SMITH

The Stripping of Coal in the United States

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THE STRIPPING OF COAL IN THE UNITED STATES

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BIBLIOGRAPHY.


Black Diamond, Volume 48, Chicago, 1912.

Stripping Made Possible by Improved Machinery. April 20, 1912.

Stripping Is Cheap If Coal Is Near the Surface. January 27, 1912.


A Novel Coal Stripping Plant. (Consumers Coal Co., Danville.)

Engineering and Mining Journal., Volume 74, New York, 1902.

Coal Stripping by Steam Shovels in Kansas. W. R. Crane.

Coal Age., Volume 3, New York, 1913.

Stripping in Kansas.

The Excavating Engineer, Volume 9, Milwaukee, 1913.

Recent Developments in Open Cut Mining in Kansas.

I. Introduction.

The coal stripping industry, although it is probably the oldest branch of the mining industry, has been developed on a commercial scale only within the past few years. For this reason there is very little data to be obtained upon the subject. The material used in this thesis was obtained from personal observation, from correspondence and from magazine articles.

The Danville field was examined personally, inspection trips being made to each stripping described with the superintendent or manager. All information such as the geology of the field, the operating conditions of the plants, and the cost of these operations was thus obtained first hand. It was found that much better results were obtained by personal inspections than could be obtained by correspondence.

An attempt was made to secure some accurate data upon the operating conditions and costs in the Kansas-Oklahoma field by means of correspondence. Blanks containing questions pertaining to this subject were sent to most of the large operators in the field. In all cases where answers were received, it was stated that the plants had not been in operation long enough for the determination of accurate costs. Even the questions regarding the geological and operating conditions were unanswered, so that it would seem that the operators either did not want to divulge their costs, that they did not want to take the trouble to fill out the blanks, or that they did not really know what their coal cost them. A copy of the blanks sent out and a list of the operators to whom they were sent and the results obtained may be found in the Appendix. The average costs for the Kansas field were
obtained by correspondence with Professor C. M. Young, of the University of Kansas, and Mr. C. S. Stephenson, of the United States Bureau of Mines, who is stationed at Pittsburg, Kansas. Copies of these blanks containing questions were also sent to the companies manufacturing steam shovels, but they replied saying that they had no accurate data upon the subject of coal stripping.

The history of this industry was obtained from articles which have appeared from time to time in the technical magazines. These usually consisted of mere descriptions of the plants, with little or no data upon the geological conditions or operating costs. This is probably due to two reasons; first, most of the plants have been in operation only a short time and even the older ones have no accurate record of the costs; and second, the operators are very secretive about their operating conditions and costs for the reason that this information is usually obtained at great expense to themselves. The material used in the chapter upon stripping in Pennsylvania was obtained entirely from literature upon the subject. In the chapter upon general stripping costs much material was taken from the chapter on "Earth and Rock Excavation" in Gillette's book entitled "Cost Data".
II. General Geology and Methods of Working.

Coal stripping or open cut work as applied to coal mining, means the removal of the superficial materials, thus exposing the coal for quarrying. This was one of the first methods used for mining coal, because of the fact that nearly all our coal beds were discovered at the outcrop. When this outcrop occurred on a gently sloping hillside, the simplest way to obtain the coal was to remove the overburden and quarry out the coal. This process was usually continued until the cost of moving the overburden exceeded the value of the coal, when it became customary to drift in upon the seam itself and to change the system from that of open cut work to that of underground mining.

The stripping fields of this country may be divided into three separate and distinct classes according to their formation and present geological structure.

The first class is found in the fields of Pennsylvania and was formed by the folding of the strata and subsequent erosion. Here the coal seam stripped was originally laid down horizontally but after the deposition of the rocks forming the overburden, the region was subjected to an extensive folding. The coal measures were crumpled up into anticlines and synclines extending in a northeast-southwest direction. The land surface was then eroded and a greater part of the coal measures removed. In the particular part of the
anthracite field where stripping is being carried on the typical cross section is as shown in Fig. 1.

At the point "A" is the lower tip of a synclinal basin the greater portion of which has been eroded. At places this syncline was completely eroded, thus leaving long, canoe-shaped basins of coal with no material over them which would form a good roof. At "B" is the top of an anticline which at places has been slightly eroded, giving rise to parallel outcrops of the seam, pitching in opposite directions. When the coal seam remains intact over the top of the anticline it usually is thinned out a little at the highest point.

On account of this peculiar formation, stripping in this field takes place at the two points "A" and "B". In the case of the point "A", the coal occurs irregularly in the form of these canoe-shaped basins and the extent of the basin must be thoroughly discovered before an attempt is made to strip. In the case of stripping at the point "B", it is seen that the extent of the coal is probably well known, for the coal down in the synclines on either side of this point has usually been worked by underground methods before stripping was attempted. This working was usually carried up the side of the basin until the roof became so bad that the cost of timber became too high or until the percentage of recovery was too low. The Mammoth seam is the one worked and it varies from 25 to 60 feet in thickness, often increasing to 100 feet at overturns, and it pitches at an angle of 30 degrees or more. The overburden consists of compact sandstones and shales. This first class of strippings may be considered as due to folding of the strata and subsequent erosion and may be regular or irregular in occurrence depending
upon the extent of erosion and the depth of the folds.

The second class of coal strippings according to the geological structure and formation is found at Danville, Illinois. Here the coal bed was laid down in a horizontal position and then covered by 150 to 200 feet of shales and sandstones. The land was then elevated above sea level in the form of a plain, the strata still remaining horizontal. Stream erosion then occurred in the area and cut irregularly through the strata. In places the coal beds were completely removed and in other places broad valleys were cut out below the bottom of which occurs the coal, covered with 20 to 25 feet of shales and drift. A typical cross section across one of these valleys is shown here, and it is in these valleys, when their extent is great enough, that most of the stripping takes place. In other places where the streams have cut the valleys still deeper, the coal outcrops higher up in the hills, often with a small enough amount of overburden to render stripping possible. This second class of coal strippings may therefore, be considered as of local and irregular occurrence and is due entirely to stream erosion.

The last class of strippings according to this classification is found where the coal seams occur close enough to the surface to render stripping possible. By this is meant that either there never was very much overburden above the seams or that by erosion it has been uniformly removed from large areas. The districts
near Marion and Millstadt in Illinois and the Kansas–Oklahoma field belong in this class. Here the coal seams come up within a few feet of the surface over large areas and they constitute by far the most important class of strippings, for the reason that in these districts the most extensive strippings in the country are being operated.

In nearly all the fields where stripping is being carried on there have been two periods of activity. The first, which took place soon after the discovery of the seam, consisted in the removal of the overburden by hand or by horse scrapers. This stage lasted until the cost of stripping became excessive, when the operations stopped. Some of these fields then remained untouched on account of poor roof or on account of the thinness of the seam, until within the last few years. Recently, however, the rapid development of the steam shovel and the consequent reduction in the cost of earth excavation, have again made these seams workable.

There are two common methods used in the stripping of coal. The first and simplest of these is known as the "thorough cut" method. In this system the shovel makes a cut along one side of the acreage and upon the completion of this, makes a second cut parallel to and immediately alongside the first and so on in this way until the acreage is exhausted. The second system is a development of the first and consists of working completely around the acreage. There are two variations of this system in use. In the first, the shovel starts in the middle of the acreage and makes a cut in a circle of as small diameter as possible and then keeps working outward from this point. This is the system originally used at the Western Brick Company's plant in Danville, but this
has since been changed. It seems to have no particular advantages because the cut is very difficult to start and could not be very well adapted to a plant where the overburden is not utilized. The other method is to make the first cut completely around the acreage and to work constantly towards the center. This gives the advantage of less difficult turns to be made with the shovel and of a long working face. After a few circuits have been completed the corners become rounded off and the face becomes practically continuous. This last is, on this account, much more efficient in the saving of time.

In all stripping work, after the first or opening cut has been made, the waste is thrown over into the space from which the coal has been mined. Now this earth will occupy from $\frac{1}{4}$ to $\frac{1}{2}$ times the space figured by area of vertical cross section, that it did originally. That is, one square yard area in the vertical cross section of the cut will require $\frac{1}{4}$ to $\frac{1}{2}$ square yards area in the waste heap. In computations of this sort it is assumed that the slope that the waste bank may reach without sliding is $1\frac{1}{4}$ to 1 and that the edge of the bank may reach within about ten feet of the coal face in order to leave room for the mining of the coal. For these reasons it is seen that the width of the cut is limited by the length of the boom and dipper handle on the shovel. From this it may be seen that a given shovel will be able to make cuts of different widths in different depths of overburden. This is illustrated in the two figures given, which show graphically the relations of the different factors. These show a shovel working in two different depths of overburden and in each case the area "B" of the cut is limited by the area of the space "A" in which the waste may be put. This space "A" depends directly upon the vertical and horizontal reach of the shovel, as may be seen from the figures. In the figure
Diagram showing shovel working in 21 foot overburden.

shown above the face of the bank is 56 feet from the shovel centre while the maximum horizontal reach of the shovel is 85 feet, yet the cut cannot be widened for there is no room for the waste material. This is shown more forcibly in the figure below where the face is only 32 feet from the shovel centre, but a shovel reach of 85 feet is necessary to dispose of the overburden.

