Pa., to Perth Amboy, where it was mixed with 400 tons of bituminous slack from the Clearfield region, by loading boats with alternate layers of about 100 tons of anthracite culm and 20 tons of bituminous, as evenly as possible, until the boat was filled. This was unloaded in New York by steam scoop and deposited in a large hopper on the dock, from which it ran into carts which took it to the basement of the steam company's station. It was dumped into the cellar and carried to the top of the building by conveyors, from which it ran through chutes to the several floors. In this way the two coals were pretty well mixed. It was burned under Babcock & Wilcox boilers, provided with McClave grates and Argand steam blowers. The coal was fed by hand with a shovel. The result was satisfactory as far as the production of steam was concerned, but there was an increased quantity of ash produced, and more of the mixture was required to produce the same results than with buckwheat coal. The steam company considered that it was worth about 35 cents per ton less than buckwheat coal.

The bituminous slack caused the mass to ignite quickly and burn freely, so that it was not necessary to use as strong a draught as when culm alone is fired. The caking of the bituminous coal cemented together to a certain extent the culm and diminished the quantity that went through the bars. The experiment was made about 1891. It seems that the freight on the culm was too great to make it a success in competition with buckwheat coal at its present price, although, as just stated, there seemed to be no trouble in burning the coal and producing the steam.

7. *Mixing with Waste from Oil Stills.*—In some of the oil refineries No. 2 or 3 Buckwheat is used, mixed with the refuse or residuum of the works, called "coke," which is obtained by cleaning the stills after the oil has been run off. This material has about the consistency of cold molasses, and needs something to granulate it so that it can be handled readily. The fuel thus prepared is used principally under the stills from which the refuse is obtained. These fine anthracite coals furnish a most excellent means of utilizing this waste product in the refineries, the result being a combination of combustibles admirably adapted for the purposes for which it is used. The field, of course, is limited, depending upon the amount of refuse obtained from the stills. It is very important that the coal should be sized well so as not to contain any more dust than possible, as it then acts better in granulating the liquid which

is obtained from the stills so that it can be fired conveniently. When placed upon the fire. the refuse burns quickly, making an intense heat, and when it is burned off leaves the coal in a highly ignited condition.

8. *Utilization of Culm for the Manufacture of Artificial Fuel.* For the last 30 or 40 years a large amount of the culm of the semi-bituminous and anthracite coals has been utilized in Europe in the form of what is known as compressed fuel. The slack, after being mixed with some binding material, such as lime, clay, cement, tar, pitch, bitumen, starch, or other glutinous material, is compressed into rectangular or spherical forms, and then burned as large coal of the same size would be.

Some idea of the variety of the mixtures and kind of binding material used, &c., may be obtained by referring to list of patents relating to artificial fuels given in Appendix "C–2."

These fuels are made of different sizes and shapes, the favored size for domestic purposes being that of a hen or goose egg. Large quantities of this material are made with profit in Europe, and many attempts have been made to utilize culm in this way in the United States. The four factors upon which success or failure depend are the cost of the culm at the factory, the cost of the binding material, the cost of the labor, and the price at which it can be sold. Where culm can be obtained at a low figure close to market, and where the price of the larger coals is materially increased by the cost of transportation from the mines, there is good prospect of a profitable business; but where the price of the compressed fuel, after being manufactured, is increased by the cost of transportation, success is not so probable.

About the year 1876 the manufacture of compressed fuel was begun by the Delaware and Hudson Canal Company at Rondout, New York, from 92 per cent. of culm and 8 per cent. of pitch. The plant was sold to the Anthracite Fuel Company in 1876, after which the making of brick was continued several years, but was discontinued in 1880.

This fuel was made by mixing 92 per cent. of culm and 8 per cent. of gas-coal pitch in a pug mill with superheated steam, which was pressed into bricks of 9 inches by 4½ inches by from 3 to 6 inches, under a pressure of about 250 pounds per square inch. It was used on locomotives on the Delaware and Hudson Canal Company's Railroad and the local railroads. The coal was washed culm from loading pockets at Honesdale, discharged into the canal, and then elevated out and shipped to Rondout in boats.

It was found that the small particles of coal dust impinging on the tube sheet, &c., in the boiler, in consequence of the forced draught, would cut out the ends of the boiler tubes, and sleeves had to be placed in the ends of the tubes to prevent this.

These bricks would not disintegrate in the fire, and could be heated red hot throughout in a blacksmith's fire, then plunged into cold water until black and cold, then reheated and recooled, &c., without disintegrating.

The fall in the price of coal about that time and increased price of the gas-coal pitch, due to the greater value of coal-tar for chemical purposes, were probably the controlling causes of the stoppage of this plant.

In 1890 a plant was erected at Mahanoy City, Schuylkill County, Pa., by the Anthracite Pressed Fuel Company for the same purpose, which continued in operation during 1890, 1891, and 1892. The following facts have been furnished to the Commission:—

It was made of pure coal (fine) direct from the colliery rolls,	92 per cent.
pitch (a residuum from the coking of bituminous coal imported from England)	8 per cent.
Cost, culm, delivered	$0 30 per ton.
Cost, pitch	1 00 per ton.
Cost, labor	50 per ton.
Total cost of fuel at works	$1 80 per ton.

Tried on locomotive engines and burnt well. Did not disintegrate. Made steam as readily as with anthracite coal.

Suspended operations temporarily in 1892 owing to high price of English pitch, as that made in America did not suit.

When the fuel is to be used for manufacturing purposes, it is a serious question whether it will not be better to spend the money on an apparatus to burn the culm as it is, rather than to spend it to put the culm in shape to be burnt in an ordinary furnace. The money spent on the culm is gone when the culm is burned, while that spent on a furnace continues to be of value in utilizing the culm as long as the apparatus remains in operation.

The manufacture of compressed fuel for domestic purposes seems to have been more successful. That most generally used is known commercially as eggettes. They are manufactured from anthracite screenings or bituminous slack, with 3 to 6 per cent. imported bitumen, in plants erected by the "FuelPatents Company," of Philadelphia, Pa.

There are now in operation the following:—

The plant at Gayton, near Richmond, Va., which manufactures the culm of the Gayton semi-anthracite into eggettes. They are sold in the city of Richmond. The original capacity of the plant has been doubled.

The plant at Milwaukee, Wis., which manufactures eggettes of the anthracite screenings made in the shipments of anthracite coal from and to lake ports.

The plant at Huntingdon, Ark. [D–4, No. 55], (capacity 200 tons per day), which makes eggettes out of the bituminous slack from the mines of the Kansas and Texas Coal Company.

A new plant for which machinery has been ordered is in course of construction at Chicago, the capacity to be 8 tons per hour from hard and soft coal.

Recently a company has been organized to erect one at Denver, Col.

This method of utilization seems to be most successful in cities where the coal can be sold well, and where there is no freight to pay to destination.

An article has appeared [D–4, No. 57], claiming very successful results from a similar fuel, made by mixing

Pennsylvania anthracite culm with a compound the nature of which is not given. The method of manufacture is very similar to that which was employed at Mahanoy City and Rondout.

9. *As Pulverized Fuel.*—During the last 36 years a large amount of experimenting has been done with a view of utilizing culm by burning it as an impalpable powder, very much as gas would be burned. The plan adopted is to pulverize the coal and blow it into the furnace with the proper quantity of air. In some cases the powdered coal is heated before being blown into the furnace, and sometimes the heat is communicated to the coal in the furnace itself. [D–4, No. 58.]

The first effort in this direction seems to have been made about 1857 by Mr. John Bourne, of England. Messrs. Whelpley & Storer about 1870 began to experiment upon this process. In 1876 Mr. Isherwood, Chief Engineer of the United States Navy, made a number of experiments with this process which are described in his report to the Government. [D–1, No. 11.]

Mr. Charles E. Emery made a test of the Whelpley & Storer system at the Chickering Piano Factory in Boston about 15 years ago. The operation of the process was satisfactory, but the economy was not sufficient to justify changing from the old method of burning ordinary coal. From his experiments it seems that the process was successful technically, but that the commercial question would depend largely upon the price of the coal. The more expensive the coal used the more economical would be the process.

About 1873 Mr. F. R. Crampton described his experiments in burning powdered fuel. [D–2, No. 11; D–5, No. 2 and No. 5.]

Mr. Richard N. R. Phelps has also been experimenting extensively in the same line, but as yet there is no official statement as to the results he has obtained.

While the data available is not sufficient to justify the Commission in expressing a definite opinion as to the value of this method of utilizing the dust, yet, from the facts before them, they feel justified in hoping that in certain lines the utilization of coal in this way may possibly lead to important results. There are no plants at present in operation in which the powdered fuel is used commercially and successfully. A number of rumors reached the Commission that one or another of the pulverized fuel processes were in actual, practical, commercial operation, but none of them on being followed up could be verified. It would be very satisfactory to find that the fine coal could be employed in this way, as it seems probable that before long everything but the actual dust will be utilized. One difficulty in the way is the cost of reducing the finer culm to an impalpable powder. It seems, from all the information that has been obtained, that the more finely pulverized the coal is, the more certain will be the success of the process. It is easy to get roughly pulverized coal, but to reduce it to an impalpable powder is not by any means a simple or cheap operation.

As far as the Commission can gather from the reports which they have examined, the fine coal was in all cases obtained by pulverizing practically pure lumps of coal. The dust obtained from the culm bank would contain not only an appreciable amount of slate, but also quite a large amount of iron pyrites and other impurities which might interfere somewhat with the process.

Messrs. William H. Richardson and J. J. Bordman, of New York, have been introducing a process for burning coal in a pulverized state under the patents of J. J. Bordman. The tests, as far as the Commission know of them, were made with bituminous coal, with results that seem to have given satisfaction, but the Commission know of no tests made with anthracite culm by this process, although the owners of it claim it to be equally applicable to anthracite.

10. *Use for Making Paint.*—Recently the black dirt or blossom, which is coal that has been weathered on the outcrops of the purer veins near the surface, has been mined

and used for making black paint. Where pure, that is, free from earthy matter and completely disintegrated, it is very valuable for this purpose.

In the study that it has made of the question, the Commission have been very much impressed with the importance of the consumers of coal being made thoroughly familiar with the value of the smaller anthracites and the proper methods of utilizing them economically. Great waste is made in consequence of the want of this knowledge. They have come into use largely in consequence of their cheapness, and enterprising manufacturers and steam users have in many cases simply substituted the smaller fuel for the larger, using exactly the same kind of furnace, and, in many cases, the same kind of grate-bar that they did for the larger coals. One of the points which may be considered to be established is that neither the furnace nor the grate-bar most suitable for large coal is by any means the best for the smaller coals, nor is a furnace and grate specially adapted to bituminous coal a proper one for the small anthracite coals. The furnace should be made to suit the fuel, and the grate-bar for small coal should be so constructed that sufficient openings are left for the passage of the air; while the running of the coal through the grate-bars into the ash-pit is as far as possible prevented.

It has also been found that in most cases the smaller coals can only be burned with a forced draught. This may be accomplished by a suction in the chimney or by the air being blown into the ash-pit by a steam jet or by a fan or equivalent apparatus. It is thought, judging from the latest observations, that a combination of a suction in the stack and a blowing of air into the ash-pit will probably give the best results; if the blowing is sufficiently strong to force the air simply through the bed of coal, and the suction sufficiently powerful to carry the gases with the proper velocity under the boilers so that the temperature of the escaping gases is the lowest consistent with economy, the most satisfactory results will probably be obtained. There then will be no forcing of the hot gases out through the doors or orifices that may exist in the furnace walls.

It may also be stated that the finer coals should be burned with as thin a bed as possible, consistent with steady consumption, and that the fire should not be disturbed any more than is absolutely necessary. The grate surface should increase with the fineness of the coal; that is, the finer the coal the less pounds of fuel per hour can be burned economically on a square foot of grate. The temperature of the gases given off by a fire of small coal is lower than that of those given off by a fire of larger coal, so that for small coal the heating surface of a boiler of a given horse-power should be greater.

A great variety of grate-bars are used. They may be divided into three types, *i. e.*:—

First.—Those in which the grate is absolutely fixed, of which the old-fashioned grate-bar—one alongside of the other—and a cast-iron plate with holes in it, are types. There are many forms of grate-bars in use of this character, the tendency being to make the part exposed to the fire in small sections so as to allow for expansion without destroying or burning the bar.

Second.—Those of which the McClave and Howe bars are types, and which are movable, but in which the motion is only employed for discharging the ash through the bars; and,

Third.—Those of which the Wilkinson, Murphy, Brightman, and Roney are types, and which are movable, the motion being used not only for discharging the ash into the pit, but more particularly for feeding the fuel forward towards a certain point where the ash is discharged.

A table giving a classified list of the various grates, furnaces, &c., as far as they have come to the attention of the Commission, is given in Appendix E.

Mr. E. B. Coxe, a member of this Commission, has been experimenting for some time upon the question of the burning of small coals, and should the result justify him in so doing he will read before one of the engineering societies a paper upon that subject, and another paper upon the construction of furnaces to burn small anthracite economically.

In these two papers certain of the matters that have been partially discussed here will be treated more at length, and the results of the experiments which are now being made, and which are not completed, will be given.

The Commission would again call attention to the importance of reducing by careful preparation the percentage of slate and refuse in the small coals as low as it can be done economically, particularly if they are to be transported any distance, as there seems to be strong evidence that the percentage of slate and ash in small anthracites is the controlling factor in fixing their commercial value, indicating, as it does practically, the amount of fixed carbon contained in them, for there is not a very great difference in the amount of moisture and volatile matter contained in the various anthracites.

The more the subject is studied the more evident it becomes that the smaller coals should be analyzed from time to time, not only by the producer but by the consumer. It is not necessary to make repeated ultimate analyses once the general constitution of a coal is known, that is, the relative percentages of moisture, volatile matter, fixed carbon, and ash, only ash determinations need be made. It may be necessary occasionally to do so in order to be sure that no change has taken place in the character of the vein or veins worked.

It is thought by some that the fixed carbon is the only one of the component parts of the coal which gives in the furnace the number of calories which theory would indicate. The hydrogen and hydro-carbons do not seem to be utilized in the production of heat to the same extent as, theoretically, they should be [D-5, No. 9, page 100, end of first paragraph], so that the fixed carbon has really, if this view be true, more importance in determining the heat value of a coal than the other combustible material. In fact, it is claimed by some that the heat developed by the fixed carbon in anthracite is greater than the amount of heat that would be developed by the burning of the same amount of fixed carbon of charcoal. [D 5, No. 7, page 81, bottom of page.]

The Commission does not in any way indorse these suggestions, but refers to them only for the purpose of drawing attention to the question and eliciting further light on the subject which has so great importance in fixing the true value of the small anthracites, as they may be considered to practically consist of fixed carbon and ash. In this connection attention would be specially called to chapter V., page 60, volume 3, of the Annual Report of the Geological Survey of Arkansas of 1888, in which considerable attention is given to the question of the burning of coal.

One of the most important questions which occupied the attention of the Commission was the value of the old culm and slate banks which have been accumulating for many years in the anthracite coal region, as well as the prospective value of those which are now being made. The old banks may be divided into three classes, viz.:—

First.—Those banks containing only culm; that is, coal too small to be sold at the time the bank was made.

Second.—Rock and slate banks, consisting exclusively of rock and slate.

Third.—The ordinary slate banks, consisting of various sizes of slate, coal, bony coal, and slate-coal mixed.

Unfortunately, in most cases all these substances have been dumped together. Where they have not it will be much easier to utilize the culm in the culm banks and the coal in the slate banks. The rock banks containing no coal are useless.

Not only has the value of the banks been much reduced by mixing the slate coal and rock with the small coal, but not infrequently ashes, old lumber, manure and other refuse have been dumped with them, thereby still further lessening their prospect of being reworked. Often, either from spontaneous combustion, accident, or maliciousness, fire has been started in the banks, and they have either been practically consumed or so damaged as to destroy their value.

In some cases, where the banks have been unfavorably situated, a large amount of coal has been lost by weathering and washing away. In many cases, where the wet method of preparation is used, a large portion, if not practically all, of the culm has been washed down the streams and forever lost.

It seems to the Commission that, in view of the future value of the banks, precaution should be taken to stock separately, as far as possible, all the different kinds of refuse, to avoid the mixture of any foreign substance, such as ashes, with the culm or slate banks, and to protect, as far as possible, the banks from fire and washing away. While it is impossible to prevent the decomposition of coal by the action of the air, this can be diminished very materially by making the banks as high and wide as possible, so as to expose the minimum amount of surface for a given quantity of culm to the action of the air.

In the Wyoming region, in the neighborhood of Plymouth, and in the Schuylkill region, in the neighborhood of Shenandoah City, a large amount of the finer culm [which is mixed with water and run into the mines], has been and is being utilized for the purpose of filling up the already partially worked-out mines, either for the purpose of allowing a larger proportion of the coal to be worked, or for supporting the superincumbent strata. [D–4, No. 28.] In Shenandoah City a large portion the town, which was threatened with destruction in consequence of the caving in of the mines, has been rendered secure by filling up the old workings in this way. In many cases it packs so solidly that pillars, which would otherwise be lost, can be worked out, the roof being largely supported on the culm run in. Of course the coal in the culm is lost, and this might be saved by using other material of no value, such as sand, &c.

A large amount of the slate, rock, and culm has been and is still being used for grading railroads and common roads, filling up cave holes, &c., but as the value of the culm increases its use for this purpose will probably decrease.

The coal washed down the streams is not entirely lost. In some places where pools or dams occur the coal deposits and is dredged out and used or sold.

At Northumberland, Pa., this is done on a large scale in the dam in the Susquehanna River. In winter holes are cut in the ice over the places where the coal has deposited and it is dredged out by hand, loaded on sleds and hauled away. In warmer weather a steam dredge is used for the same purpose.

In order to determine the amount of waste made in a breaker provided with the modern appliances for saving the small coal a test was made at Drifton, Pa., of the refuse sent from the iron breaker [D–2, No. 27], from 4 o'clock P. M., September 20th, until 9 o'clock A. M., September 24th, 1892.

It was desired to determine the general character of the material going to the bank and to see whether it contained enough carbon to burn, if dumped, without any further preparation, into a cupola-like furnace with forced draught. To do so successfully it would probably be necessary to remove all dust and No. 3 buckwheat, so as not to choke the draught. Hence the column in the accompanying table headed "For Burning at Mines."

Test of Slate Bank at Iron Breaker, Drifton. Average of Run from September 20th to 24th inclusive.

COAL SENT TO MARKET DURING PERIOD OF TEST.			PHYSICAL COMPOSITION.							CHEMICAL COMPOSITION.				
Sizes.	Tons.	Per Cent.	Sizes. Per Cent. With Dust.	Sizes. Per Cent. Without Dust.	Coal and Slate in Bank in the Various Sizes.		Fuel Value of Bank. Commercial. Bank with Dust.	Fuel Value of Bank. Commercial. Bank without Dust.	Fuel Value of Bank. For Burning at Mines.	Moisture.	Volatile Combustible Matter.	Ash.	Carbon.	Specific Gravity.
Lump . . .	662	9.83												
Steamer . .	294	4.36	7.96	13.21	Pure coal	00.00								
					$\frac{3}{4}$ coal	4.65	0.652	1.081						
					$\frac{1}{2}$ coal	9.40								
					$\frac{2}{10}$ coal	10.84			.824					
					Slate	75.11								
Broken . .	1086	16.10	7.94	13.17	Pure coal	00.00								
					$\frac{3}{4}$ coal	3.12	0.583	.950						
					$\frac{1}{2}$ coal	9.75								
					$\frac{1}{3}$ coal	16.61			1.078					
					$\frac{1}{4}$ coal	2.82								
					Slate	67.70								
Egg	1081	16.01	13.78	22.85	Pure coal	3.91								
					$\frac{3}{4}$ coal	12.89	2.735	4.536						
					$\frac{1}{2}$ coal	12.55								
					$\frac{1}{4}$ coal	12.63			3.170					
					Slate	58.02								

					Pure coal	7.63							
					$\frac{3}{4}$ coal	10.12	1.709	2.898					
Stove	813	12.04	7.01	11.62	$\frac{1}{2}$ coal	13.57							
					$\frac{1}{4}$ coal	10.56			1.964				
					Slate	54.75							
					Pure coal	21.22							
					$\frac{3}{4}$ coal	10.67	3.774	6.049		1.18	5.38	18.93	74.51	1.678
Chestnut	771	11.43	10.66	17.27	$\frac{1}{2}$ coal	11.61				0.80	6.12	32.05	61.03	1.818
					$\frac{1}{4}$ coal	8.73			4.006	0.63	6.41	45.77	47.19	1.958
					Slate	47.77								
					Pure coal	34.55	1.178	1.955	1.178	1.97	4.61	10.30	83.12	1.578
Pea	636	9.42	3.41	5.66	Slate and bone	65.45								
					Coal, bone, and slate, average					1.37	6.50	51.02	41.11	2.033
No. 1 buck-					Pure coal	55.00	1.999	1.985	1.199	.92	4.19	9.75	85.14	1.548
wheat	511	7.57	2.18	3.61	Slate and bone	45.00								
					Coal, bone, and slate, average					0.75	5.62	35.66	57.97	1.855
No. 2 buck-					Pure coal	57.71				.56	4.71	7.25	87.48	1.548
wheat	440	6.55	4.01	6.62	Slate and bone	42.29	2 314	3.820	2.314					
					Coal, bone, and slate, average					1.98	5.69	34.25	58.17	1.791
No. 3 buck-					Pure coal	74.73				1.15	5.30	8.00	85.55	1.548
wheat	452	6.69	3.59	6.00	Slate and bone	25.27	2.683	4.484						
					Coal, bone, and slate, average					1.22	4.97	25.07	68.74	1.690
Dust throu'h $\frac{3}{32}$-in. mesh	...	...	39.46	...						2.31	6.21	24.87	66.61	1.622
	6749	100.00	100.00	100.00			16.827	27.758	15.733					

Average daily output (railroad weight), 1350 tons.

From the first column under "Fuel Value" (commercial) it is evident that the larger sizes contain so little carbon that it would be advisable to remove everything above stove coal, thus diminishing the bulk 30 per cent., with a loss of only 5 per cent. of carbon, and it is doubtful if much of this carbon from these large lumps could be utilized, as only their surface would be oxidized.

After removing, in addition, the No. 3 buckwheat and dust (equal to 43 per cent.), there would remain 27.25 per cent. of the total bank, having a coal value of 39 per cent. This with a forced draught might be burnt. The table shows that if the Nos. 2 and 3 buckwheats and the dust, amounting to 47 per cent. of the total bank, and having a fuel value of 75 per cent. of good coal, were burnt, say, with a mechanical stoker, there might be a chance of utilizing them in that way.

The dust from the settling-tanks is 39.46 per cent. of the total bank, or (if we allow 4.5 per cent. to come with the slate from the jigs) 35 per cent. This could be dumped separately and would then give us other percentages. Hence the columns headed "Without Dust."

From the table we find that the refuse consisted of 48.01 per cent. of coal and 51.99 per cent. of absolute slate; that the material that would not pass through a round hole $\frac{3}{32}$ of an inch in diameter contained 18.416 per cent. of coal and that which would pass through 29.595 per cent. of coal (making the 48.01), if we assume, as the analysis seemed to show, that the dust was about 75 per cent. pure coal. The 18.416 per cent. included not only the pure coal, but the $\frac{3}{4}$ coal, $\frac{1}{2}$ coal, and $\frac{1}{4}$ coal, reducing them to their equivalent value of pure coal, but much of this latter is not at present marketable. The actual marketable coal thrown away was—

Egg	0.539 per cent. of bank.
Stove	0.770 per cent. of bank.
Chestnut	3.155 per cent. of bank.
Total large sizes	4.464 per cent. of bank.
Pea	1.178 per cent. of bank.
Buckwheat	1.200 per cent. of bank.
No. 2 buckwheat	2.314 per cent. of bank.
No. 3 buckwheat	2.683 per cent. of bank.
Total small sizes	7.375 per cent. of bank.

Total of all sizes 11.839 of bank, which is 2.48 per cent. of breaker output and 2.01 per cent. of everything hoisted. (Compare pages 130 to 145 and page 151 of Appendix A.) The coal (48.01 per cent.) mixed with the refuse is 9.88 per cent. of breaker output and 8 per cent. of run of mine hoisted, and the actual slate is 11.12 per cent. of breaker output and 9 of run of mine hoisted.

What was actually sent to the bank is 21 per cent. of breaker output and 17 per cent. of run of mine. The dust, which is 39.46 per cent. of the bank, is 8.28 per cent. of breaker output and 6.70 per cent. of run of mines.

Notes on Test.

Sampling.—The original sample consisted of 13 cars (37.06 tons), which were dumped in a pile from Tuesday, 4 o'clock P. M., till Saturday, 9 o'clock A. M. (September 20th to 24th, 1892, inclusive), 1 car being taken out of every 15 from the total that was hauled to the slate bank during that time. A smaller sample, which amounted to about 15 tons, was taken (by cutting 3 grooves from bottom to the top and 3 lengthwise.) This was further reduced to $2\frac{1}{2}$ tons, which was sized and separated in the laboratory.

Steamer.—Steamer was the largest size of coal or slate found, and was all very flat.

The $\frac{3}{4}$ coal from this would make chestnut and all below, if crushed.

The $\frac{1}{2}$ coal was slate and coal closely interstratified. About half of this would do for crushing to chestnut and all below.

The $\frac{2}{10}$ coal not suitable for crushing.

The pure slate is solid, heavy slate, very flat.

Broken.—Broken not quite as flat as steamer.

The $\frac{3}{4}$ coal suitable for chestnut and all below, if crushed.

The $\frac{1}{2}$ coal suitable for pea and all below, if crushed.

The $\frac{1}{3}$ coal not suitable for crushing, but still having this fuel value.

The $\frac{1}{4}$ coal not suitable for crushing, but still having this fuel value.

The pure slate, good, heavy slate, but not so flat as steamboat slate.

Egg.—Pure coal from egg mostly flat and thin. Bone more or less cubical.

The $\frac{3}{4}$ coal suitable for chestnut and all below, if crushed.

The $\frac{1}{2}$ coal suitable for pea and all below, if crushed.

The $\frac{1}{4}$ coal not suitable for crushing; friable and interstratified.

The pure slate flat and long.

Stove.—Pure coal is all first class.

$\frac{3}{4}$ coal. Coal approaching what is known as iron gray included in this. Much of this could go to market.

$\frac{1}{2}$ coal contains much real iron gray; would do for buckwheats.

$\frac{1}{4}$ coal rather flat. Nothing to be gained by crushing.

Pure slate (90 per cent. slate), very thin and heavy.

Chestnut.—Pure coal first class.

$\frac{3}{4}$ coal. All this would be passed as coal in opinion of Coal Inspector. (Three-quarter coal is that which has a slight layer of slate on it or approaches iron gray. All of it fairly cubical.)

$\frac{1}{2}$ coal contains bone, and real iron gray. By crushing it would make buckwheat, as it is not flat.

$\frac{1}{4}$ coal. Nothing gained by crushing. Mostly very flat.

Pure slate (90 per cent. slate), flat.

Pea and Buckwheats.—Separated by zinc chloride solution of 1.70 specific gravity, all that floated being considered coal by Coal Inspector. Not much bone in slate that sank.

According to rules for inspection in force at the time of sampling the allowable per cent. of slate and bone was:—

In broken	$1\frac{1}{2}$ per cent. of slate and bone.
In egg	1 per cent. of slate and 2 per cent. bone.
In stove	$3\frac{1}{2}$ per cent. of slate and bone.
In chestnut	$4\frac{1}{2}$ per cent. of slate and bone.

The Commission desires to call the attention of the people of the Commonwealth to the great importance of the enormous quantity of culm, bony coal, and slate coal now on the surface in the dirt banks, and which is being rapidly increased. At the present time less of the finer coals is thrown away, but it is only a few years since practically everything below pea coal was considered refuse.

This coal is a very valuable fuel for several reasons. In the first place, it will not, under ordinary circumstances, take fire, and therefore can be stocked cheaply. It is a smokeless fuel and makes a very clean fire, which is a great advantage in many manufacturing industries. It can be purchased for a very low price at the mines. It is the opinion of the Commission that not only is the culm available, but that a very large percentage of the slate banks, if roughly sized, could be used with economy and profit for making steam; provided they are burnt where they exist and do not have to bear much expense of transportation. The capacity of any fuel to bear transportation decreases very rapidly as the percentage of ash increases.

In many places in Europe coal which is no purer than the average of many slate banks is used at or near the collieries for making steam. With the improvements now being made in furnaces, grates, &c., for burning fine coal, it is probable that all, except, possibly, the actual dust, will eventually be sent to market, and that the local consumption for steam will be supplied by the inferior or slaty coal which is not suitable for shipment.

The firm of Coxe Bros. & Co. have already begun to investigate the subject with a view of erecting a furnace for the purpose of determining how high the percentage of ash in bony and slate-coal must be in order to prevent its burning in large quantities in a properly constructed furnace. Observations made upon slate banks which have been on fire lead to the conclusion that coal containing much more slate and other impurities than is generally supposed to be sufficient to render it incombustible, will burn under proper conditions on a large scale. Little or nothing has been done in this field, but the Commission thinks it wise to call the attention of those interested to the possibility of obtaining valuable commercial results in this direction. It is of great importance to the prosperity of the interior of the State that the attention of those who are engaged in such industries as require either heat or steam at a low price be called to the great advantages offered by the anthracite coal regions and their immediate vicinity for such enterprises. With the culm, bony coal, slate coal, &c., obtainable at low prices, with a good climate, healthy surroundings, good water, and unequaled railroad facilities, giving direct communication with the Mississippi River, the Great Lakes, and the seaboard, it is doubtful whether any part of the country offers greater advantages for profitable investments of this kind. The inferior coal should not be taken to the point of consumption, but the point of consumption should be brought to it.

The great industrial establishments that have been built up around Scranton by the use of cheap fuel indicate what is possible in this line. The coal regions, employing as they do only men and boys, offer great advantages to those industries which can employ female labor, of which there is a surplus there.

The Commissioners wish it to be understood that this report is and can be only a preliminary examination of the question. They realize fully how far from complete it is in every branch of the subject that has been considered; but the time and means at their disposal prevented it from being otherwise. They hope that it will call the attention of the engineering profession, of the manufacturer, of the producer, and the consumer of coal, and of all those interested in the welfare of the State and our great industries, to the lines in which effort should be made to utilize that which, *now called waste*, is really a storehouse of energy and a source of wealth. It offers a better field to the energetic, active, and enterprising young men of the country than many of the gold and silver mining districts of the world.

One of the most important and suggestive parts of this report is the estimates of coal in the ground, coal mined, coal lost, &c., contained in Mr. Smith's report (Appendix A). The Commission do not consider it wise to condense what he has written, but respectfully urge all those who may read this publication to study the figures he has given with attention; they will well repay the labor expended on them.

In conclusion, the Commission wishes to thank the coal mining and railroad companies, the private operators, and those engaged in the practical management of the works, for the enormous amount of very valuable information which has been generously furnished to it. Without the active co-operation of these gentlemen it would have been impossible to have obtained much of the more valuable material contained in this report.

ECKLEY B. COXE,
HEBER S. THOMPSON,
WILLIAM GRIFFITH,
Commissioners.

APPENDIX A-1.

By A. D W. Smith, Philadelphia.

ESTIMATE OF THE ORIGINAL GEOLOGICAL ANTHRACITE COAL-FIELD OF PENNSYLVANIA.

Our knowledge of the extent of the original anthracite coal-field and the number and the thickness of its coal-beds is quite too insufficient to make any estimate possible other than a very broad generalization.

Professor J. P. Lesley in the third volume of his Final Report Pennsylvania Geological Survey will give in full the argument for the hypothesis that the carboniferous coal-field covered the whole State of Pennsylvania, and many of the neighboring States as well.

Accepting this hypothesis, we are still confronted with the question as to what portion of this great coal-field was changed into an anthracite coal and how much remained bituminous. That the anthracitic condition was produced by, or closely connected with, the great uplifting and folding of the strata which took place at the close of the Carboniferous period is not questioned.

The disturbed area is well defined, but how much of the coal of the beds which covers this area was changed to anthracite we do not know; that it all was not changed would seem to be shown by the Broad Top coal-field in Huntingdon County, although in the midst of the disturbed region the coal-beds are semi-bituminous.

Of the vast anthracite coal-fields originally existing there remains preserved from erosion only some 480 square miles, separated into different fields and basins by the underlying rocks. In many of the basins none but the lowest coal-beds have been preserved.

That the anthracite field extended far to the east is shown by the small patches of anthracite in Rhode Island which have been preserved from erosion. This would seem to fix the Delaware River (the State line) as the eastern limit of the Pennsylvania field.

The northern limit is approximately fixed by the Bernice coal basin in Sullivan County, where the coal is an anthracite, while in the Barclay basin, some 15 miles northwest, the coal is semi-bituminous.

The Allegheny Mountains, the eastern limit of the existing bituminous field, prohibits a further western extension, while the Broad Top field in Huntingdon County would seem to limit the extension of the field in a southwesterly direction.

In the large area in the southeastern part of the State, comprised in Northampton, Lehigh, Berks, Lancaster, York, Adams, Chester, Montgomery, Bucks, Philadelphia, and Delaware Counties, erosion has carried away every trace of any coal-beds that may have existed there, and many thousands of feet of the underlying strata as well. Accepting, however, the hypothesis that "the carboniferous coal-fields originally covered the whole State, and that the anthracite condition was caused by or was attendant upon the uplifting and folding of the coal-beds and surrounding strata," as Southeastern Pennsylvania was the scene of greatest disturbance, it would seem reasonable to suppose that any bituminous coal-beds deposited here, were changed to anthracite, or, owing to the great pressure and disturbance, possibly to a graphite.

We would have then in the south and southeast the boundaries of the State as the extreme limit of the original Pennsylvania anthracite fields.

As to the number and the thickness of the coal-beds contained in the original geological coal-field, our only definite knowledge is to be gained by a study of the beds still remaining.

The accompanying sheet of columnar sections illustrates the number and thickness of the existing beds throughout the field.

Probably the highest workable coal-bed is the Brewery

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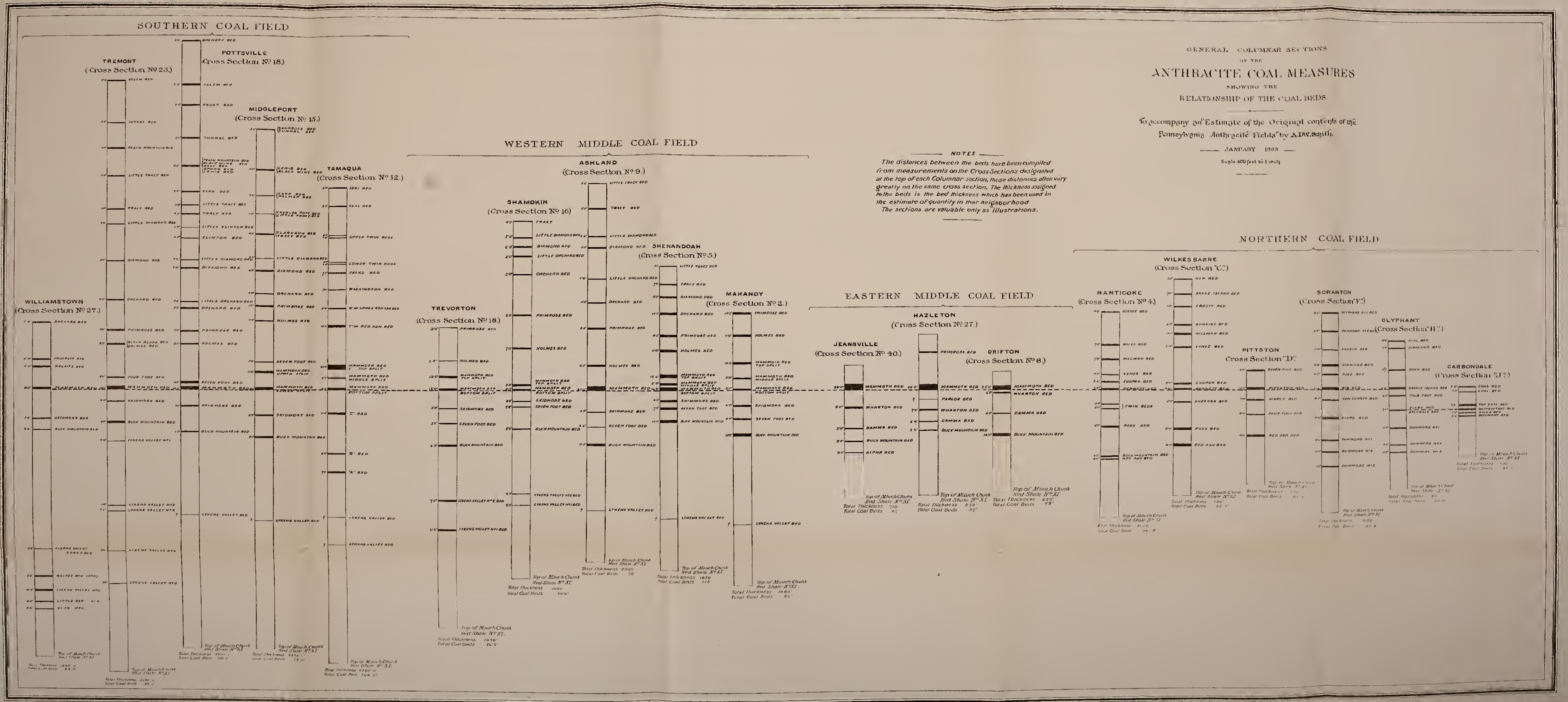
ion"F")

OLYPHANT Nº1 BED

OLYPHANT
(Cross Section"H")



JULIUS BIEN & CO LITH N.Y.

bed found in the Southern coal-field some 1900 feet above the Mammoth bed.

The number of coal-beds and the thickness of each that perhaps once existed above the Brewery bed we do not know.

A columnar section in the neighborhood of Pottsville would show some 20 workable coal-beds between (and including) the Brewery and Buck Mountain beds, with an estimated total average thickness of 108 feet, some 72 per cent. or 78 feet of which is estimated to be workable coal.

At Tamaqua a fewer number of beds show 109 feet or 78 feet of coal.

At Shamokin the section from the Tracy bed (the sixth below the Brewery) down shows 70 feet, 77 per cent. or 54 feet of coal.

At Shenandoah from the Little Tracy down the section shows 113 feet or 87 feet of coal.

In the Eastern Middle field all but one or two of the beds above the Mammoth have been carried away by erosion.

In the Northern field probably the highest existing workable bed is the New bed, only some 600 feet above the Bennett or Mammoth.

At Wilkes-Barre the section shows some 11 workable beds with a thickness of 85 feet, 81.8 per cent. or 69 feet estimated as workable coal.

A consideration of these columnar sections would indicate that the original coal-field had in the neighborhood of the existing fields an average thickness of probably not less than 75 feet of coal in workable beds. If we estimate 1900 tons per foot acre, 1 acre 75 feet thick would contain 152,-500 tons, say 150,000 tons, and 1 square mile 640 times this, or 96,000,000 tons.

In order that we may have some general idea of the relation between the existing and the original anthracite field, the following propositions might be assumed :—

First.—That lines drawn, inclosing all the existing field, would include the original field.

There is probably no reason to suppose but that the original field was of much greater extent. These boundaries are, however, used as the smallest possible area for the field.

A line drawn from the northeast end of the Northern field to Bernice, to Dauphin, to Mauch Chunk, to point of beginning (Fig. A, B, C, D, see map, page 56), the resulting polygon would inclose all the existing Pennsylvania anthracite fields, and have an area of about 3300 square miles, and a contents, estimating 96,000,000 tons per square mile, of 306,600,000,000 tons. If we assume this to have been the contents of the original field, the contents of the existing field, 19,500,000,000 tons, is about 6 per cent. of this.

Second.—That the original field is included between two parallel lines having the same general direction as the trend of the measures, the northern line just including the Bernice basin and the southern line along the Blue Ridge, extending from the State line at the Delaware, and bounded on the west by a line drawn at right angles about half way between Dauphin and the Broad Top coal-field (Fig. E, F, G, H), the area inclosed would contain roughly some 9000 square miles, and would have had a contents, estimating 96,000,000 tons per square mile, of 846,000,000,000 tons, of which the now existing fields contain about 2 per cent.

