The Cherokee and Crawford County Coal Field With Analyses of the Coal

by C.B. Carpenter and H.R. Brown

1915

Submitted to the Faculty of the School of Engineering of the University of Kansas for the Degree of Bachelor of Science in Mining Engineering

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A THESIS SUBMITTED TO THE FACULTY
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PREFACE.

In writing this thesis on the Coals of Southeastern Kansas, the authors have been actuated by the desire to make a more thorough study into the conditions of mining, costs of mining, and of production, and of the fuel value of the coal of the district, than a certain familiarity with the district would allow.

We freely admit that time allowed for a study of this kind is too short for students who are otherwise engaged to make m more than a brief study of the field involved. We chose the subject ourselves, and we have pursued it out of the desire to further our own knowledge of this field. If it can be of any help to future students we shall be very glad of the assistance offered them.

Lawrence, Kansas, May 15, 1915.

Clark B. Carpenter

Hugh R. Brown

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GENERAL DISCUSSION OF THE DISTRICT

HISTORY

The history of coal mining in Cherokee and Crawford counties begins in Cherokee county shortly after the county was opened for settlement, in 1866 when coal was discovered in several places in the southeastern part of the county, particularly along the high lands south of Shawnee creek, to the east and south of Columbus. For a number of years this county lead in coal production, but within the past twenty years Crawford county has taken the lead and held it every since. At the present time the production of coal in Crawford county is double that in Cherokee county while the two counties together produce 94% of the total coal production of the state.

LOCATION

The term southeastern Kansas coal field as used in this paper takes in Crawford and Cherokee counties in Kansas. These counties are in the eastern tier and are the first and second counties from the south border of the state.

TOPOGRAPHY

This area is unique in that the surface of the area in which mining is carried on is comparatively flat. Hills occur only in those places where there are sandstone areas, or as in the central and northern part of Crawford county the Ft. Scott lime stone sets in. The very fact that the surface is comparatively level and that the coal beds pitch downward at the rate of fifteen to twenty feet to the mile, and to northward one to two feet to the mile has made a part of this area extremely favorable to steam shovel work.

Streams are abundant, due to the large amount of rain fall of this district. The ridge or dividing line between the streams flowing north and east and those flowing south and east begins about a mile south of Mulberry and extends west by north across Crawford county. North of this ridge the streams eventually empty in to the Marmaton river, south of the ridge the streams empty into Spring river, if they are east of the "hump" which extends south from Girard, through Cherokee and Columbus, West of this "hump" the streams flow into the Neosho river.

In the southern central part of the district the hills reach a height of some thousand to a thousand and fifty feet, while in the northern part of the district while in the northern part of the district the height of the hills are practically the same. The vertical distance between extremes in the district is not over 200 ft.

Erosion over the greater part of the district has practically ceased. The fact accounts for the comparative flatness of the district.

GEOLOGY AND LITHOLOGY.

The base of the geological structure of this area is generally taken as the Mississippian limestone which outcrops over a small area in the south eastern area of Cherokee county, in and around Galena. Coal is sometimes found in small areasover this outcrop but in no instance has it ever been in sufficient extent and depth to be mined. The coal measures lie immediately above the Mississippian lime stone. The Cherokee shales lie at the base of the coal measures. They range from four-hundred to five hundred feet in thickness, and occupy the surface over nearly all of Cherokee county, southeastern, eastern, and northeastern parts of Crawford county. There is a slight variation from place to place but in general they are remarkably uniform in thickness. Shales lie both vertically and longitudinally. They vary in color from a light gray to a jet black shale of bituminous character. Some of the shales are fine grain while others are course and extremely arenaceous. Soil produced from these shales is generally grayish in color, unless bituminous matter is present, in which case the soil is black.

In many places small, irregular, lentils of limestone are found within the shales. Occasionly these lentils are of several miles extent laterally. There are no known lentils within the coal producing area. Sandstones on the other hand are very abundant in the Cherokee shales. The beds of sandstone are not however, of persistent character. They have a great vertical range, some being found near the top and others near the bottom of the coal measures. Near Cherokee there is a fairly large area, while in the vicinity of Arcadia sandstones are also found. At Fuller, Crawford county Kansas, the shales are so arenaceous in character that they must be blasted before they will yield to the attacks of the steam shovel.

In the central, western and northern part of Crawford county, the Cherokee shales are covered by the Ft. Scott lime stone. At Girard this stratum is eighteen feet thick. It is very impure, is white in color, and has no commercial value. Overlying the Ft. Scott limestone is a series of alternate of shales and limestones, but a discussion of them is beyond the scope of this paper.

METHODS OF MINING

Two methods of mining are in use in this field, shaft mining using room and pillar system and strip pit mining. In Cherokee and Crawford counties the room and pillar system only is in use in shaft mining. Strip pit mining was formerly carried on in areas near the out-crop, but since the advent of the steam shovel this is not the case, since by its use over-burden up to a depth of thirty-five feet in thinkness can be readily removed. The room and pillar system is usually used in seams ranging from three feet and upwards in thickness. The roof should be of good material and firm. Waste material, when mining coal of this thickness is not sufficient to form pack walls so that wooden props must be used to support the roof. In any case the system employed must be adepted to the local donditions.

SHAFT MINING. ROOM AND PILLAR SYSTEM.

The room and pillar system is used in seams rangeing from three feet and upwards in thickness. There are two special reasons why the room and pillar system is employed in the thicker coal beds:

First, a large amount of coal is removed,

Hamilton. No. 8.

Drilling Machine.

leaving a large vacant space and with a comparatively small amount of waste. It has been found less expensive and far more practical in thick coal beds to leave a column of coal standing every few feed as a natural support to the roof, than to remove and then introduce material from outside at an additional expense. Pillars may or may not be afterwards removed. In general in this field the pillars are not removed.

Second, it so happens that in Kansas the thick coal beds capable of being worked by the room and pillar system lie in the territory where the clay veins, horse-backs, faults, etc., are so abundant.

There are two methods generally employed in the room and pillar system namely, double entry and single entry methods, or at times a combination of these two is used. The double entry is probably the best and is used most extensively.

DOUBLE ENTRY METHOD. The shaft is sunk and the simp made. The shaft bottom is built from sixteen to twenty feet wide for about three hundred feet on each side of the shaft, or on one side of the shaft, depending on the method of recieving and disposing of loads and empties of the shaft. If coal is caged or loaded from both sides of the shaft; the first three hundred feet of the main entry will be the width of the shaft, but if the coal is loaded from only one side of the shaft this length of entry will be much less, and other provisions will be made for disposing of the loads and empties.

The main entries, two in number, are a continuation of the bottom and vary in width from six to twelve feet, in height from five to six feet depending upon the low and the local conditions. They are driven, one each way from the shaft bottom. At a distance from twelve to forty feet from these entries and parallel to them, the second entry, of approximately the same dimensions as the first, is driven. These entries are driven in this manner to the boundries of the property in which the mine is located. One of these entries is used as the main intake and the other as the main return.

At a distance of from one hundred fifty to three hundred feet along these main entries and perpendicular to them, side entries or room entries are driven in pairs. The pillar between these entries varies in thickness from twelve to twenty feet. These entries vary from six to twelve in width and five to six feet in height. Rooms are driven from these entries in some cases in both directions, in others in only one direction. These rooms are generally one hundred and fifty feet in depth when completed and are turned off these entries on from thirty to forty foot centers. The first eight to twelve feet off the entry, termed the room neck, is driven narrow, and then the room is widened either in one direction or both directions, to the room width which may vary from twenty to thirty feet. This leaves room pillars varying in thickness from six to fifteen feet between rooms.

The main entries, the side entries, and the rooms are connected by cross cuts at varying distances as the work advances. These cross cuts are for ventilating purposes and as soon as the new one is made between two entries ar rooms the one behind is stopped up with any material which may be at hand.

VENTILATION . Ventilation of these mines is accomplished by either the plenum or blowing, or the vacuum or exhaust system. In any case a separate air shaft is sunk which is required by law to be not less than three hundred feet from the main shaft, and which may be used as an escape in case of accident. Either the air shaft or the main shaft may be used as the down cast or the upcast shaft as is desired. Fans are reversible blowing or suction fans.

UNDERCUTTING AND SHEARING. The prevailing practice in this district is to shoot the coal off the solid, that is to shoot the coal without undercutting or shearing. Mining as applied to long wall work and which means undercutting the coal is not carried on. This practice of solid shooting is bad and it results in much fine coal, besides great danger to the shot firers. Both black powder and dymanite are used in shooting the coal. Dynamite is, however, prohibited unless its use is authorized by the pit boss, but this ruling is not generally enforced. No mining machines are used.

Haulage. Haulage roads are located in either one main and side entry, or in both. Mule haulage is generally used but gasolene and electric motors are used in some cases.

HOISTING. Hoisting takes place in double compartment shafts. Safety, self dump cages are used. Geared hoists are used in some of the smaller mines and in the larger shallow mines. First motion hoists are used in the deeper mines. The hoisting drums vary in diameter from four to eight feet, cylinderical drums only being used. Balanced hoisting is always done.

The coal when hoisted is dumped into a hopper and weighed. It is then released by opening the hopper door and is allowed to slide down on the screens, which will be covered in case run of mine coal is desired, or as is generally the custom it is screened into three grades, lump, nut, and slack coal. Shaking screens and revolving trommels are used in the screening operation.