Diagram showing shovel working in 35 foot overburden.
At present most of the shovels employed in the stripping of coal are of the revolving type. This is because the construction of this type of shovel makes it peculiarly adapted to this kind of work. In designing a shovel for stripping work there are two conditions to be satisfied; first, it must have a maximum reach for the disposal of the waste, and second, it must be able to operate in a small space. The revolving shovel fulfils both of these requirements. It consists of a turn-table equipped with some sort of a levelling device and mounted upon trucks. Upon this turn-table is mounted the platform of the main body of the shovel, at one end of which are mounted the boilers, water tanks, etc., while to the opposite end the projecting boom is fastened. In this way the main body of the shovel is kept in balance and this balance is maintained in all positions because the dead load is always directly behind the boom. The shovel may be rotated through a complete circle and for this reason the waste may be deposited at any point desired. (See photograph on page 36.)

Formerly the shovels used in stripping work were of the swinging boom type. These consisted of a main platform mounted upon trucks. At one end of this platform were set the boilers, etc., and at the other was pivoted the boom. This boom was supported from an "A"-frame and was rotated by means of a bull-wheel, set close to the main platform. This type of machine was in balance when digging directly in the front, but when working at one side was unbalanced and the trucks had to be set far enough apart to keep it from overturning. As most of the digging in stripping work is done at one side and the waste is deposited at the other, this type of shovel required such a great width of platform that
it could not be operated efficiently. It may readily be seen that with this type of shovel, when the reach was increased, it also became necessary to increase the width of the machine and for this reason it has been almost entirely superseded by the more modern revolving shovel. (See photograph on page 47 and 48.)
III. Conditions Affecting Costs.

Coal stripping costs are of a very complex nature and for this reason there are very few plants which keep an accurate record of them.

The actual cost of stripping per ton is divided among the several different operations as follows:

(1). Moving overburden.
(2). Mining the coal.
(3). Hauling to the tipple and loading.
(4). Office expenses and superintending.

In considering the cost of moving the overburden, it is seen that this will depend upon the following:

(a). Method used for moving the overburden.
(b). Depth of stripping.
(c). Nature of overburden.
(d). Proper selection of shovel.

The original method of moving the overburden was by means of drag scrapers. These consist of ordinary steel scoops drawn by a team. The common size used weighed about 100 pounds and held from 1/9 to 1/7 cubic yard. Gillette in his book entitled "Cost Data" gives the cost of excavating with these scrapers as follows: "To a fixed cost of 6 1/2 cents per cubic yard, add 4 1/2 cents for each hundred feet of lead or haul." This cost may easily increase 30 per cent in stiff earth.

The next method used for moving overburden after that of drag or "slip" scrapers was that of wheeled scrapers, which consisted of a steel scoop hung low between two wheels. These wheeled scrapers, even in a light soil, seldom are completely filled with
earth and the average load carried by wheelers according to "Gillette"* is:

No. 1. . . . . . . 1/5 cubic yard.
No. 2. . . . . . . 1/4 cubic yard.
No. 2 1/2. . . . . . 1/3 cubic yard.
No. 3. . . . . . . 4/10 cubic yard.

The lightest or No. 1 scrapers are to be recommended where the leads are long and the rises steep, or, in general, wherever drag scrapers are ordinarily used, for they move earth more economically than drags. The rule given by Gillette* for figuring the cost of excavation by means of wheeled scrapers is: "To a fixed cost of 54 1/2 cents per yard for No. 1 wheelers, or 6 1/2 cents for No. 2 wheelers, or 6 3/4 cents for No. 3 wheelers, add the following per cubic yard: 2 1/2 cents for No. 1 wheelers, 2 1/5 cents for No. 2 wheelers, and 1 3/8 cents for No. 3 wheelers for each hundred feet of lead."

The method of moving overburden now used entirely in commercial work is that of employing steam shovels. Here again the cost may be divided into the following:

(1). Labor.

(2). Depreciation and interest.

(3). Supplies and repairs.

Of these three charges the one of labor is the most important as it is necessary to employ comparatively high-priced help. The interest charges are probably the next in importance, followed by the depreciation charges. Gillette* uses in his calculations a depreciation charge of 6 per cent, but certain of the operators in Kansas figure upon 20 per cent a year. Mr. J. W. Ijams in an *Ibid.
article in Black Diamond for January 27, 1912 says that a charge of 30 per cent should be made for the first year and 20 per cent for each year thereafter, but certain shovel companies claim that the depreciation should in no case exceed 5 per cent. The interest charges upon a shovel costing from $20,000 to $35,000 amount to quite a factor in the computation of costs. In figuring the repairs upon shovels Gillette* uses a factor of 3 per cent per month, while one of the shovel companies uses 6 per cent a year. The cost of supplies is usually very small in comparison with the other expenses. This includes the money spent for, or the market value of oil, waste, grease, coal and water. The coal consumed is usually the largest item, but in some cases it is necessary to haul water to the shovels and this may become an important item. It is sometimes necessary even to construct reservoirs to insure a constant water supply.

In considering the costs of moving overburden it may be seen that its depth affects the cost in that it increases the yardage to be handled, but the cost per ton does not increase directly with the depth of the overburden for the following reason. The increase in depth of the bank increases the amount of earth which may be handled from one point. On this account a shovel of larger capacity may be installed which will handle the material at a smaller cost per yard than would a smaller shovel, for a large capacity shovel usually operates more economically than can one of small capacity. According to Gillette* the cost of steam shovel work where the output is 1000 cubic yards, is 5.46 cents per cubic yard with average conditions. He says, however, that tough material and other unfavorable conditions may bring this up to as *Ibid.
high as 21 cents per cubic yard. Mr. Ijam* gives the average price at which stripping might be contracted at from 7½ to 11 cents per cubic yard. This probably allows quite a large margin of profit however. In Kansas the cost of moving overburden per cubic yard has been reduced to below 3 cents.

The proper selection of the shovel affects the cost of moving the overburden in that, if properly chosen, it will stand up under the work without serious breakdowns, in this way not impairing the efficiency of the plant. A shovel which is too light for the work to which it is put will not stand up under it, while a shovel which is too large and too heavy for its work cannot be run efficiently. Also, if the shovel used is too large, the amount of capital invested is too great and consequently the interest charges and the money tied up are increased. Gillette says in his book on "Cost Data": "For small railway cuts use a 26-ton shovel with a 1-yard dipper, where the moves will be frequent. Use a 55 to 60-ton shovel with a 1½ to 2½ yard dipper where the cuts are heavy and the moves not very frequent. Where the cuts are very heavy and the moves infrequent use a 90-ton shovel with a 2½ to 3½ yard dipper. Of course a heavy shovel with a small dipper must be used in hard pan or other tough material." The average stripping cut according to this would require a 55 to 60-ton shovel, but in the Kansas field they are using 275 ton shovels with 8-yard dippers, working in overburden 35 feet deep.

The character of the overburden has a great influence upon the cost of moving it, for it may readily be seen that it is much easier and would cost much less, to move 20 feet of soft soil than it would to move 20 feet of hard shale. It is this condition which

*Ibid.
has determined the fate of many enterprises. In designing a strip-
ing plant, the nature of the overburden over the entire acreage
should be studied and the exact composition and structure deter-
mined. Plants have been designed for and started in loose soil and
before the work progressed very far, the overburden changed to a
harder, more compact substance, rendering the whole plant useless.
An example is given in Gillette* where a change in the material
handled quadrupled the cost.

The cost of mining the coal depends upon the following con-
ditions:

(1). Labor.
(2). Supplies.
(3). Condition of floor.
(4). Condition of the coal seam.

The cost of labor affects the cost of mining directly, but
there would be a difference if the men were paid by the ton or
by the day. If a man were paid by the day, he would be much more
apt to "soldier" than if paid by the ton.

The relation of the amount of supplies such as powder, drills,
etc., to the cost of mining per ton may readily be seen.

The condition of the floor would affect the mining cost in
determining the ease of loading. A man can load more coal from a
smooth floor than from a rough one. This floor condition may also
affect the market value of the coal in that it may "come up"
easily and fill the coal with dirt.

The condition of the coal seam affects the cost of mining in
that it may be easy or difficult to mine. The presence of sulphur
balls greatly increases the cost of drilling and the hardness and
*Ibid.
the cleavage may be such that it breaks into sizes that are difficult to shovel and require much picking.

In connection with the loading of coal in the pit, a new method has recently been experimented with by the Besse-Cockerill Coal Co. and the J. J. Stephenson Coal Co., in Kansas. This involves the use of the steam shovel. In one case an 18-ton Marion shovel was used which had a \( \frac{3}{4} \)-yard dipper, and was operated by four men, two on the shovel and two in the pit. This machine could load 160 tons of coal per day, thus doing the work of eight men shoveling by hand. The advantage of this method is in having a string of ten to twelve cars to load one after the other without delay and in also having but a single track to maintain.