Third.—That the original anthracite field covered all of Southeastern Pennsylvania, and is inclosed within the area included within the State boundaries on the east and south, with the same north boundary as in the second proposition, and on the west by a north and south line, passing to the east of the Broad Top field (Fig. E, F, I, J, K, H). Roughly estimated, this area would contain about 17,000 square miles; estimating 96,000,000 tons per square mile, the contents would be 1,632,000,000,000 tons, of which the now existing field contains a little more than 1 per cent.

Results.

The preceding estimates would show that the existing Pennsylvania anthracite fields, before mining commenced, contained not more than 6 per cent., probably about 2 per cent., and possibly only 1 per cent. of the coal deposited in workable beds in the original geological coal-field before erosion.

ESTIMATE OF EXISTING ANTHRACITE COAL-FIELD BEFORE COAL MINING BEGAN.

The anthracite coal-fields of Pennsylvania are found within some 3300 square miles, about 484 square miles of which contain workable coal-beds. The field is comprised in a number of separate basins, and has been divided geographically into Northern, Eastern Middle, Western Middle, and Southern fields.

The recently completed mine sheets of the Geological Survey map (on a scale of 800 feet to 1 inch) the whole area covered by workable coal-beds, showing the mine workings in each bed, the outcrop of the principal beds, and the limit of the workable beds, as well as the surface features and elevations; in connection with these sheets there are published a series of cross-sections, across each basin or field, showing the actual or probable position of each coal-bed underground on the vertical plane cut by the cross-section; also, a series of columnar sections, showing the thickness of the coal-beds and intervening strata at right angles to the dip as cut in the shafts, tunnels, rock slopes, and bore-holes throughout the field.

The estimate of contents is based upon these mine, cross-section, and columnar section sheets published by the Geological Survey; upon the reports of the first Geological Survey, published in 1858; upon some 2500 bed sections obtained in part from the note-books of the Geological Survey, and in part from the officers of the operating companies; and general information from various sources.

In the estimate only the coal in workable beds is considered. In the Northern field, where the measures are comparatively flat, 2.5 feet of coal is taken as the minimum, while in the other fields, where the beds are usually found dipping at high angles, 2 feet is used.

In all four of the coal-fields, but more especially in the Western Middle and Southern, there are, in addition to the beds which have been named and identified from place to place, other coal-beds, usually called "leaders," which frequently, and some of the persistent ones usually, exceed the requirements of workable thickness and quality; as some of these leaders are workable, I have to a small extent considered them in making up the average thickness of the adjacent beds.

The Method.

Some three methods have been used. The principal one employed, and by which the bulk of the estimate has been made, is as follows:—

First.—(*a.*) The coal-fields have been divided into a number of small areas, the cross-section lines usually being the dividing lines and determining the number and size of these areas.

(*b.*) The area in acres underlaid by the lowest workable bed as defined on the published sheets has been carefully determined, as follows: The mine sheets are blocked in 2000′ squares, the number of squares wholly underlaid by the lowest workable bed were counted and the acres computed; then the irregular area which was left, was measured by the planimeter and acreage computed, the sum being the total acreage for area. The correctness of the computation was checked by repeating the measurements, the mean of the results being taken as the correct one; and later by a comparison of the totals for each field with the measurement of the field made on a reduced map, scale 1 mile to 1 inch.

(*c.*) The ratio of the per cent. of coal to that of refuse in the beds in each field is obtained by taking all the bed sections that have been collected from any one field, and first determining the per cent. of coal in each bed section, eliminating all refuse, including bony coal, then taking the average of all the sections, the result obtained is used as the factor for that field.

(*d.*) The published cross-sections were next considered, and the probable average thickness of the coal on each section, were it all contained in one horizontal bed, having the length of the surface underlaid by the lowest workable bed (as shown on section), was determined ; the details of how these average thicknesses were obtained is best described with the first cross-section considered. See page 62.

(*e.*) The contents of the areas is now obtained by multiplying the *mean* of the average thickness of coal on the bounding sections by the number of acres in the area, by the number of tons in one acre of coal one foot thick, described in detail table A, page 75.

Second.—In the Eastern Middle field, which comprises a number of small unconnected basins, it seemed best to calculate the area and estimate the contents of each bed separately; this was made easy here by the publication on the mine sheets of the outcrops of nearly all the workable beds. This method was also used in the areas between the several ends of fields and the nearest cross-section.

Third.—The estimate of the contents of the Panther Creek basin, Southern coal-field mine sheets I., II., and III., is copied from the estimate made under the direction of the late Charles A. Ashburner, by a method devised by him and described in full in Report AA, chapter V.

The surface and bed areas for Western Middle sheets I., II., III., and IV., were also computed under Mr. Ashburner's direction. Professor Lesley has kindly allowed me to make use of these computations for this estimate.

Specific Gravity.

The number of tons in an acre of coal one foot thick is determined by the weight of a cubic foot of coal ; this varies in different benches of the same bed, in different parts of a field, and in different fields. To speak with certainty as to the probable average weight of a cubic foot of coal from any one or all of the fields would require a number of determinations in quantity of the coal from the different beds and from many parts of the field.

In this estimate I have usually taken, as the best authority available, the laboratory determinings of Mr. A. S. McCreath, the chemist of the Geological Survey. It should be noted that the results thus obtained are higher than those in general use, giving a larger yield per acre, and consequently a greater estimate of contents for the fields.

The specific gravity which has been used is noted with the estimate of each field.

ESTIMATE OF THE ORIGINAL CONTENTS NORTHERN COAL-FIELD, INCLUDING THE BERNICE COAL BASIN.

The coal of the Northern field is found in one great basin 55 miles long and from 2 to 6 miles wide, with perhaps a dozen more little patches of coal lying close to but not now connected with the main basin. The dips are usually very gentle, though occasionally reaching 40 or 50 degrees in the southwestern end of the field.

The estimate of contents has been made from the cross-sections (*First* Method), but in the areas between either end of the basin and the nearest section the contents of each bed was estimated separately.

The following discussion of the first cross-section used, No. K, will apply to all that follow. See page 63.

Column *a* gives the name of each workable bed found on the section.

Column *b* gives the probable average thickness of the bed; this average is supposed to apply to the area inclosed within lines drawn half-way between the adjoining section on either side, and is assigned, after a careful consideration of the bed sections and bed thicknesses shown by shaft, tunnel, and bore-hole sections within this territory, in connection with the geological structure.

Column *c* gives the probable average thickness of coal in each bed and is obtained in the Northern field by taking 81.8 per cent. of the thickness assigned to the bed.

Eight hundred and ninety-one bed sections well distributed throughout this field, eliminating all refuse, including bony coal in the refuse, give as an average 81.8 per cent. coal, 18.2 per cent. refuse.

Column *d* gives the total length of each bed, measured on the section; where the dips are gentle this length is but little greater than the length of surface underlaid by the bed, but where the dips are steep the difference is very decided, and is an important consideration in the estimate.

Column *dc* gives the length of each bed if lengthened out into a bed with the coal but one foot thick, and is obtained by multiplying column *d* by column *c*.

The sum of column *dc* divided by the surface length underlaid by the lowest workable coal-bed, measured on section, gives the probable thickness of the coal, imagining it to be all in one horizontal bed with a length equal to the surface length of the lowest workable bed.

Reference:—

Geological Survey of Pennsylvania.
N. C. F., mine sheet 23.
N. C. F., cross-section sheets 8 and 9.
N. C. F., columnar section sheets 16.

Cross-Section No. K.

a. Name of Bed.	*b.* Average thickness of bed.	*c.* Aver. thickness of coal, 81.8 per cent.	*d.* Length of bed.	*dc.* Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Shaft	6.5	5.32	4,700	25,004
Clifford	4.8	3.92	10,450	40,964
Total coal reduced to units of one foot in thickness				65,968
Surface length underlaid by lowest workable bed				10,340
Average thickness of coal per foot of surface				6.38

Remarks.

On the south side of the basin there is a bed between the Shaft and Clifford beds from 2 to 6 feet thick; this is not included in the estimate, as it is counterbalanced (more or less) by the fact that on the north side of the basin there is an area of somewhat uncertain extent where no coal below the Shaft bed is found of workable thickness.

Reference:—

Geological Survey of Pennsylvania.
N. C. F., mine sheets 21 and 22.
N. C. F., cross-section sheets 8 and 9.
N. C. F., columnar section sheets 15 and 16.

CROSS-SECTION No. J.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 81.8 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
"Top" coal	7.3	6.0	5,640	33,840
Shaft or "Bottom" coal	6.2	5.1	6,300	32,130
Third	3.8	3.1	3,350	10,385
Dunmore	3.5	2.9	4,600	13,340
Total coal reduced to units of one foot in thickness				89,695
Surface underlaid by lowest workable bed				8,180
Average thickness of coal per foot of surface				10.96

REMARKS.

The Third coal-bed, which is shown on the section as a split of the "Bottom" coal, and the Dunmore bed have not been found at their northern outcrop, and I have estimated these beds as workable for about one-half of their natural length on line of section.

The "Top" and "Bottom" coal-beds are extensively worked in this vicinity.

Reference:—

Geological Survey of Pennsylvania.
N. C. F., mine sheets 19 and 20.
N. C. F., cross-section sheets 8 and 9.
N. C. F., columnar section sheet 15.

CROSS-SECTION No. I.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 81.8 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Grassy Island	9.0	7.36	2,140	15,750
New County	3.0	2.45	6,040	14,798
Archbald	9.5	7.77	11,580	89,977
Dunmore beds	2.8	2.28	4,860	11,129
Total coal reduced to units of one foot in thickness				131,654
Surface underlaid by lowest workable bed				14,130
Average thickness of coal per foot of surface				9.32

Remarks.

The Dunmore beds are not worked in vicinity of this section, but have been shafted in one or two places on the north dip. I have estimated that there is a workable bed for about one-third of the sectional length.

Grassy Island bed worked at Glenwood shaft.

New County bed not worked.

Archbald principal bed of district and extensively worked; same bed as the "Top" and "Bottom" coal of Carbondale district.

Reference:—

Geological Survey of Pennsylvania.
N. C. F., mine sheets 17 and 18.
N. C. F., cross-section sheets 6, 7, and 8.
N. C. F., columnar section sheet 14.

Cross-Section No. H.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 81.8 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Small coal	3.0	2.45	3,050	7,472
Diamond	3.8	3.11	5,050	15,705
Rock	5.6	4.58	10,260	46,990
Grassy Island	8.8	7.20	11,600	83,520
New County	4.0	3.27	13,470	44,047
Clark	7.3	5.97	14,740	87,998
Dunmore No. 1	4.0	3.27	17,130	56,015
Dunmore No. 2	2.2	1.80	19,170	34,506
Dunmore No. 3	2.5	2.05	20,720	42,476
Total coal reduced to units of one foot in thickness				418,729
Surface length underlaid by lowest workable bed				20,300
Average thickness of coal per foot of surface				20.65

Remarks.

All the beds shown by this section have been worked at one or more places in the vicinity, excepting the "small coal" and the Rock bed, the thicknesses assigned to these were determined by the shaft and bore-hole records.

The Grassy Island bed is the one now most extensively worked.

Reference :—

Geological Survey of Pennsylvania.
N. C. F., mine sheets 15 and 16.
N. C. F., cross-section sheets 6, 7, and 8.
N. C. F., columnar section sheets 9, 10, 11, and 12.

Cross-Section No. G.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 81.8 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Brisbin or Olyphant No. 1,	8.0	6.54	3,300	21,582
Richmond or Olyphant No. 2	5.5	4.50	4,580	20,610
Coal bed "Church Slope,"	3.9	3.20	6,600	21,120
Diamond bed	9.7	7.93	12,420	98,490
Rock bed	6.1	5.00	9,340	46,700
Big bed	11.5	9.40	15,200	142,880
Clark bed	6.5	5.32	18,700	99,484
Dunmore No. 1	3.5	2.86	21,340	61,032
Dunmore No. 2	4.0	3.27	22,730	74,327
Dunmore No. 3	3.0	2.45	24,630	60,343
Total coal reduced to units of one foot in thickness				646,568
Surface length underlaid by lowest workable bed				24,250
Average thickness of coal per foot of surface				26.66

Remarks.

All the beds shown by this section have been worked to a greater or less degree in the neighborhood.

The Dunmore, Big, and Clark are the principal beds and have been worked most extensively.

The Dunmore beds are here at their best, and are mined to a large extent in the neighborhood of Dunmore.

Reference :—

Geological Survey of Pennsylvania.
N. C. F., mine sheets 13 and 14.
N. C. F., cross-section sheets 6, 7, and 8.
N. C. F., columnar section sheets 10, 11, and 12.

Cross-Section No. F.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 81.8 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Olyphant No. 2	5.3	4.34	3,900	16,926
"Church Slope"	4.0	3.27	6,350	20,765
Diamond	9.2	7.53	10,400	78,312
Rock	7.0	5.73	11,100	63,603
Big	12.5	10.23	12,050	123,272
New County	8.5	6.95	12,300	85,485
Clark	8.5	6.95	14,500	100,775
*Dunmore No. 1 (No. 4)	3.2	2.62	4,410	11,554
Dunmore No. 2 (No. 5)	4.4	3.60	19,200	69,120
Total coal reduced to units of one foot in thickness				569,812
Surface length underlaid by lowest workable bed				19,100
Average thickness of coal per foot of surface				29.83

*It is doubtful if Dunmore No. 1 (No. 4 bed) is workable for more than a portion of its extent (say one-fourth), and I have estimated accordingly.

Remarks.

All of the beds are worked and several of them extensively; the Dunmore beds are especially well developed on south side of the basin, but have not been worked on the north.

Reference:—

Geological Survey of Pennsylvania.
N. C. F., mine sheets 11 and 12.
N. C. F., cross-section sheets 6, 7, and 8.
N. C. F., columnar section sheets 7, 8, 9, and 10.

Cross-Section No. E.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 81.8 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Marcy (New County)	7.5	6.14	8,000	49,120
Clark	6.0	4.90	12,350	60,515
Red Ash	11.5	9.40	17,200	161,680
Total coal reduced to units of one foot in thickness				271,315
Surface length underlaid by lowest workable bed				17,050
Average thickness of coal per foot of surface				15.91

Remarks.

All these beds are worked, but the Clark less than the others. The Red Ash bed is regarded as the equivalent of the Dunmore beds.

Reference:—

Geological Survey of Pennsylvania.

N. C. F., mine sheets 9 and 10.

N. C. F., cross-section sheets 6, 7, and 8.

N. C. F., columnar section sheets 6, 7, and 8.

Cross-Section No. D.

Name of Bed	Average thickness of bed.	Aver. thickness of coal, 81.8 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Seven Foot or Checker . .	6.5	5.32	12,530	66,660
Pittston	10.6	8.67	16,000	138,720
Marcy	7.8	6.38	18,400	117,392
Fourth	4.8	3.93	8,000	31,440
Red Ash	10.5	8.59	24,240	208,222
Total coal reduced to units of one foot in thickness				562,434
Surface length underlaid by lowest workable bed				23,680
Average thickness of coal per foot of surface				23.75

Remarks.

All the beds are worked except the Fourth bed. I have estimated about one-half of its extent to be workable.

The Pittston bed, regarded as the equivalent of the Baltimore bed, is the principal bed of the district, and has been very extensively mined.

The buried river valley, with a depth of 50 to 200 feet of wash, has cut out several of the upper coal-beds. Mining beneath it is very hazardous.

References:—

Geological Survey of Pennsylvania.

N. C. F., mine sheets 7 and 8.

N. C. F., cross-section sheets 2*a*, 2*b*, and 2*c*.

N. C. F., columnar section sheets 1, 3, 4, and 5.

Cross-Section No. C.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 81.8 per cent.	Length of bed.	Length of bed, Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
New	3.7	3.03	810	2,454
Snake Island	7.4	6.05	1,630	9,862
Abbott	5.3	4.34	2,740	11,892
Bowkley	6.4	5.24	4,200	22,008
Hillman	10.0	8.18	11,390	93,170
Lance	5.8	4.74	11,750	55,695
Cooper	8.9	7.28	20,120	146,474
Bennett	8.5	6.95	22,170	154,082
Checker	5.0	4.09	16,200	66,258
Ross	10.0	8.18	29,480	241,146
Red Ash	14.0	11.45	30,850	353,233
Total coal reduced to units of one foot in thickness				1,156,274
Surface length underlaid by lowest workable bed				30,400
Average thickness of coal per foot of surface				38.03

Remarks.

The Checker bed is the only one which has not been worked, and I have regarded it as workable for only a part of its probable extent.

The Ross and Red Ash beds are in some places found in two splits, and in some instances the splits are worked separately.

The Cooper and Bennett beds when found together are called the Baltimore bed. This is the principal bed of the region.

The buried river valley, with a depth of 50 to 200 feet of wash, has cut out several of the upper coals. Mining beneath it is very hazardous.

Reference:—

Geological Survey of Pennsylvania.

N. C. F., mine sheets 5 and 6.

N. C. F., cross-section sheets 2*a*, 2*b*, and 2*c*.

N. C. F., columnar section sheets 1 to 5.

Cross-Section No. B.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 81.8 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
New or Auble	3.7	3.00	6,090	18,270
Snake Island	5.0	4.09	6,200	25,358
Seven Foot, Hutchison	5.5	4.50	10,000	45,000
Kidney, Bowkley, Lance	5.3	4.34	16,290	70,699
Hillman	9.2	7.53	17,865	134,523
Lodgement	4.0	3.27	5,006	16,350
Five Foot, Old Bennett	6.5	5.32	18,770	99,856
Lance, Five Foot	6.0	4.91	9,210	45,221
Cooper	8.0	6.54	21,200	138,648
Bennett	9.5	7.77	22,800	177,156
Checker	4.5	3.68	10,000	36,800
Ross	9.0	7.36	24,300	178,848
Red Ash	18.0	14.72	25,700	378,304
Total coal reduced to units of one foot in thickness				1,365,033
Surface length underlaid by lowest workable bed				24,550
Average thickness of coal per foot of surface				55.60

Remarks.

The Seven Foot, Snake Island, and New or Auble beds are not worked, but are cut by South Wilkesbarre shaft.

The Cooper and Bennett beds are together on the south side of the basin in vicinity of Wilkesbarre, and form the Baltimore bed.

The Red Ash bed is frequently in two splits, which are sometimes worked separately.

The buried river valley, with a depth of 50 to 200 feet of wash, has cut out several of the upper coals. Mining beneath it is very hazardous.

Reference:—

Geological Survey of Pennsylvania.

N. C. F., mine sheets 3 and 4.

N. C. F., cross-section sheets 2*a*, 2*b*, and 2*c*.

N. C. F., columnar section sheets 1 to 5.

Cross-Section No. A.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 81.8 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
George	4.6	3.76	4,090	15,378
Mills	7.0	5.73	4,920	28,192
Hillman Slope	7.0	5.73	6,610	37,875
Lance or Four Foot	4.0	3.27	6,650	21,745
Cooper	6.5	5.32	9,050	48,146
Bennett	7.8	6.38	9,910	63,226
Twin	5.0	4.09	12,410	50,757
Ross	8.0	6.55	14,500	94,975
Buck Mountain (Red Ash),	10.0	8.18	16,000	130,880
Total coal reduced to units of one foot in thickness				491,174
Surface length underlaid by lowest workable bed				14,900
Average thickness of coal per foot of surface				32.97

Remarks.

The Mills, Hillman, Bennett, and Buck Mountain are the principal beds.

What is here called the Buck Mountain is probably identical with the upper split of the Red Ash.

Reference :—

Geological Survey of Pennsylvania.
N. C. F., mine sheet 2.
N. C. F., cross-section sheet 1.
N. C. F., columnar section sheet 5.

Cross-Section No. 4.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 81.8 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Mills	6.6	5.40	600	3,240
Hillman	8.5	6.95	2,550	17,723
Cooper	6.0	4.90	4,420	21,658
Bennett or Forge	6.5	5.32	5,540	29,473
Twin	4.0	3.27	7,140	23,348
Ross	12.0	9.82	10,350	101,637
Buck Mountain	7.5	6.14	10,200	62,628
Total coal reduced to units of one foot in thickness				259,707
Surface length underlaid by lowest workable bed				8,900
Average thickness of coal per foot of surface				29.18

Remarks.

The Buck Mountain, Ross, Forge, and Cooper beds are worked. The Ross is the principal bed.

Reference:—

Geological Survey of Pennsylvania.
N. C. F., mine sheet 2.
N. C. F., cross-section sheet 1.
N. C. F., columnar section sheet 5.

CROSS-SECTION NO. 3.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal 81.8 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Forge or Bennett	5.0	4.09	2,610	10,675
Church	6.0	4.91	3,170	15,565
Ross	6 5	5.32	4,500	23,940
Buck Mountain	9.5	7.77	7,150	55,556
Total coal reduced to units of one foot in thickness				105,736
Surface length underlaid by lowest workable bed				6,490
Average thickness of coal per foot of surface				16.29

REMARKS.

The Buck Mountain (Red Ash) is the principal bed in thickness as well as extent, and is quite extensively worked from Dupont drift, and also mined at the Hasselman drift.

Reference:—

Geological Survey of Pennsylvania.
N. C. F., mine sheets 23 and 24.

AREA NO. 1.

From Northeast End of Coal-Field to Cross-Section No. K.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 81.8 per cent.	Surface and bed area in acres.	Probable original contents in tons.
	Feet.	Feet.		
Shaft	6.71	5.5	140.7	1,454,838
Clifford	4.90	4.0	1071.4	8,056,928
Probable original contents of area No. 1				9,511,766

REMARKS.

The basin is quite flat here, and I have regarded the bed area to be the same as the surface area.

Reference :—

Geological Survey of Pennsylvania.
N. C. F., mine sheets 1 and 2.

Area No. 14.

From Cross-Section No. 3 to Southwest End of Coal-Field.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 81.8 per cent.	Surface area in acres.	Bed area in acres.	Probable original contents in tons.
	Feet.	Feet.			
Church . . .	5.0	4.09	175.00	190.00	1,460,948
Ross	6.5	5.32	560.00	600.00	6,000,960
Red Ash . . .	8.7	7.12	937.64	1012.65	13,554,928
Probable original contents of area No. 14					21,016,836

Reference :—

Pennsylvania Geological Survey. Annual Report 1885, chapter XI., and Map in Atlas to Report.

Area No. 15.

Bernice Coal Basin, Sullivan County, Pa.

The shipments from this basin have, since 1884, been included in the Northern coal-field or Wyoming region tonnage, and for that reason the estimate of the original contents of this area is included with the Northern field.

Two coal-beds are found in this basin. The upper bed "B" is mined. "Bed 'A' gives no promise of a workable bed."

The area underlaid by bed B, as shown approximately on the map of the basin contained in Atlas to Annual Report, 1885, is 1950 acres; the dips are gentle, and bed and surface areas may be regarded as the same. The sections of bed B, published in the Annual Report, 1885, would show the coal to vary between 8 and 9 feet in thickness. Taking 8.5 feet as the average for the basin would give 31,161,000 tons as the probable original contents.

Probable original contents of area No. 15 . . . 31,161,000

Table A which follows shows the estimate of contents for the whole field. The following explanation of the table is now in place :—

Explanation of Table A.

The field has been divided by the cross-section lines into 14 separate divisions and numbered 1 to 14 from northeast to southwest. (See map.)

Column No. 1 gives the number assigned to each area.

An area is always understood to mean the area of the lowest workable coal-bed between the cross-sections bounding it.

Column No. 2 gives the letter or number of the cross-sections bounding the areas.

Column No. 3 gives the probable average thickness of the coal at each cross-section, imagining the coal to be all contained in one bed having the extent of the lowest workable bed. The method and data for arriving at these averages are given in detail in the preceding pages.

Column No. 4 gives the mean of the probable average thickness of coal at the cross-sections bounding each area, and is taken as the probable average thickness of coal within the included area.

Column No. 5 gives the number of acres of the lowest workable coal-bed in each area, measured on the published mine sheets 800′ to 1″ of the Pennsylvania Geological Survey.

Column No. 6 gives the estimated contents of each area in long tons, and is got by multiplying column No. 4 by column No. 5 by 1880, which is taken as the number of tons per acre per foot in thickness of coal in this field.

Several determinations by McCreath, Pennsylvania Geological Report, 1885, page 314, would show the average specific gravity of the Baltimore bed in the vicinity of Wilkes-Barre to be 1.578. This is, perhaps, too high an average for all the beds of the entire field, so, lacking more definite information, I have used 1.55 or 96.6 pounds to the cubic foot, or 1880 tons per acre per foot thickness of coal in the following estimate:—

TABLE A.

Estimate of Total Original Contents Northern Coal-Field.

1. Area No.	2. Between cross-sections.	3. Probable average thickness of coal at cross-sections.	4. Probable average thickness of coal for areas.	5. Surface area lowest workable bed in acres.	6. Probable original contents in tons.
		Feet.	Feet.		
*1 . . .	K	. . . . . .	. . . . . .	1,071.4	9,511,766
2 . . .	K J	6.38 10.96	8.67	5,927.8	96,620,768
3 . . .	J I	10.96 9.32	10.14	5,822.0	110,985,950
4 . . .	I H	9.32 20.65	14.98	10,845.5	305,537,256
5 . . .	H G	20.65 26.66	23.65	10,180.8	452,658,729
6 . . .	G F	26.66 29.83	28.25	9,892.1	525,369,431
7 . . .	F E	29.83 15.91	22.87	5.644.8	242,701,562
8 . . .	E D	15.91 23.75	19.83	13,483.5	502,670,273
9 . .	D C	23.75 38.03	30.89	13,667.3	793,703,846
10 . . .	C B	38.03 55.60	46.82	13,429.8	1,182,112,483
11 . . .	B A	55.60 32.97	44.28	11,587.7	964,634,309
12 . . .	A 4	32.97 29.18	31.08	6,593.9	385,284,214
13 . . .	4 3	29.18 16.29	22.74	1,717.2	73,412,361
*14 . . .	3	. . . . . .	. . . . . .	1,012.6	21,016,836
15 . . .	Bernice b	asin.	8.5	1,950.0	31,161,000
Totals .	. . . . .	. . . . . .	. . . . . .	112,826.4	5,697,380,784

* Area No. 1 from northeast end of field to cross-section K, and area No. 14 from cross-section 3 to southwest end of field, the contents of each bed has been estimated separately, given in detail pages 72 and 73.

Total surface area lowest workable coal-bed, 112,826.4 acres, or 176.29 square miles.

Estimated total original contents Northern coal-field, 5,697,380,784 tons.

ESTIMATE OF THE ORIGINAL CONTENTS EASTERN MIDDLE COAL-FIELD.

The Eastern Middle field is comprised in some 20 coal basins, usually separated one from the other by anticlinal ridges of Pottsville conglomerate, whose resistance to erosion has preserved these patches of softer coal measures in the synclinal hollows. The total area underlaid by the lowest workable bed in this field is a little less than 33 square miles.

In estimating the quantity of coal it was thought best to take the natural divisions made by the principal basins, and to make a separate estimate of the amount of coal in each bed; this was made easier, as the number of beds are less than in the other fields, and as the outcrops of most of them are given on the mine sheets. But little explanation will be needed of the following tables :—

Column No. 1 (see page 77) gives name of bed.

Column No. 2 probable average thickness of the beds. These thicknesses have been assigned, after a careful consideration of the bed sections and bed thicknesses shown by shaft, tunnel, or bore-hole sections within the basin, in connection with the geological structure.

Column No. 3 shows the probable average thickness of coal in each bed in this field. It is taken as 77 per cent. of the bed thickness.

Column No. 4 shows the surface acreage of each bed usually measured by planimeter on the mine sheets, but a star (*) above the acreage indicates that it has been estimated.

Column No. 5 gives the probable bed area of each coal-bed. The ratio of surface area to bed area was approximately obtained from the published sections across the basins; the beds not infrequently pitch 40 or 50 degrees, making the increased area an important factor in the estimate.

Column No. 6 gives the probable original contents of each bed, and is obtained by multiplying the bed acres by the average thickness of coal in the bed by the number of tons per foot acre (1960 used in this field).

Eight determinations by McCreath, Pennsylvania Geological Survey, Annual Report, 1885, page 314, of coal from the Mammoth and Wharton beds give an average specific gravity of 1.614. As these samples were taken from different points in the field, it gives perhaps a fair average, so I have used 1.614 or 100.85 pounds to a cubic foot, or 1960 tons per acre to each foot in thickness of coal.

Reference:—

Geological Survey of Pennsylvania.

E. M. C. F., mine sheets 3 and 4.

E. M. C. F., cross-section sheet 4.

E. M. C. F., columnar section sheet 4.

Area No. 16.

Pond Creek and Buck Mountain Basins.

1. Name of Bed.	2. Average thickness of bed.	3 Average thickness of coal, 77 per cent.	4 Surface area, acres.	5. Bed area in acres.	6. Probable original contents in tons.
	Feet.	Feet.			
Wharton	6.0	4.62	*88	98	887,409
Gamma	2.5	1.93	*290	325	1,229,410
Buck Mountain	13.5	10.39	939	1040	21,189,168
Probable original contents of area No. 16					23,305,987

Reference :—

Geological Survey of Pennsylvania.
E. M. C. F., mine sheets 1 and 5.
E. M. C. F., cross-section sheets 1, 2, and 4.
E. M. C. F., columnar section sheets 1 and 4.

Area No. 17.

Cross Creek and Woodside Basins.

Name of Bed.	Average thickness of bed.	Average thickness of coal, 77 per cent.	Surface area, acres.	Bed area in acres.	Probable original contents in tons.
	Feet.	Feet.			
Mammoth	14	10.78	*130	169	3,570,767
Wharton	6	4.62	*300	360	3,259,872
Gamma	4	3.08	*800	960	5,795,328
Buck Mountain	14	10.78	1600	1760	37,186,688
Probable original contents of area No. 17					49,812,655

Reference :—

Geological Survey of Pennsylvania.
E. M. C. F., mine sheets 1, 2, and 5.
E. M. C. F., cross-section sheets 1, 2, and 4.
E. M. C. F., columnar section sheet 2.

Area No. 18.

Big Black Creek Basin

Name of Bed.	Average thickness of bed.	Average thickness of coal, 77 per cent.	Surface area, acres.	Bed area in acres.	Probable original contents in tons.
	Feet.	Feet.			
Mammoth	27.0	20.79	910	1037	42,256,090
Wharton and Gamma .	3.5	2.70	1370	1561	8,260,812
Buck Mountain	15.0	11.55	3236	1830	41,427,540
Probable original contents of area No. 18					91,944,442

The Wharton bed is only worked near west end of basin. I estimate that, including with it the Gamma bed sometimes of a workable thickness, that a thickness of 3.5 feet might be counted upon for whole area underlaid by the Wharton.

The Buck Mountain is perhaps not a workable bed in the western half of the basin, so I have estimated on about one-half of its total area, giving it a liberal thickness of 15 feet.

Reference :—

Geological Survey of Pennsylvania.
E. M. C. F., mine sheets 1 and 2.
E. M. C. F., cross-section sheet 2.
E. M. C. F., columnar section sheet 1.

Area No. 19.

Little Black Creek Basin.

Name of Bed.	Average thickness of bed.	Average thickness of coal, 77 per cent.	Surface areas, acres.	Bed area in acres.	Probable original contents in tons.
	Feet.	Feet.			
Mammoth	40	30.80	2.80	364	21,973,952
Buck Mountain	3	2.31	9.66	1256	5,686,665
Probable original contents of area No. 19					27,660,617

Diamond drill borings show two or three small and irregular beds below the Mammoth ; these are not positively identified. I have estimated that the combined thickness below the Mammoth equivalent to a 3-foot bed with the area given the Buck Mountain bed on the mine sheets.

Reference :—

Geological Survey of Pennsylvania.
E. M. C. F., mine sheet 11.
E. M. C. F., cross-section sheet 6.
E. M. C. F., columnar section sheet 6.

Area No. 20.

(East) Black Creek and Stony Creek Basins.

Name of Bed.	Average thickness of bed.	Average thickness of coal, 77 per cent.	Surface area, acres.	Bed area in acres.	Probable original contents in tons.
	Feet.	Feet.			
Mammoth	12	9.24	172	198	3,585,859
Wharton	8	6.16	279	320	3,863,552
Buck Mountain	3	2.31	482	554	2,508,290
Buck Mountain (Stony Creek Basin)	?	?	90 ?	. . . .	. . . . . .
Probable original contents of area No. 20					9,957,701

No coal-beds have been opened in the Stony Creek basin. Some 90 acres are shown on the mine sheets as possibly underlaid by the Buck Mountain bed. No estimate of quantity for this area is made.

Reference :—

Geological Survey of Pennsylvania.
E. M. C. F., mine sheets 11, 13, and 14*a*.
E. M. C. F., cross-section sheet 6.
E. M. C. F., columnar section sheets 6 and 7.

Area No. 21.

(West) Black Creek Basin.

Name of Bed.	Average thickness of bed.	Average thickness of coal, 77 per cent.	Surface area, acres.	Bed area in acres.	Probable original contents in tons.
	Feet.	Feet.			
Mammoth	9.0	6.93	86	95	1,290,366
Wharton	7.5	5.77	294	412	4,659,390
Gamma	2.5	1.93	350	472	1,785,481
Buck Mountain	7.0	5.39	1061	1379	14,568,307
Probable original contents of area No. 21					22,303,544

Reference :—

Geological Survey of Pennsylvania.
E. M. C. F., mine sheets 13, 14, and 14*a*.
E. M. C. F., cross-section sheet 6.
E. M. C. F., columnar section sheet 7.

Area No. 22.

Roberts' Run and McCauley Basins.

Name of Bed.	Average thickness of bed.	Average thickness of coal, 77 per cent.	Surface area, acres.	Bed area in acres.	Probable original contents in tons.
	Feet.	Feet.			
Mammoth	11.0	8.47	109	153	2,539,983
Wharton	4.5	3.46	130	182	1,234,251
Gamma	2.5	1.93	*215	312	1,180,233
Buck Mountain	11.5	8.85	323	458	7,944,468
Probable original contents of area No. 22					12,898,935

Reference :—

Geological Survey of Pennsylvania.
E. M. C. F., mine sheets 1, 2, 5, and 11.
E. M. C. F., cross-section sheets 1, 3, 4, and 5.
E. M. C. F., columnar section sheets 3 and 6.

Area No. 23.

Hazleton Basin.

Name of Bed.	Average thickness of bed.	Average thickness of coal, 77 per cent.	Surface area, acres.	Bed area in acres.	Probable original contents in tons.
	Feet.	Feet.			
Primrose	5.0	3.85	*617	728	5,493,488
Mammoth	25.0	19.25	1830	2159	81,459,070
†Parlor } Wharton }	7.9	5.39	3925	3925	41,465,270
Gamma	2.5	1.93	*3700	4070	15,395,996
Buck Mountain	2.5	1.93	4948	5789	21,898,629
Probable original contents of area No. 23					165,712,453

† Parlor bed, only a small area of workable thickness, and is included with the Wharton bed in the estimate.

Reference :—

Geological Survey of Pennsylvania.
E. M. C. F., mine sheets 7, 8, and 10.
E. M. C. F., cross-section sheets 4 and 5.
E. M. C. F., columnar section sheets 4, 5, and 6.

Area No. 24.

Beaver Meadow and Dreck Creek Basins.

Name of Bed.	Average thickness of bed.	Average thickness of coal, 77 per cent.	Surface area, acres.	Bed area in acres.	Probable original contents in tons.
	Feet.	Feet.			
Mammoth	28	21.56	1337	1738	73,443,708
Wharton	8	6.16	2273	2841	34,301,097
Gamma	5	3.85	*3379	4122	31,104,612
Buck Mountain	3	2.31	4270	5124	23,199,422
Buck Mountain	. . . .	. . . .	1200	. . . .	?
Alpha bed	3	2.31	*200	240	1,086,624
Probable original contents of area No. 24					163,135,463

The probable area of Buck Mountain bed, in the Dreck Creek basin (1200 acres), is shown in table, but no beds in this basin have yet been found of a workable thickness and quality.

The Alpha bed is worked in the neighborhood of Beaver Brook. The estimate of the area workable is necessarily a rough approximation.

Reference:—

Geological Survey of Pennsylvania.
E. M. C. F., mine sheets 10, 11, 12, and 13.
E. M. C. F., cross-section sheet 5.
E. M. C. F., columnar section sheet 5.

Area No. 25.

Green Mountain Basins Nos. 1 to 5.

Name of Bed.	Average thickness of bed.	Average thickness of coal, 77 per cent.	Surface area, acres.	Bed area in acres.	Probable original contents in tons.
	Feet.	Feet.			
Wharton	4.0	3.08	*88	103	621,790
Gamma	5.0	3.85	*236	284	2,143,064
Buck Mountain	9.5	7.32	900	1184	16,987,084
Probable original contents of area No. 25					19,751,938

Reference:—

Geological Survey of Pennsylvania.
E. M. C. F., mine sheets 8*a* and 9.

Area No. 26.

Silver Brook Basins.

Name of Bed.	Average thickness of bed.	Average thickness of coal, 77 per cent.	Surface area, acres.	Bed area in acres.	Probable original contents in tons.
	Feet.	Feet.			
Mammoth	20.0±	15.40	*37	48	1,448,832
Skidmore	5.0	3.85	*400	480	3,622,080
Buck Mountain	6.5	5.00	930	1116	10,936,800
Probable original contents of area No. 26					16,007,712

The estimate of all the basins brought forward in table B shows the total area and contents of the field.

Table B.

Estimate of Total Original Contents Eastern Middle Coal-Field.

Area No.	Name of Basin.	Surface area lowest workable bed in acres.	Probable original contents in tons.
16	Pond Creek and Buck Mountain . . .	939	23,305,987
17	Cross Creek and Woodside	1,600	49,812,655
18	Big Black Creek	3,236	91,944,442
19	Little Black Creek	966	27,660,617
20	(East) Black Creek and Stony Creek .	572	9,957,701
21	(West) Black Creek	1,061	22,303,544
22	Roberts' Run and McCauley	323	12,898,935
23	Hazleton	4,948	165,712,453
24	Beaver Meadow and Dreck Creek . .	5,470	163,135,463
25	Green Mountain, Nos. 1 to 5	900	19,751,938
26	Silver Brook Basins	930	16,007,712
	Totals	20,945	602,491,447

Total surface area lowest workable coal-bed, 20,945 acres, or 32.72 square miles.

Estimated total original contents Eastern Middle coal-field, 602,491,447 tons.

ESTIMATE OF THE ORIGINAL CONTENTS OF THE WESTERN MIDDLE COAL–FIELD.

The Western Middle field is some 37 miles long with a maximum width of about 5 miles, and contains about 94 square miles underlaid by the lowest workable coal-bed. It is one continuous field, with the floor much corrugated by anticlinal and synclinal rolls. The beds are found at all angles from flat to a few areas with overturned dips. Speaking generally of the field, the dip may be said to average 30 to 40 degrees, and the bed areas show a very appreciable increase over the surface areas.

As before stated, in the eastern half of the field areas 27 to 30 (see pages 91–94) I have estimated the contents of each bed separately, as the bed areas had already been computed by the Geological Survey and kindly placed at my disposal by Professor Lesley.

The western half of the field comprised on mine sheets 5 to 8 and 5*a* to 7*a* has been estimated from the cross-sections. In discussing these cross-sections, commencing with the most eastern on mine sheet 5, section No. 12, the discussion of cross-section K, Northern field (page 62), applies equally in this field, except that column *c* is obtained by taking 77 per cent. of the bed thickness.

Eleven hundred and forty-four bed sections, well distributed throughout the field, eliminating all refuse, including bony coal in the refuse, give an average for the field 77 per cent. coal, 23 per cent. refuse.

The beds of the Lykens Valley group are important in the western part of the field, but grow thinner to the east. Just where the Lykens Valley ceases to be a workable bed is not determined. It is quite possible that future explorations may develop workable areas of the coal to the extreme eastern end of the field. I have first taken it into account in this estimate on mine sheet 3, giving it there an average thickness of 2.5 feet.