COST OF SINKING AND EQUIPPING A 60FOOT SHAFT.

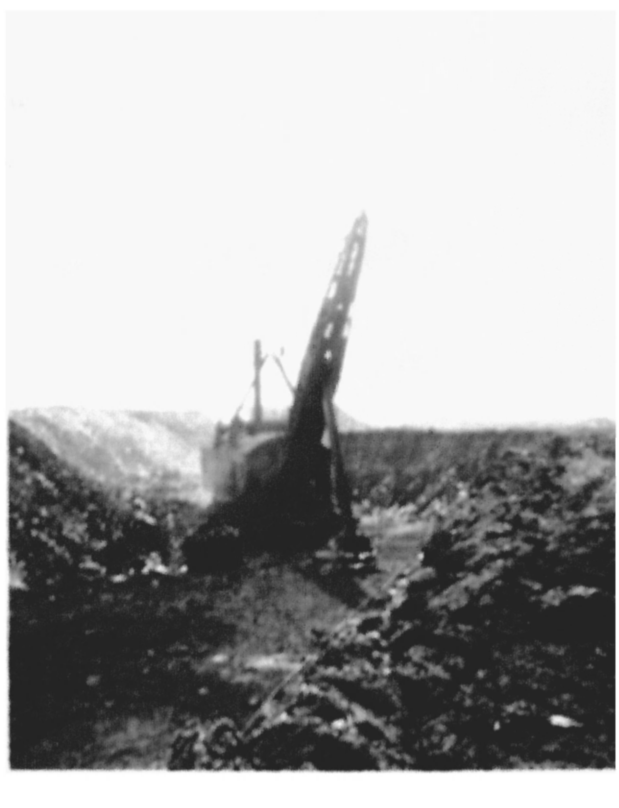
Hoisting engine	$ 250.00
Second Hand Hoist	125.00
One Boiler	400.00
Setting boiler	181.30
Centrifugal pump	25.00
Motor and pump	200.00
One motor	57.00
One fan	65.00
Sheave wheels for hoisting	75.00
Two cages	450.00
One blower for forge	14.00
92 pit ~~xxxxx~~ cars @ 10.00	920.00
Fittings for cars	64.80
Tool steel	55.11
Two rail benders	54.55
Lumber	1054.80
Nails	9.85
Cement	284.61
Chat for concrete	21.07
Miscellaneous machinery	78.15
Pipes and fittings	91.52
Bolts	58.61
Corregated iron and other iron	371.88
Steel plates	29.36
Flat sheets	25.00
One five ton scale	75.00
One wagon scale	75.00
Scale repairs	2.38
Three mules and harness	600.00
Belting	5.92
Miscellaneous supplies	100. 0
Twelve car bumpers	5.00
Fourteen car plates	7.00
Freight	33.21
Construction account	
Labor, sinking etc.	4593.72
Carpenters etc.	1531.26
TOTAL	11992.10

Mine had produced 7000 tons before being put on a tonnage basis.

STRIP PIT MINING.

Stripping with horses. Stripping with horses and scrapers has been carried on in Cherokee county every since the county was opened for settlement in 1866. Stripping has also been carried on in this same manner in Crawford county. The early stripping with homses was confined to the districts close to the outcrops. Old strip pits may be found which have been worked in this manner all around Pittsburg especially to the north and east for a distance of ten or fifteen miles north of Pittsburg and south and west three or four miles especially along the creeks. The average paying depth was about ten feet of overburden by this method of stripping.

STRIPPING WITH STEAM SHOVELS. Stripping with steam shovels is a new phase of coal mining which has been introduced in southeastern Kansas in the last few years and which has assumed such proportion that great interest attaches thereto. Mining coal by stripping, or removing the overburden by steam shovels, not only is likely in a way to perturb the coal market of south east Kansas temperarily, but is sure to add very materially to the total coal supply of the state, and incidentally to lend active assistance to the manufacturers of steam shovels by encouraging them to build machines of a size



Steam Shovel Operation.

before unknown. In fact, it is claimed that the two largest shovels ever built are now in operation near Pittsburg, and rumor has it that others as large or larger are under contemplation.

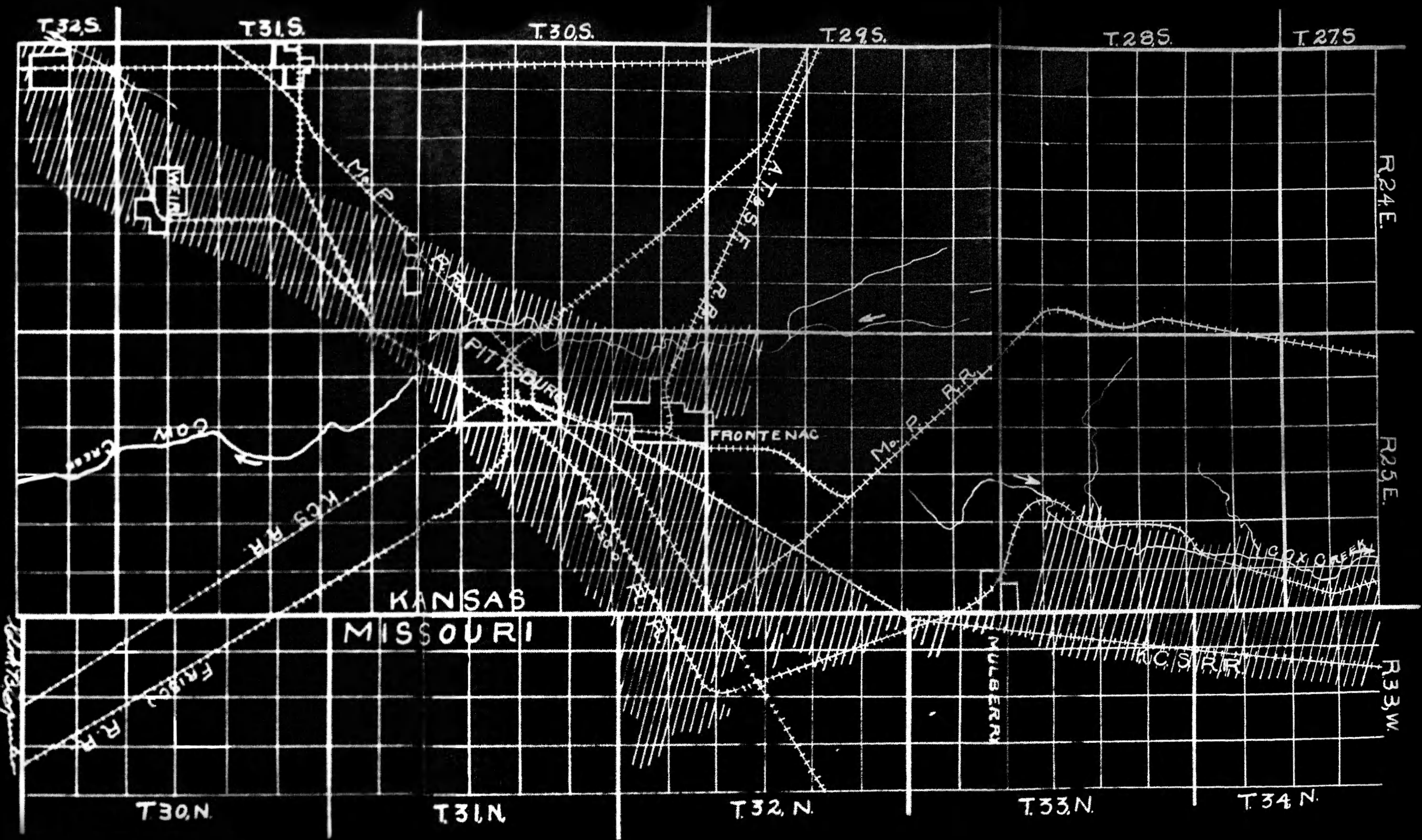
The steam shovel which began the present activity was introduced by the Miller-Durkee Coal Co. in April, 1910, on their coal lands near Scammon in Cherokee County, where it has been in continuous and successful operation ever since. Subsequently some thirty other steam shovels of varoius sizes have been installed in Cherokee and Crawford Counties and are now in more or less constant use.

The first steam shovel ever used in the district was introduced during the late seventies. It was put into use not far from the present site of Midway, where it was used for a few months. It did not prove entirely satisfactory, probably beaause it was too small and did not have the advantsge of the full swing of the shovel beam common with modern shovels. From the late seventies until 1902 no further effort was made toward the introduction of the steam shovel, but in that year Miller Bros., of Mulberry, put a steam shovel in operation on land northwest pf ~~xxxxxx~~ Mulberry. This proved to be fairly satisfactory, but for some reason its use was discontinued.

One can hardly believe the possibilities of modern methods and the monstrous steam shovels. It is practical to remove thirty-five feet of overburden from this same bed of coal and successful operators fully expect it will pay them to remove as much as fifty feet of overburden. In this way a long narrow strip of coal is made available throughout which the coal lies too deep to be recovered by horse power and too shallow to furnish a suitable roof for mining by the shafting and room and pillar method.

Area and amount of coal available.