The costs of hauling the coal to the tipple and loading it depend to a great extent upon the modernness of the plant and the efficiency of the organization. These costs would probably vary inversely as the size of the plant.

The effect of office expenses and superintendence may be readily seen and they usually vary directly as the size of the plant. The question of the correct amount of superintendence is a vital one, for an excess unnecessarily increases costs and a lack of superintendence seriously impairs the efficiency of a plant.

The whole operating costs of the plant may be said to depend upon three general conditions, which are:

(1). Age and modernness of equipment.

(2). Organization and efficiency of plant.

(3). Unionization of labor.

The costs depend upon the modernness of the plant for the
reason that the methods of working are constantly being developed and operating expenses consequently reduced. A plant installed twenty years ago, may be running under the same conditions as it was at that time and might even be running with the same operating expenses, yet it would not be able to compete with a plant designed today in regard to costs. This is supposing that its operating cost has remained constant, which is very improbable, for a machine and especially a steam shovel as it grows older requires more repairs and is subject to more breakdowns, each of which increases the cost of running.

Probably the most important condition affecting the cost of stripping is the organization and efficiency of the plant. This of course, would more seriously affect plants where it is necessary to move the overburden in cars. The shovel might be kept waiting for cars and in this way lose much time. If the organization is right, the shovel will not be required to wait and the only time lost will be in making a move. Here, also, the organization counts. If all the men work together, the time lost in making a move according to Gillette* may average as low as three minutes and should not exceed five minutes. The time required to move a train of cars forward between shovelfuls also affects the efficiency of operation. Another thing which affects this subject is the closeness with which the pitmen, mining the coal, follow the shovel. This will affect the "thorough cut" method particularly, for if the men are some distance behind the shovel, it will have to wait at the end of the cut until they catch up, before it can start the return cut. These are merely a few of the more important ways in which organization and efficiency affect the cost of stripping. Of

course, if this question of efficiency is studied closely enough, it may be carried down to the smallest details and the costs will be correspondingly reduced.

The question of unionization of labor has an important effect upon the costs of stripping for not only do the unions demand a maximum wage scale, but they also demand a minimum length of shift. Any radical changes in the organization of a plant are very often the cause of labor troubles and these labor troubles, furthermore, seriously impair the efficiency of the plant even if they do not cause a complete shut-down. In comparing costs in the different fields, this question of unionization must be considered.

These foregoing subjects affecting costs may be summarized into a condensed form as follows:

**A SUMMARY OF STRIPPING COSTS. (DAILY COSTS.)**

I. Labor.

(a). Shovel crew.
   1. Shovel runner or engineer.
   2. Crane man.
   3. Firemen, day and night.
   4. Oilers.
   5. Any other help.

(b). Loading crew.
   1. Coal shoveler.
   2. Coal shooters.
   3. Driller or shooter helpers.

(c). Haulage crew.
   1. Engineers or motormen.
2. Trip riders.
3. Track layers.
4. Track layers helpers.
5. Couplers.

(d). Tipple and power plant men.
   1. Dumpers.
   2. Firemen.
   3. Engineers.
   4. Pumpmen.

(e). Office help.

(f). Superintendence.

(g). Miscellaneous help.
   1. Blacksmiths
   2. Water carriers.
   3. Oilers for cars.

II. Supplies and repairs.

(a). For shovel.
   1. Coal.
   2. Water.
   3. Oil, waste, etc.
   4. Repairs. (3% a month to 6% a year.)

(b). For mining of coal.
   1. Powder.
   2. Tools. (Drills, picks, shovels, etc.)

(c). Equipment other than shovel.
   1. Track and haulage system. (Rails, ties, etc.)
   2. Tipple and other plant.

(d). Office supplies.
III. Depreciation.

(a). On shovel. (Figured by various authorities at from
      5% to 30% a year.)

(b). On remainder of plant.

IV. Interest.

(a). On shovel.

(b). On remainder of plant.

(c). On land owned.

V. Royalties.

VI. Any other expense not included in the above.
IV. Stripping in Pennsylvania.

Coal stripping in this country was first carried on in the anthracite fields of Pennsylvania. It was started about thirty-five years ago at the old Summit Hill mines near Mauch Chunk and at the Baltimore open cut works near Wilkesbarre, and has been carried on almost continuously in the various districts ever since.

Most of the deposits were first worked by underground methods in accordance with the same system which is used throughout the field. But much trouble was experienced in trying to support the roof, which on account of the small depth of the seam was much weathered and broken, and at the same time get out a reasonable amount of coal. Many accidents occurred and it was necessary to use much timber, yet the best result which could be obtained was to win about 45 per cent of the coal. Often, however, the breasts were run completely to the outcrop at the surface as at the old Hollywood workings near Hazleton.

There are two geological conditions in this field which permit stripping to be carried on. They are both due to the folding of the coal measures and to subsequent erosion. The first of these is an anticlinal structure in the Mammoth seam, the top of which lies close to the surface and is covered by only a comparatively few feet of drift. At places even this top is eroded, giving rise to two parallel outcrops of the Mammoth seam. It is on the top of this anticline or at these outcrops that the stripping takes place. The seams here dip very rapidly, the average angle of dip being 30 degrees or more, but stripping may be carried on because the coal here is very thick.

The other geological condition which permits stripping to be carried on is the synclinal or basin structure, which has been described...
in a previous chapter. These basins vary greatly in thickness and in length and are very irregular in occurrence, but as they are overlain with very little overburden, the conditions are ideal for stripping when their extent is great enough.

On account of the methods of formation, the deposits having the anticlinal structure are very regular in occurrence and the extent of the deposit may be very accurately foretold. The basins formed in the syncline, however, must be thoroughly prospected and their extent accurately determined before a stripping plant is installed.

Both of these formations are found at the old Summit Hill workings and both have been worked at that place by stripping methods. A cross section at that place is given below.

The anticline formation is shown at the left and it is seen that the overburden at this point was very thin. At the right is seen the overturned anticline or the base of the closed syncline.

The sections below are at the Morea colliery and at the Derringer strippings and they illustrate very well the basins formed by the erosion of the syncline. Another section at Jeanesville is given which shows clearly both the anticlinal and the synclinal structure of the beds which permit of stripping.
Section in anthracite field at Jeansville, Pa.

Section at Derringer.

Section at Morea Colliery.
The coal uncovered in these strippings is of an excellent quality and is not much weathered. Chance in Volume AC of the Reports of the Second Geological Survey of Pennsylvania, published in 1883, said: "As coal beds are readily disintegrated by atmospheric action, the occurrences of localities at which the coal is covered by a moderate amount of overlying rock and soil and is yet of good marketable value are rare. In the bituminous region extensive strippings are almost unknown but in the anthracite regions the character of the coal and the thickness of the coal beds have, at a few localities, produced conditions extremely favorable to open surface working."

In this report he also gives a description of the stripping operations at Hollywood, near Hazleton, which is the earliest description of a plant obtainable. The coal which was stripped at Hollywood was in two canoe-shaped basins, showing these deposits to be of the synclinal structure. The southern basin had been worked by a slope before the stripping operations were commenced. The basin was about 120 feet deep with the dips about 30 to 40 degrees and the sandstone and shale within it was easily broken up into fragments of manageable size. The operation of removing this covering or filling from the basin was accomplished by running it through chutes into the old workings beneath, from which it was taken out through the slope. This practically amounted to the milling system which is used in the iron ore regions.

Another stripping in the anthracite region which has received a good deal of attention during its period of operation is the one at the Hazleton No. 6 colliery. Of this Chance* said: "At the Hazleton No. 6 colliery a large amount of flat coal has been ex-

*Ibid.
posed ready for mining. The bed is quite thick, lies flat and carried from four to twelve feet of cover; yet the upper benches of the bed will furnish much good coal. The reason that the coal thus exposed, at the time of this report, was flat, was because they were stripping at the very top of the anticlinal formation. Since then this flat coal has all been removed and the vein, which is the Mammoth seam, dips in a westerly direction with an average dip of 30 degrees. At present the coal is stripped and loaded into small cars. The cars are then dumped into a hopper bin opening into the mine entry below, from which it is drawn into mine cars and hauled 3000 feet underground to be hoisted directly into the breaker. The method of mining this thick seam is to take off a layer of coal 8 or 10 feet thick and then sink down another 8 or 10 feet and take off another layer and so on until the entire thickness is removed. The stripping at this place is done by the contract system, that is, the company owning the coal has the overburden removed by some contracting company and pays them by the cubic yard removed. In this way the coal company has only to mine the coal and prepare it for market and to keep a check on the amount of overburden moved by the excavating company. The contractors are experienced men in the excavating business and by this system the stripping probably does not cost the coal operator as much as if he tried to do the work himself.