Reference:—

Geological Survey of Pennsylvania.
W. M. C. F., mine sheets 5 and 5*a*.
W. M. C. F., cross-section sheets 5, 6, and 7.
W. M. C. F., columnar section sheets 2 and 3.

Cross-Section No. 12.

a. Name of Bed.	*b.* Average thickness of bed.	*c.* Aver. thickness of coal, 77 per cent.	*d.* Length of bed.	*dc.* Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Tracy, No. XVI.	5.0	3.85	700	2,695
Little Diamond, No. XV. . .	2.5	1.93	1,450	2,799
Diamond, No. XIV.	6.0	4.62	2,000	9,240
Big Orchard, No. XII. . . .	6.0	4.62	3,100	14,322
Primrose, No. XI.	7.0	5.39	5,650	30,454
Holmes, No. X.	6.0	4.62	9,250	42,735
Mammoth, Nos. VIII. and IX.,	18.0	13.86	17,100	237,006
Skidmore, No. VII.	4.0	3.08	18,200	56,056
Seven Foot, No. VI.	?	?	. . .	. . . .
Buck Mountain, No. V. . . .	6.0	4.62	19,800	91,476
Lykens Valley, No. II. . . } Lykens Valley, No. I. . . }	6.0	4.62	22,200	102,564
Total coal reduced to units of one foot in thickness				589,347
Surface length underlaid by lowest workable coal-bed (Lykens Valley)				17,600
Probable average thickness of coal per foot of surface . . .				33.49

Reference :—

Geological Survey of Pennsylvania.
W. M. C. F., mine sheets 5 and 5*a*.
W. M. C. F., cross-section sheets 5, 6, and 7.
W. M. C. F., columnar section sheet 2.

Cross-Section No. 13.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 77 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Orchard, No. XII.	6	4.62	1,050	4,851
Primrose, No. XI.	6	4.62	5,800	26,796
Holmes, No. X.	6	4.62	12,600	58,212
Mammoth Top split, No. IX.,	8	6.16	15,800	97,328
Mammoth Bot. split, No. VIII.,	7	5.39	16,235	87,507
Skidmore, No. VII.	4	3.08	20,650	63,602
Seven Foot, No. VI.	3	2.31	3,600	8,316
Buck Mountain, No. V. . . .	6	4.62	24,425	112,844
Lykens Valley, No. II. . . } Lykens Valley, No. I. . . }	6	4.62	26,775	123,701
Total coal reduced to units of one foot in thickness				583,157
Surface underlaid by lowest workable coal-bed (Lykens Valley)				24,000
Average thickness of coal per foot of surface				24.29

Reference:—

Geological Survey of Pennsylvania.
W. M. C. F., mine sheets 6 and 6*a*.
W. M. C. F., cross-section sheets 5, 6, and 7.
W. M. C. F., columnar section sheets 1 and 2.

CROSS-SECTION NO. 14.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 77 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Little Orchard, No. XIII. . .	6.0	4.62	1,800	8,316
Orchard, No. XII.	4.0	3.08	3,200	9,856
Primrose, No. XI.	6.0	4.62	3,825	17,672
Holmes, No. X.	4.0	3.08	8,500	26,180
Mammoth Top split, No. IX.,	6.0	4.62	13,215	61,053
Mammoth Bot. split, No. VIII.	8.0	6.16	15,735	96,928
Skidmore, No. VII.	2.5	1.93	14,300	27,599
Seven Foot, No. VI.	2.5	1.93	20,100	38,793
Buck Mountain, No. V. . .	6.0	4.62	22,500	103,950
Lykens Valley, No. II. . . } Lykens Valley, No. I. . . . }	6.0	4.62	26.940	124,463
Totol coal reduced to units of one foot in thickness				514,810
Surface length underlaid by lowest workable bed (Lykens Valley)				24,000
Average thickness of coal per foot of surface				21.45

Reference:—

Geological Survey of Pennsylvania.
W. M. C. F., mine sheets 6 and 6*a*.
W. M. C. F., cross-section sheets 5 and 6.
W. M. C. F., columnar section sheets 1 and 2.

Cross-Section No. 15.

Name of Bed	Average thickness of bed.	Aver. thickness of coal, 77 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Tracy, No. XVI.	4.0	3.08	1,100	3,388
Little Diamond, No. XV. . .	5.0	3.85	2,100	8.085
Diamond, No. XIV.	6.0	4.62	3,050	14,091
Little Orchard, No. XIII. . .	5.0	3.85	4,130	15,901
Orchard, No. XII.	5.0	3.85	5.200	20,020
Primrose, No. XI.	7.0	5.39	8,936	48,160
Holmes, No. X.	7.0	5.39	11,320	61,015
Mammoth Top split, No. IX..	7.0	5.39	17,120	92,277
Mammoth Bot. split, No. VIII.	8.0	6.16	17.320	106,691
Skidmore, No. VII.	3.0	2.31	17,400	40,194
Seven Foot, No. VI.	2.5	1.93	17,450	33,679
Buck Mountain, No. V. . . .	5.0	3.85	17,785	68,472
Lykens Valley, No. II. . . } Lykens Valley, No. I. . . . }	6.0	4.62	21,550	99,561
Total coal reduced to units of one foot in thickness				611,534
Surface length underlaid by lowest workable bed (Lykens Valley)				16,200
Average thickness of coal per foot of surface				37.75

Reference:—

Geological Survey of Pennsylvania.
W. M. C. F., cross-section sheets 7 and 8.
W. M. C. F., mine sheets 7 and 7*a*.
W. M. C. F., columnar section sheet 1.

CROSS-SECTION NO. 16.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 77 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Tracy, No. XVI.	4.0	3.08	1,225	3,773
Little Diamond, No. XV. . .	5.0	3.85	2,070	7,970
Diamond, No. XIV.	6.0	4.62	3,630	16,771
Little Orchard, No. XIII. . .	5.0	3.85	4,720	18,172
Orchard, No. XII.	5.0	3.85	5,580	21,483
Primrose, No. XI.	6.0	4.62	9,125	42,158
Holmes, No. X.	7.0	5.39	11,100	59,829
Mammoth Top split, No. IX.	8.0	6.16	13,900	85,624
Mammoth Bot. split, No. VIII.	8.0	6.16	14,335	88,304
Skidmore, No. VII.	3.0	2.31	15,000	34,650
Seven Foot, No. VI.	2.0	1.93	15,100	29,143
Buck Mountain, No. V. . . .	5.5	3.85	15,670	60,330
Lykens Valley, No. II. . . } Lykens Valley, No. I. . . . }	6.0	4.62	16,315	75,375
Total coal reduced to units of one foot in thickness				543,502
Surface length underlaid by lowest workable bed (Lykens Valley)				14,500
Average thickness of coal per foot of surface				37.49

Reference :—

Geological Survey of Pennsylvania.
W. M. C. F., mine sheets 7 and 7*a*.
W. M. C. F., cross-section sheets 7 and 8.
W. M. C. F., columnar section sheet 1.

Cross-Section No. 17.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 77 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Diamond, No. XIV.	3	2.31	1,325	3,061
Little Orchard, No. XIII. . .	3	2.31	4,300	9,933
Orchard, No. XII.	5	3.85	5,150	19,828
Primrose, No. XI.	5	3.85	8,000	30,800
Holmes, No. X.	8	6.13	9,550	58,828
Mammoth Top split, No. IX.	9	6.93	10,200	70,686
Mammoth Bot. split, No. VIII.	12	9.24	10,300	95,172
Skidmore, No. VII.	3	2.31	10,650	24.602
Seven Foot, No. VI.	3	2.31	11,550	26,681
Buck Mountain, No. V. . . .	6	4.62	13,140	60,707
Lykens Valley, No. II. . . } Lykens Valley, No. I. . . }	8	6.16	14,000	86,240
Total coal reduced to units of one foot in thickness				486,538
Surface length underlaid by lowest workable bed (Lykens Valley)				12,200
Average thickness of coal per foot of surface				39.88

Reference :—

Geological Survey of Pennsylvania.
W. M. C. F., mine sheet 8.
W. M. C. F., cross-section sheet 8.
W. M. C. F., columnar section sheet 1.

CROSS-SECTION NO. 18.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 77 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Primrose, No. XI.	3.0	2.31	610	1,409
Holmes, No. X.	2.5	1.93	2,230	4,304
Mammoth Top split, No. IX.	12.0	9.24	3,345	30,908
Mammoth Bot. split, No. VIII.	12.0	9.24	3,685	34,049
Skidmore, No. VII.	3.0	2.31	4,570	10,557
Seven Foot, No. VI.	5.0	3.85	5,310	20,444
Buck Mountain, No. V. . . .	6.0	4.62	6,100	28,182
Lykens Valley, No. II. . . .	7.0	5.39	7,040	37,946
Lykens Valley, No. I.	6.0	4.62	7,500	34,650
Total coal reduced to units of one foot in thickness				202,449
Surface length underlaid by lowest workable coal-bed (Lykens Valley)				6,100
Average thickness of coal per foot of surface				33.19

Reference :—

Geological Survey of Pennsylvania.
W. M. C. F., mine sheet 1.
W. M. C. F., cross-section sheet 1.
W. M. C. F., columnar section sheet 7.

AREA NO. 27.

Mine Sheet No. 1 and Extreme Eastern End of Basin.

Name of Bed.	Average thickness of bed.	Average thickness of coal, 77 per cent.	Surface area in acres.	Bed area in acres.	Probable original contents in tons.
	Feet.	Feet.			
Primrose	10	7.70	2.9	3.68	55,539
Holmes.	10	7.70	305.9	378.40	5,710,813
Mammoth Top	10	7.70	809.0	981.21	14,808,421
Mammoth Middle . . .	4	3.08	879.5	1,085.53	6,553,127
Mammoth Bottom . .	6	4.62	1,309.1	1,582.00	14,325,326
Skidmore	6	4.62	1,724.1	2,082.07	18,853,560
Seven Foot	6	4.62	2,195.6	2,627.80	23,795,255
Buck Mountain	13	10.01	3,121.3	3,638.50	71,385,915
Lykens Valley	?	?	5,591.3	6,393.90	. . . . . .
Probable original contents of area No. 27					155,487,956

Reference :—

Geological Survey of Pennsylvania.
W. M. C. F., mine sheets 2 and 2*a*.
W. M. C. F., cross-section sheets 1 and 2.
W. M. C. F., columnar section sheets 6 and 7.

Area No. 28.

*Mine Sheet No. 2 and 2*a.

Name of Bed.	Average thickness of bed.	Average thickness of coal, 77 per cent.	Surface area in acres.	Bed area in acres.	Probable original contents in tons.
	Feet.	Feet.			
Little Tracy	5.0	3.85	129.3	199.8	1,507,691
Big Tracy	7.0	5.39	316.9	450.2	4,756,093
Big Diamond	8.0	6.16	561.4	772.7	9,329,271
Little Orchard	3.0	2.31	17.9	26.3	119,076
Orchard	10.0	7.70	958.8	1,296.5	19,566,778
Primrose	9.0	6.93	1,690.1	2,256.2	30,645,513
Holmes	11.0	8.47	2,597.3	3,428.0	56,908,914
Mammoth Top	15.6	12.01	3,704.1	4,791.0	112,778,224
Mammoth Middle . .	8.0	6.16	7,755.4	5,982,1	72,225,483
Mammoth Bottom . .	16.6	12.78	4,537.4	5,860.0	146,785,968
Skidmore	6.0	4.62	4,821.2	6,335.8	57,371,936
Seven Foot	7.0	5.39	5,052.9	6,646.4	70,215,228
Buck Mountain	10.0	7.70	5,412.4	7,143.0	107,802,156
Lykens Valley	?	?	7,115.4	9,462.2	. . . . . .
Probable total original contents of area No. 28					690,012,331

Reference:—

Geological Survey of Pennsylvania.
W. M. C. F., mine sheets 3 and 3*a*.
W. M. C. F., cross-section sheet 2.
W. M. C. F., columnar section sheets 4 and 5.

Area No. 29.

*Mine Sheet No. 3 and 3*a.

Name of Bed.	Average thickness of bed.	Average thickness of coal.	Surface area in acres.	Bed area in acres.	Probable original contents in tons.
	Feet.	Feet.			
Little Tracy	3.0	2.31	4.4	6.9	31,240
Tracy	7.0	5.39	230.4	341.5	3,607,743
Little Diamond	3.0	2.31	528.3	819.3	3,709,463
Diamond	6.0	4.62	868.5	1,378.6	12,483,499
Little Orchard	4.0	3.08	1,060.9	1,709.0	10,316,891
Orchard	6.0	4.62	1,426.2	2,293.8	20,770,818
Primrose	5.0	3.85	1,738.8	2,767.3	20,882,236
Holmes	9.0	6.93	2,156.8	3,413.5	46,364,888
Mammoth	30.0	23.1	3,095.4	4,921.6	222,830,362
Skidmore	4.0	3.08	3,733.9	5,651.5	34,116,975
Seven Foot	4.0	3.08	4,287.4	6,455.7	38,971,770
Buck Mountain	13.5	10.4	5,094.7	7,586.8	154,649,331
Lykens Valley	2.5	1.93	7,414.2	10,797.0	40,842,892
Probable total original contents of area No. 29					609,577,908

Reference:—

Geological Survey of Pennsylvania.
W. M. C. F., mine sheets 4 and 4*a*.
W. M. C. F., cross-section sheet 3.
W. M. C. F., columnar section sheets 3 and 4.

Area No. 30.

*Mine Sheet No. 4 and 4*a.

Name of Bed.	Average thickness of bed.	Average thickness of coal.	Surface area in acres.	Bed area in acres.	Probable original contents in tons.
	Feet.	Feet.			
Little Tracy	2.5	1.93	235.5	450.3	1,703,395
Tracy	5.0	3.85	370.0	707.2	5,336,531
Little Diamond	2.5	1.93	591.5	1,130.6	4,276,834
Diamond	6.0	4.62	873.5	1,650.6	14,946,513
Little Orchard	2.5	1.93	1,176.4	1,883.5	7,124,904
Orchard	4.0	3.08	1,624.5	2,867.5	17,310,524
Primrose	8.0	6.16	2,224.7	3,785.2	45,700,987
Holmes	6.0	4.62	2,780.8	4,625.6	41,885,729
Mammoth	23.0	17.71	4,331.3	6,800.0	236,038,880
Skidmore	3.0	2.31	5,042.7	7,784.5	35,245,102
Seven Foot	2.5	1.93	5,694.4	8,652.3	32,729,920
Buck Mountain	11.0	8.47	6,399.1	9,586.9	159,154,044
Lykens Valley	4.0	3.08	8,108.5	12,003.9	72,465,144
Probable total original contents of area No. 30					673,918,507

Reference:—

Geological Survey of Pennsylvania.
W. M. C. F., mine sheet 8.
W. M. C. F., cross-section sheet 8.
W. M. C. F., columnar section sheet 1.

Area No. 37.

From Section No. 18 to West End of Field.

Name of Bed.	Average thickness of bed.	Average thickness of coal.	Surface area in acres.	Bed area in acres.	Probable original contents in tons.
	Feet.	Feet.			
Primrose	3.0	2.31	12	14.4	65,197
Holmes	2.5	1.93	40	48.0	181,574
Mammoth Top	12.0	9.24	265	318.0	5,759,107
Mammoth Bottom . .	12.0	9.24	319	382.8	6,932,661
Skidmore	3.0	2.31	571	685.2	3,102,312
Seven Foot	5.0	3.85	757	908.4	6,854,786
Buck Mountain	6.0	4.62	884	1,060.8	9,605,756
Lykens Valley, No. II.	7.0	5.39	1,293	1,554.6	16,423,416
Lykens Valley, No. I. .	6.0	4.62	1,372	1,646.4	14,908,481
Probable original contents of area No. 37					63,833,290

Table C which follows shows the estimate of contents for the whole field. The explanation of table A, Northern field, page , applies equally well here, excepting the reference to the specific gravity, as in this table I have used 1960 tons per foot acre.

Ten specimens from the Primrose, Mammoth, Seven Foot, and Buck Mountain beds, determined by McCreath, Pennsylvania Geological Survey, Annual Report, 1885, page 314, give an average of 1.658, but as the Lykens Valley beds are less dense than the beds higher in the measure, I have thought best to use 1960 tons per acre for each foot in thickness of coal (or specific gravity 1.614) in the following estimate :—

TABLE C.

Estimate of Total Original Contents Western Middle Coal-Field.

1. Area No.	2. Between cross-sections.	3. Probable average thickness of coal at cross-sections.	4. Probable average thickness of coal for areas.	5. Surface area lowest workable bed in acres.	6. Probable original contents in tons.
		Feet.	Feet.		
*27 . .	(M. S. I.)	. . . . . .	. . . . . .	5,591.3	155,487,956
*28 . .	(M. S. 2 & 2*a*.)	. . . . . .	. . . . . .	7,115.4	690,012,331
*29 . .	(M. S. 3 & 3*a*.)	. . . . . .	. . . . . .	7,414.2	609,577,908
*30 . .	(M. S. 4 & 4*a*.)	. . . . . .	. . . . . .	8,108.5	673,918,507
31 . .	†(12) 13	33.49 24.29	28.89	7,464.0	422,644,522
32 . .	13 14	24.29 21.45	22.87	7,562.0	338,968,162
33 . .	14 15	21.45 37.75	29.60	5,929.0	343,976,864
34 . .	15 16	37.75 37.49	37.62	1,759.0	129,700,217
35 . .	16 17	37.49 39.88	38.69	4,141.0	314,021,968
36 . .	17 18	39.88 33.19	36.54	3,734.0	267,423,106
*37 . .	18	. . . . . .	. . . . . .	1,372.0	63,833,290
Totals, ...		. . . . . .	. . . . . .	60,190.4	4,009,564,831

*For areas 27, 28, 29, 30, and 37 the contents of each bed has been estimated separately, given in detail on pages .

†Area 31 covers the territory between the west line of sheets 4 and 4*a* and cross-section No. 13, but cross-section No. 12, which falls within this area, is used in determining the average thickness.

Total surface area lowest workable coal-bed, 60,190.4 acres, or 94.04 square miles.

Estimated total original contents Western Middle coal-field, 4,009,564,831 tons.

ESTIMATE OF THE ORIGINAL CONTENTS OF THE SOUTHERN COAL-FIELD.

The Southern field, the largest of all, the lowest workable bed covering an area of about 180 square miles, extends from the Lehigh at Mauch Chunk to the Susquehanna, above Daŭphin, some 70 miles, with a prong branching to the north, just west of Tremont, extending some 16 miles west to Lykens; maximum width of the field at Pottsville about 8 miles.

The force of the great thrust or upthrow which changed all the anthracite strata from horizontal to a wavy and folded condition was most severe in this field. The southern barrier, the strata of the Sharp Mountain, with its conglomerates and included and overlying coal-beds, stands perpendicular (and often overturned to inverted dips of 50 or 60 degrees) for the whole length of the field. This great upturning of the strata in the Sharp Mountain and in the succeeding waves to the north, has produced basins of great depth, and preserved from erosion a greater number of coal-beds and greater thickness of strata than in the other fields.

The crushing and faulting of the coal in portions of the coal-beds which have been sharply uptilted or overturned; the number of the coal-beds; the depth of the basins; the comparatively small areas developed by mining operations which, generally speaking, have been confined to the rim of the basin; and the fact that no very exact records of the earlier developments in this field have been preserved; all combine to render it difficult to make a close estimate of its contents.

In the following estimate these difficulties have been borne in mind, though, of course, only the development of the facts by future mining operations will overcome them. The probable loss from the first cause, the crushing and faulting of the coal-beds, is perhaps no more than has been generally supposed; the beds having steep or overturned dips are the ones usually most affected. A thorough study of all the published cross-sections in this field indicate that about 13 per cent. of the original coal of the field has been uplifted, until it now has a dip of 70 degrees or more.

In addition to the published columnar sections and bed-sections kindly furnished me by the operating companies, much valuable information was obtained from various old maps of some of the earlier operations, from the reports of the First Survey, from the operators and mining engineers, and from personal observations.

The estimate of the contents of the field is based upon the cross-sections, excepting on sheets 1, 2, 3, where I have copied the estimate of the Geological Survey. (Report AA, pages 138, 139, and 140.)

The discussion of cross-section K, Northern field, page , applies in this field, except that column *c* is obtained by taking 72 per cent. of the bed thicknesses.

Two hundred and seventy-five bed-sections, pretty well distributed throughout the field, eliminating all refuse, including bony coal in the refuse, give as an average for the field 72 per cent. coal, 28 per cent. refuse.

The Lykens Valley group, sometimes showing six workable beds in the western part of the field, is not found east of Tamaqua; above Tamaqua, in the Locust Mountain, this group is represented by two small beds (thickness not known), one of which has been worked to a small extent. I have made no estimate of the thickness of these beds until section 20, through Forestville, is reached. It seems quite possible that some areas of Lykens Valley coal may prove workable between Tamaqua and section 20, but the developments are now quite too few to speak with certainty. This bed was, however, at one time worked to a small extent at the Altamont No. 1 colliery, near Frackville.

It should be noted that from cross-section 12 at Tamaqua to cross-section 20 that the average thicknesses on the cross-sections, and the areas underlaid by workable coal, are based on the Buck Mountain bed; on section 20 and westward the estimate is based on the Lykens Valley bed. It seemed best to use the Buck Mountain bed in the first area, as the outcrop of the Lykens Valley is there not well defined, and consequently the area covered by it uncertain.

The total area of the lowest workable bed for the field is based on the Lykens Valley bed, as defined on the published mine sheets.

Reference:—

Geological Survey of Pennsylvania.

S. C. F., mine sheets 3 and 4.

S. C. F., cross-section sheet 3.

S. C. F., columnar section sheet 3.

Cross-Section No. 12.

a. Name of Bed.	*b.* Average thickness of bed.	*c.* Aver. thickness of coal, 72 per cent.	*d.* Length of bed.	*dc.* Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Coal	4	2.88	3,000	8,640
Jock	5	3.60	6,500	23,400
Washington	3	2.16	7,100	15,336
G or Upper Red Ash . . .	4	2.88	7,700	22,176
F or Red Ash	11	7.92	8,400	66,528
Mammoth Top split . . .	2	14.40	9,000	129,600
Mammoth Middle split .	6	4.32	9,050	39.096
Mammoth Bottom split .	8	5.76	9,200	52,992
C	8	5.76	9,700	55,872
B	8	5.76	10,500	60,480
A	5	3.60	11,000	39,600
Lykens Valley	?	?	. . . . .	. . . . .
Total coal reduced to units of one foot in thickness				513,720
Surface length underlaid by Buck Mountain bed				7,000
Average thickness of coal per foot of surface				73 39

Reference :—

Geological Survey of Pennsylvania.

S. C. F., mine sheet 4.

S. C. F., cross-section sheet 4.

S. C. F., columnar section sheet 4.

CROSS-SECTION NO. 13.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 72 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Little Tracy	2.5	1.80	600	1,080
Tracy	3.5	2.52	1,350	3,402
Diamond	4.0	2.88	2,180	6,278
Orchard	6.0	4.32	3,650	15,768
Primrose	6.0	4.32	5,450	23,544
Holmes	8.0	5.76	6,250	36,000
Mammoth Top split . . } Mammoth Middle split }	18.0	12.96	7,120	92,275
Mammoth Bottom split .	6.0	4.32	7,280	31,450
Skidmore	4.0	2.88	7,400	21,312
Buck Mountain	8.0	5.76	8,100	46,656
Lykens Valley	?	?	. . . . .	. . . . .
Total coal reduced to units of one foot in thickness				277,765
Surface length underlaid by Buck Mountain bed				5,880
Average thickness of coal per foot of surface				47.23

REMARKS.

The beds above the Orchard bed have not been worked in this vicinity, but are cut in the Reevesdale tunnel.

On the north side of the section the Mammoth bed is found (and in places worked) in three splits, while to the south along Sharp Mountain but two splits are recognized.

Reference :—

Geological Survey of Pennsylvania.
S. C. F., mine sheets 4 and 5.
S. C. F., cross-section sheet 4.
S. C. F., columnar section sheet 4.

Cross-Section No. 14.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 72 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Little Diamond	3	2.16	1,400	3,024
Diamond	6	4.32	3,600	15,552
Orchard	7	5.04	5,350	26,964
Primrose	7	5.04	7,700	38,808
Holmes	8	5.76	7,840	45,158
Mammoth Top split . . .	8	5.76	8,130	46,829
Mammoth Bottom split .	8	5.76	8,500	48,960
Skidmore	4	2.88	8,750	25,200
Buck Mountain	8	5.76	9,150	52,704
Lykens Valley	?	?	. . . . . .	. . . . .
Total coal reduced to units of one foot in thickness				303,199
Surface length underlaid by Buck Mountain bed				7,500
Average thickness of coal per foot of surface				40.43

Reference:—

Geological Survey of Pennsylvania.
S. C. F., mine sheets 5 and 9.
S. C. F., cross-section sheets 5, 6, and 7.
S. C. F., columnar section sheets 4 and 11.

Cross-Section No. 15.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 72 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Sandrock	2.5	1.80	2,480	4,464
Lewis	4.0	2.88	4,250	12,240
Palmer	2.5	1.80	4,750	8,550
Charles Pott	2.5	1.80	5,400	9,720
Clarkson	4.0	2.88	7,100	20,448
Little Diamond	2.0	1.44	9,650	13,896
Diamond	6.0	4.32	11,350	49,032
Orchard	4.0	2.88	12,400	35,712
Primrose	5.0	3.60	12,600	45,360
Holmes	4.0	2.88	12,900	37,152
Seven Foot	3.5	2.52	14,700	37,044
Mammoth Top split . . .	11.0	7.92	15,600	123,552
Mammoth Bottom split .	10.0	7.20	16,600	119,520
Skidmore	6.0	4.32	17,450	75,384
Buck Mountain	8.0	5.76	18,350	105,696
Lykens Valley	?	?	. . . . .	. . . . .
Total coal reduced to units of one foot in thickness				697,770
Surface length underlaid by Buck Mountain bed				14,400
Average thickness of coal per foot of surface				48.45

Remarks.

The published section No. 15 extends only south to the most northern outcrop of the Palmer bed. I have, however, constructed this section all the way across the field to the red shale outcrop on the south flank of Sharp Mountain, and the bed lengths given above are measured on this extended section.

Reference:—

Geological Survey of Pennsylvania.
S. C. F., mine sheets 6 and 10.
S. C. F., cross-section sheets 5, 6, 7, and 8.
S. C. F., columnar section sheets 5 and 11.

Cross-Section No. 16.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 72 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Sandrock	3.0	2.16	4,000	8,640
Lewis	4.5	3.24	5,400	17,496
Palmer	3.0	2.16	7,750	16,740
Charles Pott	3.5	2.52	8,300	20,916
Clarkson	5.0	3.60	9,350	33,660
Little Diamond	2.0	1.44	10,750	15,480
Diamond	6.0	4.32	11,050	47,736
Little Orchard	?	?	11,800	?
Orchard	3.5	2.52	13,500	34,020
Primrose	7.0	5.04	14,850	74,844
Holmes	4.0	2.88	16,250	46,800
Mammoth Top split . . .	8.0	5.76	17,250	99,360
Mammoth Middle split .	11.0	7.92	18,100	143,352
Mammoth Bottom split .	11.0	7.92	18,400	145,728
Skidmore	7.0	5.04	18,800	94,752
Buck Mountain	8.0	5.76	21,800	125,568
Lykens Valley	?	?	30,900	. . . . .
Total coal reduced to units of one foot in thickness				925,092
Surface length underlaid by Buck Mountain bed				17,000
Average thickness of coal per foot of surface				54.41

Reference:—

Geological Survey of Pennsylvania.

S. C. F., mine sheets 7, 10, 11, and 14*a*.

S. C. F., cross-section sheets 5, 6, 7 and, 8.

S. C. F., columnar section sheets 5 and 9.

Cross-Section No. 17.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 72 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Salem	3.0	2.16	2,100	4,536
Sandrock	3.0	2.16	5,200	11,232
Lewis	5.5	3.96	8,300	32,868
Yard	3.0	2.16	10,500	22,680
Little Tracy	3.0	2.16	11,850	25,596
Tracy	4.5	3.24	12,900	41,796
Little Clinton	2.0	1.44	8,200	11,808
Clinton	3.0	2.16	9,000	19,440
Little Diamond	2.5	1.80	17,550	31,590
Diamond	7.0	5.04	18,050	90,972
Little Orchard	3.0	2.16	18,750	40,500
Orchard	6.0	4.32	18,800	81,216
Primrose	8.0	5.76	20,000	115,200
Holmes	4.5	3.24	21,000	68,040
Seven Foot	10.0	7.20	22,150	159,480
Mammoth Middle split / Mammoth Bottom split	18.0	12.96	24,400	316,224
Skidmore	4.5	3.24	27,700	89,748
Buck Mountain	6.0	4.32	28,600	123,552
Lykens Valley	?	?	34,000	. . . . .
Total coal reduced to units of one foot in thickness				1,286,478
Surface length underlaid by Buck Mountain bed				21,800
Average thickness of coal per foot of surface				59.01

Remarks.

All the above beds have been opened along or in the neighborhood of this section.

Reference :—

Geological Survey of Pennsylvania.

S. C. F., mine sheets 7, 11, and 14.

S. C. F., cross-section sheets 9, 10, 11, and 12.

S. C. F., columnar section sheets 5, 6, 7, 8, 9, and 11.

Cross-Section No. 18.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 72 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Brewery	2.5	1.80	1,540	2,772
Salem	6.0	4.32	6,700	28,944
Faust	4.0	2.88	9,000	25,920
Tunnel	5.0	3.60	13,400	48,240
Peach Mountain	6.0	4.32	16,900	73,008
Yard	5.0	3.60	18,900	68,040
Little Tracy	3.0	2.16	19,300	41,688
Tracy	4.5	3.24	19,800	64,152
Little Diamond	2.5	1.80	18,700	33,660
Diamond	6.0	4.32	18,950	81,864
Little Orchard	3.0	2.16	20,350	43,956
Orchard	5.0	3.60	20,500	73,800
Primrose	7.0	5.04	21,750	109,620
Holmes	4.0	2.88	24,000	69,120
Seven Foot	10.0	7.20	25,250	181,800
Mammoth	18.0	12.96	26,700	346,032
Skidmore	4.0	2.88	27,700	79,776
Buck Mountain	4.0	2.88	29,000	83,520
Lykens Valley	?	?	41,200	. . . . .
Total coal reduced to units of one foot in thickness				1,455,912
Surface underlaid by Buck Mountain bed				22,300
Average thickness of coal per foot of surface				65.29

Reference:—

Geological Survey of Pennsylvania.
S. C. F., mine sheets 7, 8, 11, and 14.
S. C. F., cross-section sheets 9, 10, 11, and 12.
S. C. F., columnar section sheets 6, 7, 8, 9, and 11.

Cross-Section No. 19.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 72 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Salem	3.0	2.16	7,900	17,064
Rabbit Hole	2.5	1.80	9,800	17,640
Tunnel	5.0	3.60	15,300	55,080
Peach Mountain	7.0	5.04	17,900	90,216
Little Tracy	3.0	2.16	20,000	43,200
Tracy	4.5	3.24	21,100	68,364
Little Diamond	3.0	2.16	21,900	47,304
Diamond	7.0	5.04	22,200	111,888
Little Orchard	2.5	1.80	22,500	40,500
Orchard	6.0	4.32	22,800	98,496
Primrose	10.0	7.20	23,000	165,600
Holmes	6.0	4.32	25,300	109,296
Mammoth Top split	10.0	7.20	27,000	194,400
Mammoth Middle split	4.0	2.88	27,500	79,200
Mammoth Bottom split	12.0	8.64	30,100	260,064
Skidmore	6.0	4.32	31,900	137,808
Buck Mountain	4.0	2.88	33,940	97,747
Upper Lykens Valley	?	?	.....	.....
Lower Lykens Valley	?	?	41,400	.....
Total coal reduced to units of one foot in thickness				1,633,867
Surface length underlaid by Buck Mountain bed				24,800
Average thickness of coal per foot of surface				65.88

Reference :—

Geological Survey of Pennsylvania.
S. C. F., mine sheets 8, 12, and 15.
S. C. F., cross-section sheets 9, 10, 11, and 12.
S. C. F., columnar section sheets 6, 9, and 10.

Cross-Section No. 20.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 72 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Salem	3.0	2.16	6,700	14,472
Tunnel	4.0	2.88	12,300	35,424
Peach Mountain or Black Mine	5.0	3.60	14,900	53,640
Little Tracy	3.0	2.16	16,400	35,424
Tracy	4.5	3.24	16,800	54,432
Little Diamond	2.5	1.80	18,100	32,580
Diamond	7.0	5.04	19,900	100,296
Little Orchard	2.5	1.80	21,000	37,800
Orchard	4.0	2.88	21,600	62,208
Primrose	10.0	7.20	22,080	158,976
Holmes	8.0	5.76	24,200	139,392
Mammoth Top split	11.0	7.92	25,730	203,782
Mammoth Middle split	4.0	2.88	27,100	78,048
Mammoth Bottom split	8.0	5.76	30,800	177,408
Skidmore	6.0	4.32	32,300	139,536
Buck Mountain	4.0	2.88	36,000	103,680
Lykens Valley beds	4.0	2.88	42,300	121,824
Total coal reduced to units of one foot in thickness				1,548,922
Surface length underlaid by Buck Mountain bed				26,900
Average thickness of coal per foot of Buck Mountain surface,				57.54
Surface length underlaid by Lykens Valley bed				33,250
Average thickness of coal per foot Lykens Valley surface				46.58

Reference :—

Geological Survey of Pennsylvania.

S. C. F., mine sheets 8*a*, 12, 13, and 15.

S. C. F., cross-section sheets 13, 14, 15, and 16.

S. C. F., columnar section sheets 8, 9, and 10.

Cross-Section No. 21.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 72 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Salem	2.5	1.80	6,300	11,340
Tunnel	4.0	2.88	9,800	28,224
Peach Mountain	5.0	3.60	16,700	60,120
Little Tracy	4.0	2.88	18,100	52,128
Tracy	4.0	2.88	17,800	51,264
Little Diamond	2.5	1.80	17,900	32,220
Diamond	5.0	3.60	18,500	66,600
Little Orchard	2.5	1.80	19,000	34,200
Orchard	4.0	2.88	19,500	56,160
Primrose	10.0	7.20	20,100	144,720
Black Heath	8.0	5.76	22,800	131,328
Rough	5.0	3.60	21,600	77,760
Mammoth Top split . . .	10.0	7.20	24,700	177,840
Mammoth Bottom split .	10.0	7.20	25,000	180,000
Skidmore	3.0	2.16	25,900	55,944
Buck Mountain	6.0	4.32	34,600	149,472
Lykens Valley beds . . .	8.0	5.76	42,000	241,920
Total coal reduced to units of one foot in thickness				1,551,240
Surface length underlaid by lowest workable bed (Lykens Valley)				32,600
Average thickness of coal per foot of surface				47.58

Reference:—

Geological Survey of Pennsylvania.
S. C. F., mine sheets 8*a*, 13, and 16.
S. C. F., cross-section sheets 13, 14, and 15.
S. C. F., columnar section sheets 10 and 11.

Cross-Section No. 22.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 72 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Salem	2.5	1.80	4,600	8,280
Tunnel	4.0	2.88	8,000	23,040
Peach Mountain	6.0	4.32	10,400	44,928
Little Tracy	4.0	2.88	13,800	39,744
Tracy	4.0	2.88	15,300	44,064
Little Diamond	2.5	1.80	8,100	14,580
Diamond	5.0	3.60	17,500	63,000
Orchard	4.0	2.88	17,700	50,976
Primrose	8.0	5.76	17,900	103,104
Black Heath	8.0	5.76	18,200	104,832
Mammoth Top and Bottom	16.0	11.52	20,000	230,400
Skidmore	3.0	2.16	19,700	42,552
Buck Mountain	9.0	6.48	23,300	150,984
Lykens Valley No. 1 . . .	2.0	1.44	24,900	35,856
Lykens Valley No. 2 . . .	2.0	1.44	30,200	43,488
Lykens Valley No. 3 . . .	2.0	1.44	30,800	44,352
Lykens Valley No. 4 . . .	2.0	1.44	31,800	45,792
Lykens Valley Nos. 5 and 6,	3.0	2.16	32,500	70,200
Total coal reduced to units of one foot in thickness				1,160,172
Surface length underlaid by lowest workable bed (Lykens Valley)				24.000
Average thickness of coal per foot of surface				48.34

Reference:—

Geological Survey of Pennsylvania.
S. C. F., mine sheets 8*a*, 13, and 16.
S. C. F., cross-section sheets 16, 17, and 18.
S. C. F., columnar section sheets 10 and 11.

Cross-Section No. 23.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 72 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Salem	2.5	1.80	2,400	4,320
Tunnel	3.0	2.16	3,200	6,912
Peach Mountain	6.0	4.32	9,000	38,880
Little Tracy	4.0	2.88	11,800	33,984
Tracy	4.0	2.88	14,000	40,320
Little Diamond	2.5	1.80	16,000	28,800
Diamond	5.0	3.60	18,700	67,320
Orchard	4.0	2.88	18,100	52,128
Primrose	8.0	5.76	18,200	104,832
Black Heath	8.0	5.76	18,400	105,984
Four Foot	4.0	2.88	18,900	54,432
Mammoth Top and Bottom splits	18.0	12.96	19,300	250,128
Skidmore	4.0	2.88	19,600	56,448
Buck Mountain	8.0	5.76	20,000	115.200
Lykens Valley No. 1 . . .	2.5	1.80	20,400	36,720
Lykens Valley No. 2 . . .	3.0	2.16	23,900	51,624
Lykens Valley No. 3 . . .	2.5	1.80	24,600	44,280
Lykens Valley No. 4 . . .	2.5	1.80	26,700	48,060
Lykens Valley No. 5 . . .	3.0	2.16	28,100	60,696
Total coal reduced to units of one foot in thickness				1,201,068
Surface length underlaid by lowest workable bed (Lykens Valley)				18.900
Average thickness of coal per foot of surface				63.55

Reference :

Geological Survey of Pennsylvania.
S. C. F., mine sheets 17 and 21.
S. C. F., cross section sheets 16, 17, and 18.
S. C. F., columnar section sheets 7, 10, and 11.

Cross-Section No. 24.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 72 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Little Diamond	6	4.32	1,350	5,832
Diamond	4	2.88	2,300	6,624
Little Orchard	4	2.88	3,950	11,376
Orchard	6	4.32	9,500	41,040
Primrose	8	5.76	11,500	66,240
Black Heath	8	5.76	12,800	73,728
Four Foot	4	2.88	6,720	19,354
Mammoth Top and Bottom splits	18	12.96	16,300	211,248
Skidmore	4	2.88	17,200	49,536
Buck Mountain	4	2.88	18,200	52,416
Lykens Valley No. 1 . . .	4	2.88	20,600	59,328
Lykens Valley No. 2 . . .	4	2.88	23,600	67,968
Lykens Valley No. 3 . . .	3	2.16	13,900	30,024
Lykens Valley No. 4 . . .	2	1.44	25,800	37,152
Lykens Valley Nos. 5 and 6,	3	2.16	27,600	59,616
Total coal reduced to units of one foot in thickness				791,482
Surface length underlaid by lowest workable bed (Lykens Valley)				19,350
Average thickness of coal per foot of surface				40.90

Reference :—

Geological Survey of Pennsylvania.
S. C. F., mine sheet 17.
S. C. F., cross-section sheet 19.
S. C. F., columnar section sheets 10 and 11.