The accompanying map, drawn to scale, of south-eastern Kansas, shows in outline the area now recognized as suitable for coal mining by use of the steam shovel. It extends to the southwest almost to Columbus. In fact it is well known that there are two or more thin beds of coal extending much farther to the southwest, each of which could be reached by this process of mining should the price of coal advance materially. This area, however, is hot herein considered. To the northeast the area extends by way of Scammon, Weir, Pittsburg, Frontenac, Minden, Mulberry, Arcadia, and beyond. Here neither nature nor the industries recognize state lines. The area crosses from Kansas into Missouri and passes to an unknown distance, probably far up beyohd Ft. Scott towards Rich



MAP - POSSIBLE STEAM SHOVEL COAL STRIP PIT AREA. S.E. KANSAS.

SCALE OF MILES

Hill. The surface drainage of the country is to the southeast in the southern portion, and to the north east in the northern portion. In this way the available area extends up westward along the streams and valleys, making an exceedingly sinuous line for the western boundary. The eastern boundary is substantially the outcropping line of the coal seam. The country is so level that usually the outcropping cannot be detected at the surface because the coal has gradually yielded to decay, and thus grades into soil. The fine grained shales are so nearly water proof that they form an excellent protector for the coal, so that in most places one has to go but a few rods back from the outcropping line to obtain nice, fresh coal equal in quality to that obtained by shafting further back to the west. Of course, necessarily, there is more or less coal which has only partially yielded to oxidation, the "dead coal" of the operator. The amount of such coal, however, seems to be so small in the aggregate that only a small percent of the total acreage should be deducted for this cause from the total area. Naturally the dead coal is most abundant where the overburden is thinnest and therefore the actual width of the strip of dead coal varies from place to place, depending upon the details of the local erosion. Should the area have been well supplied with vertical fissures produced by dynamic disturbances as is the case in many coal mining regions, probably a very large proportion of the coal area available would be sufficiently altered to render the coal unmarketable. There is but one line of fissures or faulting known in the area. This tends substantially parallel to the outcropping line and causes considerable loss of coal. It so happens, however, that a considerable portion of this line lies to the west within the area of shafting and therefore does not materially curtail the acreage of good coal available to the shovel.

A somewhat careful estimation of the coal area which may be mined by the steam shovel process as shown on the map yields about 60 square miles. This is after making a small allowance for the dead coal areas and counting out a few square miles for hills where the overburden is beyond forty feet in thickness. It does not include the southwestern extent already mentioned where lesser seams of good coal are known to exist over wide areas nor does it include north extent from Arcadia toward Rich Hill, Mo. As this coal is the same seam or bed which is mined by shafting immediately to the west, its thickness and quality throughout the entire area is substantially the same as that already mined by shafting. This is about four feet in maximum thickness and three feet minimum thickness with an average of about three and one-half feet. A rule easily applied for finding the tonnage of workable coal is to estimate a thousand tons of coal per acre for each foot in thickness where the coal is mined by the room and pillar method. Where it is mined by the stripping method it will yield a slightly larger amount. Probably it will be safe to calculate three thousand tons to the acre for the entire area outlined on the map of sixty square miles. This gives us about 38,400 acres of available coal land and one hundred and five million tons of available coal. A conservative estimate would place the available coal at one hundred million tons.

Equipment for Steam Shovel Strippit.

In operating these steam shovel strippits as now practiced, the following equipment is used.

Top Equipment:- The top equipment must contain the following, and may have other conveniences added; A tipple house, for hoisting the coal from the pit and loading it into railroad cars for shipment; a coal hoisting engine and boiler, capacity to conform with the size of the plant; well and pump for supplying water to all boilers and all domestic uses, office, tool shed, and powder house. Fortunately, a deep well may be put down at random to from 800 to 1200 feet and obtain the same kind of water as is used for municipal supply at Pittsburg, Weir and Girard.

Pit Equipment:- The pit equipment must contain the steam shovel, "dinkey" engine and boiler for hoisting the coal, pit tracks for steam shovel and all mine cars, and pumps

Steam Shovel Tipple

Car Hoisting Crane.

with boiler for draining the pit when such is necessary. Frequently the tipple engine does all the hoisting and the "dinkey" engine is used only for pit track hauling. In the southern part of the area some of the mines have introduced electric power to a limited extent drawing their power from Inter-Urban electric wires. No Inter-Urban lines cross the northern part of the area and none of the mines are supplies with electric power. Here gasoline engines are used to a varying extent, usually for pumping but in some instances for hoisting coal in the tipple-houses.

The tipple-house usually is a simple affair, and made as cheaply as possible on account of the temporary nature of the business. The coal is emptied through the top of the house and passes over screens as desired and drops into coal cars properly placed on tracks beneath.

Two distinct varieties of steam shovel are used, a small one of one yard capacity, used in three mines for loading into the pit cars, and the shovel of mammoth size for stripping. The latter sometimes weighs as much as 235 tons and has six to seven yard capacity. The boom poles of these are from 50 feet to 90 feet long and the machine can readily strip to a depth of from 40 to 50 feet. Naturally some operators prefer a different make. It seems that all of them may be operated successfully if the location is properly chosem and experienced men conduct both the mine and sales department.

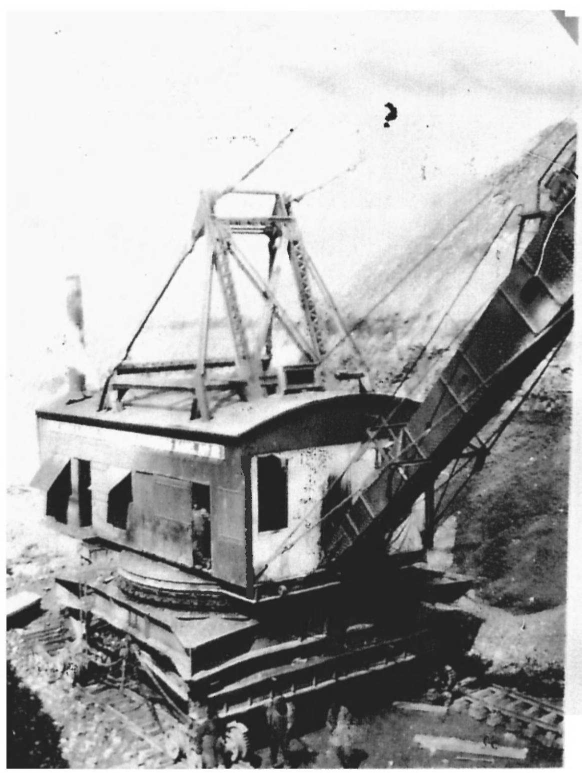
The capacity of the machines depend not only on the size of the machine but also on the skill of the operators. Skillful operators are half of the machine. They keep the machine going at its full capacity during the entire working day. Repairs for these machines average about $1,000.00 for the first year and increases after the first year. Careful management will, however, reduce this item of expense.

Methods of Opening Pits. Three general methods of opening pits are employed producing the so-called "bar-pit", "box-pit" and "side-pit".

Bar Pit. In the bar pit the overburden is generally too deep to be removed at a single trip of the steam shovel across the pit, consequently about half of the overburden is removed and deposited at the side, then on the return trip of the shovel, the depth is removed and is deposited on the unfinished pit made by the shovel's first trip.

Box Pit. The box pit is the name applied where the shovel simply burrows down to the coal and then begins a cut, as in the side pit. All Pits are side pits after being opened. In opening a side, the shovel digs down to the

Views of Steam Shovels.



Views of Steam Shovels.

coal on about an eight percent grade, dumping the waste at one side of the pit.

After the pit is opened the shovel moves forward removing the overburden until the limits of that particular pit are reached. It is then turned and digs a new path back to the other end of the pit depositing the waste in the cut made by the first cut.

Mining the Coal;- After being uncovered by the shovel holes are bored in the coal with ordinary auger drills. These holes are squibbed with a small piece of dynamite, great care being taken to see that the squibb ing fuse is entirely removed from the squibbed hole. Black powder is then used to "shoot" the coal. In performing this work the there is always one "coal shooter" and two "helpers". The coal shooter squibs the holes, loads them with black powder and fires the blasts. The helpers drill the holes and do whatever other heavy work is to be done. The coal is next loaded into cars to be moved from the pit to the tipple. At present there are two general methods of performing this work; first, by shoveling the coal into the cars by hand, and second by the use of small steam shovels. The first one of these methods is the one generally used, and usual number of shovellers necessary varying from four to twenty or more. Fourteen men ought, under favorable circumstances, to load not less than 300 tons per day.

The second method is yet in its experimental stage. It has one distinct advantage, namely, its ability to dig thru "horse backs". At present there are only three loader shovels in use. They have a capacity of about 400 tons each per day, weigh from 30 to 35 tons, have 28' booms, 22' dipper stick, and one yard dipper. There are one each of the Bucyrus, Marion and Marion-Osgood shovels doing loading work. The coal is next moved from the pit to the tipple. Here again we find two or three methods in use. In some ~~instances~~ pits mule trains are used to move the cars to thee slope, while in others "dinkey" engines are used to move the coal to the slope and in some instances to move it from the pit to the tipple itself. The other method is to have a revolving crane with a long boom, mounted on trucks which will run along the track on ground level at the edge of the pit. The boom of the crane reaches over into the pit, picks up a car, lifts it from the pit, and deposits it on the main train track, situated on the ground level back of the crane track. Such pit-cars have about four tons capacity. In some instances the crane instead of being located on the side of the pit, is located on the coal back of the shovel. The tram track is then located on the edge of the pit. The crane again lifts the empty car from the tram track into the pit, and hoists out the loaded car.