Another stripping is described in the Colliery Engineer for September 1887. This belonged to the Philadelphia and Reading Coal and Iron Company and was located at Shenandoah City, Pa. This stripping was developed for the same reason as was that at Hazelton, i.e. the difficulties encountered in attempting to mine
by underground methods. The bed developed here was also the Mam-
moth seam. Stripping was done by the contract system and the coal
was hauled out through the old underground workings.

The latest stripping to be developed in this field is that
at Derringer, Pa., about eleven miles from Hazelton. Here a canoe-
shaped bed of coal about 1200 feet long with an average thickness
of 43 feet at the centre and a width at the top of 105 feet is
being worked. The cover averages 40 feet in thickness.

The earliest costs given relative to the anthracite stripping
industry were by Chance* in 1883. He said that where the material
was loose and could be handled by gravity, as at the Hollywood
strippings, it would pay to remove two or three cubic yards of
earth for every ton of coal. The cost of handling material in this
way at $1.25 a day for laborers and at $2.50 a day for mechanics
ranged from 15 to 25 cents per cubic yard. It is seen from this
that the cost of stripping ran from 45 to 75 cents per ton of
coal. As a general rule, he stated that from two to three yards
of overburden in thickness could be removed for every yard in
the thickness of the coal.

In the Hazelton stripping and in some of the others the
stripping work is done by the contract system and it has not been
possible to get the costs for this work. In the Engineering and
Mining Journal for June 30, 1906 were given some average costs
for the mining of the coal after the stripping has been done. At
each face were employed one miner and three laborers. The miner
received $1.94 for each nine hour shift and the laborers $1.29
for each shift. In one shift the four men could get out 45 tons
of coal making the actual mining cost about 13 cents per ton. To

this should be added 1 cent for superintendence and 6 cents a ton for incidentals in the pit and for haulage to the breaker, making the total cost of mining and hauling 20 cents per ton. This does not take into account the cost of stripping or preparation for the market.

The capacity of this plant was, at the time of the writing of this article, 100 cars per day of nine hour shift. The overburden was removed by means of steam shovels which had a capacity of 1000 tons per day with a 2-yard dipper. The waste was disposed of by means of cars. Each shovel employed thirty men, one blacksmith and three or four drivers.

The costs of anthracite stripping cannot be compared with those of bituminous stripping because the working conditions are entirely different and because the material stripped is of greater market value. The anthracite seams are much thicker, thus allowing greater depths to be worked and greater operating expenses carried.
V. Stripping in Illinois.

The next stripping field to be developed was that at Danville, in Vermilion county, Illinois, where stripping was begun on a commercial scale over twenty-five years ago. As has been mentioned in a previous chapter the stripping areas in this field, on account of the method of their formation, are very irregular and on account of the wide variation in the nature of the overburden, much trouble was had until the introduction of the revolving steam shovel. On account of this wide variation in geological and operating conditions, the main stripping plants in this field will be taken up individually.

The Mission Field Strippings.

The Mission Field stripplings near Danville were practically the first bituminous coal stripplings to be conducted on a commercial scale in the United States, and it has been here that nearly all the problems connected with this industry have been worked out.

As has been mentioned before the stripping areas in this region are due entirely to stream erosion. The overburden is twenty to twenty-five feet in thickness, consisting of fifteen to eighteen feet of loose, gravelly erosion deposits on the top of six to ten feet of compact, blue shales. The coal seam, known geologically as No. 7, is about six feet in thickness and is very uniform in thickness and character. It contains much sulphur in the form of large lenses of pyrite.

Stripping was begun in this area sometime between 1886 and 1888 by the Consolidated Coal Company, of St. Louis. Hitherto all coal stripping had been done by teams and scrapers. This company
A general view of the Mission Field strippings. In the distance is seen the tipple and the tower of one of the old dismantled drag-line excavators. In the distance may also be seen the bluffs which border on the river valley.

A view of a portion of the Mission Field which has been worked out. This shows clearly the physiography of the stripping area.
decided to have the stripping done by some form of steam shovel and they also decided to have the work done by contract. The contract was let to a firm of drainage contractors from Lafayette, Indiana.

At this time the only steam shovels made were the small standard railroad shovels with a 1 or 1\(\frac{1}{2}\)-yard dipper. The contracting company decided that these shovels would not be able to do the work so one of the firm, a very ingenious young engineer, conceived the idea of building a dredge, such as they used in their drainage work, upon wheels.

Three of these were built, two with 1-yard dippers and one with a 1\(\frac{1}{2}\)-yard dipper. This large dredge had an 80 foot boom set at an angle of 45 degrees and which was supported by an "A"-frame. The dipper was mounted upon a 40 foot handle, which gave a reach equal to that of some of the modern steam shovels. The frame of this shovel consisted of two Howe trusses running longitudinally along the sides of the machine and trussed crosswise by rods to support the boilers and operating machinery. The machine was mounted upon four trucks, one at each corner, which ran upon iron rails. The boom was pivoted at the forward end of the platform so that it could be swung through an angle of 180 degrees, but it was found that on account of its great length, it was necessary to set the trucks 35 feet apart to counteract the great overturning moment. For this reason, allowing a distance of three feet between the outside rail and the coal face, twenty feet of the reach of the shovel for the disposing of the overburden, were lost on account of the great width of the platform. On this account the edge of the bank came directly up to the coal face and
in order to remove the coal it was always necessary to drive an entry lengthwise of the strip of coal uncovered, in order to obtain a face at which to work. The expense of driving this entry increased the cost of the coal 10 cents per ton, which seriously impaired the practicability of the scheme. In spite of this the plant was operated by this method for some time. In the beginning the Consolidated Company was afraid that the contractors would not be able to move enough overburden to keep the miners busy, so an iron-bound contract was made requiring the removal of a certain amount of overburden each day. After a time labor troubles arose with the miners, who were employed by the coal company and not by the contractors and mining operations were stopped. The contractors, according to the terms of their contract, continued their operations even to the extent of covering up coal already stripped and it became necessary for the coal company to buy them off. After a while the troubles were settled and operations were carried on until about eight years after they had been commenced.

At this time the workings were leased by Butler Brothers, of Danville, who installed the drag-line excavators, with the idea of depositing the waste far enough back to allow mining directly at the coal face, thus eliminating the necessity of driving an entry in the coal. These excavators operated from the top of the bank being stripped and ran parallel to the cut. They consisted of a large platform resting upon four trucks which ran upon iron rails. Upon this platform were mounted the operating engines, boilers, etc., well to the back in order to balance the great weight of the projecting boom. In the last and the most successful machine that they built, this boom was 115 feet long and was
supported by cables from a vertical frame on the platform. At the end of this boom was a sheave wheel over which passed the cable to the drag bucket. By an ingenious arrangement of sheaves and cables, they were enabled to lower the bucket and drag it back toward the machine thus filling it with earth. It was then raised and pulled out to the end of the boom where it was dumped. These machines worked well in the loose drift at the surface, but when the compact shale was reached they would not work at all. On this account it became necessary to drill and shoot the shale, and handle it in large chunks. This greatly increased the cost of operation and caused numerous breakdowns of the shovel.

On account of the great cost of building and developing these excavators, the originators of the scheme, Butler Brothers, "went broke" shortly after the completion of the shovel just described, which cost in the neighborhood of $28,000. The men in the plant then formed a co-operative company and operated the stripping for a couple of years, but they also "went broke". A man by the name of Gray then attempted to operate the plant but he, too, was unsuccessful.

At that time the present owner, Mr. Hartshorn, took hold of the plant and although using the same equipment as was used by the preceding companies, was able to make the proposition pay. The old drag-line excavator was used until 1910, when breakdowns became so frequent that it was necessary to look for some new form of steam shovel.

A steam shovel operating in connection with a conveyor belt had been installed in a neighboring plant a few years before, but this had not been entirely satisfactory, so Mr. Robert Holmes, of
A view of the pit behind the shovel at the Mission Field Strippings.

A view of the working face at the Mission Field strippings.
Robert Holmes & Bros., of Danville, was consulted and he in turn consulted the Marion Steam Shovel Company, of Marion, Ohio, as to the practicability of making a steam shovel which would do the work. It was decided that the most efficient method of moving the overburden would be to pick up the waste and in one operation deposit it on the waste bank out of the way of future operations. This could only be done by means of a revolving steam shovel for the reason that with a swinging boom an excessive width of machine is required as was seen in the first machine built in this field. The Marion people said that a revolving shovel was not practicable for the reason that the turntable required in such a shovel could not be kept level.

For this reason the attention of the operator and Mr. Holmes was again turned to the problem of operating a steam shovel in connection with some sort of conveyor. A plant was designed which consisted of an endless belt conveyor mounted upon a platform entirely separate from the shovel and operated by a boiler upon the same platform. A continuous feed upon the conveyor was to be obtained by dumping the shovel upon a pan which could be so tilted by a steam piston that the earth would be gradually fed upon the belt. This conveyor plant alone was to have cost about $25,000 and was to have been operated in connection with an ordinary standard type of railroad shovel.