Cross-Section No. 25.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 72 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Coal	6.0	4.32	1,200	5,184
Coal	4.0	2.88	2,100	6,048
Coal	3.0	2.16	3,400	7,344
Orchard	6.0	4.32	4,400	19,008
Primrose	7.0	5.04	6,200	31,248
Black Heath	8.0	5.76	7,100	40,896
Four Foot	4.0	2.88	8,100	23,328
Mammoth Top split . . .	10.0	7.20	8,200	59,040
Mammoth Bottom split .	5.0	3.60	8,300	29,880
Skidmore	5.0	3.60	8,600	30,960
Buck Mountain	3.0	2.16	9,100	19,656
Lykens Valley No. 1 . . .	3.0	2.16	9,900	21,384
Lykens Valley Nos. 2 and 3,	3.0	2.16	11,000	23,760
Lykens Valley No. 4 . . .	2.5	1.80	11,600	20,880
Lykens Valley Nos. 5 and 6,	3.0	2.16	12,000	25,920
Total coal reduced to units of one foot in thickness				364,536
Surface length underlaid by lowest workable bed (Lykens Valley)				9,000
Average thickness of coal per foot of surface				40.50

Reference :—

Geological Survey of Pennsylvania.
S. C. F., mine sheet 18.
S. C. F., cross-section sheet 19.
S. C. F., columnar section sheets 10 and 11.

Cross-Section No. 26.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 72 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Diamond	8.0	5.76	700	4,032
Little Orchard	2.5	1.80	1,500	2,700
Orchard	6.0	4.32	2,000	8,640
Primrose	6.0	4.32	2,400	10,368
Holmes	8.0	5.76	2,600	14,976
Four Foot	4.0	2.88	3,200	9,216
Mammoth Top split . . .	4.0	2.88	3,300	9,504
Mammoth Bottom split .	6.0	4.32	3,400	14,688
Skidmore	2.0	1.44	3,700	5,328
Buck Mountain	6.0	4.32	5,600	24,192
Lykens Valley No. 1 . . .	2.0	1.44	7,800	11,232
Lykens Valley Nos. 2 and 3,	4.0	2.88	11,000	31,680
Lykens Valley No. 4 . . .	3.0	2.16	11,700	25,272
Lykens Valley Nos. 5 and 6,	10.0	7.20	11,800	84,960
Total coal reduced to units of one foot in thickness				256,788
Surface underlaid by lowest workable bed (Lykens Valley) .				8,800
Average thickness of coal per foot of surface				29.18

Reference:—

Geological Survey of Pennsylvania.
S. C. F., mine sheet 19.
S. C. F., cross-section sheet 20.
S. C. F., columnar section sheet 7.

CROSS-SECTION No. 27.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 72 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Orchard	2.5	1.80	2,700	4,860
Primrose	4.0	2.88	3,600	10,368
Holmes	6.0	4.32	3,800	16,416
Mammoth	8.0	5.76	4,300	24,768
Skidmore	3.5	2.52	5,200	13,104
Buck Mountain	2.5	1.80	5,500	9,900
Lykens Valley Nos. 2 and 3,	2.5	1.80	9,000	16,200
Whites	3.5	2.52	9,500	23,940
Lykens Valley No. 5 . . .	10.0	7.20	9,700	69,840
Little	3.0	2.16	9,800	21,168
Zero	2.5	1.80	3,000	5,400
Total coal reduced to units of one foot in thickness				215,964
Surface length underlaid by lowest workable bed				7,300
Average thickness of coal per foot of surface				29.59

Reference:—

Geological Survey of Pennsylvania.
S. C. F., mine sheet 20.
S. C. F., cross-section sheet 20.
S. C. F., columnar section sheet 7.

CROSS-SECTION No. 28.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 72 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Orchard	4.0	2.88	500	1,440
Primrose	3.0	2.16	1,000	2,160
Holmes	3.0	2.16	1,500	3,240
Mammoth	3.0	2.16	2,500	5,400
Skidmore	3.0	2.16	2,900	6,264
LykensValley Nos. 2 and 3,	2.5	1.80	7,100	12,780
Whites	3.5	2.52	7,300	18,396
Lykens Valley No. 5 . . .	9.0	6.48	7,400	47,952
Little	3.0	2.16	7,500	16,200
Total coal reduced to units of one foot in thickness				113,832
Surface underlaid by lowest workable bed				5,250
Average thickness of coal per foot of surface				21.68

Reference:—

Geological Survey of Pennsylvania.
S. C. F., mine sheet 22.
S. C. F., cross-section sheet 21.
S. C. F., columnar section sheet 11.

Cross-Section No. 29.

Name of Bed.	Average thickness of bed.	Aver. thickness of coal, 72 per cent.	Length of bed.	Length of bed. Coal 1 foot thick.
	Feet.	Feet.	Feet.	Feet.
Primrose	4	2.88	2,800	8,064
Holmes	4	2.88	3,300	9,504
Mammoth	10	7.20	4,300	30,960
Skidmore	3	2.16	4,800	10,368
Buck Mountain	4	2.88	5,200	14,976
Lykens Valley beds . . .	15	10.80	8,300	89,640
Total coal reduced to units of one foot in thickness				163,512
Surface length underlaid by lowest workable bed (Lykens Valley)				4,650
Average thickness of coal per foot of surface				35.16

Remarks.

The identity of the beds on the two sides of the Schuylkill and Dauphin basin is very uncertain, nor is it certain that any of the beds here have been correctly identified with those to the east at section 24, excepting the Lykens Valley beds Nos. 4, 5, and 6, which have been worked west from Lincoln and Kalmia collieries to this section line; therefore the estimate of the number and thickness of the coal-beds along this section line is an approximate one.

Reference:—

Geological Survey of Pennsylvania.
S. C. F., mine sheet 1.
S. C. F., columnar section sheet 1.
S. C. F., cross-section sheet 1.

Area No. 38.

On Mine Sheet No. 1.

(Copied from Geological Survey of Pennsylvania, Report of Progress AA, page 138.)

Name of Bed.	Average thickness of bed.	Average thickness of coal.	Surface area in acres.	Bed area in acres.	Probable original contents in tons.
	Feet.	Feet.			
G or Upper Red Ash .	5.0	2.5	59	103	510,982
F or Red Ash	13.0	9.0	314	549	9,762,385
Five-Foot	4.5	3.0	404	706	4,182,931
E or Top split . . . } Middle Mammoth . } D or Bottom split . }	29.0	23.0	495	863	39,189,964
C	4.5	3.0	638	1,113	6,591,266
B	15.0	10.0	781	1,362	26,902,857
A	3.0	1.0	781	1,362	2,690,262
Lykens Valley	. . . .	. . . .	. . . .	. . . .	. . . . . .
Probable original contents of area No. 1					89,830,647

The Lykens Valley beds are not considered in this table, as nothing is certainly known of their extent or thickness.

Reference :—

Geological Survey of Pennsylvania.
S. C. F., mine sheet 2.
S. C. F., cross-section sheet 2.
S. C. F., columnar section sheet 2.

Area No. 39.

On Mine Sheet No. 2.

(Copied from Geological Survey of Pennsylvania, Report of Progress AA, page 139.)

Name of Bed.	Average thickness of bed.	Average thickness of coal.	Surface area in acres.	Bed area in acres.	Probable original contents in tons.
	Feet.	Feet.			
Second Twin	?	?	84	132	. . . . . .
First Twin	?	?	322	502	. . . . . .
Jock	7	3	703	1,096	6,495,400
Washington	3	1	1,083	1,689	3,335,499
G or Upper Red Ash .	6	3	1,544	2,408	14,267,400
F or Red Ash	9	5	2,288	3,511	35,243,776
Five-Foot	. . . .	. . . .	. . . .	. . . .	. . . . . .
E or Top split . . } Middle Mammoth . } D or Bottom split . }	55	27	2,817	4,406	234,933,419
C	5	3	3,070	4,801	28,443,556
B	8	2	3,322	5,196	20,522,343
A	5	2	3,322	5,196	10.262,100
Probable original contents of area No. 2.					353,503,493

Thicknesses of coal-beds above the Jock bed unknown.

Reference :—

Geological Survey of Pennsylvania.
S. C. F., mine sheet 3.
S. C. F., cross-section sheet 3.
S. C. F., columnar section sheet 3.

AREA No. 40.

On Mine Sheet No 3..

(Copied from Geological Survey of Pennsylvania, Report of Progress AA, page 140.)

Name of Bed.	Average thickness of bed.	Average thickness of coal.	Surface area in acres.	Bed area in acres.	Probable original contents in tons.
	Feet.	Feet.			
Third Upper Red Ash .	. . . .	. . . .	15	23	. . . . . .
Second Upper Red Ash,	. . . .	. . . .	39	62	. . . . . .
First Upper Red Ash .	. . . .	. . . .	189	299	. . . . . .
Second Twin	. . . .	. . . .	339	537	. . . . . .
First Twin	. . . .	. . . .	792	1,251	. . . . . .
Jock	7	3	1,245	1,967	11,658,090
Washington	3	1	1,796	2,839	5,604,832
G or Upper Red Ash .	5	3	2,347	3,707	21,969,781
F or Red Ash	12	9	3,039	4,803	85,373,325
Five-Foot	. . . .	. . . .	. . . .	. . . .	. . . . . .
E or Top split . . . } Middle Mammoth . . } D or Bottom split . . }	43	27	3,532	5,391	298,246,725
C.	11	8	3,729	5,901	93,221,738
B.	6	2	3,926	6,210	24,529,500
A.	7	4	3,926	6,210	49,059,000
Probable original contents of area No. 3					589,662,991

Thicknesses of coal-beds above the Jock bed unknown.

Reference :—

Geological Survey of Pennsylvania.
S. C. F., mine sheet 20.

AREA No. 57.

From Cross-Section No. 28 to End of Wiconisco Basin.

Name of Bed.	Average thickness of bed.	Average thickness of coal 77 per cent.	Surface area in acres.	Bed area in acres.	Probable original contents in tons.
	Feet.	Feet.			
Mammoth	3.0	2.16	104.9	131.1	514,814
Skidmore	?	?	?	?	. . . . . .
Lykens Valley (2 and 3),	2.5	1.80	1,028.5	1,285.6	4,206,997
Whites (4)	3.5	2.52	1 064.3	1,330.3	6,094,583
Lykens Valley (5) . . .	9.0	6.48	1,101.9	1,377.4	16,226,653
Little (6)	3.0	2.16	1,144.5	1,430.4	5,617,009
Probable total original contents of area No. 57					32,660,056

Reference:—

S. C. F., mine sheets 22, 23, 24, 25, 26, and 27.
S. C. F., columnar section sheet 8.
S. C. F., cross-section sheet 21.

Area No. 59.

Schuylkill and Dauphin Basin.

(Between section 29 and the west end of the basin.)

The Schuylkill and Dauphin basin extends west of section 29, as a long, narrow, deep trough, some 23 miles, ending about one mile east of the Susquehanna River, and just north of the village of Dauphin, having for its southern barrier the crest of Sharp Mountain, and for its northern that of Fourth Mountain. The width of the basin at section 29 is about one mile, tapering to a point at the western end.

With the exception of a few trial shaftings no work has been done in this area since 1860. Previous to this some 2 or 3 collieries had been opened and some shipments of coal made.

The report of the first Geological Survey, speaking of this basin, says: "The Dauphin coal basin is now (1868) entirely deserted by coal miners. For several years little or no coal has been shipped from it. So unreliable do the seams prove and so great is the outlay required that, recollecting that former experiments have failed, no disposition is manifested at present to develop its resources."

Owing to the irregularity of the beds, which is plainly shown by the maps of the collieries which were opened, the comparatively small extent of the developments made, and the meagre and somewhat uncertain knowledge we have of them, any estimate of the amount of coal in the area must necessarily be a very general one.

The second Geological Survey made a very thorough examination of this basin, and while connected with that work I became acquainted with the surface exposures and with the few maps and the old data relating to this basin.

The surface underlaid by coal is 8,170. acres.

Owing to the very steep dips on both sides of the basin the bed acreage is perhaps one and one-half times the surface acreage, or 12,255.2 acres.

The probable average thickness of coal at section 29 is estimated to be 35.16 feet. From the section westward the basin slowly diminishes in width and in depth, the coal beds gradually spooning out until the lowest bed comes today near Dauphin. Were we to use 15 feet as a rough approximation of the average thickness of workable coal for this area its contents would be 334,199,304 tons.

Estimated original contents of area No. 59, 334,199,304 tons.

Table D which follows shows the estimate of contents for the whole field.

The explanation of Table A, Northern field, page 75, applies equally well here, excepting as to specific gravity.

The only determinations of specific gravity that we have by McCreath in this field are in the Panther Creek basin, east of Tamaqua, which there give as an average 1.6307, and Mr. Ashburner used this in his estimate. (Areas 38, 39, and 40.)

Determinations by others would show that to the west the coals are less dense, and those of the Lykens Valley group decidedly so.

I am indebted to Mr. J. R. Hoffman, of the Philadelphia and Reading Coal and Iron Company, for a number of specific gravity determinations of coals from the western part of the field. The average of the Lykens Valley coals is 1.44. I have thought best to use, as in the Western Middle field, 1.614 or 1960 tons per foot acre for areas 41 to 49 inclusive, and 1.50 or 1818 tons per foot acre for the balance of the field (areas 50 to 59 inclusive). The Lykens Valley group first attains prominence in the neighborhood of area 50.

Table D.

Estimate of Total Original Contents Southern Coal-Field.

1. Area No.	2. Between cross-sections.	3. Probable average thickness of coal at cross-sections.	4. Probable average thickness of coal for areas.	5. Surface Area Acres: Buck Mountain bed.	5. Surface Area Acres: Lowest workable bed.	6. Probable original contents in tons.
		Feet.	Feet.			
*38	(M. S. I.)	. . . . . .	. . . .	. . . .	781.0	89,830,647
*39	(M. S. II.)	. . . . . .	. . . .	. . . .	3,322.0	353,503,493
*40	(M. S. III.)	. . . . . .	. . . .	. . . .	3,926.0	589,662,991
41	12, 13	73.39, 47.23	60.31	†1,773.1	2,115.4	209,593,895
42	13, 14	47.23, 40.43	43.83	†1,637.5	2,099.1	140,672,385
43	14, 15	40.43, 48.45	44.44	†5,317.3	7,570.7	463,149,591
44	15, 16	48.45, 54.41	51.43	†4,864.7	8,755.1	490,375,381
45	16, 17	54.41, 59.01	56.71	†6,285.1	8,597.7	698,598,921
46	17, 18	59.01, 65.29	62.15	†4,025.7	5,688.7	490,386,619
47	18, 19	65.29, 65.88	65.59	†6,901.9	10,467.6	887,283,417
48	19, 20	65.88, †57.54	61.71	†5,287.1	6,993.3	639,483,204
49	20, 21	46.58, 47.58	47.08	. . . .	10,802.7	996,838,587
50	21, 22	47.58, 48.34	47.96	. . . .	7,396.9	695,320,435
51	22, 23	48.34, 63.55	55 95	. . . .	4,420.8	449,670,956
52	23, 24	63.55, 40.90	52.23	. . . .	6,173.0	586,151,906
53	24, 25	40.90, 40.50	40.70	. . . .	2,536.0	187,645,234
54	25, 26	40.50, 29.18	34.84	. . . .	2,996.2	189,776,671
55	26, 27	29.18, 29.59	29.39	. . . .	3,542.8	189,295,418
56	27, 28	29.59, 21.68	25.64	. . . .	3,546.4	165,310,187
57	28	. . . . . .	. . . .	. . . .	1,144.5	32,660,056
58	24, 29	40.90, 35.16	38.03	. . . .	4,614.3	319,025,965
59	29	. . . . . .	. . . .	. . . .	8,170.1	334,199,304
Totals,	. . . . .	. . . . . .	. . . .	. . . .	115,946.2	9,198,435,263

* Areas 38, 39, 40, and 57, the contents of each bed has been estimated separately, given in detail on pages 115, 116 and 117.

† Areas 41 to 48, the estimate of contents is based on the surface area of the Buck Mountain bed.

Total surface area lowest workable coal-bed, 115,946.2 acres, or 181.16 square miles.

Estimated total original contents Southern coal-field, 9,198,435,263 tons.

Recapitulation.

Estimated total original contents and area of Pennsylvania anthracite coal-fields.

Totals by Fields.

	Area lowest workable coal-bed, square miles.	Probable original contents in tons.
Northern	176.29, say 176	5,697,380,784, say 5,700,000,000
Eastern Middle . . .	32.72, " 33	602,491,447, " 600,000,000
Western Middle . .	94.04, " 94	4,009,564,831, " 4,000,000,000
Southern	181.16, " 181	9,198,435,263, " 9,200,000,000
Totals	484.21, say 484	19,507,872,325, say 19,500,000,000

Estimated total area lowest workable coal-bed, 484 square miles.

Estimated total original contents Pennsylvania anthracite coal-fields, 19,500,000,000 tons.

The trade has made the following divisions of the anthracite fields, viz.:—

1. Wyoming region . . . Northern field and Bernice basin.
2. Lehigh region . . . . . Eastern Middle field and Southern field east of Tamaqua.
3. Schuylkill region . . . Western Middle field and Southern field west of Tamaqua.

Totals by Regions.

	Area lowest workable coal-bed, square miles.	Probable original contents in tons.
Wyoming	176.29, say 176	5,697,380,784, say 5,700,000,000
Lehigh	45.25 " 45	1,635,488,578, " 1,600,000,000
Schuylkill	262.67 " 263	12,175,002,963, " 12,200,000,000
Totals	484.21, say 484	19,507,872,325, say 19,500,000,000

Estimated total area lowest workable coal-bed, 484 square miles.

Estimated total original contents Pennsylvania anthracite coal regions, 19,500,000,000 tons.

A COLLECTION OF DATA SHOWING THE PER CENT. OF COAL ACTUALLY WON AT SOME OF THE COLLIERIES THROUGHOUT THE ANTHRACITE REGION.

In order to obtain some base for an estimate of the amount of coal which has been exhausted by mining, the Commission authorized the collection of the available data, showing the per cent. of coal which had been won, from worked out areas, at different collieries throughout the region. In this connection I wish to acknowledge my indebtedness for the data following to :—

W. A. May, General Superintendent Hillside Coal and Iron Company.

M. Barnard, of the Hillside Coal and Iron Company.

E. H. Lawall, General Superintendent Lehigh and Wilkes-Barre Coal Company.

William J. Richards, Chief Engineer Lehigh and Wilkes-Barre Coal Company.

J. H. Bowden, Chief Engineer Susquehanna Coal Company.

John R. Law, Mining Engineer Pennsylvania Coal Company.

H. H. Ashley, Superintendent Parrish Coal Company.

C. R. Marcy, Superintendent Raub Coal Company.

C. H. Reynolds, Superintendent Chauncy Coal Company.

H. S. Thompson, Engineer Girard Estate.

Executors of the Estate of P. W. Sheafer.

A. W. Sheafer, E. M.

R. C. Luther, General Superintendent Philadelphia and Reading Coal and Iron Company.

J. R. Hoffman, Division Engineer Philadelphia and Reading Coal and Iron Company.

G. S. Clemens, Division Engineer Philadelphia and Reading Coal and Iron Company.

N. C. F. (1.)

Keystone Colliery.

Hillside Coal and Iron Company, Operators.

Mining operations from 1882 to 1890 :—

Area worked, 119.5 acres.

Archbald bed, average thickness 7.6 feet, average thickness of coal (20 sections), 7.116 feet.

Surface of little or no value, 100± feet of cover over bed.

Pillars yet to be robbed and gob to be worked over.

Production, 769,383 tons, including all sizes except culm.

Average yield per foot acre, 904 tons, or 48 per cent.

Specific gravity taken at 1.55.

Coal actually won from this area, including buckwheat, 48 per cent.

Mr. May, the superintendent of this company, says they usually count on winning 1000 tons to the foot acre in this neighborhood. Should the pillars and gob bring the yield to this, and it seems quite probable that they will equal or even exceed it, the area mined would then show a yield of 53.2 per cent.

Estimate of coal won, including what can probably be got from pillars and gob, 53.2 per cent.

N. C. F. (2.)

Nottingham Colliery.

Lehigh and Wilkes-Barre Coal Company, Operators.

Area worked, 522.5 acres.

Red ash bed, about 22 feet thick, with 13 feet of coal.

Surface valuable; workings 200 to 400 feet below surface.

Dip, 15 to 20 degrees.

Worked out, pillars robbed.

Coal won per foot acre, exclusive of buckwheat, 709.1 tons, or 37.7 per cent.

Coal won per foot acre, estimating buckwheat at 10 per cent., 780 tons, or 41.5 per cent.

Estimate of coal won, including buckwheat, 41.5 per cent.

N. C. F. (3.)

Nottingham Colliery.

Lehigh and Wilkes-Barre Coal Company, Operators.

Area worked, 138.1 acres.

Ross bed, 7 feet thick, with 6 feet of coal.

Workings near the outcrop, and it was not necessary to keep the surface up.

Dip, 15 to 25 degrees.

Worked out and pillars robbed.

Coal won per foot acre, exclusive of buckwheat, 919 tons, or 48.9 per cent,

Coal won per foot acre, adding 10 per cent. for buckwheat, 1000 tons, or 53.2 per cent.

Estimate of coal won, including buckwheat, 53.2 per cent.

N. C. F. (4.)

Hillman Bed, in vicinity of Wilkes-Barre.

Area worked, 7.25 acres.

Hillman bed, 7 to 8 feet thick, with 6 feet of coal.

Surface kept up. Worked out, pillars robbed.

Coal won per foot acre, exclusive of buckwheat, 800 tons, or 42.5 per cent.

Coal won per foot acre, adding 10 per cent. for buckwheat, 880 tons, or 46.8 per cent.

Estimate of coal won, including buckwheat, 46.8 per cent.

N. C. F. (5.)

Lance Colliery.

Lehigh and Wilkes-Barre Coal Company, Operators.

Area developed, 88 acres; fault area, 5 acres.

Area worked, 83 acres; estimate based on area worked.

Bennett bed, 9 feet thick, 7 feet of coal.

Surface valuable. Dip, 15 to 20 degrees. Worked out and pillars robbed.

Coal won per foot acre, exclusive of buckwheat, 828.6 tons, or 44.1 per cent.

Coal won per foot acre, adding 10 per cent. for buckwheat, 911 tons, or 48.5 per cent.

Estimate of coal won, including buckwheat,48.5 per cent.

N. C. F. (6.)

SUGAR NOTCH, BREAKER NO. 9.

Lehigh and Wilkes-Barre Coal Company, Operators.

Area worked, 74 acres.

Kidney bed, 7 to 8 feet thick, with 6 feet of coal.

Dip, 30 to 40 degrees. Worked out and pillars robbed.

Coal won per foot acre, exclusive of buckwheat, 762 tons, or 40.5 per cent.

Coal won per foot acre, adding 10 per cent. for buckwheat, 838 tons, or 44.6 per cent.

Estimate of coal won, including buckwheat, 44.6 per cent.

N. C. F. (7.)

HOLLENBACK NO. 2.

Lehigh and Wilkes-Barre Coal Company, Operators.

Area worked, 160 acres.

Baltimore bed, 16 feet thick, 13 feet coal.

Workings under city of Wilkes-Barre; necessary to keep surface up.

Dip, 10 to 15 degrees. Worked out and pillars robbed.

Coal won per foot acre, exclusive of buckwheat, 525 tons, or 27.9 per cent.

Coal won per foot acre, adding 10 per cent. for buckwheat, 577.5, or 30.7 per cent.

Estimate of coal won, including buckwheat, 30.7 per cent.

N. C. F. (8.)

HOLLENBACK NO. 2.

Lehigh and Wilkes-Barre Coal Company, Operators.

Area worked, 75 acres.

Hillman bed, about 12 feet thick, with 9 to 10 feet of coal.

Workings under city of Wilkes-Barre; necessary to keep surface up.

Dip, 10 to 15 degrees. Worked out and pillars robbed.

Coal won per foot acre, exclusive of buckwheat, 625 tons, or 33.2 per cent.

Coal won, adding 10 per cent. for buckwheat, 687.5 tons, or 36.6 per cent.

Estimate of coal won, including buckwheat, 36.6 per cent.

N. C. F. (9.)

PENNSYLVANIA COAL COMPANY.

Mr. John R. Law, mining engineer for the Pennsylvania Coal Company, estimates that his company is winning 800 tons per acre above pea coal and 1000 tons per acre, all sizes, including pea and buckwheat, or about 53.2 per cent.

In deep workings or where the workings are under towns or the river, making it necessary to leave a large portion or all of the pillar coal in, the per cent. won is much less.

The beds worked by this company are in a general way from 3 to 14 feet thick.

Their breaker loss he estimates at from 17 to 25 per cent.

Estimate of coal won, including buckwheat, 53.2 per cent. and less.

N. C. F. (10.)

PARRISH COLLIERY.

Parrish Coal Company, Operators.

Mining operations 1882 to 1892 :—

Area of bed, 152 acres, of which 140 acres have been mined out.

Ross or Seven Foot bed, average thickness, 7 feet; average thickness of coal, 5 feet 7 inches.

Typical Section of Bed.	Top:—1′ 6″ coal.
	0′ 6″ bone.
	0′ 9″ coal.
	0′ 3″ sulphur.
	0′ 8″ coal.
	0′ 8″ bone.
	2′ 8″ coal.
	7′ 0″. Total, 5′ 7″ coal, 1′ 5″ refuse.

Roof fairly good, dips gentle, conditions favorable for thorough working.

Bed thoroughly mined and robbed whenever it could be done with safety and economy.

Production :—	Tons.
Prepared coal	808,702.00
Pea	103,787.08
Buckwheat	34,787.10
Total	947,277.00

This is the amount of coal sold and does not include buckwheat used for steam.

Average yield *coal sold* per foot acre, 1213 tons, or 64.5 per cent.

The report of the mine inspector for 1890 shows the production for that year at this colliery to exceed the shipment by about 2 per cent.; adding 2 per cent. to the total coal sold gives for total production 966,213 tons.

Average yield per foot acre, 1237 tons, or 65.8 per cent.

Breaker Waste.

On September 6th, 7th, and 8th, 1892, the colliery produced, in mine cars, 3539 tons 2 cwt. and 53 lbs. of coal, prepared as follows:—

Broken	342.13		
Egg	357.09		
Stove	696.03		
Chestnut	701.18		
Pea	264.00		
Buck (used for steam)	384.00		
			2,746.03.00
Dirt or culm		515.17.21	
Slate and rock		277. 2.32	
			792.19.53
			3,539. 2.53
Coal prepared (as shown above)			2,746.03.00
Lost in fine coal and coal-dirt			515.17.21

Breaker waste, 18.8 per cent. of production.

RECAPITULATION.

Probable original contents of area worked out (140 acres; average thickness of coal, 5 feet 7 inches), 1,468,656 tons.

Total production	966,213 tons, or	65.8 per cent.
Total coal and coal-dirt sent to culm bank,	181,648 tons, or	12.4 per cent.
Total coal and coal-dirt in pillars and gob,	320,795 tons, or	21.8 per cent.
	1,468,656 tons, or	100.0 per cent.

Specific gravity taken as 1.55, or 1880 tons per foot acre.

N. C. F. (11.)

COLLIERY NO. 3.

Susquehanna Coal Company.

Mr. J. H. Bowden, chief engineer, has recently made a thorough examination and report relative to the coal won at this colliery, showing the following general results:—

Mining operations from January 1st, 1873, to January 1st, 1892:

Area worked over, 233.8 acres; above water level, 89.5 acres; below water, 144.3 acres.

Red Ash bed: Thickness, 15 to 19 feet; thickness worked, 13 to 17 feet; average thickness for area, 16.10 feet; average thickness worked, 14.57 feet.

The bed is quite free from faults, the mining fairly regular, and the pillars have been robbed as per statement below.

Coal produced from mining over:—		
Prepared	1,753,401	
Pea	142,267	
		1,895,668 tons.
The pillars were robbed excepting in 137.2 acres (below water level), where the bottom bench was but partly mined out, owing to heavy slate partings and faults in seam, when workings caved and balance of coal was lost.		
Coal produced from robbing:—		
Prepared	118,725	
Pea	11,217	
		129,942 tons.
Total production of area in pea and prepared sizes . .		2,025,610 tons.

Actual coal won in pea and prepared sizes, 595 tons per foot acre, or 31.6 per cent.

Estimating Pea Coal for Whole Period of Mining.

Pea coal was not made during the early years of this colliery. Had it been produced at the average yield of the past 10 years (1881–91), viz., 11.7 per cent. of the total, or 13.2 per cent. of coal above pea size, the yield of pea coal from the mining over of these properties would have been 232,448 tons, or the total production, all sizes except buckwheat, 2,115,791 tons.

Estimate of coal won, all sizes except buckwheat, if pea coal had been made for whole period, 621 per foot acre, or 33 per cent.

Estimating Buckwheat Coal for Whole Period of Mining.

Buckwheat coal is now made at this colliery. Allowing 10 per cent. for this size, had it been produced for whole period, the total product would have been 2,327,370 tons.

Estimate of coal won, including buckwheat, 683 tons per foot acre, or 36.3 per cent.

N. C. F. (12.)

Raub Washery.

Raub Coal Company.

This company are washing and preparing the coal from the old dirt bank of the Waddel Colliery, Mill Hollow, Pa.

They find that about 50 per cent. of the bank can be won in marketable coal, with the sizes in about the following proportions:—

Chestnut	10 per cent.
Pea	20 per cent.
Buckwheat No. 1	35 per cent.
Buckwheat No. 2	35 per cent.
	100 per cent.

N. C. F. (13.)

Reynolds Washery.

Chauncy Coal Company.

This company are washing and preparing the coal from the old dirt bank of Reynolds Colliery, Plymouth, Pa.

They find that about 70 per cent. of the bank can be won in marketable coal. An average taken from the books for five months show sizes in the following proportions:—

Chestnut	10½ per cent.
Pea	22 per cent.
Buckwheat No. 1	37½ per cent.
Buckwheat No. 2	30 per cent.
	100 per cent.

This is one of the oldest banks in the field, and the proportion of coal very large.

W. M. C. F. (14.)

Hammond Colliery.

Philadelphia and Reading Coal and Iron Company, Operators.

Estimate of the per cent. of coal won from the commencement of mining, 1863, to December 1st, 1891, made from the mine maps and information furnished by Heber S. Thompson, engineer Girard estate:—

Name of Bed.	Average dip.	Average thickness of bed.	Average thickness of coal.	Area Worked.		Probable original contents in tons.
				Surface acres.	Bed acres.	
	Degrees.	Feet.	Feet.			
Holmes	42	13.6	10.0	42.9	57.7	1,154,000
Mammoth Top	40	13.0	10.8	41.5	54.2	1,156,628
Mammoth Bottom	35	25.0	18.0	107.4	131.1	4,719,600
Buck Mountain	15	11.6	8.4	306.2	317.0	5,283,122
Probable total original contents of area						12,313,350

Shipments, 1863 to December 1st, 1891, 4,288,157 tons.

The consumption of coal at this colliery to produce steam for the past three years has averaged 12.6 per cent. of the shipments. This has, no doubt, increased somewhat with the increased depth of the workings. Estimating that the average consumption at the colliery since the commencement of mining, 1863, has been 9 per cent. of the shipments, would make the total production to December 1st, 1891, 4,674,091 tons, or 38 per cent. of the original contents.

Estimate of coal actually won, shipments and colliery consumption, 4,674,091 tons, or 38 per cent.

The first buckwheat coal was shipped about 1878. The total shipments up to this time had been 1,649,706 tons. Were we to allow 10 per cent. of this, or 164,971 tons, for the buckwheat, had it been made during the whole time, the total production would have been 4,839,062 tons, or 39.3 per cent. of the original contents.

Estimate of coal won, if buckwheat had been made from commencement of mining, 39.3 per cent.

The areas as given here have been mined over and the pillars robbed. The coal remaining in the pillars yet to be robbed, in the comparatively small portion of the mine now in active operation, has been considered in the above estimate.

The thickness of the beds and coal as given are taken as the probable average thickness for the whole area exploited, including any faulty or crushed areas encountered.

Specific gravity has been taken as 1.65, or 2000 tons per acre per foot in thickness.

Ten specific gravity determinations by McCreath of coal in this neighborhood average 1.658.

From the following measurements and estimate made by Mr. Thompson, of the Hammond Colliery culm bank, his report of which follows in detail, I would draw the following inferences (see pages 133–135):—

Mr. Thompson estimates that the Hammond Colliery has produced since the commencement of mining to August 1st, 1892, 2,057,833 tons of culm.

The shipments to August 1st, 1892, have been	4,403,707 tons.
Shipments to December 1st, 1891, were	4,288,157 tons.
Shipments between Dec. 1st, 1891, and August 1st, 1892,	115,550 tons.

Estimating the culm produced between December 1st, 1891, and August 1st, 1892, as 30 per cent. of the shipments, the production of culm in that time would have been 34,665 tons.

Hence the culm produced up to time of our estimate, December 1st, 1891, was 2,023,168 tons.

Mr. Thompson analyzes the culm bank as follows:—

Dirt	35 per cent.
Slate	23 per cent.
Marketable coal	42 per cent.
	100 per cent.

Were we to subdivide the dirt, calling 25 per cent. powdered coal and coal too small to market, and 10 per cent. refuse, the table would then show:—

Coal and coal-dirt	67 per cent.
Refuse	33 per cent.
	100 per cent.

Taking 67 per cent. of the culm produced as coal and coal-dirt would give us 1,355,523 tons.

The following general distribution of the coal lost and won at this colliery can then be made:—

Estimated original coal contents of area exploited . . . 12,313,350 tons.

		Tons.
Total production of coal, shipment and colliery consumption	38 per cent.	4,674,091
Total coal and coal-dirt sent to culm bank	11 per cent.	1,355,523
Total coal and coal-dirt left in mine	51 per cent.	6,283,736
	100 per cent.	12,313,350

Mr. Thompson estimates that there are 720,242 tons of coal now (August 1st, 1892) in the Hammond culm bank, which can be won by rescreening say 715,000 tons, December 1st, 1891. If this were added to the production up to that time, it would make a total of 5,389,091 tons, or 43.8 per cent. of the original contents.

Estimate of coal won, including coal to be won by rescreening culm banks, 43.8 per cent., or 5,389,091 tons.

COPY OF MR. HEBER S. THOMPSON'S REPORT ON THE HAMMOND COLLIERY CULM BANK.

Measurement of banks and tests of weight of material and proportions of coal, slate, and refuse made in August, 1892:—

Total contents of Hammond Colliery culm banks, 1,972,090 cubic yards (not including rock banks, 550,922 cubic yards).

Coal, culm, and refuse used in filling excavated spaces in the mines, and carried away by the action of the elements, estimated to be 20 per cent., 394,418 cubic yards.

Total coal, culm, and refuse of dirt banks, 2,366,508 cubic yards.

Weight of culm banks per cubic yard, 1,941.75 lbs. 1.15 cubic yards contain one ton.

Weight of culm banks, 2,057,833 tons.

Coal in culm banks, 42 per cent. of contents (864,290 tons), of which 19.94 per cent. is large coal (172,339 tons) and 80.06 per cent. is small coal, or such as will pass through a $\frac{5}{8}$-inch and over a $\frac{3}{16}$-inch screen mesh (691,951 tons).

The total shipment of coal from the Hammond Colliery lease from 1863, the first year of its operation, to August 1st, 1892, is 4,403,707 tons. The coal thrown in its dirt banks has been therefore equivalent to 19.62 per cent. of its shipment to market (3.91 per cent. large and 15.71 per cent. small).

The coal in the Hammond dirt banks, on the ground now, is 42 per cent. of 1,972,090 cubic yards (720,242 tons), of which the large coal, which will not go through a $\frac{5}{8}$-inch screen mesh, is 143,616 tons, and the small coal, which will go through a $\frac{5}{8}$-inch and will pass over a $\frac{3}{16}$-inch screen mesh, is 576,626 tons.

The total shipment of coal from all the collieries on the Girard estate from their opening to January 1st, 1892, has been 26,953,328 tons.

Taking the proportion of coal thrown aside as refuse by the other collieries to be the same as that thrown aside by

Hammond Colliery, then the coal in the dirt banks on the Girard estate, or washed down by the elements and carried away by the streams, is 5,288,243 tons. It is probable that the proportion of the refuse banks washed away is greater at all the other collieries on the Girard estate than at Hammond Colliery.

Tests of Hammond Colliery Culm Banks by Mr. John B. Granger, Mine Inspector of the Girard Estate, August 15th, 1892.

First sample of bank, dumped in 1872:—

Weight of a cubic foot			71 lbs.
Containing, of dirt		30.5 lbs.	
slate		7.0 lbs.	
large coal	5.0 lbs.		
small coal	28.5 lbs.		
		33.5 lbs.	
			71 lbs.

Second sample of bank, dumped in 1877:—

Weight of a cubic foot			71.5 lbs.
Containing, of dirt		25.75 lbs.	
slate		12.50 lbs.	
large coal	5.25 lbs.		
small coal	28.00 lbs.		
		33.25 lbs.	
			71.5 lbs.

Third sample of bank, from old Connor breaker, which prepared only Buck Mountain bed coal, about 1885:—

Weight of a cubic foot			70 lbs.
Containing, of dirt		19.75 lbs.	
slate		15.75 lbs.	
large coal	9.5 lbs.		
small coal	25.0 lbs.		
		34.50 lbs.	
			70 lbs.

Fourth sample of bank, deposited in 1888:—

Weight of a cubic foot			70.5 lbs.
Containing, of dirt		20.75 lbs.	
slate		17.50 lbs.	
small coal	22.75 lbs.		
large coal	9.50 lbs.		
		32.25 lbs.	
			70.5 lbs.

Fifth sample of bank, deposited in 1891:—

Weight of a cubic foot			80 lbs.
Containing, of dirt		24.50 lbs.	
slate		36.75 lbs.	
large coal	5.00 lbs.		
small coal	13.75 lbs.		
		18.75 lbs.	
			80 lbs.

Sixth sample of bank, from old McMichael breaker, deposited about 1866:—

Weight of a cubic foot			68.5 lbs.
Containing, of dirt		29.5 lbs.	
slate		9.5 lbs.	
large coal	2.0 lbs.		
small coal	27.5 lbs.		
		29.5 lbs.	
			68.5 lbs.

Average weight of culm bank per cubic foot			71.9166 lbs.
Average weight of culm bank per cubic yard			1,941.75 lbs.
Containing, of dirt		35 per cent.	
slate		23 per cent.	
large coal	8.38 per cent.		
small coal	33.62 per cent.		
		42 per cent.	
			100 per cent.

"Quantity and percentage of large and small sizes of coal shipped from the Girard Estate at different periods for 20 years, from 1871 to 1891 inclusive.

H. S. Thompson, Mining Engineer.

	Larger than Chestnut.		Chestnut.		Pea.		Buckwheat.	
	Tons. Cwt.	Per cent.	Tons. Cwt.	Per cent.	Tons. Cwt.	Per cent.	Tons. Cwt.	Per cent.
1891	899,604.15	62.64	227,717.08	15.86	170,992.02	11.91	137,622.14	9.59
1886	759,604.06	68.94	131,408.10	11.92	149,381.10	13.56	61,501.08	5.58
1881	1,073,869.12	75.62	159,687.04	11.25	158,711.03	11.18	27,722.17	1.95
1876	614,404.12	76.19	117,063.05	14.51	74,992.03	9.30	. . . . . .	. .
1871	519,284.05	83.62	76,229.08	12.27	25,503.05	4.11	. . . . . .	. .

NOTE.—Pea coal first appears returned separately April, 1867 (Girard Colliery of J. J. Conner).

Buckwheat coal first appears returned separately August, 1878 (Hammond Colliery of Philadelphia and Reading Coal and Iron Company)."

W. M. C. F. (15.)

Girard Colliery.

Philadelphia and Reading Coal and Iron Company, Operators.

Estimate of the per cent. of coal won from the commencement of mining, 1864 to March 1st, 1892, made from the mine maps and information furnished by Heber S. Thompson, Engineer Girard Estate.

Name of Bed.	Average dip.	Average thickn's of bed.	Average thickness of coal.	Area Worked.		Probable original contents in tons.
				Surface acres.	Bed acres.	
	Degrees.	Feet.	Feet.			
Mammoth . . .	{ 68 N. / 57 S. }	31	22.6	{ 40.8 / 50.0	108.9 / 91.8 }	9,031,500
Buck Mountain . .	57 S.	14	9.0	6.7	12.3	221,400
Probable total original contents of area						9,252,900

Shipments, 1864 to March 1st, 1892, 1,627,491 tons.