The Coal next goes to the tipple where it is xx screened and emptied into cars. Mine run, nut, and slack are the general grades of caol produced. These tipples are in reallity only frames for the screens. It is the universal custom here for the coal companies to depend entirely upon the railroads to weigh the coal.

The question of water supply is one think that has caused more or less trouble. In some instances deep wells have been sunk to supply the necessary water. Where this has been done the water is not always of the best quality and often results in injury to the boilers in which it is used. Where the wells are not used, surface ponds are depended upon to supply the water. In some cases the surface water which collects in the pits may be used, but such water usually contains a large amount of soluble sulphates and is therefore unsatisfactory. During wet weather these pits are much bothered by water so that occasionally work must be suspended. Therefore, every pit should be well equipped with drain pumps. Pumps now in use are of two general types, the centrifugal and the Chinese. The chinese pumps are generally constructed on the ground. The have a very great capacity and entail but little expense after installation. Jets are sometimes used but are not found to be generally satisfactory.

COST OF INSTALLING STEAM SHOVEL PLANT.

One steam shovel Marion # 250	$23000.00
Freight on shovel	1810.00
One set of teeth, syphon collectot ring and 100# rails and bridle	482.29
40 pit cars at $59.25	2370.00
One car 20# rails and spikes	921.22
1 #3 brass fitted pump	73.75
Railroad switch complete about 3/4 mi.	7450.00
Six 20# switches complete	135.00
Railroad right of way to line track	1000.00
One well 856 ft. deep complete and piped to engine	1400.00
Drain ditch	333.63
35 ft. of 24" tiling for ditch	32.00
86 tons of coal	129.75
Teaming	36.50
One 6½ by 12" locomotive	2500.00
1500 pit ties 4x6x5	275.00
50 white oak ties 6-6-8	22.50
One engine and pump	125.00
Six tons of 12# rails	166.00
Pond	212.78
Hose for shovel	15.00
Pipe lines	319.12
Tipple account	2645.64
200 ties for pit	20.00
Pipe fittings	54.32
Supplies	12.18
Equipment account	227.22
500 ft. 3/4 inch cable	33.18
Two 10# hammers, spike bar and hatchet	4.40
Engineering, drafting and stationary	138.30
Incorporating	268.00
Pay roll, salaries and office expense, fixtures	1486.64
Total	$ 47699.39

COST OF PRODUCING COAL AT A STRIP PIT FOR THE YEAR 1914 WITH THE EXPECTION OF MONTH OF DECEMBER.

Month	Tons	Stripping	Loading and selling	Total
January	952	1.336	1.672	$ 3.008
Feburuary	2540	.549	.7669	1.3316
March	3444	.2296	.9207	1.150
April	1885	.3020	1.045	1.348
May	3105	.157	1.02	1.177
June	4258	.216	.84	1.056
July	3632	.358	.90	1.360
August	1639	.578	1.253	1.831
Spetember	3971	.245	.854	1.100
October	3581	.352	.982	1.334
November	4349	.293	.878	1.171

Total production for eleven months 33356 tons.

Average cost per ton $1.28

Total for ten months omitting January which was not a representative month 32404 tons.

Average per month 3240.4 tons

Average cost per ton for ten month period

$ 1.229

SAMPLING AND ANALYSIS

SAMPLING

In taking samples two methods of sampling were used, i.e. car sampling and face sampling in the mines.

CAR SAMPLING. Car sampling consists in collecting the sample from railroad cars, as loaded for shipment. If the coal is run of mine, i.e. not screened, the sample is all taken from one car, of the other hand if the coal is not run of mine, i.e. the coal is screened into several grades, and each grade loaded into a separate car, parts of the sample are taken from each car, or a sample of the particular grade of coal is taken from a single car.

As loaded, the railroad cars do not receive their coal continuously from the same part of the mine, but from different parts of the mine because of the method used in caging the coal at the bottom of the shaft. Thus a sample taken from a car would, if carefully taken, give a representative sample of the mine.

The method of taking the mine sample under these circumstances consists of taking a small shovel-full of coal from each car after each mine car is dumped until a total sample of about 200 pounds of coal is collected. The coal from the different cars is then placed on a piece of forty ounce duck cloth, about four feet by four feet in size, and is thoroughly mixed. The largest pieces of coal are then broken down to small size, and the mixing continued. The sample is next quartered, opposite quarters being rejected and the remainder is further reduced in size, mixed, quartered and opposite quarters rejected each time until the sample of about two pounds is finally taken.

This sample is then placed in an air tight fruit jar and is thus transported to the laboratory for analysis.

FACE SAMPLING. Face sampling consists in taking the sample at the working face in rooms or entries, different parts of the sample being taken from rooms or entries widely distributed throughout the mine in order to obtain a representative mine sample.

The method consists in placing the canvas as described above, immediately in front of the face of the coal seam, and in making a shearing cut from the top to the bottom of the seam, about four to six inches wide and two inches deep, and allowing the coal to fall on the canvas. This procedure is followed in the various rooms and entries until the total sample of 150# to 200# is secured.

The reduction, quartering and final selection of the sample is the same as that described for car sampling.

PREPARATION OF THE SAMPLE FOR ANALYSIS.

The sample as taken at the mine is first run through a small grinding machine and further reduced in size. It is next run through a Jones sampler and half the sample rejected. The half of the sample taken becomes the laboratory sample for analysis. It is further reduced in the grinder and finally bucked down until it would pass through an eighty mesh screen. The sample ~~was~~ is then replaced in the jar and is set aside for analysis.

ANALYSIS OF SAMPLE.

The procedure followed in the analysis is that recommended by the committee on coal analysis, of the American Chemical Society. This procedure is as follows:

MOISTURE DETERMINATION. Dry one gram of the coal in open porcelain or platinum crucible at 104 to 107 degrees Centigrade for one hour, best in double walled bath containing pure toluene. Cool in a dessicator and weigh covered. The loss in weight of the sample, divided by the weight of the of the sample taken gives the percentage of the moisture in the sample. In the case of a one gram sample, the loss of weight is centigrams gives the moisture percent direct.

(A) Hillegrand and Badger in their discussion of the errors in the determination of moisture in coal state that methods of determining moisture in general, belong to the class of indirect methods, which in the absence of a simple reagent are most convenient and expeditious; but when applied to so complex and easily oxidized a substance as coal, a number of reactions occur which greatly modify the results.

In general the reactions are:

(a) The sensitiveness of coal to atmospheric conditions, especially when finely powdered.

(b) The giving off of volatile substances other than water.

(c) The Absorption of oxygen which may take the form of: 1. Oxygen added directly to the coal substance. 2. Oxygen combined with the carbon and split off as carbon dioxide. 3. Oxygen combined with hydrogen and split off as water.

All of these reactions have been recognized by many investigators, and though they may not appear with equal prominence in all coals, undoubtedly most all of them take place simultaneously in all cases, with one or another predominating.(A)(W.F.Hillebrand and W. L. Badger. Eighth Int. Cong. Applied Chem. Vol. 10. 1912.)

(B) With coals high in moisture and in all cases when accuracy is desired, determinations must be made both with the coarsely ground and with powdered coal. The coarsely ground coal will usually show a higher percentage of moisture than the powdered coal. In case great accuracy is desired the sample should be dried in vacuo over sulphuric acid. For coals containing not over two percent of moisture satisfactory results can be obtained by drying for 24 hours in a watch glass over sulphuric acid at atmospheric

Pressure. (B) (Report of committee on coal analysis Journal of the American Chemical Society. Vol 21. 1899.)

(C) Powdered coal after drying is exceedingly hygroscopic, probably even more so than calcium chloride. This condition together with the complex nature of the substance gives rise to variations in analysis far beyond those which most analysts, who have not studied the matter carefully, realize. It has seemed necessary, therefore to the committee to place rather liberal estimates on the allowable variations in the analysis, and in addition to this, we wish to impress it upon every analyst that it is necessary for him to convince himself by personal experiment, first, that the variations in his own method of procedure do not cause errors greater than the allowable amount and, second, if possible, that the methods give results which will agree with those of other analysts. (C) (Journal of Industrial and Engineering Chemestry. June 1913, Page 517. Preliminary Report for the Committee on Coal Analysis of the American Society for Testing Materials and the American Chemical Society.)

VOLATILE COMBUSTIBLE. The term volatile combustible matter does not represent any definite compound or class of compounds which exist in the coal before heating. Mr. N. M. Austin of Rose Polytechnic has demonstrated that some of the carbon which escapes in the form of volatile compounds on rapid heating is separated in the free state and remains as fixed carbon where the first heat is applied slowly. It is well known, too, that many of the compounds contained in the gas and tar formed by heating bituminous coals are decomposed by heat with the formation of free carbon.

Procedure. Place one gram of fresh, undried, powdered coal in a platinum crusible weighing 20 or 30 grams and having a tightly fitting cover. Heat over the full flame of a bunsen burner for seven minutes. Crucible should be supported on either a platinum or a nichrome triangle, with the bottom of the crucible six to eight centimeters above the top of the burner. The flame should be fully twenty centimeters high when burning free, and the determination should be made in a place free from draughts. The upper surface of the crucible cover should burn clear, but the under surface should remain covered with carbon.

To find the weight of volatile combustible, subtract the weight of the moisture found above from loss of weight found here. When one gram sample is used the difference found expressed in centigrams gives percentage direct.

The most serious objection to this method is the claim that certain non-coking coals suffer mechanical loss from the rapid heating. No evidence to support this contention has been submitted.