The foregoing plant was never installed for at this time Mr. Holmes brought forth an invention which rendered possible the construction of the modern steam shovel. He had come to the conclusion that it would only be necessary to keep the turntable level laterally, that is, in right angles to the track upon which
the shovel is operated. With this end in view, he placed hydraulic cylinders over each truck, the pair on each end being connected by means of a pipe. A valve was placed in this pipe so that this connection could be cut off at any time. Each cylinder was also connected to a hand pump. Lock nuts were placed upon the pistons so that if the packing leaked, the cylinders would merely settle down upon these nuts. In making a move the connection between these pairs of cylinders is opened and if one truck rises due to any inequality in the track, the opposite truck is forced down a like amount, thus maintaining the level of the shovel laterally. If for any reason one of the cylinders should stick it may be moved to the correct position by means of the hand pump.

In 1910 a Marion shovel, Model 250, of 150 tons weight (at that time the largest revolving shovel in the world), and equipped with this device, was installed at the Mission Field strippings. It was found to work satisfactorily and has been in operation ever since.

The thorough cut system of stripping is used at this plant, the cut being made the entire remaining width of the valley from east to west. The drilling is done by means of electric rotary drills. The coal is broken with light shots and then pried out with bars and loaded. In this way a maximum amount of lump is obtained. The cars are hauled from the face to the base of the incline, about 9 cars to the trip, by means of a dinkey locomotive and are then hauled up the incline by means of a wire rope haulage. In the tipple is a Philips cross-over dump and the coal is run over a 1½ inch screen when it is desired to ship screened coal.

On account of the geological formation of the field it is necessary to pump much water, which comes down the ravines around
Marion shovel, Model 250, used at the Mission Field stripping.

A view in the pit at Mission Field stripping.
the valley and runs into the pit through the gravelly drift. Much trouble is also experienced every spring during the flood season in keeping the water from the river out of the workings. As a precaution a system of levees has been built but during the floods at Easter of this year the river broke through the levee and filled the pit up with mud. That was about eight weeks ago and it will still be three weeks before the plant begins operations again.

It was possible to get only a rough estimate of the costs for this plant, for the reason that the company is operating a drift, a slope, and the strippings altogether and it is almost impossible to get such items as supplies, repairs, etc. for one plant alone.

On account of the great variation of the character of the overburden, the distance the shovel moves per day varies from 40 to 120 feet. The width of the cut is about 20 feet. If in an average days work the shovel is assumed to move about 80 feet, this in 22 foot overburden would make a total yardage of 1380. The expense of operating the shovel per day is as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineer</td>
<td>$3.38</td>
</tr>
<tr>
<td>Graderman</td>
<td>3.00</td>
</tr>
<tr>
<td>Fireman</td>
<td>3.00</td>
</tr>
<tr>
<td>Oiler</td>
<td>3.00</td>
</tr>
<tr>
<td>3 Men around shovel @ $2.62</td>
<td>7.86</td>
</tr>
<tr>
<td>Coal. 3 tons @ $1.10</td>
<td>3.30</td>
</tr>
<tr>
<td>Oil, waste, grease, etc. (estimated)</td>
<td>2.00</td>
</tr>
<tr>
<td>Repairs at $800.00 per year</td>
<td>4.00</td>
</tr>
<tr>
<td>Interest on $25,000</td>
<td>7.50</td>
</tr>
<tr>
<td>Depreciation at 5% per year</td>
<td>6.25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$42.18</strong></td>
</tr>
</tbody>
</table>
This gives an approximate cost of 3.05 cents per cubic yard of overburden excavated. The only costs which could be obtained for this plant were the labor costs. These are found in a tabulated form in the appendix and they amount to about 35 cents per ton of coal output of the plant. If the depreciation of the plant and the loss due to floods and other unfavorable conditions is divided over the tonnage, the cost of the coal per ton is probably between 60 and 70 cents.

The drift operated by this company goes in upon the coal seam under the bluff at the north side of the stripping. The cars are hauled from the mouth by means of the locomotive used at the stripping and are dumped at the same tipple.

A new stripping is being opened up by this company in a field of 75 acres about a mile and a half west of the present operations and is one which was operated unsuccessfully until about ten years ago by the Butler Brothers. A Marion steam shovel, Model 270, of 250 tons weight, with an 8-yard dipper is being installed. At present a small Marion revolving traction shovel, Model 31, with a 1½-yard dipper is on the ground excavating for tracks, etc. It is the intention of the company, when the plant gets into operation, to use this shovel in loading coal in the pit. On this account it was necessary to install a picking table in the tipple, in order to get rid of the sulphur lenses which occur in the coal. The pyrite thus obtained will be sold as a by-product. This company is also operating two large shovels at Silverwood, Indiana.

The operations at these plants are as extensive as those in Kansas, and when the new plant just described gets into operation it will be one of the most complete in the country.
The Gray Mine Stripping.

The Gray Mine stripping was begun about three or four years ago in connection with the underground operations at that place. The field being worked is of about 80 acres in extent and lies about one half mile northeast of the Mission Field strippings. Originally the coal was stripped and hauled through a drift to the old mine shaft where it was hoisted to the surface. About two years ago the boiler-house and hoisting-engine house were burned and the plant became flooded and remained idle until less than a year ago. An incline was built and a new tipple constructed and near the first of the year the opening out was completed. About Easter of this year this plant was flooded during the rainy season and the pit was filled with soil rendering necessary the driving of another entry for the haulage of the coal.

The geology of this stripping is the same as that of the Mission Field. The operations are carried on in a broad valley which extends on both sides of the river. The overburden is about twenty to twenty-five feet thick and consists of a few feet of compact shales and the remainder of loose, gravelly drift. The coal seam (No. 7) is about 6 feet in thickness and is filled with lenses of pyrite.

The shovel in use here is of the revolving type made by the Browning Manufacturing Company and uses a 3-yard dipper. Under average conditions it will handle about 1500 cubic yards per day. The cost of moving overburden with this shovel is practically the same as with the Marion shovel used at the Mission Field strippings. The labor costs are exactly the same but the cost of repairs and supplies are not known for this shovel as it has
A view of the mouth of the drift at the old Gray mine stripping. The coal from the stripping was originally hauled through this drift to the old mine shaft where it was hoisted to the surface. Since the burning of the engine house the use of this drift has been discontinued.
not been in operation long enough for them to be determined.

The coal is hauled from the face to the base of the incline by a mule, one mule and one driver being sufficient to handle the entire output of the plant. The coal is hauled up the incline, the length of which is 650 feet, to the top of the tipple by an electric hoist. The motor used is one of the induction type made by the Westinghouse company. The coal is run over a \( \frac{3}{4} \) inch screen and the slack screened out and shipped separately from the lump. The pyrite lenses or "sulphur rock" as they call it, is saved and hoisted to the tipple where it is cleaned by hand and sold.

It was only possible to get the labor costs for this plant and these may be found in a tabulated form in the appendix. With an output of 250 tons per day, the labor charge is \( \frac{35}{2} \) cents per ton of coal produced. The interest and depreciation charges could not be obtained because the plant has not been operating long enough for them to be determined. At present the plant is just in the process of being opened up and it is possible that even the labor charges are high.

The Consumers' Coal Company Stripping.

In 1906 or 1907 a steam shovel plant was installed at the stripping of the Consumers' Coal Co. southwest of Danville. This plant marks the step in the improvement of stripping machinery intermediate between the drag-line excavator and the modern steam shovel. As has been seen from the history of the first two plants at Mission Field, the two problems connected with stripping in this field were first, to have the machine able to operate successfully in both the loose overburden and hard shales and second,
to have the machine deposit the waste at a great enough distance from the coal face to obviate the necessity of driving an entry in the coal. The machine built at this place was designed with the idea of solving these two problems. An article in Mines and Minerals for October 1907, which states very clearly the conditions at this plant, says: "There has recently been begun at Danville, Illinois, a coal stripping operation which has several features of unusual interest and novelty, both in the physical conditions met and in the plant employed."

"The Consumers' Coal Co. of that city has about 35 acres of coal lying approximately horizontal and outcropping on all sides of a flat-topped hill. The seam is about eight feet thick and the overburden is from 38 to 40 feet deep, of which 16 to 24 feet is shale and the balance gravel, clay and surface soil."

"It was decided to have the stripping work done by contract and the job was let to G. W. Prutzman, of Danville, who placed the matter of equipment in the hands of the Bellefontaine (Ohio) Foundry and Machine Co. and by whom the plant herein described was designed and put into successful operation."

"It was decided to have the stripping go down to the coal in a single cut across the face of the overburden and to take as wide a cut as possible so as to better provide for efficient mining or quarrying out of the coal."

"The plant consists of a deep dredge equipment mounted on wheels instead of a float and provided with a belt conveyor for disposing of the material removed. This equipment combines the efficiency and speed of operation of the largest steam shovel with very economical handling of material after the excavating proper
Two views of the old conveyor shovel in use at the plant of the Consumers' Coal Company, near Danville.
is done, some 80 per cent of the material being disposed of without second handling, requiring no labor beyond that of an ordinary steam shovel and this delivery is automatic and continuous."