The consumption of coal to produce steam at this colliery for the past three years has averaged 31 per cent. of the shipments. This, of course, has increased with the increased depth of the workings. Estimating that 20 per cent. has been the average colliery consumption since mining commenced (1864) would make the total production to March 1st, 1892, 1,952,989 tons, or 21.1 per cent. of the original contents.

Estimate of coal won, shipments and colliery consumption, 1,952,989 tons, or 21.1 per cent.

The first buckwheat coal was shipped about 1878. The total shipments up to this time had been 732,797 tons. Were we to allow 10 per cent. of this, or 73,280 tons, for buckwheat, had it been made during the whole time, the total production would be 2,026,269 tons, or 21.9 per cent. of the original contents.

Estimate of coal won if buckwheat had been made from commencement of mining, 21.9 per cent.

The areas as given have been mined over and the pillars robbed. The coal remaining in the pillars yet to be robbed in the comparatively small portion of the mine now in active operation has been considered in the above estimate.

The thickness of the beds and coal as given are taken as the probable average thickness of the whole area exploited, including any faulty or crushed areas that may have been encountered.

The mining operations in the Mammoth at this colliery are now in the bottom of the narrow and deep basin. The gangways are in the underlying Skidmore bed, tunnels being driven at short intervals to the basin of the Mammoth.

The estimate of the total coal in the area worked by this bed includes that in the wedge at the axis of the basin, a large per cent. of which cannot be mined.

Specific gravity is taken as 1.65, or 2000 tons per acre per foot in thickness.

Ten specific gravity determinations by McCreath of coal in this neighborhood average 1.658.

W. M. C. F. (16.)

Kehley's Run Colliery.

Thomas Coal Company, Operators.

Estimate of the per cent. of coal won, made from the mine maps and information furnished by Heber S. Thompson, Engineer Girard Estate. This estimate embraces the time between the commencement of mining, 1865 to January 1st, 1892.

Name of Bed.	Average dip.	Average thickn's of bed.	Average thickness of coal.	Area Worked		Probable original contents in tons.
				Surface acres.	Bed acres.	
	Degrees.	Feet.	Feet.			
Mammoth . .	35	45.0	30.0	65.3	79.7	4,782,000
Skidmore	35	7.0	3.10	21.0	25.6	196.275
Seven Foot . . .	35	7.0	5.8	53.9	65.8	745,777
Buck Mountain .	35	10.2	7.0	58.7	71.7	1,003,800
Probable total original contents of area						6,727,852

Shipments, 1865 to January 1st, 1892, 2,266,339 tons.

The consumption of coal at this colliery to produce steam for the past three years has averaged 6.39 per cent. of the shipments. This has no doubt increased somewhat with the increased depth of the workings. Estimating that the average consumption at the colliery since the commencement of mining, 1865, has been 5 per cent. of the shipments would make the total production to January 1st, 1892, 2,379,656 tons, or 35.4 per cent. of the original contents.

Estimate of coal actually won, shipments and colliery consumption, 2,379,656 tons, or 35.4 per cent.

The first buckwheat coal was shipped about 1878. The total shipments up to that time had been 895,604 tons. Were we to allow 10 per cent. of this, or 89,560 tons, for buckwheat, had it been made during the whole time, the total production to January 1st, 1892, would be 2,469,216 tons, or 36.7 per cent. of the original contents.

Estimate of coal won if buckwheat had been made from commencement of mining, 36.7 per cent.

The areas given have been mined over and the pillars robbed. The coal remaining in the pillars yet to be robbed in the comparatively small portion of the mine now in active operation has been considered in the above estimates.

The thickness of the beds and coal as given are taken as the probable average thickness for the whole area exploited, including any faulty or crushed areas encountered.

Specific gravity is taken as 1.65, or 2000 tons per acre per foot in thickness.

Ten specific gravity determinations by McCreath of coal in this neighborhood average 1.658.

W. M. C. F. (17.)

Locust Run Colliery.

Mr. Franklin Platt, in Report A–2, Coal Waste (1879), Pennsylvania Geological Survey (page 38), publishes an estimate by Mr. E. M. Riley, of Ashland, of the coal won at the *Locust Run Colliery*. The Mammoth bed was worked with a thickness of 13 feet 6 inches to 25 feet 6 inches, the dip ranging from 15 to 60 degrees. The results show:—

Percentage of waste	66.5 per cent.
Percentage of coal won	33.5 per cent.

W. M. C. F. (18.)

Stanton Colliery.

Information furnished by Mr. A. W. Sheafer.

Mining operations 1868 to 1880:—
Area worked (measured on dip), 87.07 acres.
Mammoth bed, 35 feet thick, 25 feet coal used in estimate.
Pillars to be worked over.
Dip, 60 to 70 degrees.

Estimated original contents of area	3,796,693 tons.
Production	678,067 tons.
Coal actually won	17 per cent.

W. M. C. F. (19.)

Gilberton Colliery

Information furnished by Mr. A. W. Sheafer.

Mining operations 1863 to 1880:—
Area worked (measured on dip), 107 acres.
Mammoth bed, 35 feet thick, 25 feet coal used in estimate.
Dip, 45 to 60 degrees.

Estimated original contents of area	4,664,264 tons.
Production	1,117,525 tons.
Coal actually won	24 per cent.

W. M. C. F. (20.)

Cambridge Colliery.

Information furnished by Mr. A. W. Sheafer.

Mining operations to 1880:—
Holmes bed, 6 feet clean coal.
Pillars well robbed.
Dip, 12 to 20 degrees.

Estimated original contents of area	202,000 tons.
Shipments	106,000 tons.
Coal actually won	52 per cent.

W. M. C. F. (21.)

The following estimates, prepared under the direction of Mr. P. W. Sheafer, have been kindly furnished by the executors of his estate.

"Estimate of contents of culm bank at Gilberton, Schuylkill County, Pa., prepared under the direction of P. W. Sheafer, engineer and geologist:—

Lawrence Colliery.

Total shipment to January 1st, 1890	1,852,000 tons.
Estimated contents of culm banks	978,000 tons.
Estimated amount to be won by rescreening banks	450,000 tons.

Stanton Colliery.

Total shipment to January 1st, 1890	1,163,000 tons.
Estimated contents of culm banks	860,000 tons.
Estimated amount to be won by rescreening banks	500,000 tons.

Draper Colliery.

Total shipment to January 1st, 1890	2,194,000 tons.
Estimated contents of culm banks	1,000,000 tons.
Estimated amount to be won by rescreening banks	500,000 tons.

Gilberton Colliery.

Total shipment to January 1st, 1890	1,750,000 tons.
Estimated contents of culm bank,	1,000,000 tons.
Estimated amount to be won by rescreening banks	500,000 tons.

35 cubic feet of bank equals one ton.

W. M. C. F. (22.)

Rescreening Stanton Culm Bank.

1889.	Tons.	
Stove	5,202.15	20.59 per cent.
Nut	4,229.05	16.74 per cent.
Pea	3,597.60	14.24 per cent.
Buckwheat	12,233.60	48.42 per cent.
	25,262.40	
1890.	Tons.	
Stove	8,929.06	14.21 per cent.
Nut	12,782.04	20.35 per cent.
Pea	9,763.06	15.55 per cent.
Buckwheat	31,333.04	49.89 per cent.
	62,808.00	

Equals 60 per cent. of bank."

S. C. F. (23.)

Panther Creek Basin.

Mr. Charles A. Ashburner, Report AA, page 176, Pennsylvania Geological Survey, estimates that from the commencement of mining to January 1st, 1883, the average percentages at all the collieries in this basin as follows:—

Coal left in mines, unfinished breasts and for roof supports,	41 per cent.
Waste coal sent directly from mines and breakers to banks,	32 per cent.
Fuel coal sent to market and consumed locally	27 per cent.
	100 per cent.

And the average percentages for two years from January 1st, 1881, to January 1st, 1883:—

Coal left in mines, unfinished breasts and for roof supports,	30 per cent.
Waste coal sent directly from mines and breakers to banks,	24 per cent.
Fuel coal sent to market and consumed locally	46 per cent.
	100 per cent.

S. C. F. (24.)

EAGLE HILL COLLIERY.

Philadelphia and Reading Coal and Iron Company, Operators.

Special survey and examination to determine efficiency of mining method.

Mining operations from 1881 to 1885:—

Selected area of 17.5 acres, including fault area of 1.14 acres which produced no coal.

Mammoth bed, thickness about 20 feet, and Seven Foot bed (Top split of Mammoth), thickness about 7 feet 6 inches.

Dip about 35 degrees.

Estimating that 50 per cent of coal in pillars can be got, gives total result as follows:—

Prepared coal	41.1 per cent.
Sent to dirt bank	26.6 per cent.
Lost in pillar	18.4 per cent.
Lost in gob	13.9 per cent.
	100.0 per cent.

Buckwheat was prepared for the last two years. Had this coal been saved for the whole period, estimating it at 10 per cent. of the product, the statement would be about as follows:—

Prepared coal	43.5 per cent.
Sent to dirt bank	24.2 per cent.
Lost in pillar	18.4 per cent.
Lost in gob	13.9 per cent.
	100.0 per cent.
Estimate of coal won, including buckwheat	43.5 per cent.

S. C. F. (25.)

POTTSVILLE SHAFT COLLIERY.

Philadelphia and Reading Coal and Iron Company, Operators.

Special survey and examination to determine efficiency of mining method.

Selected area of about 4.5 acres.

Seven Foot bed (Top split of Mammoth), average thickness about 7 feet, with 5 feet of coal.

Roof strong, coal good.

Dip, 35 to 40 degrees.

Estimating the coal yet to be robbed from pillars gives total results as follows:—

Prepared coal	52 per cent.
Sent to dirt bank	28 per cent.
Lost in mine	20 per cent.
	100 per cent.
Estimate of coal won	52 per cent.

S. C. F. (26.)

MINE HILL GAP COLLIERY.

Philadelphia and Reading Coal and Iron Company, Operators.

This colliery, from 1873 to 1884 inclusive, yielded to market from the contents of coal in the ground, embraced within the area exploited during the years named, 29.2 per cent., not including the coal consumed under the boilers for steam generation, which was mainly slate picker and a little pea.

The beds worked were :—

Crosby	about 5.0 feet thick ;	dip, 55 to 60 degrees.
Lelar	about 6.0 feet thick ;	dip, 55 to 60 degrees.
Daniel	about 12.5 feet thick ;	dip, 55 to 60 degrees.

If we roughly estimate the coal consumed under boilers as 9 per cent. of the shipments, we would then have :—

Coal sent to market	29.2 per cent.
Coal consumed for steam	2.5 per cent.
Lost in mine and sent to dirt bank	68.3 per cent.
	100.0 per cent.
Estimate of coal won	31.7 per cent.

S. C. F. (27.)

Phœnix Park No. 3 Colliery.

Philadelphia and Reading Coal and Iron Company, Operators.

Special survey and examination to determine efficiency of mining method made in 1885.

Mining operations January 1st, 1881 to 1885:—

Area exploited, 63 acres.

Fault area, from which no coal was obtained, 22.68 acres.

Area of good coal, on which estimate is based, 40.32 acres.

Diamond bed, average thickness about 6 feet.

Dip, 10 to 20 degrees.

Estimating that 65 per cent. of the pillars left can be got, gives total results as follows :—

Prepared coal (not including buckwheat)	56.0 per cent.
Sent to dirt bank	26.5 per cent.
Lost in mine	17.5 per cent.
	100.0 per cent.

Estimating buckwheat coal at 10 per cent. of the product, had that coal been saved, the statement would be about as follows :—

Prepared coal (including buckwheat)	61.0 per cent.
Sent to dirt bank	21.5 per cent.
Lost in mine	17.5 per cent.
	100.0 per cent.
Estimate of coal won, including buckwheat	61.0 per cent.

S. C. F. (28.)

West Brookside Colliery.

Philadelphia and Reading Coal and Iron Company, Operators.

A special and very thorough survey and examination was made at this colliery, having in view the determination of the results obtained from the system of mining employed. The mining operations cover a period from 1869 to 1889, during which time the colliery was operated by individuals as well as by the Philadelphia and Reading Coal and Iron Company.

Area exploited, 665.5 acres; of this 36.6 acres were faulty and are not included in the estimate.

Area considered, 628.9 acres.

The bed mined is Lykens Valley No. 5, thickness quite variable but with a probable average of 10 feet, 70 per cent., or 7 feet of which is good coal.

Average dip, 10 to 15 degrees.

Estimating the quantity of coal which could still be mined and robbed from pillars in this area gives the following results:—

	Tons.	Per cent.
Shipments	3,746,120	54.1
Local sales	9,051	.2
Colliery consumption	90,124	1.3
Total prepared coal	3,845,295	55.5
Sent to dirt bank	1,873,060	27.0
Lost in pillars and gob	1.205,219	17.5
Total	6,923,574	100.0

Previous to 1883 all buckwheat coal was sent to the dirt bank. Buckwheat coal now forms about 10 per cent. of the production. Had this coal been saved between 1869 and 1883, the statement would be about as follows:—

Prepared coal (if buckwheat included)	59.5 per cent.
Sent to dirt bank	23.0 per cent.
Loss in pillars and gob	17.5 per cent.
Total	100.0 per cent.
Estimate of coal won, including buckwheat	59.5 per cent.

The conditions at this mine are very favorable; the roof is excellent.

Mr. Franklin Platt, in A–2, page 120, reports the breaker record for 8 months in 1879 (?), as follows:—

"The total product was 322,173 tons, of which 68.8 per cent. went into the cars for shipment to market, and 31.2 per cent. went on to the dirt heap.

"The percentages of waste by months ran thus: 32, 31, 31, 32, 31, 32, 33, 30, averaging 31.2 per cent., as above.

"This average may be somewhat too low, but it is not much away from the actual facts.

"For the bed is nearly flat; it is clean coal; there is but little wasted in the mines, and the coal is not brittle and does not splinter up into buckwheat and dust. The actual breaker waste at the Lykens Valley collieries for breaking and screening is probably not over 21 per cent."

S. C. F. (29.)

West Brookside Colliery.

Philadelphia and Reading Coal and Iron Company, Operators.

Special survey and examination to determine efficiency of mining method in 1885.

Selected area of acres.

Fair average condition of bed, roof strong, coal good.

Lykens Valley No. 5 bed, general thickness 10 feet, with 7 feet coal.

Dip, 10 to 15 degrees.

Estimating coal yet to be robbed from pillars gives total results as follows:—

Prepared coal (including buckwheat)	62.5 per cent.
Sent to dirt bank	32.7 per cent.
Lost in pillars	4.8 per cent.
Total	100.0 per cent.
Estimate of coal won (including buckwheat)	62.5 per cent.

S. C. F. (30.)

West Brookside Colliery.

Philadelphia and Reading Coal and Iron Company, Operators.

Special survey and examination to determine efficiency of mining method made in 1885.

Selected area of acres.

Fair average condition of bed, roof strong, coal good.

Lykens Valley No. 5 bed, general thickness 10 feet, with 7 feet of coal.

Dip, 10 to 15 degrees.

Estimating the coal yet to be robbed from pillars gives total results as follows :—

Prepared coal (including buckwheat)	57.1 per cent.
Sent to dirt bank	30.8 per cent.
Lost in pillars	12.1 per cent.
Total	100.0 per cent.
Estimate of coal won (including buckwheat)	57.1 per cent.

THE PROBABLE AVERAGE PER CENT. OF COAL WON FROM THE COMMENCEMENT OF MINING, ABOUT 1820 TO JANUARY 1st, 1893.

The per cent. of coal won has been influenced by the thickness of the bed, the dip or pitch, the character of the roof, the depth of the working, the character of the coal, the necessity for keeping up the surface, as well as the personal management of the collieries.

An average of the 27 instances collected would show the coal actually won in those cases to be 41.5 per cent. of the original contents of the areas worked over.

In the Southern field 6 of the examples given are of selected areas and undoubtedly show too high an average for the field, though the estimate at the Brookside Colliery covering 628.9 acres, showing coal won as 51.5 per cent., probably represents that particular colliery.

If we omit these 6 estimates the remaining 21 give an average of 38.5 per cent.

At some of the collieries taken, buckwheat coal has been prepared during the whole time covered by the estimate, at others for only a portion of the time, and at some it is not included. An average on the basis that buckwheat had been prepared for the whole time in each instance would show for the 27 collieries some 44 per cent. won, and for the 21, 41 per cent.

It is to be doubted whether we can rely upon the averages thus obtained as representing what has been won for the whole region since the commencement of mining; and again, there are losses whose extents is not wholly covered by these estimates: (1.) The damage to upper coal-beds by the breaking and settling of the strata when the lower beds are worked first, especially if an upper bed is only a few feet above the one worked. (2.) The coal that it is necessary in many cases to leave always unmined along the outcrop to prevent the surface wash from entering the mine, particularly under the old river bed of the Susquehanna. (3.) A small amount destroyed by mine fires. (4.) The coal intentionally left in large pillars for particular purposes, and the mining of only part of the bed. The coal thus left may or may not be recovered.

A careful consideration of the subject and a study of the data obtained and its probable value as relating to the past output, leads to the conclusion that since the commencement of mining the coal won does not exceed 35, and possibly not more than 30 per cent. of the coal originally contained in the areas mined over, that this will probably be increased to 40 per cent. by the utilization of the coal contained in the culm banks, and by a reworking of part of the territory mined over.

It is estimated that the production, including coal sold and consumed at the collieries, has exceeded the shipments by about 10 per cent.

The table compiled by Mr. P. W. Sheafer for the years 1820 to 1868, and since 1868 by Mr. John H. Jones, show the shipments to January 1st, 1893, to have been :—

	Shipments. Tons.	Production, adding 10 per cent., say. Tons.
Wyoming region	382,990,423	421,000,000
Lehigh region	147,652,656	162,500,000
Schuylkill region	289,719,916	318,500,000
Total	820,362,995	902,000,000

Basing our estimate on that for every ton produced $1\frac{1}{2}$ additional tons are lost, the following table would show the probable amount of coal still contained in the ground :—

Region.	Estimated original contents. Tons.	Amount used up $2\frac{1}{2}$ times production. Tons.	Estimated contents remaining. Tons.
Wyoming	5,700,000,000	1,052,500,000	4,647,500,000
Lehigh	1,600,000,000	406,250,000	1,193,750,000
Schuylkill	12,200,000,000	796,250,000	11,403,750,000
Total	19,500,000,000	2,255,000,000	17,245,000,000

THE FUTURE SUPPLY.

The estimate just made shows 17,245,000,000 tons of marketable coal still in the ground; what per cent. of this will be won the future alone can determine.

It is to be doubted whether the total coal won when the field shall be abandoned will exceed 40 per cent. of the total contents. An estimate on that basis would show the available marketable coal still now in the ground to be as follows:—

Wyoming region	1,859,000,000 tons.
Lehigh region	477,500,000 tons.
Schuylkill region	4,561,500,000 tons.
In all	6,898,000,000 tons.

The amount of coal won at the modern colliery due to improvements in mining methods, the appliances for handling the coal, and in the utilization of the small sizes, shows a decided advance over the earlier years of mining; a still further advance will undoubtedly be made in these directions, and the mining of the small beds, where a larger per cent. can be won, will all tend to increase the total. Future estimates for a long time will in all probability show an advance in the total per cent. won.

But it should not be forgotten that the difficulties, the dangers, and the cost of mining are and will continue to increase, due to the increasing depth at which the coal must be mined and the increased amount of water which must be pumped.

The coal first mined was by drifts or tunnels at water level, and a natural outlet for both coal and water was secured; as the coal above water level became exhausted, slopes were sunk in the beds, or where the beds were nearly horizontal shallow shafts were sunk to them; these slopes and shafts have gradually increased in depth, until now at a number of the collieries mining is carried on at a depth of 1000 or 1100 feet below the outlet.

Depth of Mining.—That this depth must greatly increase before the exhaustion of the fields the following data, based on the published cross-sections, show:—

In the Northern field the deepest part of the basin is between Wilkes Barre and Nanticoke, and it is to this neighborhood that we must look for the future supply in this field; here the Baltimore bed attains a depth in the basin of 1500 or 1600 feet and the Red Ash of 1700 or 1800 feet.

In the Eastern Middle field the difficulty is not so great, as but little of the coal is more than 1000 feet below the surface.

In the Western Middle field the Mammoth attains a maximum depth of about 2000 feet, with the underlying beds still deeper; over considerable areas of the field the Mammoth is below 1200 or 1500 feet.

In the Southern field, which is estimated to now contain about one-half of all the anthracite remaining in the ground, a careful estimate, based on the cross-sections, shows that one-half the contents of the field is to be found at a depth of more than 1100 feet, and that the lowest workable bed (the Lykens Valley) attains a maximum depth of more than 4000 feet.

Pumping.—The increased pumping due to letting in of the surface water and tapping of the underground water-courses, by breaking and settling of the strata over the areas mined, increases with the extent of the working, and as the strata becomes honeycombed with workings will be a more and more serious obstacle, especially when the pumping will not only include the area under operation, but perhaps miles of older workings; and again, the difficulty in holding the water on the upper lifts will make it necessary to raise the bulk of it from the lowest point in the mine. Some of the collieries are already using from 15 to 25 per cent. of their production under the boilers. In the Schuylkill and Lehigh regions, where the beds are steeply inclined, the strata is easily accessible to the surface water.

In the deep basins where the coal-beds are numerous (some 20 in parts of the Southern field), if the principal beds are mined first and pillars robbed out, the breaking and settling of the strata will undoubtedly seriously damage the beds above and interfere with the economical working of them.

THE QUANTITY OF COAL AND COAL-DIRT IN CULM BANKS.

Just what proportion of coal taken from the mines is now contained in the culm banks it is impossible, without a survey of all the banks in the region, to determine.

At the Parrish Colliery, Northern coal-field, which may be taken as a good example of a modern colliery, and where all the small sizes are saved, the estimate would show that a quantity of coal equal to 19 per cent. of the total production goes to the dirt bank.

"In 1890 and 1891 the Clear Spring Coal Company produced 342,523 tons of coal; and 66,532 tons of culm (including all the buckwheat coal) went to the culm pile, *i. e.*, the culm was about 19.7 per cent. of the total production."

At the Hammond, Western Middle field, the estimate, covering a period of 29 years, shows that a quantity of coal equal to 29 per cent. of the production has gone to the dirt banks.

The estimate of the dirt banks on the Gilbert estate would show the contents of the bank at the Lawrence Colliery to equal 53 per cent. of the shipments, the Stanton Colliery 74 per cent., the Draper Colliery 46 per cent., and the Gilberton Colliery 57 per cent. These collieries are some of the oldest in the anthracite region.

Mr. Ashburner's estimates of the Panther Creek basin show that from the commencement of mining, 1820 to 1883, 20 per cent. more coal had gone to the dirt banks than had been marketed, but for two years, 1881 to 1883, the amount of coal sent to dirt bank equaled 52 per cent. of the production.

The Estimates.—At Eagle Hill Colliery (Southern coal-field), 1881 to 1883, shows the coal sent to dirt bank to equal about 60 per cent. of the production.

At Phœnix Park No. 3 Colliery (Southern coal-field), 1881 to 1885, 47 per cent. went to dirt bank.

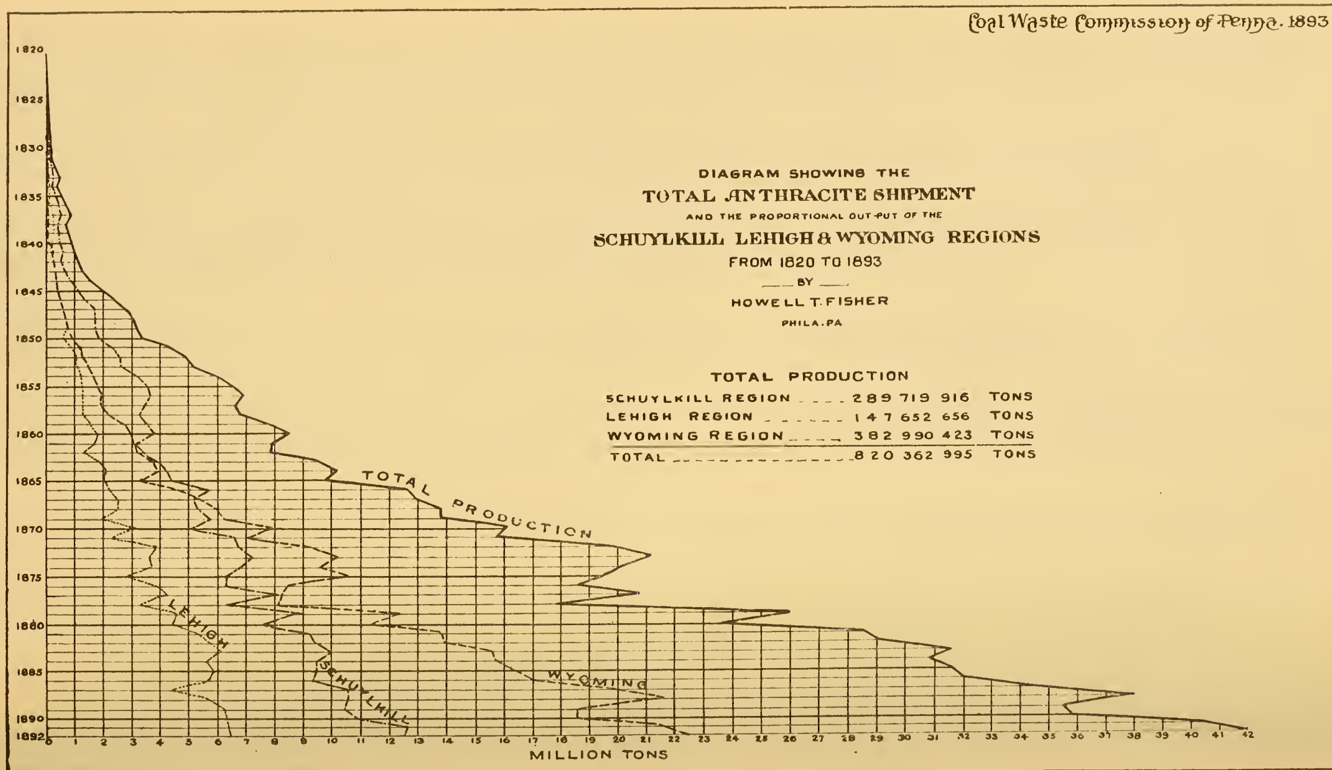
At Brookside Colliery, 1869 to 1889, the coal sent to the dirt bank equaled about 49 per cent. of the total product.

Taking into consideration that the per cent. of coal now sent to the dirt bank is much less than formerly, and the annual production greatly increased, it perhaps would not be unfair to estimate that since the commencement of mining the *coal and coal-dirt* sent to the culm banks has been 35 per cent. of the total production, say 315,700,000 tons.

Annual Shipments from the Schuylkill, Lehigh, and Wyoming Regions from 1820 to 1892.

	Schuylkill Region.		Lehigh Region.		Wyoming Region.		Total.
Years.	Tonnage.	Per Cent.	Tonnage.	Per Cent.	Tonnage.	Per Cent.	Tons.
1820 . .	. . . . . .	. . .	365	. . .	. . . . . .	. . .	365
1821 . .	. . . . . .	. . .	1,073	. . .	. . . . . .	. . .	1,073
1822 . .	1,480	39.79	2,240	60.21	. . . . . .	. . .	3,720
1823 . .	1,128	16.23	5,823	83.77	. . . . . .	. . .	6,951
1824 . .	1,567	14.10	9,541	85.90	. . . . . .	. . .	11,108
1825 . .	6,500	18.60	28,393	81.40	. . . . . .	. . .	34,893
1826 . .	16,767	34.90	31,280	65.10	. . . . . .	. . .	48,047
1827 . .	31,360	49.44	32,074	50.56	. . . . . .	. . .	63,434
1828 . .	47,284	61.00	30,232	39.00	. . . . . .	. . .	77,516
1829 . .	79,973	71.35	25,110	22.40	7,000	6.25	112,083
1830 . .	89,984	51.50	41,750	23.90	43,000	24.60	174,734
1831 . .	81,854	46.29	40,966	23.17	54,000	30.54	176,820
1832 . .	209,271	57.61	70,000	19.27	84,000	23.12	363,271
1833 . .	252,971	51.87	123,001	25.22	111,777	22.91	487,749
1834 . .	226,692	60.19	106,244	28.21	43,700	11.60	376,636
1835 . .	339,508	60.54	131,250	23.41	90,000	16.05	560,758
1836 .	432,045	63.16	148,211	21.66	103,861	15.18	684,117
1837 . .	530,152	60.98	223,902	25.75	115,387	13.27	869,441
1838 . .	446,875	60.49	213,615	28.92	78,207	10.59	738,697
1839 . .	475,077	58.05	221,025	27.01	122,300	14.94	818,402
1840 . .	490,596	56.75	225,313	26.07	148,470	17.18	864,379
1841 . .	624,466	65.07	143,037	14.90	192,270	20.03	959,773
1842 . .	583,273	52.62	272,540	24.59	252,599	22.79	1,108,412
1843 . .	710,200	56.21	267,793	21.19	285,605	22.60	1,263,598
1844 . .	887,937	54.45	377,002	23.12	365,911	22.43	1,630,850
1845 . .	1,131,724	56.22	429,453	21.33	451,836	22.45	2,013,013
1846 . .	1,308,500	55.82	517,116	22.07	518,389	22.11	2,344,005
1847 . .	1,665,735	57.79	633,507	21.98	583,067	20.23	2,882,309
1848 . .	1,733,721	56.12	670,321	21.70	685,196	22.18	3,089,238
1849 . .	1,728,500	53.30	781,556	24.10	732,910	22.60	3,242,966
1850 . .	1,840,620	54.80	690,456	20.56	827,823	24.64	3,358,899
1851 . .	2,328,525	52.34	964,224	21.68	1,156,167	25.98	4,448,916
1852 . .	2,636,835	52.81	1,072,136	21.47	1,284,500	25.72	4,993,471
1853 . .	2,665,110	51.30	1,054,309	20.29	1,475,732	28.41	5,195,151
1854 . .	3,191,670	53.14	1,207,186	20.13	1,603,478	26.73	6,002,334
1855 . .	3,552,943	53.77	1,284,113	19.43	1,771,511	26.80	6,608,567
1856 . .	3,603,029	52.91	1,351,970	19.52	1,972,581	28.47	6,927,580
1857 . .	3,373,797	50.77	1,318,541	19.84	1,952,603	29.39	6,644,941
1858 . .	3,273,245	47.86	1,380,030	20.18	2,186,094	31.96	6,839,369
1859 . .	3,448,708	44.16	1,628,311	20.86	2,731,236	34.98	7,808,255
1860 . .	3,749,632	44.04	1,821,674	21.40	2,941,817	34.56	8,513,123
1861 . .	3,160,747	39.74	1,738,377	21.85	3,055,140	38.41	7,954,264
1862 . .	3,372,583	42.86	1,351,054	17.17	3,145,770	39.97	7,869,407
1863 . .	3,911,683	40.90	1,894,713	19.80	3,759,610	39.30	9,566,006
1864 . .	4,161,970	40.89	2,054,669	20.19	3,960,836	38.92	10,177,475
1865 . .	4,356,959	45.14	2,040,913	21.14	3,254,519	33.72	9,652,391
1866 . .	5,787,902	45.56	2,179,364	17.15	4,736,616	37.29	12,703,882
1867 . .	5,161,671	39.74	2,502,054	19.27	5,325,000	40.99	12,988,725
1868 . .	5,330,737	38.62	2,502,582	18.13	5,968,146	43.25	13,801,465
1869 . .	5,775,138	41.66	1,949,673	14.06	6,141,369	44.28	13,866,180
1870 . .	4,968,157	30.70	3,239,374	20.02	7,974,660	49.28	16,182,191
1871 . .	6,552,772	41.74	2,235,707	14.24	6,911,242	44.02	15,669,721
1872 . .	6,694,890	34.03	3,873,339	19.70	9,101,549	46.27	19,669,778
1873 . .	7,212,601	33.97	3,705,596	17.46	10,309,755	48.57	21,227,952
1874 . .	6,866,877	34.09	3,773,836	18.73	9,504,408	47.18	20,145,121
1875 . .	6,281,712	31.87	2,834,605	14.38	10,596,155	53.75	19,712,472
1876 . .	6,221,934	33.63	3,854,919	20.84	8,424,158	45.53	18,501,011
1877 . .	8,195,042	39.35	4,332,760	20.80	8,300,377	39.85	20,828,179
1878 . .	6,282,226	35.68	3,237,449	18.40	8,085,587	45.92	17,605,262
1879 . .	8,960,829	34.28	4,595,567	17.58	12,586,293	48.14	26,142,689
1880 . .	7,554,742	32.23	4,463,221	19.05	11,419,279	48.72	23,437,242
1881 . .	9,253,958	32.46	5,294,676	18.58	13,951,383	48.96	28,500,017
1882 . .	9,459,288	32.48	5,689,437	19.54	13,971,371	47.98	29,120,096
1883 . .	10,074,726	31.69	6,113,809	19.23	15,604,492	49.08	31,793,027
1884 . .	9,478,314	30.85	5,562,226	18.11	*15,677,753	51.04	30,718,293
1885 . .	9,488,426	30.00	5,898,634	18.65	*16,236,470	51.35	31,623,530
1886 . .	9,381,407	29.19	5,723,129	17.81	*17,031,826	53.00	32,136,362
1887 . .	10,609,028	30.63	4,347,061	12.55	*19,684,929	56.82	34,641,018
1888 . .	10,654,116	27.93	5,639,236	14.78	*21,852,365	57.29	38,145,717
1889 . .	10,474,364	29.58	6,285,421	17.75	*18,647,925	52 67	35,407,710
1890 . .	10,867,821	30.31	6,329,658	17.65	*18,657,694	52.04	35,855,173
1891 . .	12,741,258	31.50	6,381,838	15.78	*21,325,239	52.72	40,448,335
1892 . .	12,626,784	30.14	6,451,076	15.40	*22,815,480	54.46	41,893,340

* Includes Loyalsock field.


Coal Waste Commission of Penna. 1893.
DIAGRAM SHOWING THE
TOTAL ANTHRACITE SHIPMENT
AND THE PROPORTIONAL OUT-PUT OF THE
SCHUYLKILL LEHIGH & WYOMING REGIONS
FROM 1820 TO 1893
BY
HOWELL T. FISHER
PHILA. PA
TOTAL PRODUCTION
SCHUYLKILL REGION ..... 289 719 916 TONS
LEHIGH REGION .... 147 652 656 TONS
WYOMING REGION ..... 382 990 423 TONS
TOTAL .... 820 362 995 TONS
TOTAL PRODUCTION
WYOMING
LEHIGH
SCHUYLKILL
1820
1825
1830
1835
1840
1845
1850
1855
1860
1865
1870
1875
1880
1885
1890
1892
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42
MILLION TONS

APPENDIX A-2.

Tabular Estimate, Showing the Approximate Quantity, Past and Future, Production of Coal in the Several Districts of the Northern Anthracite Coal Basin of Pennsylvania.

By Wm. Griffith, *Engineer and Geologist, Scranton, Pa.*

[Republished from *The Colliery Engineer*.]