ASH. In the determination of ash, either a new sample or the sample used in the moisture determination may be taken. Burn the sample in an inclined and open crucible until free from carbon. The heat is applied slowly at first in order to prevent caking of the coal by driving off the volatile combustible matter too rapidly.

Procedure. The procedure as followed by us, was as given below: A fresh one gram sample was weighed out in a porcelain crucible and placed in a muffle furnace which had just been started. By slowly increasing the temperatureof the furnace the volatile combustible was driven off, leaving the coal in a powdered condition. The temperature was then increased, and the crucible was left in the furnace until the carbon was completely burned. The crucible was then removed to a dessicator while still hot, cooled and weighed. The loss in weight subtracted from the weight of the sample taken represents the weight of the ash, which expressed in centigrams gave the percent of ash direct.

FIXED CARBON. The loss in weight from the ash determined was composed of the weights of moisture, volatile combustible, and fixed carbon contents of the sample. The sum of the weights of moisture and volatile combustible, as found in the previous determinations, subtracted from the total loss as found in the ash determination, gives the weight of fixed carbon. This weight expressed in centigrams gives the percentage of fixed carbon direct.

SULPHUR. Sulphur is not usually determined in proximate analysis of coal, but it is determined in case calorimeter determinations are made to obtain the heating value of the coal. Sulphur occurs in coal in the form of calcium sulphate, or gypsum, and iron pyrite. It is maintained by some that free sulphur sometimes occurs in coal. In any case sulphur may be determined by one of the following methods: Eschka's method for the determination of sulphur or by the treatment of the washings from the calorimeter.

Determination of Sulphur by the Eschka Method.

Sulphur is determined by the Eschka method. The Eschka mixture is made by thoroughly mixing light calcined magnesium oxide two parts, with anhydrous sodium carbonate one part. A sample of the coal weighing 1.3736 grams is thoroughly mixed with about two grams of the mixture in a porcelain crucible. The mixture is spread over the top of the coal to form a cover. The crucible and its contents is placed on a triangle in a slanting position and the mixture is burned over a natural gas flame. In starting the burning a very low flame must be used to avoid driving off volatile matter so fast that the sulphur excapes unburned. The contents of the crucible should never be heated hot enough to cause the blackening of the Eschka-mixture.

After the crucible has been heated very slowly and and cautiously for about thirty minutes the heat is increased, and after the crucible becomes red hot the contents are stirred occasionally until all black particles are burned out, a condition that indicates the process is completed. The crucible and contents are then allowed to cool, and the contents are transferred to a 200-cc. beaker and digested with 75-cc. of hot water for at least thirty minutes. Filter into a 300 cc. beaker, wash the insoluble residue twice with hot water by decantation, then transfer the residue to the filter paper and wash with small quantities of hat water until the volume of the solution is about 300 cc. Add about 4-cc of saturated bromine water and enough hydrochloric acid to make the solution slightly acid. Bring the solution to boiling and add barium chloride, precipitating the sulphur as barium sulphate. The barium chloride solution should be hot. The solution containing the precipitate is allowed to stand for at least two hours at a temperature just below boiling. Set aside until the following day and filter, wash the precipitate with warm water until a drop of silver nitrate fails to show the presence of chlorides. Place the precipitate and filter paper in a crucible and ignite to constant weight. The weight in grams of the barium sulphate, multiplied by ten, equals the percentage of sulphur in the sample.

Sulphur may also be determined from the washings from the calorimeter. After a test is run, the calorimeter is thoroughly washed and the washings collected in a 300 - cc. beaker. An indicator is added and the washings are titrated to secure the acid correction for the heating value; 5-cc. of dilute hydrochloric acid are then added and the solution is heated to boiling. The insoluble material is then filtered off and washed four or five times with hot water. The filtrate and washings should have a volume of a volume of about 200-cc. Heat the filtrate to boiling and add hot barium chloride to precipitate the sulphur as barium sulphate. Proceed as in the case of the Eschka-mixture method.

$$\frac{\text{Weight of Barium sulphate} \times 13.74}{\text{Weight of sample}} = \%\ \text{of sulphur.}$$

The results obtained by this method are somewhat lower than those obtained by the Eschka method. This is due to the loss of sulphur trioxide in the gas escaping from the bomb and to the retention of sulphur in the coal ash. The method has the advantage over the Eschka in that it saves time. The results are sufficiently accurate for use in the purchase of fuel on the B.t.u. basis. This method is used in the fuel inspection laboratory of the Bureau of Mines. (Methods of analysing Coal and Coke, Bureau of Mines, Technical paper #8.)

CALORIFIC VALUE OF DETERMINATION.

The calorific value of the coal was determined in a Mahler bomb calorimeter. In such an apparatus the fuel is completely burned and the heat generated by such combustion is absorbed by the water, the amount of heat being calculated from the elevation of the temperature of the water. A calorimeter which has been accepted as the best for such work is one in which the fuel is burned in a bomb, which may either be nickel or steel, with a porcelain or platinum lining and filled with compressed oxygen. The function of the oxygen which is ordinarily under a pressure of some 15 to25 atmospheres, is to cause the rapid and the complete combustion of the fuel sampled. The fuel is ignited by means of an electric current, allowance being made for the heat produced by such current, and by the burning of the fuse wire.

A calorimeter of this type which has been found to give satisfactory results is that of M.Pierre Mahler.

THE MAHLER BOMB CALORIMETER.

The calorimeter consists essentially of the following parts:- (See figure 1)

A. Water jacket, which maintains constant conditions outside of the calorimeter proper, and thus makes possible the more accurate computations of radiation losses.

B. The porcelain steel bomb, in which the combustion of the fuel takes place in compressed oxygen.

C. The platinum pan for holding the fuel.

D. The calorimeter proper, surrounding the bomb and containing a definite, weighed, amount of water.

E. An electrode connection with the fuse wire for igniting the fuel placed in the pan.

F. A fuse wire for igniting the charge.

G. A support for a water agitator.

I. A thermometer for temperature determination of the water in the calorimeter. The thermometer is best supported by a stand independently of the calorimeter, so that it may not be moved by tremors in the parts of the calorimeter, which would render the making of readings difficult. To obtain accuracy of readings, they should be made through a telescope or eyeglass.

K. A spring and screw device for revolving the agitater.

L. A lever, by the movement of which the agitator is revolved.

M. A pressure gauge for noting the amount of oxygen admitted to the bomb.

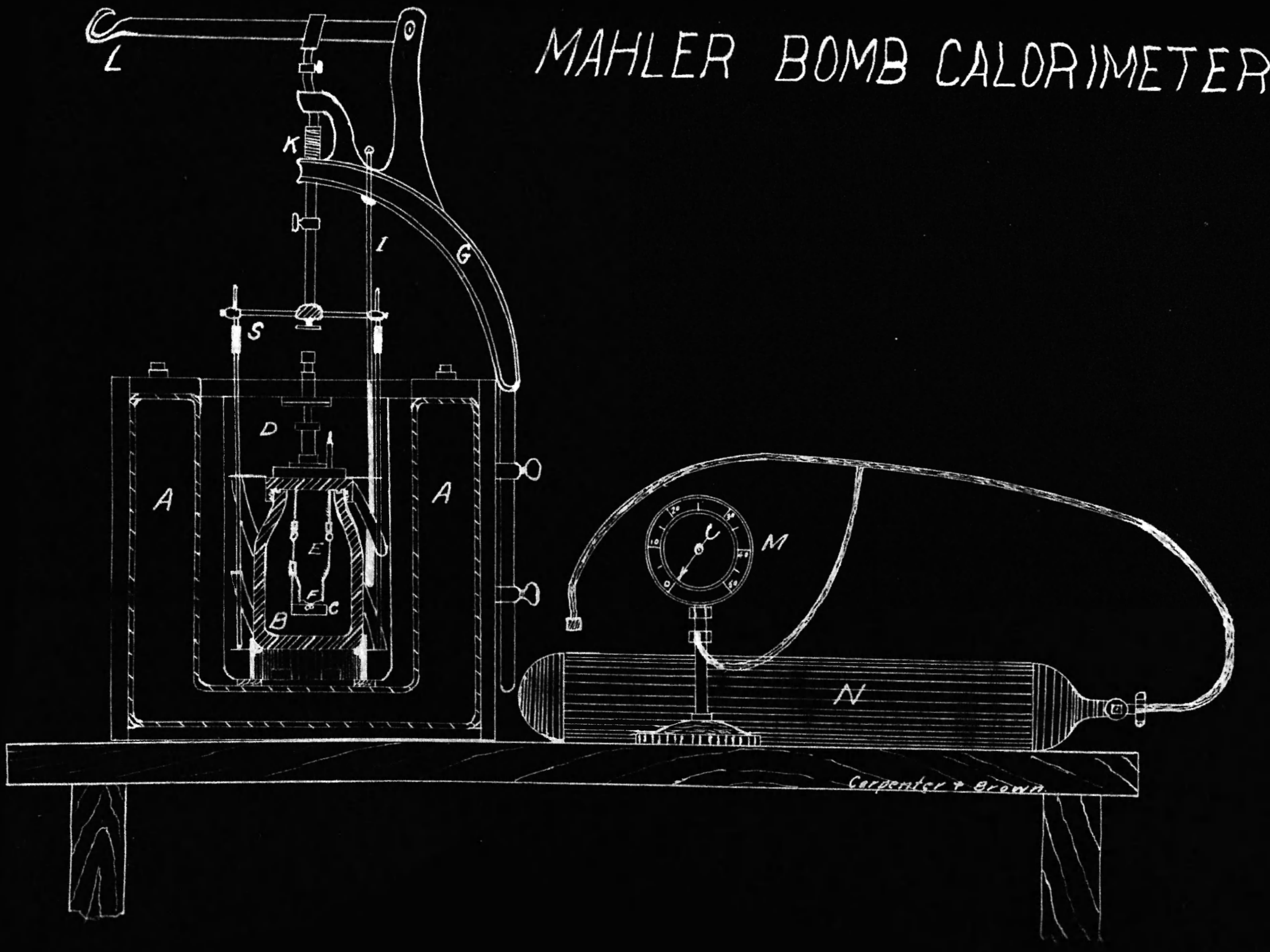
N. An oxygen tank.