The conveyor on this machine was 105 feet long and the dumping clearance at the outer end was nearly 60 feet above the tracks. With a 24 foot handle on the dipper it was possible to move all logs, boulders etc. directly into the space from which the coal had been removed. The machine was propelled by means of steel rope tackles and it was kept from oscillating by means of jacks. The article goes on to say: "This machine has been fully and thoroughly tested in what is believed to be one of the heaviest and roughest stripping operations for coal ever attempted."

Originally the material was dumped from the shovel into a hopper and it was found impossible to maintain a continuous feed to the belt. It was on this machine that the tilting pan described in connection with the proposed plant at Mission Field was worked out.

This shovel is very inefficient as compared with the modern steam shovel, for it can handle only about 800 cubic yards of overburden in eight hours and it requires twelve or thirteen men to operate it. The reason for this is that in addition to the regular crew required on a steam shovel, one man is required to operate the pan and another to tend the conveyor. In addition to the regular track men and "ground-hogs" about the shovel, it is necessary on account of the means of moving it forward, to keep two or three men boring holes in the coal and putting in iron rods for the attachment of steel cables.

It was impossible to obtain any costs for this plant but
A general view of the shale mining plant of the Western Brick Company, of Danville.

A photograph showing the method of removing the surface materials from the shale at the Western Brick Company's plant.
an authority on coal stripping in the vicinity stated that coal produced at this plant could not cost any less than $1.00 per ton. Although this plant at the time of its installation was one of the most modern in the country, it is now nothing more than a freak plant. The costs of operation are abnormally high and are worth nothing when making a study of stripping costs. If the operating company could afford it, they would probably make money by scrapping this old machine and installing a modern steam shovel.

Other Stripping Plants at Danville.

Coal stripping is being carried on at two brick plants near Danville in connection with the mining of the shale.

At the plant of the Western Brick Company, the overburden is 30 to 40 feet thick and consists of 25 to 30 feet of blue shale, used for making brick, covered with 5 to 10 feet of gravelly drift. The unique thing at this plant and the thing which makes it worth notice, is the method of removing this top drift. This is done by two hydraulic giants, the refuse being washed into a ravine below. The shale is then removed with an old style, swinging-boom type, Bucyrus shovel and loaded directly into cars and hauled to the brick works by a dinkey locomotive. The shale is removed clear down to the coal, which in this place has been worked previously by room and pillar methods, and the remaining coal is then mined and used for burning the brick.

The operations of these plants which are very interesting in themselves, are of no value when studying coal stripping operations alone for they undoubtedly could not be carried on at the present time primarily for the recovery of the coal.
Two views of the shale mining operations at the plant of the Western Brick Company, near Danville.
A view at the plant of the Western Brick Company, near Danville. In the immediate foreground may be seen a face in the abandoned workings in the coal underlying the shale at this plant.

A view of the coal mining operations at the plant of the Western Brick Company, near Danville. In the foreground may be seen the men digging coal in the abandoned mine workings.
VI. Stripping in Kansas.

The latest stripping field to be developed was that in Kansas and Oklahoma. Here the greatest development has taken place within the past two years. This may be accounted for directly by the rapid failure of the oil and natural gas supplies and their consequent rise in price. It became necessary to find some cheaper substitute for these fuels and attention was turned toward the coal fields of southeastern Kansas and northeastern Oklahoma.

In 1882 steam shovels were introduced into this field and operated with a fair degree of success. This was at Milden, Missouri. One of the oldest stripplings in Kansas was started at Mulberry in the same year. A description of the excavator used there in 1902 is found in the Engineering and Mining Journal for November 8, 1902. The overburden here was wet and soft and the operators, Miller Bros., were advised against trying to run a steam shovel there. After investigation they adopted an excavator of the design used by the Garden City Sand Co., of St. Charles, Illinois. The principle of operation of this machine was practically the same as that of the machine installed at the plant of the Consumers' Coal Co., at Danville, Illinois. It consisted of a bucket dipper which dumped the material into a hopper. The material was drawn from the hopper by a conveyor belt and was deposited upon the spoil bank 75 feet from the point of loading and 21 feet above the track. This style of machine proved very efficient and greatly reduced the cost of moving the overburden. In the district around Pittsburg stripping was carried on in a desultory way for many years. A recent article in the Coal Age on the subject of stripping in this field says: "All the steam shovels used in the coal stripping operations
in the Pittsburg district are working constantly and four new ones are being erected. It is expected that by the end of February (1913) that there will be twenty in active operation. A noteworthy fact is that all have been installed within the last two years, thus demonstrating the greater advantage and economy in strip mining as compared with shaft mining. The coal in this field averages three feet in thickness or about 3000 tons to the acre and it is claimed that a depth of ten to thirty feet of overburden can be removed with the new type of revolving steam shovel at a low cost per ton of coal."

The coal measures in Kansas are made up of the coal seams of medium thickness, interbedded with comparatively soft shales. They outcrop in southeastern Kansas and northeastern Oklahoma, the outcrop running over into Missouri and Arkansas. The dip is toward the northwest. The coal seams themselves are comparatively thin, the average thickness being probably between two and three feet. Mining has gone on intermittently in this region ever since its discovery, but the industry has never assumed any importance because of the difficulty of mining such thin seams by underground methods and because of the cheapness of oil and gas as a source of power. In most cases merely enough coal was mined to supply the local demand.

Probably the most rapid progress in the reduction of striping costs has been made in this field within the past two years. Here they have installed some of the largest steam shovels in the world and have reduced the cost of handling material to the lowest point possible. The shovels used are nearly all of the revolving "Marion" and "Bucyrus" types and they vary in size from those
weighing 140 tons, with a 65 foot boom, a 40 foot dipper handle and a bucket of 2\(\frac{1}{2}\) cubic yards capacity, to those having a weight of 275 tons, a 90 foot boom, a 45 foot dipper handle and a bucket of 5 cubic yards capacity. The cost of maintenance of these shovels is not known as they have come into use only recently and have not been in operation long enough to enable any determinations to be made. The depreciation on and life of these shovels is not known, but one of the leading operators in the field is using 20 per cent as the amount of yearly depreciation. This figure is evidently high but it is on the safe side. The cost of these shovels varies from $30,000 to $35,000.

Labor in Kansas is paid according to an agreement between the Strip Pit Operators and the United Mine Workers of America. All of the labor about the pits, except the superintendence, is unionized. The wage scale for the steam shovel pits is as follows per day:

<table>
<thead>
<tr>
<th>Position</th>
<th>Wage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineers or motormen pulling coal from the</td>
<td></td>
</tr>
<tr>
<td>strip pit to the tipple, or tipple engineer.</td>
<td>$2.75</td>
</tr>
<tr>
<td>Tail rope engineers, electric, gas or steam.</td>
<td></td>
</tr>
<tr>
<td>pulling coal out of the strip pit</td>
<td>2.65</td>
</tr>
<tr>
<td>Coal shovelers.</td>
<td>2.62</td>
</tr>
<tr>
<td>Drivers.</td>
<td>2.62</td>
</tr>
<tr>
<td>Coal shooters.</td>
<td>2.75</td>
</tr>
<tr>
<td>Driller or coal shooter helpers.</td>
<td>2.40</td>
</tr>
<tr>
<td>Track layers.</td>
<td>2.62</td>
</tr>
<tr>
<td>Track layers helpers.</td>
<td>2.40</td>
</tr>
<tr>
<td>Ditchers.</td>
<td>2.40</td>
</tr>
<tr>
<td>Ground men around shovel.</td>
<td>2.40</td>
</tr>
<tr>
<td>Trip riders.</td>
<td>2.40</td>
</tr>
<tr>
<td>Job Description</td>
<td>Wage</td>
</tr>
<tr>
<td>------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Flat trimmers and dumpers at the tipple</td>
<td>2.25</td>
</tr>
<tr>
<td>Blacksmiths on construction work</td>
<td>3.34</td>
</tr>
<tr>
<td>Blacksmiths on repair work</td>
<td>3.05</td>
</tr>
<tr>
<td>Stationary firemen</td>
<td>2.25</td>
</tr>
<tr>
<td>Pumpers</td>
<td>2.62</td>
</tr>
<tr>
<td>Sledgers</td>
<td>2.62</td>
</tr>
<tr>
<td>Couplers</td>
<td>2.25</td>
</tr>
<tr>
<td>Water carriers. (Boys)</td>
<td>1.95</td>
</tr>
<tr>
<td>Car greasers. (Boys)</td>
<td>1.95</td>
</tr>
</tbody>
</table>