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Districts.	Names of the Coal-Beds.	Descriptive Remarks.	Average thickness of beds.	Approximate workable area of bed in acres.	Approximate quantity of solid coal originally in the ground before mined—23.4 per cent. of contents of all beds deducted for refuse, faults, thin coal, &c. Leaves 1400 tons per foot per acre, good coal. 2240 pounds per ton.	Approximate area of mine workings to January 1st, 1892, in acres.	Equivalent area for bed 1 foot thick.	Approximate number of tons produced to January 1st, 1892—826 tons per foot thickness of bed per acre.	Approximate quantity of coal wasted (including culm, or wasted coal at 20 per cent. of production)—165.2 tons per foot per acre.	Approximate quantity of coal remaining in worked areas (pillars, gob, &c.)—408.8 tons per foot per acre.	Approximate area from which no coal has been mined—the unworked area.	Approximate quantity of solid coal in place in the unworked area—1400 tons per foot per acre.	Approximate future production for unworked areas, based upon the present yield per foot per acre, and present conditions of mining methods, &c. Including, however, the thin seams as minable.	Production for past five years and per cent. of total produced by each district.	Approximate time required to exhaust the coal at present rates of production. Also percentage of the minable coal possessed by each district.
Forest City and Carbondale District. From extreme northeastern end of basin to Powderly Slope, two miles southwest of Carbondale Station, D. & H. R. R.	Top coal	Known as Slope Bed at Forest City.	6.85	6,700	64,253,000	2,010	13,770	11,374,026	2,274,805	5,629,167	4,690	44,976,400	Factor 900 tons per acre. 28,913,400	1887— 886,845 1888—1,024,823 1889— 872,181 1890—1,016,220 1891—1,009,818	1,200,000 tons per year. About 10 years. 3½ % of future production.
	Bottom Coal or Shaft Bed	Principal beds of district.	6.63	6,800	63,117,600	2,230	13,688	11,411,488	2,291,297	5,595,654	4,570	42,418,600	27,269,100		
	Clifford Bed, Dunmore, or Third Bed	Only workable over portions of area with an outcrop.	4.01	7,490	42,992,600	155	634	523,684	104,736	259,179	7,335	42,102,200	27,065,700		
Production, 1891, 1,009,818 tons.		Totals	17.58	20,990	170,363,200	4,395	28,052	23,309,198	4,673,838	11,484,000	16,595	129,497,200	83,248,200	Past production 6 % of whole production.	
Jermyn District. From Carbondale District to ¾ mile southwest of Jermyn Station, D. & H. R. R.	Diamond	Not worked.	5.0	10	70,000						10	70,000	45,000	1887— 789,201 1888— 897,933 1889—1,044,388 1890— 986,318 1891—1,381,817	1,000,000 tons per year, excluding New County bed, 14 years; including New County bed, 19 years. 1½ % of future production.
	Rock	Not worked. Good.	5.8	70	568,400						70	568,400	365,400		
	Grassy Island	Good.	9.0	700	8,820,000	90	810	669,060	133,812	331,128	610	7,686,000	4,941,000		
	New County	Not worked.	3.0	2,500	10,500,000						2,500	10,500,000	6,750,000		
	Archbald	Principal bed of district.	8.7	3,040	37,027,200	1,680	14,616	12,072,616	2,414,663	5,975,020	1,360	16,164,800	10,648,800		
	Dunmore	Very thin and sometimes absent.	2.0	2,000	5,600,000						2,000	5,600,000	3,600,000		
Production, 1891, 1,381,817 tons.		Totals	33.5	8,320	62,585,600	1,770	15,426	12,741,676	2,548,375	6,306,148	6,550	40,989,206	26,350,200	Past production 3 % of whole.	
Archbald District. From Jermyn District to Winton Station, D. & H. R. R. Includes S. V. White and Eaton Collieries.	New County Bed Archbald	Small area, thin and divided. Principal bed of district.	8.0	3,100	34,710,000	1,410	11,160	9,218,160	1,842,752	4,807,488	1,630	18,256,000	11,736,000	1887— 479,538 1888— 505,175 1889— 424,788 1890— 455,925 1891— 540,961	530,000 tons per year. Archbald bed only, 21 years; including thin beds, 36 years. ⅞ % of production.
	Dunmore or Red Ash	Very thin over large part of the area within the outcrop.	3.0	3,300	13,860,000						3,300	13,860,000	8,910,000		
Production, 1891, 540,961 tons.		Totals	11.0	6,400	48,580,000	1,470	11,760	9,713,760	1,942,752	4,807,488	4,930	32,116,000	20,646,000	Past production 2 % of whole.	
Peckville, Olyphant, and Priceville District. From Archbald District to Dickson Station, D. & H. R. R.	Olyphant, No. 1	Very clean.	8.0	335	3,752,000	327	2,600	2,147,600	429,520	1,062,880	10	112,000	72,000	Past production 4 % of whole.	At 1,400,000 tons per annum, excluding the thin beds, 75 years; including the thin beds, 140 years. 8⅞ % of future production.
	Olyphant, No. 2	Very clean.	7.5	350	3,675,000	225	1,687	1,393,462	278,692	789,645	125	1,311,800	843,380		
	Coal Bed	Thin, not workable at present	2.5	1,800	6,300,000						1,800	6,300,000	4,050,000		
	Coal Bed	Thin, not worked.	3.0	2,000	8,400,000						2,000	8,400,000	5,400,000		
	Diamond	Thin, not worked.	3.5	2,800	13,720,000	25	87	71,862	14,372	35,560	2,775	13,632,800	8,776,800		
	Rock	Often contains dividing stratum of rock.	5.0	3,700	25,900,000						3,700	25,900,000	16,650,000		
	Grassy Island	Principal bed of district.	9.0	4,500	56,700,000	1,650	14,850	12,266,100	2,453,220	6,070,680	2,850	35,910,000	23,085,000		
	New County	Sometimes double this thickness. Rock or slate parting.	3.6	6,500	32,760,000	1	3	2,973	594	1,471	6,499	32,754,400	21,056,400		
	Clark	Usually divided, rock parted, and not much worked at present.	7.0	7,700	75,460,000	170	1,190	982,940	196,588	486,472	7,530	73,794,000	47,439,000	1887— 876,039 1888—1,155,825 1889—1,020,523 1890— 934,017 1891—1,301,590	
	Dunmore, No. 1	Only one bed workable at present.	4.0	9,600	53,760,000	130	520	429,520	85,904	212,576	9,470	53,032,000	34,092,000		
	Dunmore, No. 2		2.0	10,000	28,000,000						10,000	28,000,000	18,000,000		
	Dunmore, No. 3		2.5	10,700	37,450,000						10,700	37,450,000	24,075,000		
Production, 1891, 1,301,590 tons.		Totals	57.6	50,985	345,877,000	2,526	20,937	17,294,457	3,458,890	8,659,284	57,459	316,517,000	203,639,400		
Scranton District. From Priceville District to ½ mile northeast of Moosic Station, D. & H. R. R. Includes Pancoast and Sibley Collieries.	Brisbin	Thin cover.	8.9	40	498,400						40	498,400	Factor 800 tons per acre. 284,800	Past production 31 % of whole.	6,300,000 tons per annum, excluding two thin beds, 53 years; including two thin beds, 61 years. 16 % of future production.
	Richmond		5.0	2,380	16,660,000	320	1,600	1,321,600	264,200	651,080	2,060	14,420,000	8,240,000		
	Church Slope		3.5	5,000	24,500,000	30	105	86,730	17,346	42,924	4,970	24,353,000	13,916,000		
	Diamond		9.4	7,700	101,332,000	2,890	27,166	22,699,116	4,619,983	11,432,580	4,810	63,299,600	36,171,200		
	Rock		6.4	7,760	69,529,600	1,380	8,832	7,295,232	1,459,046	3,610,521	6,380	57,164,800	32,665,600		
	Big	Principal bed of district.	11.7	9,200	150,696,000	4,425	51,772	42,763,672	8,552,734	21,164,393	4,775	78,214,500	44,693,600		
	New County	Large area divided, and thin.	6.9	9,330	90,127,800	1,150	10,935	6,554,310	1,310,862	3,243,756	8,180	79,018,800	45,153,600		
	Clark	Often in two parts, separated by rock.	7.3	15,180	155,139,600	2,700	19,710	16,280,460	3,256,092	8,057,448	12,480	127,545,600	72,883,200		
	Dunmore, No. 1	Large area not workable.	4.0	10,000	56,000,000	800	3,200	2,643,200	528,640	1,308,160	9,200	51,520,000	29,440,000	1887—5,571,260 1888—6,620,634 1889—5,643,260 1890—5,960,379 1891—6,193,390	
	Dunmore, No. 2		4.8	19,700	132,384,000	1,960	9,408	7,771,008	1,554,201	3,845,990	17,740	119,212,800	68,121,600		
	Dunmore, No. 3	Large area not workable.	3.9	12,000	65,520,000	645	2,496	2,061,696	412,339	1,020,364	11,355	61,997,600	35,427,200		
Production, 1891, 6,193,390 tons.		Totals	71.8	98,290	862,327,400	16,300	136,024	110,877,224	21,975,441	54,379,536	81,990	677,244,400	386,996,800		
Pittston District. From Scranton District to ½ mile northeast of Plainsville Station, L. V. R. R. Includes Keystone Colliery.	Hillman		7.2	800	8,064,000	5	36	29,736	5,947	14,717	795	8,013,600	4,579,200	Past production 16 % of whole.	At 4,000,000 tons per year, excluding thin bed, 81 years; including thin bed, 81 years. 14 % of future production.
	Coal Bed (?)		3.5	2,400	11,760,000						2,400	11,760,000	6,720,000		
	Checker or 7 ft.		6.8	6,348	60,437,760	1,120	7,616	6,290,816	1,258,163	3,113,420	5,228	49,770,560	28,440,000		
	Pittston or 11 ft.	Principal bed of district.	11.2	8,080	126,694,400	3,810	42,672	35,247,072	7,049,414	17,444,313	4,270	66,963,600	38,259,200		
	Marcy	Sometimes divided by rock.	7.0	12,700	124,460,000	1,300	9,100	7,516,600	1,503,320	3,720,080	11,400	111,720,000	63,840,000	1887—2,514,170 1888—2,838,633 1889—2,357,976 1890—2,476,473 1891—3,777,802	
	4 ft. or Fourth Bed	Known also as Checker Bed. Often carries considerable refuse.	5.4	8,000	60,480,000	20	108	89,208	17,841	44,150	7,980	60,328,800	34,473,600		
	Powdermill or Red Ash	Generally divided by thick rock parting.	10.1	19,800	279,972,000	1,700	17,170	14,182,420	2,836,484	7,019,096	18,100	255,934,000	146,248,000		
Production, 1891, 3,777,802 tons.		Totals	51.2	58,128	671,838,160	7,955	77,026	63,355,852	12,671,169	31,355,176	50,173	564,480,000	329,960,000		
Wilkes-Barre and Plymouth District. From Pittston District to ½ mile northeast of Warrior Run Station, L. V. R. R. Includes Avondale and Maffet Collieries.	Audle or New		3.7	500	2,590,000	1	4	3,304	661	1,635	499	2,584,460	Factor 700 tons per acre. 1,292,200	Past production 32 % of whole.	At 7,500,000 tons per year, excluding thin beds, 127 years; including thin beds, 134 years. 42 % of future production.
	Snake Island or K Bed		7.4	4,000	41,400,000	10	74	6,112	1,222	3,025	3,990	41,336,400	20,668,200		
	Abbott, 7 ft., or Hutchinson	Only limited area.	5.2	9,200	66,976,000	250	1,300	1,073,800	214,760	531,440	8,950	65,156,000	32,578,000		
	Thin Coal Bed		2.9	5,000	20,300,000						5,000	20,300,000	10,150,000		
	Lance, Kidney, or Bowkley		6.3	11,000	97,020,000	600	3,780	3,024,000	604,800	1,545,264	10,400	91,728,000	45,864,000		
	Hillman	Workable for small area only.	10.0	13,800	193,200,000	1,190	11,900	9,829,400	1,965,880	4,864,720	12,610	176,540,000	88,270,000		
	Lodgment		4.3	4,000	24,080,000						4,000	24,080,000	12,040,000		
	G, or Old Bennett		5.9	15,300	126,378,000	40	236	194,936	38,987	96,476	15,260	126,047,600	63,023,800		
	5 ft. to 6 ft. or Lance		5.8	19,800	160,776,000	275	1,595	1,317,470	263,494	652,036	19,525	158,543,000	79,271,500		
	Cooper	These two beds often unite and form the Baltimore. Principal bed of district.	9.1	21,500	273,910,000	5,160	46,956	38,785,656	7,757,131	19,195,612	16,340	208,171,600	104,085,800	1887—7,361,877 1888—8,177,987 1889—6,760,001 1890—6,816,451 1891—7,312,687	
	Bennett		8.5	22,000	261,800,000	5,180	44,036	36,373,736	7,274,747	18,011,916	16,820	200,158,000	100,079,000		
	Checker	Workable for limited area.	4.5	12,000	75,600,000						12,000	75,600,000	37,800,000		
	Ross	Often split or divided into Upper and Lower Ross.	10.0	25,000	350,000,000	1,020	10,404	8,593,704	1,718,741	4,253,155	23,980	335,720,000	167,860,000		
	Red Ash	Often split or divided into Top and Bottom Red Ash.	14.0	26,772	524,731,200	1,940	26,931	22,245,006	4,449,001	11,009,392	24,832	486,707,200	243,353,600		
Production, 1891, 7,312,687 tons.		Totals	97.6	189,872	2,218,761,200	15,666	147,216	121,447,121	24,289,424	60,154,671	174,206	2,012,672,200	1,006,336,100		
Nanticoke and Mocanaqua District. From Wilkes-Barre and Plymouth District to southwest end of basin. Includes Chauncy and Warrior Run Collieries.	George		6.6	2,400	22,176,000						2,400	22,176,000	11,088,000	Past production about 6 % of whole.	At 2,300,000 tons per year, excluding thin beds, 121 years; including thin beds, 138 years. 14 % of future production.
	Mills		6.7	4,000	37,520,000						4,000	37,520,000	18,760,000		
	Hillman		6.2	5,200	45,136,000	180	1,116	921,816	184,363	456,220	5,020	43,598,800	21,799,400		
	G		2.5	5,500	19,250,000						5,500	19,250,000	9,625,000		
	Lance or 4 ft.		4.0	6,000	33,600,000						6,000	33,600,000	16,800,000	1887—2,240,304 1888—2,606,071	
	Cooper		7.3	7,500	76,650,000						7,500	76,650,000	38,325,000	1889—2,370,610	
	Bennett or Forge		7.9	8,000	88,480,000	550	4,345	3,588,970	717,794	1,776,236	7,450	106,075,200	53,037,600	1890—2,176,412	
	Ross	Frequently divided into Upper and Lower Ross.	6.6	12,100	111,804,000	620	4,224	3,489,024	697,805	1,726,771	11,450	80,875,200	40,437,600		
	Red Ash or Buck Mtn.	Often split into Upper and Lower Red Ash. Principal bed of district.	13.2	13,260	244,860,000	1,600	21,120	17,445,120	3,489,024	8,633,856	11,650	215,292,000	107,646,000	1891—2,111,918	
Production, 1891, 2,111,918 tons.		Totals	61.0	63,950	679,476,000	2,950	30,805	25,444,930	5,088,986	12,594,083	61,000	635,037,200	317,518,600		At 21,000,000 tons per year the whole basin will be exhausted in about 99 years.
Total production, 23,620,083 tons.		Grand total		505,935	5,057,808,560	53,032	467,287	383,244,421	76,648,478	180,739,986	452,903	4,408,663,200	2,371,191,600		

EXPLANATION OF TABULAR ESTIMATE.

Showing the Approximate Quantity, Past and Future, Production of Coal in the Several Districts of the Northern Anthracite Coal Basin of Pennsylvania.

Editors "The Colliery Engineer":—

Sirs:—I herewith offer for publication an estimate of the approximate quantity and past and future production of coal in the several districts of the Northern Anthracite Coal Basin, more generally known as the Wyoming and Lackawanna coal-fields.

In making this estimate it was found most convenient to divide the region into districts as shown in Column No. 1 of the table. This will serve to show the distribution of the coal. Column No. 2 gives the local names applied to the various beds in each district, and are arranged with reference to their relative positions in the measures.

Column No. 3 contains short descriptive remarks as to known peculiarities of the individual beds. Column No. 4 contains the average thickness of the individual coal-beds in each district, and includes all beds that average over two feet thick. While these thin beds are not worked at the present time, they cannot be disregarded in an estimate of this sort, as the time will doubtless come when they will be profitably mined. The items in this column were obtained by taking the average thickness of each bed as found by using all the bore-hole, shaft, and other sections in the different parts of the basin, as published in the atlases of the State Geological Survey of the region.

The number of columnar sections of the measures thus used was 372, about evenly distributed throughout the basin. The totals in this column show the aggregate thickness of coal beds at the deepest point of the measures for each district. The items given in this column include whatever slate, bone, and other refuse there may be in the beds.

Column No. 5 contains the approximate superficial area of workable coal in each bed, and was obtained from the published maps of the Geological Survey, which very correctly show the outcrops of the lowest coal-bed and one other bed that is the most worked in each locality.

The outcrops of all the other beds were sketched approximately upon these maps by the author from his personal knowledge of the geology of the region, aided by the published cross-sections and columnar sections. The area of each bed was then computed for each district, deductions were occasionally made from the areas thus found, in order to allow for those areas where certain beds are known to be too thin to be included in the table.

Owing to the prevailing flatness of the measures in this region, no account has been taken of the greater area of coal caused by steeper dips at the margin of the basin, or on the sides of the anticlinals. The actual area of the coal-beds will therefore be somewhat in excess of the items given in the table, but this increase of area will doubtless be more than counterbalanced by the loss caused by poor and unminable coal on the outcrops, anticlinals, faults, troubles of various kinds, &c. The totals in this column show the area that would be covered if the beds were spread out side by side upon a level surface.

Column No. 6 contains the approximate quantity of solid coal in the ground before any was mined. The items are obtained by multiplying the thickness of each bed as is given in Column 4 by the items in Column 5, and this product by the factor 1400, as being the number of tons of pure coal per foot per acre in the average coal-bed after deducting 23.4 per cent. for the slate, bone, and other refuse, including an allowance for rock and thin faults, &c., which always occur in greater or less degree in all large areas.

In order to arrive at an average percentage for the refuse, the author obtained bed sections in various parts of the region from as many coal-beds as possible, and from them ascertained the following facts:—

	No. of bed sections.	Total thickness of beds.	Total thickness of refuse.	Per cent of refuse.
Wilkes-Barre and Plymouth District	61	593.01 feet.	115.1 feet.	19.4 per cent
Pittston District	28	236.91 "	43.3 "	18.4 "
Scranton District	33	322.72 "	57.5 "	17.8 "
Total	122	1,152.64 feet.	21.59 feet.	18.7 per cent.

The above would seem to show that the refuse material in the average coal-bed will amount to 18.7 per cent. of the contents of the bed.

The frequent occurrence of troubles, such as thin and poor coal, various kinds of faults, slips, squeezes, &c., would seem to call for an allowance in addition to those referred to under Column 5. An arbitrary deduction of 4.7 per cent. is therefore made on this account. Therefore, taking specific gravity of anthracite coal at 1.5, the weight of good coal in ground per foot thickness of bed per acre would be—

Weight of solid coal per foot thick per acre . . . . 1,828 tons.
Deduct 18.7 per cent. for refuse . . . . 342 tons.
Deduct about 4.7 per cent. for faults, troubles, &c. 86 "
428 tons. 428 "

Good coal in ground per foot thickness of bed per acre . . . . 1,400 tons.

The long ton of 2240 pounds is used throughout this estimate.

Column No. 7. The items in this column were found in manner similar to No. 5, by measuring the areas worked in each bed as shown upon the published mine sheets of the State Survey. In doing this the areas were measured full to make approximate allowance for the areas mined over since the dates of publication of the maps.

Column No. 8 is found by multiplying items of Column 7 by those of Column 4.

Column 9. The total approximate production of this coal basin to January 1st, 1892, as found from Mine Inspectors' Reports and other published statistics, is about 383,244,421 tons, and this amount divided by the grand total footings of Column 8 would give 826 tons as the average quantity of coal produced per foot thickness of bed per acre to January 1st, 1892. The items of Column 8 multiplied by the factor 826 will give the items of Column 9.

While the factor 826 tons may fairly represent the average yield for the whole basin in the past, it will not necessarily be correct for the special areas, particularly in the future when more mining is done in deeper parts of the basin.

The conditions under which coal is mined have a direct effect upon the yield per acre; where the conditions are favorable (North of Scranton, for instance), light covering over the coal, few surface improvements, little trouble from gas, &c., more tons per acre can be won than in the Wilkes-Barre region, where the beds are deep and gassy surface either much improved or covered by deep gravel deposits filled with water, that will flood the mine if the roof is cracked, thus requiring stronger pillars, better ventilation, and more careful mining in every way.

Column 10 is intended to show the approximate quantity of clean coal wasted in mining and preparing the coal for market. (The slate, bone, and other refuse being fully accounted for above under head of Column 6.)

In 1890 and '91 the Clear Spring Coal Company produced 312,523 tons of coal, and 65,532 tons of culm (including all the buckwheat coal) went to the culm pile, *i. e.*, the culm was about 17.7 per cent. of the total production. This seems to agree fairly well with the experiments made by the Lehigh and Wilkes-Barre Coal Company as published in Report A of the Geological Survey of Pennsylvania, page 56, where the average percentage of waste for old style rolls is shown to be 15.7 per cent. of quantity charged into the breaker, or 19.8 per cent. of the coal shipped. And on page 123 another experiment shows the culm to be 21.1 per cent. of shipments. The average of these percentages shows the culm to be 20.3 per cent. of the production.

Of course in cases where the buckwheat and bird's-eye are taken out the percentage is much reduced; this is now being done to a large extent. Quite a saving is also made by using the more improved machinery. On the other hand, all of the pea coal and much of the chestnut formerly went to the culm pile, so that the factor 20 per cent. of the production, or 165.2 tons per foot per acre, as used in this column, cannot be considered as excessive for the waste in the past.

Column 11. By deducting the sum of factors used in Columns 9 and 10 from the factor 1400, we have 408.8 as the percentage of coal per foot per acre now remaining in the ground in the areas that have been mined over. It exists in the form of solid pillars, and coal wasted with the "gob" or mine refuse. While part of this area has been worked out there are still considerable areas where much coal can yet be won by robbing these pillars, but no account has been taken of this item in the table.

By deducting the items of Column 7 from those of Column 5 we obtain the items of Column 12, and using these as a basis we obtain the items of Columns 13 and 14 from it in same way as Columns 6 and 9 were obtained by using Column 5.

In Column 14, in view of the facts referred to under Column 9, as to the effect of the conditions under which the coal is mined upon the yield per acre, we have thought best to use a larger factor, *i. e.*, 900 tons for the yield per acre for areas north of Scranton, where the conditions are more favorable for mining in the future.

For the Scranton and Pittston districts 800 tons per acre is used, and for the lower end of the basin 700 tons, as this is about all that can be obtained under the present conditions, methods of mining, &c.

From the footings of Columns 13 and 14 we see that the result of the estimate is that something over half the solid coal remaining in the ground can be mined.

Column 15 shows the production of the several districts for each year for the past five years, together with the percentage of the total output that each has produced.

Column 16 shows approximately the probable life of each district at present rate of production, also the percentage of total quantity of coal in the field that each district possesses.

The greatest portion of the mining in the past has been at those points where the coal was thickest, best, and most accessible, where the mining could be done at the greatest profit to the operator, and those parts where the beds were thinner have been left for the future, and hence the items in Column 4, which represent the average thickness of beds for the whole district, may be less than the average thickness of same beds for area worked in any particular district, while, at the same time, they may be more than average of the unworked areas. In this case the quantity of coal we have credited to the unworked areas would overrun, because the beds would not be as thick as estimated. In view of this, therefore, the estimate may be somewhat excessive. On the other hand future developments may prove more and better coal than has been anticipated in portions of these unworked areas.

In addition to this the experience and methods of mining that have prevailed in the past and upon which our estimate is based), which have been, to say the least, very wasteful, may be very much improved in the future, so that larger yields per acre will eventually be obtained from the unmined areas, and the worked and abandoned parts of the region may be partially remined and thus increase the quantity of available coal above our estimate.

WM. GRIFFITH.

Scranton, Pa., April 20th, 1892.

APPENDIX B.

Results of Use of Small Anthracite Coals on Locomotives.

Questions asked.	Philadelphia and Reading Railroad Company. (Main Line and Williamsport Divisions.)	Philadelphia and Reading Railroad Company. (Eastern and Northern Divisions.)	Central Railroad of New Jersey.
Divisions on which small anthracite is used as fuel on locomotives	All	Beaver Meadow, Mahanoy, and Wyoming	All
Names of parties giving information as to locomotives	L. B. Paxson, Superintendent Motive Power and Rolling Equipment	A. Mitchell, Superintendent Motive Power and Rolling Equipment	J. G. Thomas, Assistant Superintendent Motive Power; L. C. Brastow, Master Mechanic L. and S. Division
As to coal	R. C. Luther, General Superintendent P. and R. C. and I. Co.	W. A. Lathrop, General Superintendent L. V. Coal Co.	E. H. Lawall, General Superintendent L. and W. B. Coal Co.
Number of locomotives burning large anthracite	382	470	129
Small anthracite	351	108	41
Bituminous	About 25 or 30 on some lately-acquired New England roads	73	69
Class of work done by locomotives burning small anthracite, and number engaged in each class	28 suburban passenger 251 freight and coal 72 shifting	68 coal 34 freight 6 passenger	Coal and freight 1 passenger (compound)
Dimensions, &c., of locomotives for burning small anthracite	Wooten fire-box consolidation for freight and coal. " " standard 8-wheel, for passenger. " " 4 and 6 wheel, coupled, for shifting.		
Type of locomotive	1–50 Consolidation. / Standard passenger.	Consolidation and 10-wheel	Ordinary consolidation. / Heavy consolidation. / Heavy 10-wheel. / 8-wheel passenger Vauclain compound.
Diameter of boiler	60 in. / 67½ in.	Consolidation, 58 in.; 10-wheel, 56 in.	57 in.–61 in. / 69 in. / 65 in. / 57 in.
Type of grate	Water-bars, with cast-iron (slotted) grate-bars intervening	Water bars, with cast-iron (slotted) grate-bars intervening; some rocker-bars (shaking grates)	Water-bars, with cast-iron (slotted) grate-bars intervening
Size of grate	76 sq. ft. / 68 sq. ft.	63 sq. ft.	62 sq. ft. / 76 sq. ft. / 56 sq. feet. / 68 sq. ft.
Width of air opening in grate-bars	$\frac{5}{16}$ in. / $\frac{5}{16}$ in.	⅜ in.	⅜ in. / ⅜ in. / ⅜ in. / ⅜ in.
Number and size of flues	256, 2 in. x 12 ft. 6 in. / 385, 1½ in. x 9 ft. 1⅝ in.	200, 2 in.	256, 2 in. x 12 ft. 5 in. / 304, 2 in. x 11 ft. 3 in. / 258, 2 in. x 10 ft. 10 in. / 339, 1¾ in. x 9 ft. ½ in.
Heating surface	1846 sq. ft. / 1355 sq. ft.	About 1800 sq. ft.	1758 sq. ft. / 2066 sq. ft. / 1790 sq. ft. / 1474 sq. ft.
Size and type of exhaust nozzle	6 in., single	Various; single and double	5¼ in., single. / 6 in., single. / 4¼ in., single. / 5 in., single.
Special construction of fire-box	Wootten / Wootten	No combustion chamber	Wootten. / Wootten. / Wootten. / Wootten.
Special draught appliances	None / None	Extension smoke-box, flat screen and diaphragm	None. / None. / None. / None.
Method of firing small anthracite coal on locomotives	Fire light and often		Fire light and often
Advantages of burning large anthracite coal on locomotives	Better results than with any other fuel for fast trains	Duration of fire greater than with small anthracite, and requires less attention; also stand sharper blast	Steam can be kept up to required pressure with less labor and less skillful firing
Disadvantages of so doing	Large cost of fuel	Not so easily handled, and more expensive	Large cost of fuel
Advantages of burning small anthracite coal on locomotives	Saving of 70 per cent. in fuel bill	Cheapness, and nearly as much work obtained by using it	Cheap fuel
Disadvantages of so doing	Cannot get satisfactory results with it on simple engines hauling trains of exceedingly high speed. Sharp blast turns up the fire	Requires closer attention	Requires constant, skillful attention
Advantages of burning bituminous coal on locomotives,		Easier handled and more flame	Cheaper than large anthracite
Disadvantages of so doing		Disagreeable smoke and dust, and not so lasting as anthracite	Leakage in flues and flue-sheets
Quantity of fuel consumed in doing a certain amount of work with large anthracite		5 tons	No official tests
Small anthracite	23 per cent. more than with large anthracite	7 tons	" "
Bituminous		Not tested—no trial	" "
How do locomotives burning small anthracite compare with those burning large anthracite?	Get equally good results except on fast runs	Under the same conditions the odds are in favor of small coal	Do the work as well with cheaper fuel
Bituminous?		No trial made	
Disposition of company in matter of building new locomotives, *i. e.*, whether for burning large or small anthracite or bituminous coal	President has ordered that all locomotives built shall have fire-boxes for burning small anthracite coal	They are in favor of small coal generally	All freight and coal engines for small anthracite
Does a locomotive for burning small anthracite cost more than one for large anthracite or bituminous?	*From Baldwin Locomotive Works, Philadelphia.* Additional cost of building locomotives for burning anthracite coal as compared with cost of building locomotives for burning bituminous coal:— For large anthracite (fire-box between frames), $250, " " (" on top of "), 400, For small " (Wootten fire-box), $500 plus royalty " " (modified wide fire-box), $400	Same	About the same
Is cost of repairs greater on locomotive for burning small anthracite than on one for large anthracite or bituminous?	About the same	No	Probably greater in the long run. Estimate about 10 per cent.
Special points in construction, applying particularly to locomotives for burning small anthracite	Larger grate surface and exhaust nozzle	Larger grate surface and exhaust nozzle	Larger grate surface and exhaust nozzle
Size of coal used on locomotives for burning small anthracite	Buckwheat; never tried anything smaller	Pea and buckwheat	Pea or buckwheat of good quality
Type of screen used in preparation of same	Revolving	Revolving	Revolving; wire mesh
Whether round or square perforations in screen jackets,	Mostly square; some round	Oval	Square
Size of perforations for— Pea		Through ¾ in. □, 1⅛ in. x ¾ in. ⬭. Over ⅝ in. □, 1 in. x ½ in. ⬭	Through ¾ in. □. Over ½ in. □
Buckwheat	Through ½ in. □, $\frac{9}{16}$ in. ○ Over $\frac{5}{16}$ in. □, ⅜ in. ○	Through ⅝ in. □, 1 in. x ¼ in. ⬭. Over ¼ in. □, 1¼ in., 1½ in. x ¼ in. ⬭	" ½ in. □. " ¼ in. □
No. 2 buckwheat			
Rice			
Bird's eye			
Is coal of cubical or flat fracture?	Cubical	Wyoming, cubical; Lehigh, cubical; Schuylkill, flat	Mostly cubical
" prepared wet or dry?	Wet	" chiefly dry; Lehigh wet; " wet	Dry in Wyoming region; wet in Lehigh
" jigged?	Yes	" " not; " yes; " yes	No
" red or white ash?	White	" white; " white; " red	Red and white
" heavy or light?	Heavy	" medium; " heavy; " light	Heavy and light
" free or hard burning?	Hard	Free	Generally free
To what extent does coal clinker?	Very little	Not a great deal	To some extent
Is slate of cubical or flat fracture?	Flat	Flat	Flat
" heavy or light?	Light	Light	Heavy
Where is coal from?	Philadelphia and Reading Coal and Iron Company's collieries	Lehigh Valley Coal Company	Lehigh and Wilkesbarre Coal Company
Analysis of coal (sample taken at random from tender).	No. 1 buckwheat. Moisture 1.22 Volatile combustible matter 4.87 Ash 22.35 Carbon 71.56		Pea coal. Moisture 1.25 Volatile combustible matter 5.60 Ash 14.40 Carbon 78.75
Actual size of above sample	Large No. 1 buckwheat, with ash as high as 22 per cent.		Size, pea, and about 20 per cent. buckwheat. Average size pea coal, with ash, 14.4 per cent.
General remarks	Mr. Paxson says that much better results can be obtained with small anthracite on compound than on simple engines. Larger nozzle is used on compounds and they are consequently easier on fire. Thinks that buckwheat coal can probably be burnt on compound locomotives hauling fast trains; or, at any rate, pea coal. At the present time they generally burn egg coal on their fast passenger and fast freight trains		Passenger engine No. 229 (Vauclain compound Wootten fire-box) was tested in regular passenger train service March 15th, 18th, 19th, 24th, 25th, 28th, and 29th, 1892, running between Scranton and Phillipsburg on L. & S. Division. It was successfully demonstrated that fair quality pea and buckwheat coal can be burned in Wootten fire-boxes on passenger service.

Trip.	Date.	Mileage	Cost of coal per run.	Cost of coal per mile.	Cost of coal per car mile.	Size of coal.	Number of cars in train.
	1892.						
1	Mar. 17, 18, & 19	237	$6 53	.0276	.0069	Pea	4
2	Mar. 24 & 25	328	9 45	.0284	.0071	"	4
3	Mar. 28 & 29	328	7 65	.0233	.0058	Buckwheat	4

Questions asked.	Delaware, Lackawanna and Western Railroad. (Exclusive of Buffalo Division.)	Delaware and Hudson Canal Company.	Erie and Wyoming Valley Railroad. (Pennsylvania Coal Company.)
Divisions on which small anthracite is used as fuel on locomotives	All	Pennsylvania	All
Names of parties giving information as to locomotives	David S. Brown, Master Mechanic D. L. and W. R. R.	C. E. Retlew, Master Mechanic D. and H. C. Co.	D. E. Barton, Master Mechanic E. and W. V. R. R.
As to coal	W. H. Storrs, Assistant General Coal Agent D. L. and W.	William Bowers, Superintendent Coal Dept. D. & H. C. Co.	George B. Smith, Superintendent E. and W. V. R. R.
Number of locomotives burning large anthracite	114	73	7
Small anthracite	94	19	27
Bituminous	None	None	None
Class of work done by locomotives burning small anthracite, and number engaged in each class	15 passenger 2 switching 77 coal and freight	19 freight and coal	24 freight and coal 3 passenger
Dimensions, &c., of locomotives for burning small anthracite			
Type of locomotive	Mogul. / Consolidation. / 8-wheel passenger.	15 Wooten fire-box moguls 4 ordinary wide fire-box moguls	1 Consolidation. / 23 Moguls. / 3, 8-wheel passenger.
Diameter of boiler	54 in. / 58 in. / 54 in.	52 in.	60 in. / 52 in. / 53 in.
Type of grate	Water-bars, with cast-iron (slotted) grate-bars intervening	Water-bars, with cast-iron (slotted) grate-bars intervening	Water bars, with cast-iron (slotted) grate-bars intervening
Size of grate	76 sq. ft. / 80 sq. ft. / 80 sq. ft.	68 sq. ft.	84 sq. ft. / 69¼ sq. ft. / 68 sq. ft.
Width of air opening in grate-bars	$\frac{5}{16}$ in. / $\frac{5}{16}$ in. / $\frac{5}{16}$ in.	¼ in.	$\frac{5}{16}$ in. / $\frac{5}{16}$ in. / $\frac{5}{16}$ in.
Number and size of flues	193, 2 in. x 12 ft. / 228–236, 2 in. x 12 ft. / 210–220, 2 in. x 10 ft. 10 in.	156, 2 in. x 11 ft.	/ 183, 2 in. x 9 ft. 3 in. / 341, 1½ in. x 9 ft. 2¼ in.
Heating surface	1344 sq. ft. / 1558 sq. ft. / 1350 sq. ft.	1074 sq. ft.	
Size and type of exhaust nozzle	3¼ in., double. / 3½ in.–3⅜ in., double. / 3⅛ in. 3¼ in., and 3½ in., double.	3½-in., double	3½ in., double. / 3¼ in., double. / 3¼ in., double.
Special construction of fire-box	48 plain wide. 3 Wootten. / 21 plain wide. 5 Wootten. / 4 plain wide. 11 Wootten.	15 Wootten, 4 modified wide	Wootten. / Wootten. / Wootten.
Special draught appliances	None. / None. / None.	None	None. / None. / None.
Method of firing small anthracite coal on locomotives	Fire light; by so doing the fire is kept cleaner		
Advantages of burning large anthracite coal on locomotives	There are no advantages in burning large coal on our road. The fine anthracite engines will do better work		
Disadvantages of so doing	Great cost of fuel	Great cost of fuel	Great cost of fuel
Advantages of burning small anthracite coal on locomotives	Cheap fuel; better results than with large anthracite. Larger grate surface allows larger exhaust nozzle, and there is, consequently, less back pressure when running fast	Cheap fuel. Better results than with large anthracite. Larger grate surface allows larger exhaust nozzles, and there is, consequently, less back pressure	Cheap fuel
Disadvantages of so doing	No disadvantage whatever		
Advantages of burning bituminous coal on locomotives,	Use no bituminous coal, except on Buffalo Division		
Disadvantages of so doing			
Quantity of fuel consumed in doing a certain amount of work with large anthracite			
Small anthracite	Same amount as large anthracite. No test	Same as large anthracite; difference, if any, in favor of small anthracite. No test	
Bituminous			
How do locomotives burning small anthracite compare with those burning large anthracite?	Better than large anthracite on any class of work	Get equally good results in train service	Equally good results
Bituminous?			
Disposition of company in matter of building new locomotives, *i. e.*, whether for burning large or small anthracite or bituminous coal	Small anthracite	Large anthracite. Have had considerable trouble with crown-sheets on wide fire-box locomotives, due to faulty construction. Crown-sheet too "flat." On this account tendency of road is, for the present, at least, towards locomotives for burning large anthracite	Small anthracite
Does a locomotive for burning small anthracite cost more than one for large anthracite or bituminous?	About same	$300 more	No difference
Is cost of repairs greater on locomotive for burning small anthracite than on one for large anthracite or bituminous?	No difference	On account of trouble they have had with crown sheets on their wide fire-box engines, such engines are considerably more expensive for repairs than narrow fire-box engines	No difference
Special points in construction, applying particularly to locomotives for burning small anthracite	Larger grate surface and exhaust nozzle	Larger grate surface and exhaust nozzle	Larger grate surface and exhaust nozzle
Size of coal used on locomotives for burning small anthracite	Buckwheat on coal and freight. Pea on passenger. Can't get satisfactory results with buckwheat on passenger engines	Pea or buckwheat	Buckwheat and bird's-eye mixed: one part of buckwheat to two of bird's-eye
Type of screen used in preparation of same	Revolving: Wire mesh—Square perforations; Cast iron—Square perforations; Punched plates—Round perforations	Shakers	Revolving pentagon
Whether round or square perforations in screen jackets,	Mostly square	Round and square	Round
Size of perforations for— Pea	Through ¾ in. □; $\frac{13}{16}$ in. ○. Over ½ in. □; $\frac{9}{16}$ in. ○	Through ¾ in. □. Over ½ in. □; ⅝ in. ○	
Buckwheat	" ½ in. □; $\frac{9}{16}$ in. ○. " ¼ in. □; $\frac{5}{16}$ in. ○	" ½ in. □; ⅝ in. ○. Over $\frac{5}{16}$ in. ○	Through $\frac{7}{16}$ in. □. Over ⅜ in. ○
No. 2 buckwheat			
Rice			
Bird's eye		Through $\frac{5}{16}$ in. ○. Over $\frac{3}{16}$ in. ○	Through ⅜ in. ○. Over $\frac{3}{16}$ in.–¼ in. ○. When "wet" $\frac{3}{16}$ in. x 1½ in. slot
Is coal of cubical or flat fracture?	Cubical	Generally cubical	Generally cubical
" prepared wet or dry?	Dry	Dry	Dry
" jigged?	No	No	No
" red or white ash?	Nearly all white	White	White
" heavy or light?	Medium	Generally light	Medium
" free or hard burning?	Free	Free	Fair to free
To what extent does coal clinker?	Little	Not much	Little
Is slate of cubical or flat fracture?	Flat	Flat	Flat
" heavy or light?	Light	Light	Light
Where is coal from?	Delaware, Lackawanna and Western collieries	Delaware and Hudson Canal Company	Pennsylvania Coal Company
Analysis of coal (sample taken at random from tender).	Pea and buckwheat mixture. / No. 1 buckwheat. Moisture 1.30 / 1.45 Volatile combustible matter 5.80 / 6.25 Ash 8.22 / 12.70 Carbon 84.68 / 79.60	Pea and buckwheat mixture. Moisture 1.00 Volatile combustible matter 6.75 Ash 8.70 Carbon 83.55	
Actual size of above sample	Mixture of pea and buckwheat, with ash, 8.22 per cent. Large No. 1 buckwheat, with ash, 12.7 per cent.	Clean No. 1 buckwheat, containing considerable pea coal, with ash, 8.7 per cent.	
General remarks		Tried bird's-eye coal on their locomotives for about three months. As long as coal was of good quality they got satisfactory results. Collieries got "pushed" for this size of coal; too much fine stuff was the result, and they could not keep up steam with it on their locomotives.	

Questions asked.	New York, Ontario and Western Railway.	Delaware, Susquehanna and Schuylkill Railroad.
Divisions on which small anthracite is used as fuel on locomotives	All	All.
Names of parties giving information as to locomotives	George W. West, Superintendent Motive Power	A. J. Beltz, Master Mechanic.
As to coal	Dickson & Eddy, General Sales Agents	Eckley B. Coxe, Coxe Bros. & Co.
Number of locomotives burning large anthracite	6	2.
Small anthracite	41	10.
Bituminous	79	3.
Class of work done by locomotives burning small anthracite, and number engaged in each class	Consolidation for freight and coal Moguls for passenger	9 coal. 1 passenger.
Dimensions, &c., of locomotives for burning small anthracite		
Type of locomotive	Consolidation. / Mogul.	Wide fire-box consolidation / Wide fire-box mogul.
Diameter of boiler	60 in. / 56 in.	58 in. / 56 in.
Type of grate	Water-bars, with cast-iron (slotted) grate-bars interven'g	Water-bars, with cast-iron (slotted) grate-bars intervening.
Size of grate	80 sq. ft. / 71¼ sq. ft.	63 sq. ft. / 61 sq. ft.
Width of air opening in grate-bars	¼ in. / ¼ in.	⅜ in. / ⅜ in.
Number and size of flues	230, 2 in. x 11 ft. / 190, 2 in. x 11 ft.	193, 2¼ in. x 13 ft. 7¾ in. / 213, 2 in. x 11 ft. 1 in.
Heating surface	1653 sq. ft / 1436 sq. ft.	
Size and type of exhaust nozzle	3¼ in., double. / 3¼ in., double.	Double, 3 in. / Double, 3 in.
Special construction of fire-box	None. / None.	No combustion chamber. / No combustion chamber.
Special draught appliances	None. / None.	None. / None.
Method of firing small anthracite coal on locomotives		Light and frequently.
Advantages of burning large anthracite coal on locomotives		None.
Disadvantages of so doing	Great cost of fuel. Cannot get fire-box of sufficient area *between frames* to supply steam to large cylinders now being put on locomotives	High cost of fuel.
Advantages of burning small anthracite coal on locomotives		Low cost of fuel.
Disadvantages of so doing		None.
Advantages of burning bituminous coal on locomotives,	Cheaper than large anthracite	None. The 3 bituminous-burning locomotives were bought second-hand, when the road was very short of power.
Disadvantages of so doing		High cost of fuel.
Quantity of fuel consumed in doing a certain amount of work with large anthracite		
Small anthracite	Estimate: 50 per cent. *more* fuel than with large anthracite. (This is partly due to slaty condition of small coal.)	
Bituminous	About 50 per cent. *less* than with small anthracite. (This is also partly due to slaty condition of small coal.)	
How do locomotives burning small anthracite compare with those burning large anthracite?	Much cheaper for fuel	Do the work as well with much cheaper fuel.
Bituminous?	Cheaper for fuel	" " "
Disposition of company in matter of building new locomotives, *i. e.*, whether for burning large or small anthracite or bituminous coal	Small anthracite for all traffic	Small anthracite.
Does a locomotive for burning small anthracite cost more than one for large anthracite or bituminous?	About $500 more	
Is cost of repairs greater on locomotive for burning small anthracite than on one for large anthracite or bituminous?	No difference	
Special points in construction, applying particularly to locomotives for burning small anthracite	Larger grate surface and exhaust nozzle	Larger grate surface and exhaust nozzle.
Size of coal used on locomotives for burning small anthracite	Buckwheat for all traffic. Use pea when they cannot get buckwheat	Pea and buckwheat.
Type of screen used in preparation of same	Revolving wire mesh (principally) and punched plates	Gyrating (Coxe).
Whether round or square perforations in screen jackets,	Square, round, and oval	Round punched.
Size of perforations for— Pea	Through ¾ in. □; ¾ in. ○. Over ½ in. □; $\frac{13}{16}$ in. x 1½ in. ⬭	Through ⅞ in. ○ and over $\frac{9}{16}$ in. ○
Buckwheat	Through ½ in. □; $\frac{13}{16}$ in. x 1½ in. ⬭. Over ¼ in. □; $\frac{3}{16}$ x ½ in. ⬭	" $\frac{9}{16}$ in. ○ " ⅜ in. ○ punched.
No. 2 buckwheat		
Rice		
Bird's eye		
Is coal of cubical or flat fracture?	Generally flat	
" prepared wet or dry?	Dry and wet	Wet.
" jigged?	Generally not. (Jigged at one colliery)	Yes.
" red or white ash?	White	Reddish gray.
" heavy or light?	Generally free	Heavy.
" free or hard burning?	Generally light	Hard burning.
To what extent does coal clinker?	Light	Not much.
Is slate of cubical or flat fracture?	Generally flat	Generally cubical, with some flat.
" heavy or light?	Generally light	Heavy.
Where is coal from?	New York, Ontario and Western Coal Dept.	Coxe Bros. & Co.'s collieries.
Analysis of coal (sample taken at random from tender).	Pea coal. Moisture 1.27 Volatile combustible matter 8.05 Ash 15.12 Carbon 75.56	Pea coal. / No. 1 buckwheat. Moisture 1.685 / 1.685 Volatile combustible matter, 4.612 / 4.612 Ash 12.50 to 15.00 / 10.00 to 12.00 Carbon 78.70 to 81.20 / 81.70 to 83.70
Actual size of above sample	Pea coal containing some buckwheat, with ash, 15.12 per cent.	Use pea coal when by analysis it is shown to have 12.5 to 15 per cent. ash, but can use buckwheat when the ash is not higher than 12 per cent.
General remarks		

APPENDIX C–1.