S. Agitator for keeping the water well agitated.

METHOD OF PROCEDURE. A one gram sample of the pulverized coal was weighed out into the platinum pan. The fuse wire was weighed and attached to the ends of the platinum electrodes. The platinum pan containing the sample

FIGURE I.

MAHLER BOMB CALORIMETER.



was then attached to an extension of one of the electrodes, and in such a manner that the fuse wire, extended down into the pulverized sample. The platinum electrodes and the platinum pan are attached to the cap of the bomb, and in such a manner, that when the cap of the bomb is screwed in place, the electrodes and pan will be with-in the bomb. The cap of the bomb was screwed tightly in place with a wrench, supplied for the purpose. Oxygen was then admitted into the bomb, care being taken to admit the gas slowly so that the sample in the pan would not be disturbed. The pressure is noted on the pressure gauge, and when the desired pressure is reached, the needle valve in the cap of the bomb is closed. The bomb was then placed in the calorimeter. A known quantity of water (2200-cc.) was the pored into the calorimeter, completely covering the bomb. The agitator was then placed in the calorimeter and attached to the spring and screw device. The thermometer was fixed in place, and the lead wires connected to the electrode. The apparatus was now in readiness for running the test.

In making the test the time was divided into three periods, namely, the preliminary, the combustion, and the final period. Before the preliminary period begins, the water in the calorimeter and surrounding the bomb is agitated for a few minutes to insure equal temperature of all parts, within the calorimeter. The preliminary period consists of a five minute interval, during which the temperature is read and recorded every minute. At the end of the last minute interval of the preliminary period, the circuit igniting the fuse wire is momentarily closed, and the combustion period beings. The first two readings during the combustion period are taken at half minute intervals, and the remainder at minute intervals. Usually five or six readings will be taken. The temperature rises to a maximum and then begins to fall. This denotes the beginning ~~period~~ of the final period, during which readings are taken at minute intervals for five minutes, or until the radiation loss has become constant.

The lead wires to the bomb were then removed, the agitator taken out of the calorimeter, the bomb removed from the calorimeter, the cap unscrewed, and the platinum pan electrodes and inside of the bomb and the bomb cap were thoroughly washed with distilled water, and the water collected in a beaker to be titrated for the acid formed. From the data thus obtained the heat value of the sample was calculated.

DATA AND CALCULATION.

Weight of sample	1.000 gram
Weight of iron wire	17.75 milligrams
Weight of water	2200. Grams
Water equivalent	500. grams
To titrate washings	36. cc.

Temperature Readings

Preliminary	Combustion	Final
0. 23.624	5. 23.674	9. 26.345
1. 23.636	$5\frac{1}{2}$. 24.260	10. 26.334
2. 23.645	6. 25.626	11. 26.330
3 23.656	7. 26.294	12. 26.324
4. 23.663	8. 26.342	13. 26.318
5. 23.674	9. 26.345	14. 26.310

Observed temperature rise 2.671 degrees

Corrected temperature rise 2.686 "

Fuel value.

2700 X 2.690 =	7263	Calories per gram	
36 cc Na_2CO_3 =	-36	" " "	
17.75 Mg. wire =	-29	" " "	
	7198	" " "	

7198 X 1.8 = 13950 Bt. U. per pound.

Detailed calculation.

Rate of change during preliminary period	+ .010	Degrees
" " " " final period	- .007	"
" " " per degree-combustion "	+ .0063	"

		Radiation Gain or loss
Rate of change preliminary	+ .010	
" " " A	+ .0064	+ .004
" " " B	+ .0022	+.0011
" " " C	- .0064	-.0043
" " " D	- .0067	-.0066
" " " E	- .007	-.0068
" " " Final	- .007	-.007
		-*.0195

Corrected temperature .0195 + 2.671 = 2.690 Deg.

The reading 23.624 degrees or number 0 is the first reading of the preliminary period. The temperature reading 23.674 degrees is the last reading of the preliminary period and was taken five minutes after the first reading; hence 23.674 - 23.624 = .050 degrees, the total change in temperature during the preliminary period; also .050 ÷ 5 = .010 degrees, the rate of change of temperature per minute during the preliminary period.

The rate of change per minute during the final period is found in like manner to be -.007 degrees; hence .010 - (-.007) = .017 degrees the change in rate during the combustion period.

The observed change in temperature during the combustion periodis 2.671 degrees, the change in rate per degree of temperature change in the combustion period is therefore equal to $\frac{.017}{2.671} = .0063$ degrees.

The change in temperature during the first half minute of the combustion period is .586 degrees and .586 X .0063 = .0036 degrees, the change in rate during the first half minute of the combustion period.

$.010^\circ - .0036^\circ = .0064$ degrees, the rate of temperature change at the half minute reading or number $5\frac{1}{2}$.

The rate of change for each succeeding reading in the combustion period is calculated in the same way.

The temperature correction for the heat loss during the half minute reading is made by dividing the algebraic sum of the rates by 4, and for the minute readings by dividing the algebraic sum by 2, because the temperature correction for heat loss during each interval is the mean rate per minute of temperature change multiplied by the time of the interval in minutes. For example at reading "5" the rate per minute of temperature change is +.010 degrees and at reading $5\frac{1}{2}$, the rate per minute of temperature change is +.0064 degrees, therefore the mean rate per minute of temperature change for the one half minute interval is $\frac{.010^\circ - (-.0064^\circ)}{2} = .0082$ degrees and $\frac{1}{2} \times .0082^\circ = .0041$ degrees which is the correction for heat loss taking place during the half minute interval. The algebraic sum of all the temperature corrections for heat loss during each interval is added to the observed temperature change, and this figure multiplied by the water equivalent of the apparatus gives the total heat developed.

CORRECTIONS FOR ACIDITY.

Corrections for acidity are divided into two parts: first, correction for the oxidation of nitrogen and second, correction for the oxidation of sulphur.

(Z) White, in his text on gas and fuel analysis, says that " when coal is burned on a grate minute amounts of oxides of nitorgen are formed by the combination of some of the nitrogen of the air and possibly also of the fuel with the oxygen of the air. At the higher temperature of combustion in the compressed oxygen of the calorimeter more oxides of the nitrogen are formed and account should be taken of the heat evolved in their formation. The heat of formation of aqueous nitric acid from nitrogen, oxygen, and water is represented according to Thomson, by the following equation.

$$2N + 5O + H_2O = 2HNO_3 + 29800 \text{ calories.}$$

This corresponds to 1058 calories per gram of nitrogen or 238 calories per gram of nitric acid. The nitric acid is formed may be estimated by the rinsing out of the bomb and titrating the washings with standard alkali. From this total acidity is deducted the sulphuric acid formed and the balance is considered nitric acid. The amount of nitrogen oxidized is roughly about one per cent of the total nitrogen present whether introduced as free nitrogen with the oxygen or as combined nitrigen of the coal. The correction is not usually more than eight calories and may be considered to be offset by the heat absorbed in keeping the gases in the calorimeter at constant volume.(Z)(White Fuel and Gas Analysis.)

(X) The Bureau of Mines used a similar method of correction for nitric acid. The standard alkali solution used contains .00587 grams of N H_3 per CC. and is equivalent to .00483 grams of nitrogen, which when burned to HNO_3 generates five calories of heat. There is a discrepancy, however, between its calculation of the heat of formation of nitric acid of 23 calories per gram of nitrogen and that given by White. This discrepancy is not worthy of consideration. (X) (Methods of Analyzing Coal and Coke. Technical Paper #8. 1913)

The corrections due to the oxidation of sulphur are due to the fact that when sulphur or pyrites burns in air only about five percent of the sulphur is oxidized to SO_3 , and the rest of it remaining as SO_2 . When combustion takes place in the calorimeter a much larger percentage burns to SO_3 , and a correction must be made for it. The equations are $S + O_2 = SO_2 + 69100$ calories

$S + 3O + H_2O =$ dilute $H_2SO_4 + 141100$ calories

One gram of sulphur burning to SO_2 evolves 2165 calories to 2250 calories and to dilute H_2SO_4 evolves 4410 calories

(White) and 4450 calories (Tech. Paper #8). The difference between these would be 2245 calories in the one case and 2200 calories in the other, for each gram of sulphur thus oxidized in the bomb. The determination of this oxidized sulphur requires a chemical analysis of the washings of the bomb and increases the amount of work required. A further difficulty is the fact that the sulphur may be present as pyrites, sulphur in organic compounds, free sulphur and gypsum and the corrections will vary fro each of these various forms. For free sulphur burning to H_2SO_4 the correction will be 2245 calories per gram of sulphur. (White) For sulphur as pyrites 2042 calories, (Somermeier) while for sulphur as gypsum or sulphate of iron, no correction is necessary. Free sulphur and sulphur in organic compounds do not burn completely to SO_3 which further complicates matters. It is therefore customary to assume that all sulphor in the coal exists in the form of pyrites.