**Wage scale per month.**

<table>
<thead>
<tr>
<th>Job Description</th>
<th>Wage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineers on shovel</td>
<td>$155.00</td>
</tr>
<tr>
<td>Cranemen on shovel</td>
<td>100.00</td>
</tr>
<tr>
<td>Firemen on shovel. (Day and night men.)</td>
<td>75.00</td>
</tr>
<tr>
<td>Oilers on shovel</td>
<td>63.00</td>
</tr>
</tbody>
</table>

There is also another agreement in this state to cover the small pits where the overburden is removed by teams and scrapers. The wage scale in this agreement where it differs from that above is as follows per day:

<table>
<thead>
<tr>
<th>Job Description</th>
<th>Wage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dirt shooters</td>
<td>$2.75</td>
</tr>
<tr>
<td>Team and driver, when the team is furnished by</td>
<td>3.75</td>
</tr>
<tr>
<td>the employee, for all work in and around strip pits</td>
<td></td>
</tr>
<tr>
<td>or hauling coal</td>
<td></td>
</tr>
<tr>
<td>Dirt shooters helpers</td>
<td>2.40</td>
</tr>
<tr>
<td>Man unloading coal at flat or at other places</td>
<td>2.62</td>
</tr>
<tr>
<td>as may be designated by the foreman</td>
<td></td>
</tr>
<tr>
<td>Teamsters hauling coal from the strip pit when</td>
<td>2.25</td>
</tr>
<tr>
<td>the team is furnished by the company</td>
<td></td>
</tr>
</tbody>
</table>
Drivers on strip pit when the team is furnished by the company.

Plow holders.

Slip holders.

As an example of the costs of moving overburden in Kansas by means of steam shovels, the following data was kindly furnished by Professor C. M. Young, of the University of Kansas. It is from a Bucyrus company where two different shovels are being operated.

Model 150-B per Month.—Charges.

1 Engineer per month. $150.00.
1 Craneman per month. 90.00.
1 Fireman per month. 75.00.
4 Pitmen. Each $50.00. 200.00.
70 tons coal. 70.00.
Water. 50.00.
Oil, waste, packing, etc. 30.00.
Repairs. 100.00.
Interest on $20,000. 100.00.
Share on superintendence. 90.00.

$955.00.

Credit.

20 days at 1600 cubic yards per day—32,000 cubic yards a month which gives a cost of 2.98 cents per cubic yard moved.

Model I75-B per Month.—Charges.

1 Engineer per month. $150.00.
1 Craneman per month. 90.00.
1 Fireman per month. 75.00.
4 Pitmen. Each $50.00. 200.00.
80 tons coal. 80.00.
Water. 60.00.
Oil, waste, packing, etc. 35.00.
Repairs. 125.00.
Interest on $28,000. 140.00.
Share on superintendence. 30.00.
$1045.00.

Credit.
20 days at 2000 yards per day—40,000 cubic yards per month which gives a cost of 2.61 cents per cubic yard moved.

These costs assume that the smaller shovel is working in overburden of a depth of 17 feet and that the larger is working in overburden 20 feet thick, and they show very nicely the advantage of using a large shovel whenever such is possible and the necessity of choosing the proper size of shovel for the work to be done. It is seen that the operating costs in the case of the smaller shovel are only $50.00 below those of the larger, while there is 8,000 cubic yards difference in the yardage moved per month. This is due to the fact that the labor costs which constitute over one half of the operating costs are the same for both machines. The only increase in the operating expense comes in the supplies, depreciation and interest charges and these are not increased in proportion to the change in capacity. The foregoing costs are a fair example of those in the Kansas field and as seen the cost runs below 3 cents per cubic yard. This varies from 3 to 6 cents in the different
parts of the field and this variation is due to the difference in depths worked and to the difference in the types of machines used. For any given shovel there is a certain limit of depth at which the cost of moving earth will be at a minimum and above and below which the cost per yard will increase. This range may be determined only by actual experiment with each shovel.

It was impossible to obtain any figures upon the cost of mining the coal in this district, but Ijams in his article in Black Diamond for January 27, 1912 gives the average cost of mining the coal at 25 cents per ton and the cost of screening and loading at 10 cents per ton.

Mr. C. S. Stephenson, of the U. S. Bureau of Mines Station at Pittsburg, Kansas, gives the average cost of obtaining coal by stripping methods in Kansas to be 85 cents per ton as compared to $1.50 per ton by underground methods. This shows the reason for the remarkable developments in the stripping fields of this district.

The article in Coal Age for January 4, 1913 concludes by saying: "There are many thousand acres of good coal land available for stripping, with an overburden varying from 10 to 25 feet in depth. This land can be bought or leased and operated at a good profit; in fact, the Kansas coal fields offer as great inducements for stripping as any other section of the country. The coal is of a good quality and is quite free from sulphur. It burns freely and does not clinker."
VII. Conclusion.

It may be seen that the coal stripping industry has a field of operation of its own and that at the present time when the method to be used in mining a coal seam, depends upon the cost of operating, the limits of practicability of stripping rarely overlap those of underground mining. Coal seams are rare indeed, which are equally adapted to both stripping and underground mining, but the introduction of the modern steam shovel has done much to bring the limits of application of the two methods closer together.

Formerly it was impossible to strip a seam of coal of ordinary thickness, which was covered by twenty to twenty-five feet of fairly hard shales and it was almost equally impossible to mine it by underground methods upon a paying commercial basis. The introduction of the steam shovel has, however, made it possible to strip almost to a depth at which profitable underground mining may be begun.

It may be also seen that at present the average cost of strip mining is slightly below that of underground mining, the average cost of stripping in the bituminous regions being probably between 80 and 85 cents per ton, while the average cost of mining coal by underground methods in the same region is between 90 and 95 cents per ton. This difference is due to the fact that at present stripping is being carried on only under the most favorable circumstances and it shows that the field of stripping may still be considerably extended and yet compete successfully with underground mining.

The cost of underground mining is probably as low now as it ever will be, for as a general rule the most favorable seams are
now being worked and the methods used do not permit of much improvement being made. For this reason, it may be seen that as the steam shovel is developed and the capacity increased, coal stripping may be carried constantly to greater depths.

This industry is still in its youth and within the next ten or twenty years many new fields will be opened. In some of them even now stripping is being done on a small scale. In an article in the Black Diamond for April 27, 1912 is a description of a plant at Lily, Kentucky. Here the coal was two feet six inches thick and the overburden was twelve feet deep. It consisted of four feet of black slate on top of the coal, then two feet of soapstone, with the remainder of sandy loam. The stripping was done with a Vulcan traction shovel, which handled 900 cubic yards of overburden with a 1½ cubic yard dipper per day, elevating it 28 feet from the surface of the coal where the shovel was working. This same article also stated that there were fields in eastern Kentucky where bituminous coal occurs in such a manner as to render stripping possible.

Stripping operations have also been carried on near Marion, Illinois, on a small scale, the operations being at the outcrop of the No. 6 coal. The overburden was removed here by means of horse scrapers. This same seam has also been stripped at Duquoin, Illinois, where it comes near the surface at the summit of an anticline at that place. In the vicinity of Harrisburg, Illinois, this coal occurs at a depth at which stripping would be very profitable, but the region has not been developed and probably will not be for some time for the reason that the coal rights are all owned by companies working lower seams by underground methods,
the mines having been started before the remarkable development of the stripping industry.

Another field in Illinois has recently been opened. This is at Millstadt, where the No. 6 seam is stripped. The quality of the coal here, however, is not so good as that obtained by stripping the same seam in the eastern portion of the state. A large steam shovel has been installed and the overburden is being sent to an aluminium reduction plant in East St. Louis.

Several articles of a semi-technical nature have appeared in the recent magazines describing coal fields in Canada and while they are not very reliable, there are fields in that country which will be favorable for coal stripping when that region becomes sufficiently developed.

In the past it was thought that coal stripping was only a temporary or at least a very short-lived method for obtaining coal and no close study of the operations and the operating costs was made. But it may be seen now that the limit to which it may be carried is constantly growing greater and that a close and careful study of the costs and operating conditions will enable this limit to be further extended. For this reason, it would seem wise for the operators to get together and study costs instead of concealing them as seems to be done at present.
VIII. Appendix.