Devices for Utilizing or Burning Culm.

No. Patent.	Date.	Name of Patentee.	Description.
12,286	Jan. 23, 1855	E. Schmitz	Pulverizing fuel.
28,226	May 8, 1860	J. P. Wigal	Feeding boiler furnace.
29,794	Aug. 28, 1860	S. Kennedy	" " "
59,695	Nov. 13, 1866	Wheply & Storer	Apparatus for feeding fuel to furnace.
77,822	May 12, 1868	T. J. Leigh	Furnace for burning pulverized fuel.
79,914	July 14, 1868	J. G. McCormick	Feeding boiler furnace.
101,067	Mar. 22, 1870	Wheply & Storer	
103,695	May 31, 1870	" "	Furnace.
103,804	" 31, 1870	" "	Feeding pulverized fuel to furnace.
111,614	Feb. 7, 1871	T. R. Crampton	Pulverized fuel furnace.
111,616	" 7, 1871	" "	" " "
111,615	" 7, 1871	" "	" " "
112,636	Mar. 14, 1871	Rodgers & Tarrant	Feeding fuel to furnace.
116,165	June 20, 1871	George F. Deacon	Improvement in appliance for feeding furnace with fuel.
120,007	Oct. 17, 1871	J. T. Smith	Apparatus for feeding pulverized fuel in furnace.
120,008	" 17, 1871	J. G. Smith	Feeding pulverized fuel to furnace.
120,680	Nov. 7, 1871	" "	" " "
122,521	Jan. 9, 1872	E. F. Griffin	Improvement in steam boiler furnaces.
180,550	Aug. 1, 1876	A. Codsreil	Feeding pulverized fuel to furnace.
184,122	Nov. 7, 1876	W. West	Pulverized fuel feeder for smelting furnaces.
185,592	Dec. 9, 1876	G. K. Stevenson	Apparatus for introducing powdered fuel into furnace.
224,237	Feb. 13, 1880	C. Smith	Apparatus for supplying fuel to steam boiler.
227,176	May 4, 1880	J. G. McAuley & W. West	Feeder for pulverized fuel.
228,334	June 1, 1880	A. Faber du Faur	Process and appliance for burning pulverized fuel.
238,891	Mar. 15, 1881	A. Greiner	Device for feeding fine fuel.
240,265	April 19, 1881	C. H. Palmer	
243,593	June 28, 1881	J. G. McAuley	Furnace.
245,427	Aug. 9, 1881	J. D. Averhill	Machine for feeding fine fuel.
247,333	Sept. 20, 1881	A. Gearing	Feeding fuel to puddling and other furnaces.
247,570	" 27, 1881	J. G. McAuley	Fuel-feeding apparatus.
251,131	Dec. 20, 1881	C. H. Palmer	Pulverized fuel feeder.
261,864	Aug. 1, 1882	H. Mason	Feeding light fuel.
265,347	Oct. 3, 1882	E. Tourangin	Burning pulverized fuel.
274,778	Mar. 27, 1883	J. B. Hyde	Means for feeding pulverized fuel.
278,209	May 22, 1883	W. E. Wright	Means for burning, &c.
292,236	Jan. 22, 1884	J. Leede	Process of mixing and consuming hydrocarbon with pulverized earth.
292,237	Jan. 22, 1884	J. Leede	Appliance for feeding and consuming fine fuel.
295,145	Mar. 18, 1884	H. A. Bradley	Coal-dust feeder.

327,210	Sept. 29, 1885	W. Westlake	Feeding fine fuel.
331,731	Dec. 1, 1885	J. A. Price	Furnace for burning culm.
332,975	" 22, 1885	S. W. Valentine	Feeding fuel to boilers.
333,337	" 29, 1885	R. W. O. Rehmenklan	Feeding coal to furnace.
405,966	June 25, 1889	A. Mason	Process of burning culm or pulverized coal.
164,729	June 22, 1875	W. S. Greggs	Hollow grate-bar.
167,087	Aug. 24, 1875	W. Farris	Grate-bars.
203.233	April 30, 1878	J. E. Wookri	Grate for steam boiler furnaces.
312,293	Feb. 17, 1885	J. A. Price	Furnace grate.
318,007	May 19, 1885	Wm. McClave	Grate.
318,008	May 19, 1885	" "	Combined steam and air blower for boiler furnaces.
345,019	July 6, 1886	W. A. Barnes	Mechanism for burning fine fuel.
346,086	July 27, 1886	T. Bujac	Grate for burning coal dust.
454,490	June 23, 1891	S. J. Miles	Grate for burning hard stock coal.
468,814	Feb. 16, 1892	" "	Furnace.
480,538	Aug. 9, 1892	A. Wilkinson	Furnace grate.
325,837	Dec. 8, 1885	S. M. Hess	Culm-bar.
343.370	June 8, 1886	" "	"
393,843	Dec. 4, 1888	Wm. McClave	Stationary grate for furnace.
409,304	Aug. 20, 1889	Wm. R. Roney	Steam boiler or other furnaces.
409,650	" 20, 1889	" "	Furnaces.
423,465	Mar. 18, 1890	J. Ashcroft	Grate-bars.
428,595	May 27, 1890	S. W. Evans	"
46,070	Jan. 31, 1865	W. E. Brown	Coal sifter.
92,737	July 20, 1869	J. M. Mitchell	Improved drying and baking apparatus for preparing fuel from coal waste.
137,820	Apr. 15, 1873	A. Berney	Improvement in process of using anthracite coal dust as fuel in furnaces.
332,613	Dec. 16, 1885	J. M. Kelley	Manufacture of coke.
388,375	Aug. 21, 1888	Hamilton Ruddick	Apparatus for reducing and pulverizing fuel.
405,967	June 25, 1889	A. Mason	Process of burning coal and hydrocarbon fuel.
406,659	July 9, 1889	"	Apparatus for burning culm or pulverized coal.
406,753	July 9, 1889	"	Apparatus for burning culm.
413,916	Oct. 29, 1889	V. W. Blanchard	Furnace.
413,922	" 29, 1889	" "	"
414,322	Nov. 5, 1889	E. Pait	Coal-dust feeder.
416,252	Dec. 3, 1889	John J. Bordman	Rotary pulverizing machine.
416,253	Dec. 3, 1889	" "	Pulverizing machine.
436,613	Sept. 16, 1890	R. W. R. Phelps	Method of supplying furnace with carbonaceous fuel.
441,688	Dec. 2, 1890	J. G. McAuley	Pulverized fuel feeder.
441,689	" 2, 1890	" "	Fuel-feeding apparatus.
444,659	Feb. 24, 1891	G. W. Wood	Device for feeding boiler furnace.
454,490	June 23, 1891	F. J. Miles	Grate for burning hard coal slack.
458,207	Aug. 25, 1891	G. W. Wood	Furnace.
469,859	Mar. 1, 1892	W. A. Koneman	Method of burning coal slack.

APPENDIX C–2.

List of Patents relating to Artificial Fuels. Mechanical Mixtures, formed into Briquettes, &c., containing Coal Waste.

Description.	Name of Patentee.	No. of Patent.	Date.
Coal waste,			
Combined with clay and water	Joseph Lyon	332	July 31, 1837.
" charcoal, sawdust, resin, turpentine	Levi T. Cheever	6,125	Feb. 20, 1849.
" peat, &c.	E. D. Williams	27,401	Mar. 6, 1860.
" plaster paris and clay	Jacob H. Hubbard	40,753	Dec. 1, 1863.
" clay, molasses, water, and petroleum	William Budd	40,791	Dec. 1, 1863.
" asphaltum	Thomas M. Fell	40,920	Dec. 15, 1863.
" insoluble soaps	Dominic E. Courtaret	41,832	Mar. 8, 1864.
" residuum of petroleum	Binsson Pierre	42,163	April 5, 1864.
" coke, tar, tan, and water	William Halsted and O. S. Halsted, Jr.	43,112	June 14, 1864.
" peat	H. S. Lucas	43,695	Aug. 2, 1864.
" asphaltum and petroleum	Richard Covert	44,940	Nov. 8, 1864.
" peat, coal-tar, rye-paste, glue	William Halsted	45,922	Jan. 17, 1865.
" hydraulic lime, plaster paris, water	Frederick E. Payne	45,935	Jan. 17, 1865.
" coke dust, slacked lime, and clay	Gilbert R. Gladding	47,296	April 18, 1865.
" lime and sulphurous acid gas	Julius Augustus Roth	47,337	April 18, 1865.
" cow-dung and blood	Henry Redlich	48,439	June 27, 1865.
" petroleum and vegetable fibres	R. B. Bayard	48,506	July 4, 1865.
" animals' blood and water	Charles Korff	48,564	July 4, 1865.
" glue	S. D. Hovey	50,588	Oct. 24, 1865.
" glue	William Footner	77,970	May 19, 1868.
Anthracite and bituminous coal dusts	B. F. Penny	111,555	Feb. 7, 1871.
Combined with slacked lime, calcined plaster, sulphur	H. Cutler	124,553	Mar. 12, 1872.
" calcined dolomite, &c.	Adrian Kloezewski and Demetry Mindeleff	128,636	July 2, 1872.
Combined with bituminous mastic	Martin Rae	136,263	Feb. 25, 1873.
" calcareous clay and coal waste, boiling water	J. R. Hayes	136,375	Mar. 4, 1873.
" resin, coarse sawdust, paraffine	J. C. Crumpton	138,382	April 29, 1873.
Method of utilizing culm dust	A. Berney	139,288	May 27, 1873.
Combined with lime, water, &c.	W. Broad	150,393	May 5, 1874.

Combined with lime, dried peat, &c.	S. H. Daddow	150,537	May 5, 1874.
" loam, carbonate of soda, &c.	H. Manthe	151,041	May 19, 1874.
" pitch, &c.	C. C. F. Otto	151,424	May 26, 1874.
" clay, turpentine, &c.	Isadore McCormack	152,395	June 23, 1874.
" sawdust, benzine, &c.	S. J. Whiting and J. K. Blyler	155,559	Sept. 29, 1874.
" resinous substances	D. F. Packer	157,758	Dec. 15, 1874.
" peat, lime, tar, and hydrocarbons	Charles Jenty	160,201	Feb. 23, 1875.
" crushed coal-tar heated by steam	J. J. Endres	162,362	April 20, 1875.
" pulverized clay, rye paste, lime	Emile F. Loiseau	167,914	Dec. 21, 1875.
" pitch, tar, and coking coal	W. Primrose and W. F. Richards	175,744	April 4, 1876.
" glauber salts and wood ashes	M. B. Eaton	182,809	Oct. 3, 1876.
" lignite, coke, sawdust, &c.	W. C. A. Roettger	190,724	May 15, 1877.
" decomposed fucus (seaweed)	F. F. E. Muck	212,150	Feb. 11, 1879.
" sea-grass, seaweed, &c.	Otto Hassel	216,613	June 17, 1879.
" coal-tar, pitch, and slack	L. L. Crounse	222,466	Dec. 9, 1879
" ammonium sulphate, soda ash, &c.	J. M. Child	224,649	Feb. 17, 1880.
" chloride of sodium, sulphate of iron, &c.	J. C. McCarty	229,159	June 22, 1880.
" powdered lime and asphalt	A. Berney	239,642	April 5, 1881.
" pitch	G. S. Page	251,458	Dec. 27, 1881.
" clay, sawdust, and water	W. C. Siffken	257,985	May 16, 1882.
" coke	J. M. Cooper	269,640	Dec. 26, 1882.
" animals' blood and quicklime	A. Romeau	301,525	July 8, 1884.
" soap water, caustic soda, salt	R. M. Breinig	307,838	Nov. 11, 1884.
" bituminous coal slack	William Griffith	308,154	Nov. 18, 1884.
" vegetable refuse	Carl Van Gulpon	308,714	Dec. 2, 1884.
" coke, tar, petroleum, carbonate of sodium, &c.	F. Wilhelm and Christian Waldeck	309,587	Dec. 23, 1884.
" rosin, asphaltum, soot, corn-cobbs, sawdust, &c.	C. H. Sternberg	316,580	April 28, 1885.
" fire-brick clay, sand, and hard white ash coal	L. E. Osborne	329,070	Oct. 27, 1885.
" carbonaceous dust, silicate of potash, &c.	W. H. Corey	332,498	Dec. 15, 1885.
" wood charcoal, &c.	G. Waudrey and R. J. Schimper	367,015	July 19, 1887.
" indian corn-meal, &c.	J. I. Irving	374,679	Dec. 13, 1887.
" charcoal, sugar, &c.	E. Henn	378,249	Feb. 21, 1888.
" ground oil-cakes	G. L. Montgomery	391,179	Oct. 16, 1888.

APPENDIX C-2.—Continued.

Description.	Name of Patentee.	No. of Patent.	Date.
Combined with rosin, clay, and water	Cornelius Kemplen	392,868	Nov. 13, 1888.
" potter's clay, &c.	" "	392,869	Nov. 13, 1888.
" clay, plaster paris, and petroleum oil	J. A. Freeman	393,427	Nov. 27, 1888.
" lime, &c.	Levi Hess	394,486	Dec. 11, 1888.
" sawdust, clay, sand solution, saltpetre, and tar	Leopold Wacks	398,810	Feb. 26, 1889.
" rosin, sawdust, and pine needles	J. D. Baudman	405,865	June 25, 1889.
" brick-dust, &c.	R. J. Schimper	408,854	Aug. 13, 1889.
" furnace slag, charcoal, &c.	D. C. Fischee	413,110	Oct. 15, 1889.
" wheat flour, &c.	A. Mayer	414,116	Oct. 29, 1889.
" sawdust and blue clay	A. K. Murray	419,869	Jan. 21, 1890.
" lixivated wood	J. Wiesner	421,878	Feb. 18, 1890.
" water, tar, or pitch	J. Bowing	422,907	Mar. 11, 1890.
" quicklime, tar, salt, and turpentine	J. J. Hiertz	424,299	Mar. 25, 1890.
" peat, rosin, pitch, rye flour, lime	G. Y. Smith	425,351	April 8, 1890.
" pulverized charcoal, carbonate of soda, nitric acid, &.	E. K. Baoyerlin	426,519	April 29, 1890.
" rye flour, &c.	A. Mayer	433,653	Aug. 5, 1890.
" charcoal, starch, saltpetre, and brown sandstone	A. Pagenstecher	435,076	Aug. 26, 1890.
" sodium, &c.	H. M. Baker	446,505	Feb. 17, 1891.
" sand, lime-dust, and asphaltum	W. B. McClure	437,163	Sept. 23, 1890.
" rosin, sawdust, and black or teroxide of manganese,	J. C. Bandman	446,845	Feb. 24, 1891.
" powdered charcoal saturated with solution of acetate of lead, lime, and gypsum	R. J. Schimper	447,138	Feb. 24, 1891.
" ashes and sawdust saturated with petroleum and coated with resin or its equivalent	D. E. Bangs	450,924	April 21, 1891.
" wood-pulp, wood ashes, pitch, rosin, paraffine, soda	D. E. Bangs	451,358	April 28, 1891.
" waste of distilleries and starch factories	A. Parks	452,949	May 26, 1891.
" charred garbage, flag, powdered marine shells, coal tar, rosin, and crude oil	D. C. Fischel	455,492	July 7, 1891.
" camomile, bark of eucalyptus, cobra, bitumen, russian chesk, bark from brazos trees, and zevietesa,	A. Edelmann	465,249	Dec. 15, 1891.
" geyserite jelly and petroleum	H. Zahn	478,039	June 28, 1892.
" vegetable pulp, Irish moss, calcined limestone, asbestus fiber, and water	E. K. Baoyerlin and F. G. Hginig	480,243	Aug. 9, 1892.

APPENDIX D–1.

References to Official Reports. (Utilization of Anthracite Waste.)

Serial No.	Subject.	Author.	Report.	Page.	Publishers.	Place and Date.
1	Method used in Wales for coking anthracite slack coal,	F. Platt	Penna. Second Geological Survey, Report "L"	86	Bd. of Com. of the Survey	Harrisburg, 1876.
2	On the utilization of anthracite slack coal with a mixture of bituminous coal	"	" " " "M M"	382	" " "	" 1879.
3	The utilization of coal dust or slack	J. C. Branner	Arkansas Geol. Survey Report, 1888, vol. 3, Coal	88	Press Printing Company	LittleRock,Ark.,1888.
4	Preparation and utilization of small sizes of anthracite	E. B. Coxe	Saward's Coal Trade, 1892	108	F. E. Saward	New York, 1892.
5	Scranton Board of Trade—Report on value of culm or anthracite waste	Transportation Committee	Transportation Committee's Report	. . .	. . .	Scranton, 1889.
6	Scranton Board of Trade—Report on powdered anthracite and gas-fuel	Manufacturers' Report	Scranton Board of Trade	. . .	. . .	" 1886.
7	Waste in mining and preparing anthracite	H. M. Chance	Pa. Second Geol. Survey, Rpt. "A C"	475	Board of Commission	Harrisburg, 1883.
8	Waste in mining—Per cent. going to market and to dirt-bank	C. A. Ashburner	" " " "A A," Anth. Regn.	174	" "	" 1883.
9	The causes, kinds, and amount of waste in mining anthracite	F. Platt	" " " "A-2," Coal Waste	. . .	" "	" 1881.
10	Briquetting of brown coal and lignites	E. T. Dumble	Geol. Survey of Tex., Rpt. on Brown Coal Lignites	. . .	Benjamin C. Jones & Co.	Austin, 1892.
11	The Whelpley & Storer dust-fuel process	B. F. Isherwood	Annual Report Bureau of Steam Engineering	260	Gov. Printing Office	Washington, 1876.
12	A Report to the Navy Department of the U. S. on American coals	W. R. Johnson	. . .	. . .	Gales & Seaton	" 1844.

APPENDIX D-2.

References to Engineering Societies. (Utilization of Anthracite Waste.)

Serial No.	Subject.	Author.	Journal or Transaction of Society.	Vol.	Page.	No.	Month.	Date.	Year.
1	Mr. Wootten's method of burning coal dust in stationary and locomotive boilers	John E. Wootten	American Institute of Mining Engineers	5	4	. .	. . . .	. . .	1876-7
2	The use of anthracite waste	John F. Blandy	" " "	5	465	. .	. . . .	. . .	1876-7
3	The preparation and utilization of small sizes of anthracite	Discussion: E. B. Coxe and others	" " "	20	613	. .	. . . .	. . .	1891
4	The utilization of anthracite waste by gasification in producers	W. H. Blauvelt	" " "	20	625	. .	. . . .	. . .	1891
5	The use of the McClave grate and Argand steam blower, utilizing small sizes of anthracite or bituminous slack in boiler and similar furnaces	R. J. Foster	" " "	20	628	. .	. . . .	. . .	1891
6	Brief description of the anthracite coal-fields of Pennsylvania: Waste in mining and preparation	C. A. Ashburner	Engineers' Club of Philadelphia	4	177	. .	June	21	1884
7	On the manufacture of artificial fuel at Port Richmond, Philadelphia,	E. F. Loiseau	American Institute of Mining Engineers	6	214	. .	Feb.	. . .	1878
8	Notes on the manufacture of anthracite coke in South Wales	William Hackney	Journal Iron and Steel Institute	. . .	528	. .	. . . .	. . .	1875
9	Cory's artificial fuel	W. H. Cory	Engineers' Club of Philadelphia	3	178	. .	Oct.	7	1882
10	Report on Loiseau's artificial fuel	E. F. Loiseau	" " "	3	178	. .	Dec.	16	1882
11	On the combustion of powdered fuel in revolving furnaces and its application to heating and puddling furnaces	T. Crampton	Journal Iron and Steel Institute	. . .	91	. .	. . . .	. . .	1873
12	Meldrum's patent self-contained dust-fuel furnace	William Boby	Federated Institution of Mining Engineers	3	250	. .	May	6	1892
13	A combination of apparatus by which ordinary anthracite coal waste can be successfully and profitably burned in furnaces of stationary and locomotive boilers	John E. Wootten	American Philosophical Society	16	214	. .	. . . .	. . .	1876-7
14	The anthracite coal-fields of Pennsylvania and their exhaustion	P. W. Sheafer	American Ass'n for the Advancement of Science	29	. . . .	. .	Aug.	. . .	1880
15	The successful manufacture of artificial fuel at Port Richmond, Va.	E. F. Loiseau	American Institute of Mining Engineers	8	314	. .	Feb.	. . .	1880
16	Perret's furnace for dust-fuel	John Holliday	South Wales Institute of Engineers	16	50	. .	. . . .	. . .	1888-9
17	Remarks on t c waste in coal mining	R. P. Rothwell	American Institute of Mining Engineers	1	55	. .	. . . .	. . .	1871-3
18	Preliminary report of the committee on the waste of anthracite coal	E. B. Coxe	" " "	1	59	. .	. . . .	. . .	1871-3
19	Pillars of coal a great waste and very dangerous besides	S. H. Daddow	" " "	1	170	. .	. . . .	. . .	1871-3
20	On the wasting of coal at the mines	J. W. Harden	" " "	1	406	. .	. . . .	. . .	1871-3
21	On the wasting of coal at the mines and in mining	Discussion	" " "	5	417	. .	. . . .	. . .	1876-7
22	The waste in mining and preparation—60 per cent.	R. P. Rothwell	" " "	11	7	. .	. . . .	. . .	. . .
23	The waste of coal	James Tonge	Transactions Federated Inst'n of Mining Engineers,	4	184	. .	Jan.	20	1893
24	The utilization of coke bre ze	J. Pettre	Proceedings Institution of Civil Engineers	105	383	. .	Aug.	. . .	1891
25	Steam boilers with forced blast: The Perret system of burning dust and rejected fuels, with notes on boiler testing	Bryan Donkin, Jr.	Transactions Federated Inst'n of Mining Engineers,	4	154 & 348	. .	Jan.	20	1893
26	Notes on the energy and utilization of fuel, solid, liquid, and gaseous	W. J. Taylor	American Institute of Mining Engineers	18	859	. .	Feb.	. . .	1890
27	The iron breaker at Drifton, with a description of some of the machinery used for handling and preparing coal at the Cross Creek collieries	E. B. Coxe	" " "	19	398	. .	Sept.	. . .	1890
28	Coal bricks: A very exhaustive treatise in Bull. de la Societie Encouragement, &c., October, 1865	M. Gruner	Journal Franklin Institute	81	55	. .	July	. . .	1866
29	Compressed coal	Alexander Bassett	" " "	74	57	. .	July	. . .	1862
30	Use of pulverized fuel	Lieut. C. E. Dutton	" " "	91	377	. .	. . . .	. . .	1871
31	" " "	" "	" " "	92	17	. .	. . . .	. . .	1871
32	Utilization of coal dust	Editorial	" " "	93	4	. .	. . . .	. . .	1872
33	Utilization of coal waste	William H. Wahl	" " "	94	419	. .	. . . .	. . .	1872
34	Description of E. F. Loiseau's machinery for utilizing coal waste	. . . .	" " "	96	266	. .	. . . .	. . .	1873
35	Atmospheric oxidation or weathering of coal	Dr. J. P. Kimbal	American Institute of Mining Engineers	8	204	. .	. . . .	. . .	1879
36	On the relative heating and economic values of round and small coals	John Daglish	North of England Institute of Mining Engineers	4	283	. .	. . . .	. . .	1855-6
37	Coal washing	S. Stutz	American Institute of Mining Engineers	9	461	. .	. . . .	. . .	1880-1
38	The English *vs.* The Continental system of jigging: Is close sizing advantageous?	H. S. Munroe	" " "	17	637	. .	. . . .	. . .	1888-9
39	Remarks on the quantity, rate of consumption, and probable duration of North American coal	I. J. Wistar	Academy of Natural Sciences of Philadelphia	. . .	. . . .	. .	Jan.	26	1892

APPENDIX D-3.

References to Private Reports. (Utilization of Anthracite Waste.)

Serial No.	Subject.	Author.	Printer.	Place.	Year.	Volume or Page.
1	Artificial fuel and press for use in its manufacture	W. H. Cory	Engineers' Club, Phila. Press	Philadelphia, Pa.	1882	Extract from vol. 3, page 178.
2	The patent atomizer, pulverized coal for fuel, perfect combustion, no smoke	H. M. Morrison	. . .	Central Chambers, 109 Hope Street, Glasgow	. . .	
3	The utilization of culm in agriculture	J. A. Price	M. R. Walter	Scranton, Pa.	1885	
4	Notes on waste in mining and preparing coal	Heber S. Thompson	. . .	Girard estate, Philadelphia	1892	
5	The anthracite coal-fields of Pennsylvania and their exhaustion	P. W. Sheafer	Lane S. Hart	Harrisburg, Pa.	1881	Am. Asso. Adv. of Science, 1881.
6	Brief description of the anthracite coal-fields of Pennsylvania—waste in mining and preparation, utilization, &c., pages 25 and 26	C. A. Ashburner	Engineers' Club, Phila. Press	Philadelphia, Pa.	1884	Extract from vol. 4, page 177.

APPENDIX D–4.

References to Technical Journals. (Utilization of Anthracite Waste.)

Serial No.	Subject.	Author.	Name of Journal.	Volume.	Page.	No.	Month.	Day.	Year.
1	Coal and coke briquette manufacture	Patent Fuel Company	Practical Engineer,	6	808	. . .	October	28	1892
2	The McAuley process of burning pulverized fuel	J. G. McAuley	Iron Age	43	816	. . .	May	30	1889
				41	316	. . .	February	23	1888
3	The champion briquette (or eggette) fuel	Editorial	Black Diamond	38	270	. . .	"	2[illegible]	1892
4	Another mode of making briquettes	Editorial	Industrial World	8	11	11	March	17	1892
5	Ueber die Anwendung von pulverförmigen Brennmaterial	B. F. Isherwood	Berg.-Ztg.	. . .	429	. .	. . .	. . .	1876
6	Presskohlen aus Steinkohlen-staub	E. Jenkner	Oest.-Zeitschrift	40	198	. . .	April	16	1892
7	Notes on compressing brown coal into briquettes—proc ss and mach.	B. Straubel	Colliery Guardian	64	280	. . .	August	12	1892
8	Kohlenwäsche und Briquettes-f brik für die Türkische Regierung	Editorial	Uhland's Technik	6	260	. . .	May	19	1892
9	The manufacture of briquettes as carried on in France	G. G. Andre	Colliery Guardian	57	337	. . .	March	8	1889
10	" " "	Editorial	Industrial World	36	29	9	"	5	1891
11	Patent pitch process of briquetting	"	Colliery Manager	8	76	. . .	April	15	1892
12	Pettre's Feuerungs anlagen für koaksstaube	"	Uhland's Technik	5	127	. . .	January	29	1891
13	Coal-washing and briquette plant for th Ottoman government	Southgate Engineering Co.,	The Engineer	73	158	. . .	February	19	1892
14	Briquette-making machinery at the Paris Exhibition	M. N. Fouquemberg	Engineering	47	588	. . .	May	24	1889
15	Pulverized fuel and the cyclone pulverizer, McAuley's process	H. H. Suplee	Mechanics	10	32	. . .	February	. . .	1888
16	Perret's furnace for dust-fuel	Bryan Donkin	Engineering	40	401	. . .	October	23	1885
17	Machinery for the treatment of coal slack	Editorial	The Iron Age	32	21	9	August	30	1883
18	The Bietrix briquette-making machine	"	Railroad Gazette	18	488	. . .	July	16	1886
19	Fuel made of coal culm—J. E. Denton's test of heating power of eggettes	"	Coal Trade Journal,	30	237	. . .	May	20	1891
20	The Phelps fuel process	"	Scranton Truth	. . .	. . .	. . .	March	30	1891
21	Stevenson's apparatus for burning coal-dust	"	The Engineer	43	335	. . .	"	18	1877
22	Arrangement for supplying and burning powdered fuel in furnaces	R. W. O. Rehmenklau	Official Gazette	33	1,563	. . .	December	29	1885
23	Ueber den Heizwerth und die Fabrikation der Braunkohlen-briquettes	Editorial	Uhland's Technik,	6	66	. . .	November,	26	1891
24	Meldrum's system of forced draught, applicable to dust fuel	Meldrum Bros.	Practical Engineer,	6	454	. . .	June	17	1892
25	The utilization of anthracite coal-dirt (Col. Price on the Gas Theory)	Editorial	Colliery Engineer	9	34	. . .	September	. . .	1888
26	Powdered anthracite as a fuel (extract Scranton Board of Trade)	Col. J. A. Price	" "	9	42	. . .	"	. . .	1888
27	Cheap fuel for manufacturing establishments—coal-gas from culm	Editorial	" "	9	107	. . .	December	. . .	1888
28	Waste in mining—running culm into mines to support roof and enable to rob pillars	P. W. Sheafer	" "	9	135	. . .	January	. . .	1889
29	Some remarks on wasted coal	W. J. May	" Guardian,	65	253	. . .	February	10	1893
30	The amount of culm or coal waste	Col. J. A. Price	Coal Trade Journal,	23	683	. . .	September,	24	1884
31	The Universal briquette machine	Editorial	Iron	41	48	. . .	January	20	1893

32	The use of cross-sections in the development and working of collieries—avoiding waste in mining	Editorial	Colliery Engineer	11	37	. . . .	September,	. . .	1890
33	Modified Longwall, as affecting economy	W. S. Gresley	“ “	10	32, 57, and 82	. . . .	“	. . .	1889
34	Anthracite mining and the Longwall system	“	“ “	10	137	. . . .	January	. . .	1890
35	The principles and practice of Longwall mining	“	“ “	11	1, 30, 49, 73, and 98	. . . .	August	. . .	1890
36	Briquettes—blast-furnace and other uses	Editorial	“ Guardian	61	612	. . . .	April	10	1891
	“ and briquette-making	Yeadon & Co.	“ “	61	699	. . . .	“	24	1891
37	Pulverized fuel—the greatest economy	Editorial	“ “	56	12	. . . .	July	6	1888
38	Briquettes	“	“ “	55	312	. . . .	March	2	1888
39	Compressed fuel—Mowll & Messenger's patent briquette machine	“	“ Manager	4	183	. . . .	October	. . .	1888
40	Coal briquette—patent binding material	“	Oest. Zeitschrift	40	576	. . . .	November,	19	1892
41	Coal cleaning and jigging—waste and its remedies	Walter J. May	Colliery Guardian	64	931	. . . .	“	18	1892
42	The culm pile washery at Honeybrook	Editorial	Black Diamond	9	497	. . . .	October	15	1892
43	Saving the coal—using slack at the boilers and to support roof in mines	“	“ “	9	236	. . . .	August	13	1892
44	To manufacture fuel in Chicago—Fuel Patents Company's process	“	Coal Trade Journal,	31	40	. . . .	January	20	1892
45	Working the culm dumps at Winton and Plymouth	“	“	31	47 and 366	. . . .	“	27	1892
							July	20	1892
46	The utilization of waste anthracite—Colonel Price's theory	“	“ “	31	628	. . . .	December	28	1892
47	The new washery at the Gilberton culm-dump—percentage of coal in bank	“	“ “	30	570	. . . .	November,	18	1891
48	Machinery for the manufacture of artificial fuel	William B. Westlake	Official Gazette	62	54	. . . .	January	3	1893
49	Machinery for forming fuel bricks	Johann P. Schmidt	“ “	59	814	. . . .	May	10	1892
50	Tabular estimate, showing the approximate quantity, past and future—production of coal in the Northern coal-field of Penna.	William Griffith	Colliery Engineer	12	222	. . . .	“	. . .	1892
51	The preparation of coal for coking	Communicated	“ Guardian	53	563, 604, 640	. . . .	. . . .	. . .	1887
	“ “	“	“ “	53	700, 772, 920	. . . .	. . . .	. . .	1887
	“ “	“	“ “	54	60, 120, 601, 818	. . . .	. . . .	. . .	1887
	“ “	“	“ “	55	311	. . . .	. . . .	. . .	1888
52	A new coal brick	Editorial	Iron	41	158	. . . .	February	24	1893
53	Quantity of refuse in anthracite coal-beds	William Griffith	Engineering and Mining Journal	53	494	. . . .	May	7	1892
54	Discussion on forced draught with Meldrum & Perret's furnace	Donkin, Boby, Colquhoun	Colliery Manager	9	34	. . . .	February	. . .	1893
55	Artificial fuel—Huntingdon plant of the Fuel Patents Company	Editorial	Black Diamond	10	29 and 30	. . . .	January	21	1893
56	Coal-dust fuel	. . . . . .	Sc. American Supplement	4	1295	. . . .	. . . .	. . .	. . .
57	Dampfkessel mit Feuerung für staubformiges Brennmaterial	Stevenson	Dingt. Journal	225	131	. . . .	. . . .	. . .	. . .
58	Powdered coal and smoke	Editorial	The Engineer	75	168	. . . .	February	24	1893
59	The smokeless combustion of coal (by pulverizing)	Editorial	Coal Trade Journal	. . . .	91	. . . .	“	8	1893

APPENDIX D–5.

References to Text-books, Treatises, &c. (Utilization of Anthracite Waste.)

Serial No.	Subject.	Author.	References to Books—Title.	Publishers.	Date.
1	Coal-dust, coke-dust, breeze, and similar refuse fuels—Test of Perret's furnace	W. S. Hutton	Practical Engineer's Handbook, page 78	Crosby, Lockwood & Co.	London, 1887.
2	Powdered fuel furnaces, Crampton, Whelpley & Storer, and Stevenson,	D. K. Clark	The Steam Engine, volume 1, page 352	Blackie & Son	1891.
3	Coal-dust fuel, United States Government experiments by Stevenson,	William M. Bar	The Combustion of Coal, page 233	Yohn Brothers	Indianapolis, Ind., 1879.
4	Furnace with a thick layer of ash, on which inferior fuel may be utilized	J. Percy	Percy, Metallurgy—Fuels, page 281	John Murray	London, 1875.
5	A method of coking by which the slack from a non-coking coal could be utilized	"	Percy, Metallurgy—Fuels, page 309	" "	" 1875.
6	The coal question, by Green, Miall, Thorpe, Rucker, and Marshall	Thorpe	Coal—Its History and Uses, page 292	MacMillan & Co.	" 1878.
	TREATISES ON FUEL ARE:—				
7	"Fuel and Water," Schwackhofer & Brown	Schwackhofer		Charles Griffin & Co.	London, 1884.
8	"Fuel—Its Combustion and Economy"	D. K. Clark		D. Van Nostrand Company	New York, 1879.
9	"Conversion of Heat into Work"	Anderson		Whittaker & Co., London	1889.
10	"The Combustion of Coal and Prevention of Smoke"	C. W. Williams		John Weale, London	1854.
11	"Metallurgy, Refractory Materials, and Fuels"	John Percy		John Murray	London, 1875.
12	"Fuels, Evaporation, and Combustion"	G. L. Fowler		American Railway Publishing Company, 113 Liberty St., N.Y.	1887.
13	"Chemical Technology," volume 1, Fuel	Groves & Thorp Mills & Rowan		P. Blakiston, Son & Co., 1012 Walnut Streeet, Philadelphia,	Philadelphia, 1889.
14	"Coal Economy"	F. C. Danvers	Utilization of Slack Coal, page 67	W. H. Allen & Co.	London, 1872.
15	"Coal Economy"	T. S. Prideaux	Utilization of Inferior Fuel, page 15	John Weale	" 1853.
16	"Experimental Researches in Steam Engineering"	B. F. Isherwood		Wm. Hamilton, Hall of Franklin Institute	Philadelphia, 1863 & 1865
17	"Notes on Anthracite Iron and Evaporative Power of Anthracite"	W. R. Johnson		Little & Brown	Boston, 1841.
18	"Researches on American and Foreign Coals"	"		A. Hart	Philadelphia, 1850.

APPENDIX D–6.

Patentees and Manufacturers' Circulars.

Serial No.	Name of Patentee or Firm.	Place and Address.	Subject Treated and Article Manufactured.
1	Fuel Patents Company	220 S. Third St., Philadelphia, Pa.	Eggettes from anthracite and bituminous waste
2	H. M. Morrison	Central Chambers, 109 Hope St., Glasgow	Patent fuel atomizer
3	George A. Purbeck	71 Tribune Building, New York	Manufacturer of briquettes
4	The Acme Gas Fuel Company		Coal-gas from anthracite waste
5	Fuel Patents Company of Philadelphia	Gayton, Va.	Eggette plant, report by J. E. Denton

APPENDIX E-1.

References to Inclined Grates—Reciprocating.

Patenteee or Author.	Name of Manufacturer or Address of Author.	Periodical or Book.			
		Title.	Vol.	No.	Page.
Gow, A. M.	Pittsburgh, Pa	Official Gazette	54	. . .	1,733
Murphy, T.	Detroit, Mich.	"	31	. . .	432
Brightman, J. W.	Cleveland, Ohio	"	31	. . .	981
" "	" "	"	31	. . .	1,023
Palmer, G. E., Chicago, Ill.	Babcock & Wilcox Company, New York.	"	21	. . .	24
Cotiart, J. P.	Havanna, Cuba	"	27	. . .	474
Backus, A., Jr.	Detroit, Mich.	"	28	. . .	61
Oehlstrom, W.	Cleveland, Ohio	"	62	. . .	198
Pierce, H. M.	Grand Rapids, Mich.	"	19	. . .	1,614
Wilkinson Manufacturing Co.	Philadelphia, Pa.	Iron Age	51	. . .	14
Moskovits, M. H.	Kansas City, Mo.	Official Gazette	46	. . .	1,413
Wilkinson, A.	Philadelphia, Pa.	"	60	. . .	835
Cohen, L. P., and Herrmann, E.	Paris, France	"	56	. . .	1,113
" " " "	" "	"	44	. . .	86
" " " "	" "	R. R. and Engineering Journal,	66	. . .	454
" " " "	" "	Bull. de l'Ecole des Mines, Paris	Apr 1892	. .	79
" " " "	" "	Maschinen Constructeur	25	. . .	163
" " " "	" "	Uhland's Technik	6	. . .	506
Sooy, E. C.	Kansas City, Mo.	Official Gazette	60	. .	1,212
Schomberg, M., and Söhne	Berlin-Moabit, Germany	Uhland's Technik	6	. . .	284
Hall, S.	. . . . . .	D. K. Clark's Steam Engine	1	. . .	333
Knap, C.	. . . . . .	" "	1	. . .	336
Moskovits, M. H.	Kansas City, Mo.	Official Gazette	53	. . .	1,087

APPENDIX E-2.