The washings from the bomb are therefore treated as stated in the analysis for sulphur and further correction of 13.0 calories per centigram of sulphur made. This correction is due to the fact that the heat of the oxidation of sulphur is greater than that of nitrogen and the alkali determination cannot take account of this excess heat.

A standard alkali containing 3.706 grams of pure sodium carbonate per liter was used in making titrations. This solution had the following values; 1cc. alkali .0043

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(White. Fuel and Gas analysis, Page 230.)

(Somermeier. Journal of the American Chemical Society. Volume 26, Page 566, 1904).

TABLE 1

ANALYSIS OF SOUTHEASTERN KANSAS COALS By C.B.Carpenter and H.R.Brown

Sample No	Moist Coal Per Cent					Dry Coal Per Cent				Combustible			Heat Value B.T.U's Per Pound			Per Cent Combustible in Moist Coal	Remarks	
	Moisture	Volatile Matter	Fixed Carbon	Ash	Total	Volatile Matter	Fixed Carbon	Ash	Total	Volatile Matter	Fixed Carbon	Total	Moist Coal	Dry Coal	Combustible			
1	347	3264	54.72	912	100.00	3386	5668	9.46	100.00	37.39	62.61	100.00	12800	13360	14750	87.41	Skidmore	Shovel
2	1.87	3395	4801	1557	100.00	3459	4952	15.88	100.00	41.12	58.88	100.00	12000	12220	14530	82.56	Skidmore	"
3	218	3527	5049	1206	100.00	3605	5161	1234	100.00	41.13	58.87	100.00	12700	12980	14810	85.76	Steppville	Shaft
4	241	3499	53.72	888	100.00	35.86	55.04	9.10	100.00	39.45	60.55	100.00	13400	13730	15100	88.71	Skidmore	"
5	[illegible]	[illegible]	4826	1767	100.00	32.61	49.33	18.06	100.00	39.79	60.21	100.00	11000	11240	13720	80.17	Scammon.	"
6	2.44	30.34	4740	1962	100.00	31.30	48.59	20.11	100.00	39.18	60.82	100.00	11600	11810	14880	77.94	Scammon.	"
7	1.78	3411	51.05	1306	100.00	34.72	51.96	13.32	100.00	40.05	59.95	100.00	12700	12930	14910	85.16	Scammon.	"
8	2.24	3358	50.92	1326	100.00	34.35	52.08	13.57	100.00	39.74	60.26	100.00	12000	12280	14220	84.50	West Mineral	"
9	1.88	3486	4858	1468	100.00	35.42	49.51	15.07	100.00	41.70	58.30	100.00	12600	12840	15100	83.44	Roseland.	"
10	192	3425	50.03	13.80	100.00	34.92	51.01	14.07	100.00	40.64	59.36	100.00	12900	13150	15310	84.28	Radley	"
11	239	33.22	48.76	15.43	100.00	34.03	50.16	15.81	100.00	40.42	59.58	100.00	12200	12490	14840	82.18	Radley	"
12	210	3418	4860	1492	100.00	34.91	49.95	15.14	100.00	41.14	58.86	100.00	12400	12760	15010	82.98	Radley	"
13	2.84	33.43	49.15	14.58	100.00	34.41	50.59	15.00	100.00	40.48	59.52	100.00	12500	12760	15060	82.58	Ringo	"
14	1.73	34.38	51.30	1258	100.00	34.98	52.20	13.82	100.00	39.43	60.57	100.00	12800	13020	14930	85.68	Ringo	"
15	214	3563	51.36	10.87	100.00	3641	52.47	11.12	100.00	40.97	59.03	100.00	13080	13370	15040	86.99	Edson	"
16	3.41	35.58	53.70	7.31	100.00	36.83	55.59	7.58	100.00	39.85	60.15	100.00	13500	13970	15120	89.28	Edson.	Washery
17	3.16	32.61	49.74	1449	100.00	33.67	51.36	1497	100.00	39.59	60.41	100.00	12200	12590	14810	82.35	Franklin	Shaft
18	145	3849	4888	11.18	100.00	39.06	49.59	11.35	100.00	44.06	55.94	100.00	12500	12680	14300	87.37	Franklin	"
19	317	3546	47.72	1315	100.00	37.13	4928	1359	100.00	42.96	57.04	100.00	12700	13110	15170	83.68	Breezy Hill.	"

Sulphur.

Sample No.	Per cent Sulphur.
1.	2.40
2.	3.70
3.	4.50
4.	3.70
5.	4.40
6.	4.60
7.	3.60
8.	3.70
9.	2.10
10.	2.80
11.	1.00
12.	3.20
13.	2.90
14.	3.10
15.	4.20
16.	2.80
17.	3.90
18.	7.00
19.	5.40

Mines where samples were taken.

Sample	Mine No.	Name of Company.	Location of mine.
1		Fleming Coal Co.	Skidmore.
2			
2		Pratt-Durkee Coal Co.	Skidmore.
3.	43	Central Coal and Coke Co.	South Skidmore
4.	42	" " " " "	West Skidmore
5	F.	Mackie Fuel Co. (all)	" "
6	F.	" " " (Slack)	" "
7.	9.	Clemens Coal Co.	" "
8.	1.	Scammon Fuel Co.	" Mineral
9.	2.	Cresent Fleming Coal Co.	Roseland.
10.		Girard Coal Co.	Radley.
11.	6.	Nevius-Coulter Coal Co.	Radley.
12.	7.	Hamilton Coal & Mercantile Co.	Radley.
13.	45.	Central Coal and Coke Co.	Ringo.
14	48.	" " " " "	Ringo.
15.	19.	Wear Coal Mining Co.	Edson.
16.	2.Washery.	Central Coal and Coke Co.	Edson.
17.	21.	Wear Caol Mining Co.	Franklin.
18.	8.	Pittsburg Northern Co.	Franklin.
19.	7.	McCormack Coal Co.	Breezy Hill.

PREVIOUS INVESTIGATION

The first man to investigate the properties of Southeastern Kansas coals was Prof. E. H. S. Bailey of the Chemistry Department of the University of Kansas. Prof. Bailey carried on an extensive investigation of the character of the coals of Kansas, to obtain the moisture, volatile combustible, fixed carbon and ash contents. The investigation was simply that of proximate analysis. Prof. Bailey, so far as we have been able to ascertain did not make sulphur and calorific determinations. An extensive discussion of his methods is contained in volume IX, Transactions of the Kansas Academy of Science, page 49. We append hereto a copy of his analysis in so far as they concern Southeastern Kansas coal. (See Table 2).

TABLE 2

SOUTHEASTERN KANSAS COALS

Sample No.	Chemical Analysis					Bailey
	Water	Volatile Matter	Fixed Carbon	Ash	Total	Remarks
1	1.54	38.06	53.44	6.96	100.00	Cherokee
2	1.26	35.60	52.20	10.94	100.00	,,
3	1.37	37.19	50.23	11.21	100.00	,,
4	2.59	39.12	51.54	6.75	100.00	,,
5	1.35	36.11	50.94	11.60	100.00	,,
6	2.49	34.59	54.11	8.81	100.00	,,
7	2.76	36.21	54.91	6.12	100.00	,,
8	2.75	36.76	53.08	7.41	100.00	,,
9	1.33	37.33	51.59	9.75	100.00	,,
10	2.25	34.17	49.51	14.07	100.00	Cherokee Upper Vein
11	2.07	34.37	50.21	13.35	100.00	,,
12	1.91	37.44	46.19	14.46	100.00	,,

WORK OF WL R. CRANE.

Following Prof. Bailey, Prof. W. R. Crane of the Mining Department of the University carried on a series of very extensive experiments into the Chemical, calorific, and physical properties of the Kansas coals, and especially of Southeastern Kansas Coals. A detailed discussion of the results of Dr. Crane's methods and results is contained in volume III, University Geological Survey of Kansas.

In brief his method of proximate analysis was somewhat as follows;

Miosture. One gram of the sample was heated at 110 degrees centigrade in a platinum crucible for 15 minutes, then cooled in a dessicator and weighed. It was next reheated for 10 minutes, cooled and weighed again. This procedure was repeated to constant weight.

Volatile Combustible. One gram of the sample was burned for 3½ minutes in a covered platinum crucible held over the bunsen flame, then for 3½ minutes over a blast lamp. The crucible and contents were then cooled and weighed.

Fixed Carbon and Ash. One gram sample was burned in oxygen. The residue was termed ash.

Sulphur. Sulphur was determined by digesting a sample of coal in concentrated nitric acid, evaporating to dryness, digesting the precipitate in warm water, filtering, and precipitating the sulphur as barium sulphate by adding barium chloride to the filtrate.

Calorific Value. Thompson's calorimeter was used in determining the calorific value of the coal. This instrument consists of a copper cylinder in which a weighed quantity of coal, intimately mixed with potassium chlorate or potassium nitrate is deflagrated under a copper case like a diving bell, placed at the bottom of a deep glass jar, filled with a known weight of water. The gases produced by the combustion rising through the water are cooled with a corresponding increase of temperature in the latter, so that the difference between the temperature observed before and after the experiment furnishes a measure of the calorific value of the coal.