The following questions were sent to the various operators in the Kansas-Oklahoma field:

1. What is the make, number and capacity of your shovel?
2. What was the original cost of your shovel?
3. How much do you spend per year for repairs on your shovel?
4. What is the estimated value of your entire plant?
5. What do you spend per year for repairs in connection with your stripping plant other than those on your shovel?
6. How many of the following do you have on your shovel crew and what are the daily wages paid each?
   Shovel men?
   Crane men?
   Firemen?
   Other help?
7. How many men do you have loading coal in the pit and what is the daily pay of each?
8. How many men do you have blasting coal and what is the daily pay of each?
9. How is your coal hauled from the pit to the loading tipple?
10. If by mules, how many drivers do you have and what is the daily pay of each?
11. How many mules do you use?
12. How much does it cost to keep them per year?
13. If you use rope haulage, how many men do you have to take care of the haulage and what are the daily wages of each?
14. If you use rope haulage, how much do repairs on it cost per tear?
15. Do you have a foreman at the tipple and how much do you pay him?
16. How many laborers do you have at your tipple and what is the daily pay of each?
17. How many men do you have in your office and what is the daily pay of each?
18. If you have any other help not included in the foregoing questions what do they do and what is the daily pay of each?
19. How much coal do you burn at your shovel per day?
20. Is it necessary to haul water for the shovel?
21. If so what is the cost of hauling per day?
22. How much does your oil, waste, etc. cost you per day, per month or per year? (State which.)
23. How many tons of coal do you get per 25 lb. keg of powder?
24. What kind and size of powder do you use?
25. What does your powder cost?
26. What do your track repairs, ties, rails, spikes, etc. cost you per year?
27. How much do your small tools, drills, picks, shovels, etc. cost you per year?
28. Do you blast your overburden or bank?
29. If so, how many men do you have blasting the bank and how much do they receive per day?
30. Is it necessary to pump water from the pit?
31. How much water do you have to pump per day and to what height do you pump it?
32. How many pumpmen do you employ and what is their daily pay?
33. What is the depth of your overburden or the height of your
The above questions were sent to the following companies and the results obtained were as given:

The New State Coal Co., Tulsa, Oklahoma. No answer received.
The New State Coal Co., Collinsville, Okla. No answer received.
J. J. Stephenson Coal Co. Pittsburg, Kansas. No answer received.
Pratt-Durkee Coal Co. Shidmore, Kansas. Answer received saying that no data was available.
Miller-Durkee Coal Co., Scammon, Kansas. Answer received saying that no data was available.
The Smith, Scott, White Co., Chicaope, Kansas. Answer received saying that no data was available.
The Pittsburg-Scammon Coal Co., Scammon, Kansas. No answer re-
The E. H. Markham Coal Co., Curranville, Kansas. No answer received.
The Roy Millner Coal Co., Weir City, Kansas. No answer received.
The Ellsworth-Klaner Coal Co., Chicacpe, Kansas. Answer received saying that no data was available.
The J. R. Crowe Coal Co., Weir City, Kansas. No answer received.
The Sternberg Construction Co., Minden, Missouri. Letter returned by the postal authorities.
The Fischer Fuel Co., Millstadt, Illinois. Answer received saying that no data was available.

The following shovel companies were written to and reported that they had no available data upon the subject:
The Marion Steam Shovel Co., Marion, Ohio.
The Bucyrus Shovel Co., South Milwaukee, Wis.
The Thew Automatic Shovel Co., Lorain, Ohio.
A SUMMARY OF STRIPPING COSTS. (MISSION FIELD.)

I. Labor.

(a). Shovel crew.

1 Engineer. (Per day.) $3.38.
1 Craneman. ( " " ) 3.00.
1 Fireman. ( " " ) 3.00.
1 Oiler. ( " " ) 3.00. (Sometimes more.)
3 Dirt men. (2.25 each.) 6.75.

Total $19.13.

(b). Loading crew.

20 Shovelers. (2.62 each.) $52.40.
1 Driller. 2.62.
1 Drillers' Helper. 2.62.
1 Shot firer. 2.62.
3 Men barring coal. 5.24

Total $65.50.

(c). Haulage crew.

1 Engineer. $3.38.
1 Brakeman. 3.00.
1 Tracklayer. 3.00.
1 Helper. 2.75.

Total $12.13.

(d). Tipple crew.

1 Weigh boss. $3.00.
5 Loaders, etc., (2.49 each.) 12.45.

Total $15.45.

(e). Office help.—Not given.

(f). Superintendence. ($400.00 per month). $16.00.
(g). Miscellaneous Help.

1 Blacksmith. $3.00.
1 Carpenter. 3.00.
3 Pumpmen. (Each 2.62.) 7.86.
2 Ditchers. (Each 2.62.) 5.24.

Total $19.10.

II. Supplies and Repairs.

(a). For shovel.

3 Tons coal @ $1.10. $3.30.
Repairs—$800.00 per year. 4.00.
Other items not given. ——

Total $7.30.

(b). For mining coal.

4 kegs Powder.
Other items not given. ——

Total $7.00.

(c). Equipment other than shovel.

Nothing given.

(d). Office supplies.

Nothing given.

III. Depreciation.

(a). On shovel. (5% per year.) $6.25.

(b). On remainder of plant.

Nothing given.

Total $6.25.

IV. Interest.

(a). On shovel. (6% on $25,000.) $7.50.

(b). On remainder of plant.

Total $7.50.
V. Royalties.——None.

VI. Any other expense.

None given.

Total operating expense $175.36.

This expense does not include the interest, depreciation and supply charges on the plant exclusive of the shovel. With a daily output of 500 tons the above items make the coal cost 35.07 cents a ton and if to this the depreciation and other expenses is added the coal at this plant costs somewhere between 60 and 70 cents a ton. This great difference is due to the fact that much time is lost in this stripping every year on account of floods and the expense of getting the pit into shape after one of these floods is often very great.
A SUMMARY OF LABOR COSTS—GRAY MINE STRIPPING.

I. Labor.

(a). Shovel crew.

<table>
<thead>
<tr>
<th>Position</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineer</td>
<td>$3.38</td>
</tr>
<tr>
<td>Craneman</td>
<td>3.00</td>
</tr>
<tr>
<td>Fireman</td>
<td>3.00</td>
</tr>
<tr>
<td>Oilier</td>
<td>3.00</td>
</tr>
<tr>
<td>Dirt men (2.25 each)</td>
<td>4.50</td>
</tr>
</tbody>
</table>

Total: $16.88

(b). Loading crew.

<table>
<thead>
<tr>
<th>Position</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shovelers (2.62 each)</td>
<td>$39.30</td>
</tr>
<tr>
<td>Drillers (2.62 each)</td>
<td>5.24</td>
</tr>
<tr>
<td>Shot firer</td>
<td>2.62</td>
</tr>
</tbody>
</table>

Total: $46.16

(c). Haulage crew.

<table>
<thead>
<tr>
<th>Position</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver</td>
<td>2.62</td>
</tr>
<tr>
<td>Coupler</td>
<td>2.62</td>
</tr>
<tr>
<td>Trip rider</td>
<td>2.62</td>
</tr>
</tbody>
</table>

Total: $7.86

(d). Tipple crew.

<table>
<thead>
<tr>
<th>Position</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineer</td>
<td>$3.38</td>
</tr>
<tr>
<td>Loader</td>
<td>2.49</td>
</tr>
</tbody>
</table>

Total: $5.87

(e). Office help—Not given.

(f). Superintendence (Estimated.) $10.00

(g). Miscellaneous help.

<table>
<thead>
<tr>
<th>Position</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumpman</td>
<td>2.62</td>
</tr>
</tbody>
</table>

Total operating expense (labor): $89.49
With the output of the plant at 250 tons per day, the labor charges per ton will be 35.75 cents per ton. This is a little higher than those at the Mission Field plant and this difference is probably due to the difference in the size of the plants.
A SUMMARY OF DAILY LABOR COSTS.

CONSUMERS' COAL CO.

I. Labor.

(a). On shovel.

<table>
<thead>
<tr>
<th>Position</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Engineer</td>
<td>$3.38</td>
</tr>
<tr>
<td>1 Crane man</td>
<td>3.00</td>
</tr>
<tr>
<td>1 Firemen</td>
<td>3.00</td>
</tr>
<tr>
<td>1 Oiler</td>
<td>3.00</td>
</tr>
<tr>
<td>1 Pan man</td>
<td>3.00</td>
</tr>
<tr>
<td>1 Conveyor man</td>
<td>3.00</td>
</tr>
<tr>
<td>4 Dirt men (2.62 each)</td>
<td>10.48</td>
</tr>
<tr>
<td>3 Men moving shovel (2.62)</td>
<td>7.86</td>
</tr>
</tbody>
</table>

**Total** $36.72.

(b). Loading crew.

<table>
<thead>
<tr>
<th>Position</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 Shovelers</td>
<td>$20.96</td>
</tr>
<tr>
<td>2 Drillers</td>
<td>5.24</td>
</tr>
<tr>
<td>1 Shot firer</td>
<td>2.62</td>
</tr>
</tbody>
</table>

**Total** $28.72.

(c). Haulage crew.

<table>
<thead>
<tr>
<th>Position</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Drivers</td>
<td>$7.86</td>
</tr>
</tbody>
</table>

(d). Tipple crew.

<table>
<thead>
<tr>
<th>Position</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 men at 2.49 per day</td>
<td>$9.96</td>
</tr>
</tbody>
</table>

(e). Office help—Not given.

(f). Superintendence (Estimated) | $10.00 |

(g). Miscellaneous help—Not given.

**Total operating expense (labor)** | $93.26.

With an output of 200 tons per day, the labor charge per ton
is 46.63 cents. This is excessively high due to the large number of men necessary to run the shovel. An authority on stripping costs in this field stated that coal from this plant could not possibly cost less than $1.00 a ton to produce.