References to Inclined Grates—Rocking.

Patentee or Author.	Address of Manufacturer.	Periodical or Book.			
		Name.	Vol.	No.	Page.
Roney, Wm. R.	Westinghouse, Church, Kerr & Co., Pittsburgh, Pa.	Official Gazette	48	. . .	1,019
" "	Westinghouse, Church, Kerr & Co., Pittsburgh, Pa.	"	48	. . .	1,020
" "	Westinghouse, Church, Kerr & Co., Pittsburgh, Pa.	"	59	. . .	662
Roney, Wm. R., and Arnold, J. T.	. . . . .	"	59	. . .	779
Roney, Wm. R.	Westinghouse, Church, Kerr & Co., Pittsburgh, Pa.	Engineers' Club of Phila.	9	. . .	147
Kasolovsky, J.	. . . . .	Oest.-Zeitschrift	28	. . .	562
Wood, Geo. W.	Philadelphia, Pa.	Official Gazette	56	. . .	950
Bannister, L.	" "	"	23	. . .	877
Backus, A., Jr.	Detroit, Mich.	"	40	. . .	985
Hall, J. J.	Hall's Automatic Feed Boiler Furnace Company, Chicago, Ill.	"	26	. . .	976

APPENDIX E–3.

References to Inclined Grates—Stationary (mostly what are termed Halbgasfeuerungen in German).

Patentee or Author.	Name of Manufacturer or Address of Author.	Periodical or Book.			
		Title.	Vol.	No.	Page.
Campbell, H. H.	Cleveland, Ohio	Official Gazette	47	...	920
Wilcke, H.	Berlin, Germany	"	36	...	58
Wilson, O.	Cleveland, Ohio	"	28	...	218
Ramsay, J.	England	N. E. Inst. of Mining Engrs.	19	...	63
De Strens, E.	Rome, Italy	Official Gazette	57	...	638
Schomberg, M., and Söhne	Berlin-Moabit, Germany	Uhland's Technik	6	...	284
Reich, C.	Hanover, Germany	Dingler's Journal	287	...	84
" "	" "	Chemiker Zeitung	16	...	925
Schulze, H.	Bernburg, "	"	16	...	1,075
De Strens, E.	Rome, Italy	Dingler's Journal	287	...	84
Gartman, C. H. L.	Altona, D. R. P.	"	287	...	84
Mannesmann, R.	D. R. P.	"	287	...	84
Schomberg, M., and Söhne	Berlin-Moabit, Germany	Official Gazette	60	...	316
" " "	" "	Maschinen Constructeur	25	...	13
" " "	" "	Uhland's Technik	6	...	487
" " "	" "	Dingler's Journal	287	...	106
Kudlicz, J.	Prag-Bubna	Maschinen Constructeur	25	...	180
Reich, C.	Hanover, Germany	Uhland's Technik	6	...	487
Bartels, C.	Oschersleben	Dingler's Journal	287	...	107

APPENDIX E-4.

References to Horizontal Grates—Reciprocating.

Patentee or Author.	Name of Manufacturer or Address of Author.	Periodical or Book.			
		Title.	Vol.	No.	Page.
Reilly, O.	New York, N. Y.	Official Gazette	45	. . .	198
Henderson, T.	Liverpool, England	"	60	. . .	1,559
Mark, C. E.	Cleveland, Ohio	"	60	. . .	1,523
Williams, H. S.	Boston, Mass.	"	56	. . .	367
Cooper, J.	" "	"	44	. . .	1,225
Bryant, Z. F.	Malden, Mass.	"	44	. . .	1,385
Wilson & Smith		Rowan's Chemical Technology	1	. . .	523
McDougall		" "	1	. . .	533
"		D. K. Clark's Steam Engine	1	. . .	539
Aulds		Rowan's Chemical Technology	1	. . .	533
Proctor, J.		D. K. Clark's Steam Engine	1	. . .	342
" "		Rowan's Chemical Technology	1	. . .	533
Bennis		D. K. Clark's Steam Engine	1	. . .	343
Hall & Whittaker		N. E. Institute Mining Engrs.	18	. . .	52
Jordan	Liverpool, England	" "	18	. . .	114
Goodman		" "	18	. . .	49
Culver, L. L.	St. Louis, Mo.	Official Gazette	55	. . .	117
Gulickson, G.	Chicago, Ill.	"	43	. . .	133
Tallmadge, H. P.	Boston, Mass.	"	42	. . .	133
" "	" "	"	42	. . .	1,226
Weaver, F. W., and Norton, D.	Troy, N. Y.	"	21	. . .	884
St. Clair Engineering Company	Broughton Bridge, Manchester	Iron	39	. . .	421
Bell, A. J.	Manchester, England	Engineering	53	. . .	513
New Conveyor Company	London, England	Uhland's Technik	6	. . .	214
Little, G.	" "	Engineering	54	.	247
Jernberg, L. W.	Cleveland, Ohio	Eng. and Mining Journal	54	. . .	173
Bryant, Z. F.	Brookline, Mass.	Official Gazette	55	. . .	211
Müller, F.	New York	"	33	. . .	610
Evans, J.	Philadelphia, Pa.	"	55	. . .	1,541
Weaver, F. W., Norton, D.	Troy, N. Y.	"	22	. . .	1,643
Richards, P.	Wilkes-Barre, Pa.	"	22	. . .	2,056
Warren, B. F.	Boston, Mass.	"	38	. . .	325
Mershon, G. B.	Philadelphia, Pa.	"	24	. . .	243

Henderson, T.	Liverpool, England	Official Gazette	47	. . .	1,051
Buzzini, S. J.	New York, N. Y.	"	47	. . .	1,291
Galley, J. G.	Forest Gate, Co. of Essex, England	"	23	. . .	199
Turner, R.	Wilkes-Barre, Pa.	"	29	. . .	1,114
Boutcher, E.	London, England	"	40	. . .	186
Dolliver, P. C.	Augusta, Me.	"	40	. . .	456
Weaver, H. M.	Mansfield, Ohio	"	36	. . .	719
Gulickson, G.	Chicago, Ill.	"	31	. . .	927
Felton, A. C.	Warwick, Mass.	"	21	. . .	350
Montgomery, J. F.	Taunton, Mass.	"	21	. . .	510
Vicars, J. and T.	Liverpool, Co. of Lancaster, England	"	27	. . .	97
" "	" " "	D. K. Clark's Steam Engine	1	. . .	333
" "	" " "	Rowan's Chemical Technology	1	. .	531,523
" "	" " "	N. E. Institute Mining Engrs.	18	. .	{ 53,109 114,118
" "	" " "	Maschinen Constructeur	25	. . .	163
Newton, R.	Providence, R. I.	Official Gazette	18	. . .	779
Knox, J. L. L.	Allegheny City, Pa.	"	17	. . .	1,470
Burke, S. E.	Edon, Ohio	"	32	. . .	491
Stone, E. H.	West Bay City, Mich.	"	32	. . .	673
Card, E.	Pawtucket, R. I.	"	30	. . .	1,100
Goodenow, A. L.	Utica, N. Y.	"	37	. . .	392
Christie, J.	Long Island City, N. Y.	"	37	. . .	601
Merritt, H. W.	Somerville, Mass.	"	37	. . .	1,065
Vœgtle, J.	Indianapolis, Ind.	"	37	. . .	1,244
Williams, H. S.	Boston, Mass.	"	39	. . .	176
Reilly, O.	New York, N. Y.	"	52	. . .	1,162
Mitchell, W. L.	" "	"	53	. . .	709
Tallmadge, H. P.	Boston, Mass.	"	47	. .	786
Mather, E.	Harrisburg, Pa.	"	52	. . .	915
Mason, J. L.	Brooklyn, N. Y.	"	60	. . .	978
Tallmadge, H. P.	Boston, Mass.	"	48	. . .	425
Moskovits, M. H.	Kansas City, Mo.	"	48	. . .	573
St. Clair Engineering Co.	Salford, Manchester	Practical Engineer	6	. . .	234
Henderson, T.	Liverpool, England	Official Gazette	60	. . .	1,559
" "	" "	Rowan's Chemical Technology	1	. . .	526
" "	" "	D. K. Clark's Steam Engine	1	. . .	341
St. Clair Engineering Company	Salford, Manchester	" "	1	. . .	337
Sterling, S.	40 Vesey Street, New York	Power and Steam	8	1	4
Weaver, H. M.	Mansfield, Ohio	Official Gazette	41	. . .	107
Bissell, F. S.	Pittsburgh, Pa.	"	19	. . .	575

APPENDIX E-5.

References to Horizontal Grates—Rocking.

Patentee or Author.	Name of Manufacturer or Address of Author.	Periodical or Book.			
		Title.	Vol.	No.	Page.
Bannister, L.	Philadelphia, Pa.	Official Gazette	26	. . .	208
Jones, J. C.	Chicago, Ill.	"	26	. . .	296
Price, J. A.	Scranton, Pa.	"	26	. . .	561
Peslin, F. C.	Van Dyne, Wis.	"	39	. . .	539
Oehrle, E., and Perkins, J. R.	Omaha, Neb.	"	39	. . .	1,032
Rockett, T. T.	Philadelphia, Pa.	"	48	. . .	775
Joy, T. C.	Titusville, Pa.	"	23	. . .	2,269
Ward, W. J.	Pittsburgh, Pa.	"	20	. . .	667
Jennings, W. C.	New Brunswick, N. J.	"	20	. . .	1,323
Rockett, T. T.	Philadelphia, Pa.	"	52	. . .	1,622
Walker, G. W.	Malden, Mass.	"	20	. . .	689
Fish, J. R.	Grand Rapids, Mich.	"	20	. . .	1,058
Walker, G. W.	Malden, Mass.	"	20	. . .	1,150
Ogden, W. J.	Baltimore, Md.	"	50	. . .	1,014
Livermore, F. D.	Rochester, N. Y.	"	50	. . .	1,316
Ashcroft, J.	New York, N. Y.	"	50	. . .	1,469
Thomas, J. P.	Detroit, Mich.	"	50	. . .	1,693
Bowers, W.	Carbondale, Pa.	"	22	. . .	{ 370 725
Taylor, F. E., and Palmer, H. R.	Allegheny, Pa.	"	22	. . .	928
Shriver, F.	Grand Rapids, Mich.	"	22	. . .	1,109
Rockett, T. T.	Philadelphia, Pa.	"	53	. . .	1,052
Settle, J.	Bolton, Co. of Lancaster, England	"	41	. . .	431
Kirkwood, T.	New York, N. Y.	"	45	. . .	929
Hayna, J. M. C.	St. Louis, Mo.	"	45	. . .	1,176
Air Valve Furnace Bar Company,	Neville Road, Upton Park, Forest Gate E.	The Engineer	74	. . .	459
Dorrance, C. J.	Chicago, Ill.	Official Gazette	47	. . .	871
Hill, C. D. W.	Willimantic, Conn	"	23	. . .	1,659
Price, J. A.	Scranton, Pa.	"	23	. . .	1,704
Kirkwood, T.	Chicago, Ill.	"	23	. . .	1,847

Kitson, G. L., and Reagan, J.	Philadelphia, Pa.	Official Gazette	44	. . .	1,030
Knox, J. H.	Allegheny, Pa.	"	49	. . .	1,564
Cone, J.	Philadelphia, Pa.	"	43	. . .	4
Morton, A. C.	Chicago, Ill.	"	43	. . .	772
Woodcock, L. M.	Auburn, N. Y.	"	43	. . .	1,291
Whelan, R.	Chicago, Ill.	"	42	. . .	49
Heeson, W. H.	Baltimore, Md.	"	42	. . .	702
Whelan, R. and R. A.	Chicago, Ill.	"	59	. . .	987
Johnstone, F. W.	Mexico, Mex.	"	60	. . .	1,083
Forney, M. N.	New York, N. Y.	"	59	. . .	10
Strong, G. S.	" "	"	59	. . .	1,135
Hull, A. J.	Newark, N. Y.	"	59	. . .	1,305
Bannister, L.	American Grate Bar Co., Phila., Pa.	"	22	. . .	350
Kitson, G. L., Reagan, J.	Philadelphia, Pa.	"	45	. . .	253
Martin, C.	Paris, France	"	32	. . .	1,301
Boileau, E.	St. Louis, Mo.	"	49	. . .	2,096
Graves, R. C.	Barnesville, Ohio	"	20	. . .	1,659
Kirkwood, T.	Chicago, Ill.	"	40	. . .	1,026
Burke, J. V.	230 La Salle Street, Chicago, Ill.	Industrial World	38	7	1
" "	" " " "	Official Gazette	62	. . .	271
Kelly, W. E.	New Brunswick, N. J.	"	55	. . .	200
Dorrance, C. J.	Chicago, Ill.	"	55	. . .	629
White, C. P.	Taunton, Mass.	"	35	. . .	903
Swallow, I. W.	Kingston, Pa.	"	35	. . .	997
Murphy, J.	Brooklyn, N. Y.	"	35	. . .	1,479
Burnham, L. T.	Hyde Park, Ill.	"	35	. .	1,547
Browne, W. H.	Brooklyn, N. Y.	"	33	. . .	932
Knox, J. L. I.	Allegheny, Pa.	"	33	. . .	941
Kelley, W. E.	New Brunswick, N. J.	"	33	. . .	960
Fish, J. R.	Grand Rapids, Mich.	"	22	. .	1,494
Bard, J. C.	Albany, N. Y.	"	22	. . .	1,578
Woodcock, L. M.	Auburn, N. Y.	"	38	. . .	1,097
Van Stone, E. D.	Utica, N. Y.	"	54	. . .	1,886
Heeson, W. H.	Dudley, Pa.	"	24	. . .	431
Price, J. A.	Scranton, Pa.	"	24	. . .	519
Rexford, P.	Syracuse, N. Y.	"	24	. . .	648
Rogers, H.	New York, N. Y.	"	24	. . .	720
Boileau, E.	St. Louis, Mo.	"	47	. . .	1,018
Lahman, W. H.	Chicago, Ill.	"	47	. . .	470
Bannister, L.	Philadelphia, Pa.	"	23	. . .	660
" "	" "	"	23	. . .	763

APPENDIX E-5.—Continued.

Patentee or Author.	Name of Manufacturer or Address of Author.	Periodical or Book.			
		Title.	Vol.	No.	Page.
La Rue, S. H.	Reading, Pa.	Official Gazette	29	. . .	192
Eckerson, C. W.	Creston, Iowa	"	40	. . .	457
Dunning, W. B.	Geneva, N. Y.	"	40	. . .	1,369
Williams, E. W.	San Francisco, Cal.	"	40	. . .	1,384
Kelly, W. E.	New Brunswick, N. J.	"	45	. . .	1,477
" "	" "	"	40	. . .	385
Mahoney. M.	Troy, N. Y.	"	36	. . .	358
Bannister, O. C.	Council Bluffs, Iowa	"	36	. . .	462
Walrath, J.	J. I. Case Thrashing Machine Co., Racine, Wis.	"	36	. . .	661
Weaver, H. M.	Mansfield, Ohio	"	36	. . .	719
Barrow, T. E.	" "	"	31	. . .	125
Chisholm, W. B., and Walker, J.,	Cleveland, Ohio	"	31	. . .	496
Bannister, L.	Philadelphia, Pa.	"	27	. . .	362
Kirkwood, T.	Chicago, Ill.	"	27	. . .	835
" "	" "	"	27	. . .	835
Goodenow, A. L., & Owens, W. J.,	Utica, N. Y.	"	18	. . .	481
Kohlhofer, A.	Munich, Bavaria	"	17	. . .	489
Haycox, E.	Detroit, Mich.	"	17	. . .	587
Fahrig, F. E.	Scranton, Pa.	"	25	. . .	893
Culver, F. E.	Chicago, Ill.	"	32	. . .	144
Culver, L. L.	St. Louis, Mo.	"	32	. . .	1,338
Fisher, S. D.	Chicago, Ill.	"	30	. . .	484
Williamson, H. C.	Michigan City, Ind.	"	30	. . .	1,014
Alston, S. W.	Philadelphia, Pa.	"	37	. . .	310
Reed, J. R.	Westfield. Mass.	"	37	. . .	1,169
Schoen, C. T.	Philadelphia, Pa.	"	37	. . .	1,174
Passmore, L.	American Grate Bar Co., Camden, N. J.,	"	28	. . .	47
Mershon, G. B.	Philadelphia, Pa.	"	28	. . .	491
Burke, J. V.	230 La Salle Street, Chicago, Ill.	Industrial World	39	16	9

APPENDIX E-6.

References to Horizontal Grates—Stationary.

Patentee or Author.	Name of Manufacturer or Address of Author.	Periodical or Book.			
		Title.	Vol.	No.	Page.
Boby, Wm.		Fed. Inst. Mining Engineers	3	. . .	251
McClave, Wm.	Scranton, Pa.	Official Gazette	45	. . .	1,102
Sears, T. H.	Holyoke, Mass.	"	45	. . .	1,308
Herbert, M. E.	St. Joseph, Mo.	"	55	. . .	1,498
Adams, H.	New York, N. Y.	"	22	. . .	1,578
Hoffmann, C.	" "	"	38	. . .	360
Van Duzen, E. W.	Newport, Ky.	"	38	. . .	1,398
Miller, H.	Providence, R. I.	"	21	. . .	355
Hill, H. T.	Manchester, N. H.	"	21	. . .	1,705
Forrest, W. W.	Philadelphia, Pa.	"	42	. . .	41
Perret, M.	Paris, France	Institution Civil Engineers	92	. . .	336
Holliday, J.	England				
Donkin, B.	Bermondsey, England.	Fed. Inst. Mining Engineers	4	. . .	154
Getchell, C. E.	Palmer, Mass.	Official Gazette	50	. . .	1,505
Fletcher, A. C.	New York, N. Y.	"	52	. . .	422
Kelly, W. E.	New Brunswick, N. J.	"	41	. . .	172
" "	" "	"	41	. . .	305
" "	" "	"	41	. . .	1,110
" "	" "	"	45	. . .	1,477
Hayna, J. M. C.	St. Louis, Mo.	"	45	. . .	1,176
Montgomery, J.	Jersey City, N. J.	"	59	. . .	2,044
Dickinson, I. N.	Pennsylvania Iron Works, Reading, Pa.	"	42	. . .	762
Lucas, T. H.	Valley City, Dakota	"	23	. . .	1,900
Allen, J. A.	Adams, Mass.	"	47	. . .	531
Butman, T. R.	Chicago, Ill.	"	60	. . .	552
Parketon, G. W.	Laurens, Laurens County, S. C.	"	43	. . .	240
Tolhurst, A.	Gravesend, England	"	43	. . .	277
Moskovits, M. H.	Kansas City, Mo.	"	43	. . .	576
Tilloy, C. A.	Lille, France	"	62	. . .	689
Meldrum Bros.	Manchester, England	Practical Engineer	6	. . .	454
Sahler, C.	Cologne, Prussia, Germany	Official Gazette	44	. . .	1,502
Umholtz, P.	Tremont, Pa.	"	4	. . .	492
Wren, W. C., and Meyrick, W.	Jeddo, Pa.	"	5	. . .	383

APPENDIX E-7.

References to Mechanical Feeding Arrangements—Fuel and Air.

Patentee or Author.	Name of Manufacturer or Address of Author.	Periodical or Book. Title.	Vol.	No.	Page.
Gordon, E. J.	Gordon Hollow Blast Grate Company, Greenville, Mich.	Official Gazette	57	. . .	1,586
Bielenberg, J.	Chemnitz, Germany	"	52	. . .	1,649
Hibbard, G. E.	Evanston, Ill.	"	24	. . .	509
Whittaker, Wm.	Burnley, County of Lancaster, England	"	43	. . .	1,310
Affeltranger, R.	Zurich, Switzerland	"	43	. . .	1,416
Fraser, W., and Chapman, J. G.	Birkenhead	Dingler's Journal	287	. . .	107
Oelstrom, W.	Cleveland, Ohio	Official Gazette	62	. . .	198
Alves, J.	Dunedin, New Zealand	"	19	. . .	561
Wilkinson Manufacturing Co.	515 Commerce Street, Philadelphia	Iron Age	51	. . .	74
Cohen, L. P., and Herrmann, E.	Paris, France	Official Gazette	56	. . .	1,113
" " " "	" "	"	44	. . .	86
Schulze, H.	Bernburg, Germany	Chemiker Zeitung	16	. . .	1,075
Mannesmann, R.	D. R. P.	Dingler's Journal	287	. . .	84
Sennett	. . . . . .	"	287	. . .	105
Kudlicz, J.	Prag-Bubna	Maschinen Constructeur	25	. . .	180
Bartels, C.	Oschersleben	Dingler's Journal	287	. . .	107
Richards, R. S.	London, England	Official Gazette	52	. . .	772
Payen, M.	Grenelle	Rowan's Chemical Technology	1	. . .	515
Prideaux	. . . . . .	" "	1	. . .	520
Smith, D.	. . . . . .	" "	1	. . .	523
Proctor, J.	. . . . . .	" "	1	. . .	533
Player, M.	. . . . . .	" "	1	. . .	534
Henderson, T.	Liverpool, England	D. K. Clark's Steam Engine	1	. . .	341
Proctor, J.	. . . . . .	" "	1	. . .	342
Bennis	. . . . . .	" "	1	. . .	343
Newton, J., & Sons	. . . . . .	" "	1	. . .	344
Hall & Whittaker	. . . . . .	N. E. Institute Mining Engrs.	18	. . .	52
Whelan, R.	Chicago, Ill.	Official Gazette	42	. . .	49

Tinkham, G. F.	Cedar Rapids, Iowa	Official Gazette	41	. . .	317
Butman, T. R.	Chicago, Ill.	"	60	. . .	552
Western Smoke Preventer Co.	167 Dearborn Street, Chicago, Ill.	Industrial World	38	4	1
Colton, G. H.	Hiram, Ohio	Power	12	8	8
Complete Combustion Co.	Boston, Mass.	Engineering News	27	. . .	98
Zell, R.	Baltimore, Md.	Official Gazette	60	. . .	786
Howden, J.	Glasgow, Scotland	Uhland's Skizzenbuch	13	. . .	154
Uhland, W. H.	Leipzig, Germany	Maschinen Constructeur	10	. . .	127
McClave, Wm.	Scranton, Pa.	Official Gazette	61	. . .	794
Gordon, E. J.	Greenville, Mich.	"	62	. . .	923
New Conveyor Company	London, England	Uhland's Technik	6	. . .	214
Donneley, J. G. A.	Hamburg, Germany	Ztscht.-Ver. Deutsch. Ing.	37	. . .	86
The Gaseous and Liquid Fuel Supply Company	Manchester, England	Practical Engineer	6	. . .	509
Joicey, W. B.	Gateshead-on-Tyne, Durham, England	Engineering	55	. . .	429
Lishman	. . . .	Uhland's Technik	6	. . .	135
Grimshaw, W. D.	Accrington, Lancaster, England	Engineering	54	. . .	24
Sennett	. . . .	The Engineer	74	. .	179
Gillespie, W. C. D.	Chicago, Ill.	Iron Age	51	. . .	615
Carrio-Feuerung	. . . .	Preussische Zeitschrift	40	. . .	450
Leach, Wm.	Accrington, Co. of Lancaster, England	Official Gazette	48	. .	1,454
Davis, J. H.	Boston, Mass.	"	49	. . .	140
Ward, J. B.	Minneapolis, Minn.	"	54	. . .	765
Wood, Geo. W.	Philadelphia, Pa.	"	54	. . .	1,000
Newton, R.	Providence, R. I.	"	54	. . .	1,203
Meldrum, J. J. & T. F.	Manchester, England	"	54	. . .	1,317
Wood, Geo. W.	Philadelphia, Pa.	"	56	. . .	949
Blanchard, V. W.	Joseph A. Davis, New York	"	49	. . .	641
" "	" " "	"	49	. . .	647
" "	" " "	"	49	. . .	649
" "	" " "	"	49	. . .	650
" "	" " "	"	49	. . .	651
Colton, Geo. H.	Hiram, Ohio	"	59	. . .	1,071
Williamson, R. H.	Ashton, England	"	59	. . .	1,640
Sargent, Z.	Rochester, N. Y.	"	45	. . .	261
Cochran, L. Y., & Lindsay, W. J.	Allegheny, Pa., and Cleveland, Ohio	"	45	. . .	318
" " " "	" " " "	"	44	. . .	230
Allington, W. E.	East Saginaw, Mich.	"	45	. . .	497

APPENDIX E-7.—Continued.

Patentee or Author.	Name of Manufacturer or Address of Author.	Periodical or Book.			
		Title.	Vol.	No.	Page.
Warne, A.	Buffalo, N. Y.	Official Gazette	44	...	971
Dennis, G. P.	Chester, Pa.	"	50	...	1,074
Bell, Sir I. L.	England	N. E. Inst. of Mng. Mech. Engrs.	18	...	115
Fales, E.	St. Louis, Mo.	Official Gazette	35	...	810
Hanna, E. A.	Chicago, Ill.	"	33	...	584
Rehmenklau, R. W. O.	Minneapolis, Minn.	"	33	...	1,563
Russmann, C.	Hamburg, Germany	"	22	...	2,215
Hodgkinson, J.	Salford, County of Manchester, England,	"	38	...	1,275
Hawley, M. C.	St. Louis, Mo.	"	54	...	1,074
Tinkham, G. F.	Tinkham Smoke Consumer Company, Cedar Rapids, Iowa	"	44	...	1,502
Hawley, M. C.	St. Louis, Mo.	Engineers' Club of Phila.	9	...	147
Sloper, B.	New York, N. Y.	Official Gazette	29	...	771
Cochran, L. Y., & Lindsay, W. J.	Allegheny, Pa., and Cleveland, Ohio	"	40	...	881
Benton, R. O.	Chicago, Ill.	"	40	...	1,407
Barnes, W. A.	New York, N. Y.	"	36	...	58
Thomas, W.	Pittston, Pa.	"	31	...	53
Simmons, A. J.	Indianapolis, Ind.	"	21	...	13
Van Duzen, E. W.	Newport, Ky.	"	21	...	1,861
McMillan, J., & Robertson, W. A.	Glasgow, County of Lanark, Scotland	"	25	...	874
St. Clair, W. M.	Philadelphia, Pa.	"	32	...	1,278
Fahrig, F. E.	Scranton, Pa.	"	30	...	1,303
Rösiche, H.	Berlin, Germany	"	37	...	125
Otto, C.	Greifenhagen, Prussia, Germany	"	37	...	651
McMillan, C.	Chicago, Ill.	"	26	...	1,033
Sennett	...	Dingler's Journal	287	...	105
Langfield & Sharpless	Manchester	"	287	...	107
Hargreaves, J.	Farnworth, Lancaster	Engineering	54	...	770
Perret, M.	Paris, France	Institution Civil Engineers	92	...	336
Holliday, J.	England				
Donkin, B.	Bermondsey, England	Fed. Inst. Mining Engineers	4	...	154

APPENDIX E-8.

References to Traveling Chain Grates.

Patentee or Author.	Name of Manufacturer or Address of Author.	Periodical or Book.			
		Title.	Vol.	No.	Page.
Crowe, P. L.	Kansas City, Mo.	Official Gazette	55	...	1660
Craney, T.	Bay City, Mich.	"	35	...	1517
Swindell, W.	Allegheny City, Pa.	"	22	...	1388
Pratt, N. W.	Brooklyn, N. Y.	Engineers' Club of Phila.	9	...	147
Bodmer, J. G.	England	Clark's Steam Engine	1	...	332
" "	"	Institution Civil Engineers	5	...	362
" "	"	Thorpe's Chemical Technology	1	...	517
Townsends, J.	"	Grove's & Thorpe's Chem. "	1	...	520
Juckes, J.	"	" " " "	1	...	523
" "	"	N. E. Inst. Mining Engineers,	18	..	41, 43, 52, 53, 109, 112, 118, 121
" "	"	D. K. Clark's Steam Engine	1	...	332
Shoemaker, R. J.	Philadelphia, Pa.	Official Gazette	57	...	1543
Coulson, Wm.	Spring Valley, Ill.	"	59	..	1071
" "	" "	Power	12	8	9
Loughran, S. J.	Des Moines, Iowa	Official Gazette	59	...	1126
" "	" "	Power	12	8	10
Wilkinson, T., & Glendenning, J.	Kansas City, Mo.	Official Gazette	46	...	845
Poore, T.	Scranton, Pa.	"	34	...	15
" "	" "	"	34	...	150
Playford, G., and Swaine, G. R.,	Cleveland, Ohio	"	27	...	440
Duncan, J. M.	Warsaw, N. Y.	"	32	...	120
Holt, C. H.	Philadelphia, Pa.	"	30	...	622
Coxe, Eckley B.	Drifton, Pa.	A. I. Mining Engineers (Chicago meeting)	...	...	...
" "	" "	Official Gazette	...	...	...

APPENDIX E-9.

References to Circular Grates—Horizontal, Outward and Inward, including Underfeeding.

Patentee or Author.	Name of Manufacturer or Address of Author.	Periodical or Book.			
		Title.	Vol.	No.	Page.
Rohan, P.	St. Louis, Mo.	Official Gazette	55	. . .	631
Colton, G. H.	Hiram, Ohio	"	59	. . .	1,071
Williamson, R. H.	Ashton, England	"	59	. . .	1,640
Smith, H.	England	Rowan's Chemical Technology	1	. . .	530
Frisbie, M.	New York	" "	1	. . .	528
" "	"	D. K. Clark's Steam Engine	1	. . .	345
Smith, H.	England	" "	1	. . .	338
Pratt, N. W.	Brooklyn, N. Y.	Official Gazette	61	. . .	594
" "	" "	"	61	. . .	595
Fales, E.	St. Louis, Mo.	"	35	. . .	810
Foster, M. A.	" "	"	33	. . .	1,119
Watson, R. S.	Bay City, Mich.	"	38	. . .	780
Porter, S.	Denver, Col.	"	54	. . .	334
Waterman, J. H.	Detroit, Mich.	"	54	. . .	472
Harthan, P.	Worcester, Mass.	"	44	. . .	1,199
Hopcraft	. . . . . .	Engineers' Club of Phila.	9	. . .	148
Pederson, O.	Moline, Ill.	Official Gazette	56	. . .	463
Reynolds, J.	Philadelphia, Pa.	"	40	. . .	262
Dunning, W. B.	Geneva, N. Y.	"	40	. . .	1,369
McFarland, E., and Passmore, L.	Philadelphia, Pa.	"	34	. . .	1,172
Richardson, D. S.	Brooklyn, N. Y.	"	31	. . .	1,322
Bannister, L.	Philadelphia, Pa.	"	27	. . .	362
Goodenow, A. L., & Owens, W. J.	Utica, N. Y.	"	18	. . .	481
Alston, S. W.	Philadelphia, Pa.	"	37	. . .	310
Haslam, W.	" "	"	37	. . .	624
Cissel, R. S. T.	Elizabeth, N. J.	"	28	. . .	976
Fiske, S.	New York, N. Y.	"	39	. . .	1,231
Brunton, W.	England	D. K. Clark's Steam Engine	1	. . .	331
Phipps, W.	Milwaukee, Wis.	Official Gazette	44	. . .	189
Kitson, A.	Philadelphia, Pa.	"	62	. . .	653
Morrin, T. F.	Jersey City, N. J.	"	39	. . .	1,268
Brown, T.	Des Moines, Iowa	Engineering	53	. . .	275
Hopcraft	. . . . . .	Colliery Guardian	57	. . .	12

APPENDIX E–10.

References to Rotary Grates and Grate-Bars.

Patentee or Author.	Name of Manufacturer or Address of Author.	Periodical or Book.			
		Title.	Vol.	No.	Page.
Duffy, J.	Quincy, Ill.	Official Gazette	33	. . .	484
Price, J. A.	Scranton, Pa.	"	33	. . .	1,127
Rafferty, P.	Ovid, N. Y.	"	38	. . .	1,003
Beisheim, J.	Rochester, N. Y.	"	54	. . .	1,687
Lawrence, F. M.	Portland, Me.	"	24	. . .	462
Hibbard, G. E.	Evanston, Ill.	"	24	. . .	509
Thompson, T. J., Jr.	Chicopee, Mass.	"	24	. . .	543
Spicer, W. A.	Providence, R. I.	"	23	. . .	169
Card, E.	Pawtucket, R. I.	"	29	. . .	46
Shaw, J. W.	St. Louis, Mo.	"	34	. . .	1,093
Scheef, C.	Chicago, Ill.	"	34	. . .	1,296
Burrell, J.	Bristol, County of Somerset, England	"	31	. . .	649
Richardson, D. S.	Brooklyn, N. Y.	"	31	. . .	1,322
McClave, W., and Price, J. A.	Scranton, Pa.	"	21	. . .	86
James, H. H., and Dunbar, J. C.,	Bangor, Me.	"	21	. . .	1,171
Breslauer, E.	Berlin, Germany	"	27	. . .	947
Kroupa, J.	St. Louis, Mo.	"	25	. . .	82
Huntingdon, S. H.	West Pittston, Pa.	"	32	. . .	1,297
Palmer, C. F.	Utica, N. Y.	"	30	. . .	364
Price, J. A.	Scranton, Pa.	"	30	. . .	577
Crawley, J. B.	Brooklyn, N. Y.	"	30	. . .	667
Huntington, S. H.	West Pittston, Pa.	"	37	. . .	725
Newburn, W.	United States Army	"	37	. . .	1,263
Fischer, W. G.	Cincinnati, Ohio	"	28	. . .	155

APPENDIX E-10.—Continued.

Patentee or Author.	Name of Manufacturer or Address of Author.	Periodical or Book.			
		Title.	Vol.	No.	Page.
Price, J. E., and Wright, D. E.	Scranton, Pa.	Official Gazette	26	...	561
Born, H.	Cleveland, Ohio	"	39	...	1,092
Kirkwood, T.	Chicago, Ill.	"	45	...	54
Wakeham, J., & Cunningham, J.,	Toronto, Ontario, Canada	"	46	...	300
Wodell, J.	Boynton Furnace Company, New York,	"	53	...	479
Owens, W. J.	Utica, N. Y.	"	53	...	914
Phipps, W.	Milwaukee, Wis.	"	44	...	189
Walker, G. W.	Malden, Mass.	"	20	...	689
" "	" "	"	20	...	1,150
Born, H.	Cleveland, Ohio	"	50	...	846
Bostwick, H. H.	Auburn, N. Y.	"	41	...	151
Ashcroft, J.	New York, N. Y.	"	50	...	1,469
Münning, C., and Fritzsche, H.	Leipzig, Germany	Dingler's Journal	287	...	107
Rohweder, H.	Newmunster, Holstein	"	287	...	107
Cory, D. U.	Englewood, N. J.	Official Gazette	52	...	779
Doten, C. W.	Doten Rotary Fire-grate Company, Boston, Mass.	"	19	...	492
Mershon, G. B.	Philadelphia, Pa.	"	22	...	228
Bowers, W.	Carbondale, Pa.	"	22	...	370
Shriver, F.	Grand Rapids, Mich.	"	22	...	1,109
Owens, W. J.	Utica, N. Y.	"	53	...	1,871
De Pereira, J.	New York, N. Y.	"	41	...	1,335
Sutcliffe, H.	Oakland, Cal.	"	47	...	1,726
Page, W. H.	W. H. Page Wood Type Company, Norwich, Conn.	"	52	...	745

APPENDIX E-11.

References to Domestic or Stove Grates.

Patentee or Author.	Name of Manufacturer or Address of Author.	Periodical or Book.			
		Title.	Vol.	No.	Page.
De Guerre, F. H., & De Lano, W. W.	San Francisco, Cal.	Official Gazette	38	...	444
Waterman, J. H.	Detroit, Mich.	"	54	...	472
Pederson, O.	Moline, Ill.	"	56	...	463
Price, J. A.	Scranton, Pa.	"	59	...	1,679
Buzzini, S. J.	New York, N. Y.	"	47	...	1,291
Galley, J. G.	Forest Gate, County of Essex, England,	"	23	...	199
Reynolds, J.	Philadelphia, Pa.	"	40	...	262
Bergner, S., and Sajous, C. E.	" "	"	36	...	1,286
Hare, C. C.	Kansas City, Mo.	"	21	...	1,219
Snyder, J. T.	Luzerne, Pa.	"	27	...	1,183
Graff, T. J.	Pittsburgh, Pa.	"	32	...	664
Culver, L. L.	St. Louis, Mo.	"	32	...	1,338
Earl, S. D.	Philadelphia, Pa.	"	39	...	595
Barry, J. C.	Rochester, N. Y.	"	48	...	607
Rockett, T. T.	Philadelphia, Pa.	"	48	...	775
Scharf, S. R.	Washington, D. C.	"	45	...	577
O'Keefe, J.	St. Louis, Mo.	"	43	...	499
Watson, R. S.	Bay City, Mich.	"	38	...	780
Cronin, W. D.	Philadelphia, Pa.	"	42	...	620
Tontz, J.	Girard, Kan.	"	52	...	1,832
Fiske, S.	New York, N. Y.	"	57	...	1,803
Graves, J. J.	Sherman S. Jewitt & Co., Buffalo, N. Y.	"	50	...	115
Bostwick, H. H.	Auburn, N. Y.	"	41	...	151
Kohler, J. C.	Philadelphia, Pa.	"	41	...	1,111
Van, J.	Cincinnati, O.	"	22	...	1,116
Murphy, J. R.	Allegheny, Pa.	"	19	...	1,265
Mershon, G. B.	Philadelphia, Pa.	"	23	...	1,643
Joy, T. C.	Titusville, Pa.	"	23	...	2,269
Knox, F. A.	Woodland, Cal.	"	23	...	2,381
Wakeham, J., & Cunningham, J.	Toronto, Ontario, Canada	"	46	...	300
Wodell, J.	Boynton Furnace Co., New York	"	53	...	479
Owen, W. J.	Utica, N. Y.	"	53	...	914
Gavin, S. J.	Philadelphia, Pa.	"	44	...	910
Bissell, F. S.	Pittsburgh, Pa.	"	44	...	972
Wicke, W.	Cleveland, Ohio	"	44	...	1,278
Church, W. A.	Waterbury, Conn.	"	49	...	1,199
Walker, G. W.	Malden, Mass.	"	22	...	106
De Guerre, F. H.	San Francisco, Cal.	"	41	...	1,050
Cobb, J. M.	Cobb Stove & Machine Co., Taunton, Mass.	"	62	...	173

COAL WASTE COMMISSION OF PENNSYLVANIA
ORIGINAL COMMISSIONERS
J. A PRICE, P.W. SHEAFER, ECKLEY B COXE.
PRESENT COMMISSIONERS
ECKLEY B. COXE, HEBER S THOMPSON, WILLIAM GRIFFITH.
OUTLINE MAP
OF THE
ANTHRACITE COAL FIELDS OF PENNSYLVANIA
SHOWING THE POSITION OF CROSS SECTIONS
AND
AREAS USED IN COMPUTATION OF CONTENTS
To accompany an "Estimate of the existing Anthracite Coal Fields before mining began" by A. D W. Smith.
SCALE 4 MILES TO AN INCH
JANUARY 1893
WYOMING REGION
LEHIGH REGION
SCHUYLKILL REGION
NOTES
1 The numbered rectangular outlines in red show the position of the mine sheets of the Geological Survey
2 The heavy irregular red line shows the outcrop of the Mammoth coal bed, the blue line the outcrop of the Buck Mountain or Red Ash coal bed, and the yellow line the outcrop of the Lykens Valley coal bed.
NORTHERN COAL FIELD
EASTERN MIDDLE COAL FIELD
WESTERN MIDDLE COAL FIELD
SOUTHERN COAL FIELD
CARBONDALE
OLYPHANT
SCRANTON
PITTSTON
WILKESBARRE
NANTICOKE
HAZLETON
ASHLAND
SHENANDOAH
MAHANOY CITY
WILLIAMSTOWN
TREMONT
POTTSVILLE
SCHUYLKILL HAVEN
TAMAQUA
MAUCH CHUNK
DAUPHIN