There can be no doubt entertained but that Dr. Crane was a very careful, painstaking observer, but no man can do accurate work with an instrument of the character of Thompson's calorimeter. This instrument, while undoubtedly good at that time of its invention, has now become obsolete. The method and apparatus were crude throughout but the greatest source of error lay in the heat absorbed in the decomposition of the chlorate and nitrate. (M). Scheurer*-Kestner has determined that if 15 percent be added to the heating value obtained with the Thompson calorimeter, the results never differ by more than four percent from those bbtained with the ~~Thompson~~ Favre and Silverman calorimeter which burns the coal in a stream of oxygen. It is therefore readily seen that the calorific values obtained by Dr. Crane are much too low. Calculations made by the use of N. W. Lord's (N) formula for heating value, show a discrepancy which varies from 500 to 2300 B.t.u. per pound. Dr. Crane also found coals containing as high as 94.26 percent of combustible material in the moist coal, in contrast Bohnstengel found 90.95 per cent, Bailey 91.50 percent while the highest in our determinations was 89.28 percent. These differences may be and probably are due to the differences in the methods of analysis. For Dr. Crane's results, see table 3.

(M) (Bulletin of the Society of Industrial Chemestry. Mulhouse.page 506. 1888).

(N) (Somermeier. Coal, its Composition, Utilization and Valuation. Page 34 to 41.)

TABLE 3.

ANALYSIS OF SOUTHEASTERN KANSAS COALS By W.R. Crane

Sample No	Moist Coal Per Cent					Dry Coal Per Cent				Combustible			Heat Value B.T.U's Per Pound			Per Cent Combustible in Moist Coal	Sulphur Per Cent		Remarks
	Moisture	Volatile Matter	Fixed Carbon	Ash	Total	Volatile Matter	Fixed Carbon	Ash	Total	Volatile Matter	Fixed Carbon	Total	Moist Coal	Dry Coal	Combustible		Moist Coal	Dry Coal	
1	2.15	32.42	58.38	7.05	100.00	33.13	59.76	7.11	100.00	35.68	64.32	100.00	11400	Not Calculated		90.80	1.01	1.11	Mineral
2	1.35	36.85	52.40	9.40	100.00	37.35	53.12	9.53	100.00	41.29	58.71	100.00	11500	,,	,,	89.25	2.68	3.00	Cherokee
3	1.96	40.62	53.30	4.12	100.00	41.43	54.36	4.21	100.00	43.25	56.75	100.00	13145	,,	,,	93.92	1.46	1.55	,,
4	2.13	36.71	57.55	3.61	100.00	37.51	58.80	3.69	100.00	39.00	61.00	100.00	12850	,,	,,	94.26	0.68	0.72	Steppville
5	3.03	33.77	57.48	5.72	100.00	34.83	59.27	5.90	100.00	37.01	62.99	100.00	12070	,,	,,	91.25	1.89	2.07	Scammon.
6	3.33	35.91	54.70	6.06	100.00	37.15	56.58	6.27	100.00	39.63	60.37	100.00	10720	,,	,,	90.61	1.62	1.78	,,
7	3.77	35.94	60.48	9.81	100.00	37.34	52.46	10.20	100.00	41.59	58.41	100.00	10530	,,	,,	86.42	1.29	1.49	Cherokee
8	3.57	36.96	51.84	7.63	100.00	38.33	53.76	7.91	100.00	41.60	58.40	100.00	11500	,,	,,	88.80	2.55	2.86	Weir City
9	3.16	39.21	53.87	3.76	100.00	40.49	55.63	3.88	100.00	42.12	57.88	100.00	11980	,,	,,	93.08	0.76	0.81	,,
10	2.34	36.88	55.69	5.09	100.00	37.87	57.02	5.11	100.00	39.91	60.04	100.00	11300	,,	,,	92.57	1.06	1.14	,,
11	2.75	34.22	57.22	5.79	100.00	35.19	58.84	5.97	100.00	37.42	62.58	100.00	——	,,	,,	91.44	0.99	1.08	Fleming
12	2.63	38.80	53.74	4.83	100.00	39.95	55.19	4.86	100.00	41.99	58.01	100.00	11690	,,	,,	92.54	1.24	1.34	Weir City
13	3.14	34.87	55.39	6.60	100.00	36.00	57.18	6.82	100.00	38.63	61.37	100.00	11110	,,	,,	90.26	2.56	2.83	,,
14	2.57	36.34	54.99	6.10	100.00	37.29	56.44	6.27	100.00	39.78	60.22	100.00	11210	,,	,,	91.33	2.79	3.05	,,
15	2.58	36.73	55.02	5.62	100.00	37.70	56.46	5.84	100.00	40.04	59.96	100.00	11210	,,	,,	91.75	1.71	1.86	,,
16	3.17	34.83	55.10	6.90	100.00	35.97	56.90	7.13	100.00	38.73	61.27	100.00	11300	,,	[redacted]	89.93	1.38	1.53	Chicopee
17	3.06	35.92	54.89	6.13	100.00	37.05	56.62	6.33	100.00	39.55	60.45	100.00	10920	,,	[redacted]	90.81	2.33	2.57	Frontenac
18	3.32	34.57	57.08	5.03	100.00	35.76	59.04	5.20	100.00	37.72	62.28	100.00	11300	,,	,,	91.65	1.87	2.04	Pittsburg
19	2.51	33.70	56.06	7.73	100.00	34.57	57.50	7.93	100.00	37.55	62.45	100.00	10820	,,	,,	89.76	1.51	1.68	,,
20	2.44	33.64	56.83	7.09	100.00	34.48	58.25	7.27	100.00	37.18	62.82	100.00	10820	,,	,,	90.47	3.06	3.38	Midway
21	3.10	34.76	55.86	6.28	100.00	35.87	57.65	6.48	100.00	38.35	61.65	100.00	10920	,,	,,	90.62	1.56	1.72	Cornell
28	5.13	38.41	52.03	4.03	100.00	40.59	54.85	4.56	100.00	42.53	57.47	100.00	——	,,	,,	90.44	1.02	1.12	Pittsburg
23	2.55	33.42	56.22	7.81	100.00	34.29	57.69	8.02	100.00	37.27	62.73	100.00	11791	,,	,,	89.64	2.37	2.64	Arcadia

WORK BY PROF. P. F. WALKER.

The next investigator into the character of Southeast Kansas coals was Mr. Albert F. Smethers, laboratory assistant in the Mechanical Engineering Department during the year 1909-1910. The territory covered by Mr. Smethers was that North and East of Pittsburg, including Frontenac, Midway, Yale, Nelson, Franklin, Edson and some isolated mines between these towns. Mr. Carpenter, one of the authors of this paper collected some 14 or 15 samples, which were analysed by Mr. Smethers. We understand that this work was done for a Master's Thesis, but we have been unable to find any record of the same and consequently, we are not able to present a copy of the results obtained by him.

The work by Mr. Bohnstengel, carried on during the winter of 1910-1911 was under the supervision of Prof. Walker of the Mechanical Engineering Department, now Dean of the School of Engineering. It may be possible that Mr. Bohnstengel, has included in his analyses some of the work done by Mr. Smethers but we have nothing to sustain this belief for we have not been able to secure the data of these investigations.

The method of analysis pursued by Mr. Bohnstengel is that recommended by the "Committee on Coal Analysis of the American Chemical Society", which with a few changes in detail is the same as has been followed by us, in our investigations.

Mr Bohnstengel found that the fixed carbon in the moist coal varied from 42.65 to 60.45 percent. Dr. Crane found 50.46 to 59.38 per cent, while we have been able to find only 47.40 to 54.72 between extreme limits. The average fixed carbon content as determined by the three investigations is respectively 51.55, 54.45 and 51.06 per cent. The range in volatile combustible is not quite so great. Mr. Bohnstengel found the extremes to be from 26.75 to 34.15 per cent, Dr. Crane 32.42 to 40.62 percent, while we found from 30.54 to 38.49 percent. The averages of these are respectively 30.45, 36.52 and 34.51 per cent. The sample in which only 26.75 per cent of volatile combustible matter was found may have been from a piece of "dead" coal, but since the location of the mine from which the sample was taken, is unknown to us, we cannot say. Mr. Bohnstengel contends that the volatile combustible material is uniformly under 39 per cent, meaning thereby when calculated on a combustible basis. We find it hard to agree with this view, since in our analyses we have repeatedly found coals which ran over 41. percent when calculated on this basis, the highest one being 44.06 per cent combustible material. Dr. Crane also found numerous samples which exceeded 40. per cent combustible material. It might also be of interest to add here that there are in the aggregate several hundred thousand tons of coal in the area which will run less

~~which will run less~~ than 20 percent combustible material.

Mr. Bohnstengel used the same method of determining the fuel value that we have used, i.e. the Mahler bomb. We found it impracticable however to use the system of calculation used by him, preferring instead the system adapted as standard, by the Bureau of Mines. In making our calculations we have also found it convenient to drop the last two figures in our heating value determinations, because the limit of accuracy which can possibly be obtained by an investigator using the Mahler bomb or any other similar contrivance, carries an error which varies from .3 to .4 percent, and then only when the greatest precautions are observed. For this reason we have included the heating value only to the hundreds place, in contrast with that of Mr. Bohnstengel, who has given the value down to the last units place. Take for instance the value of sample number 11, which shows a heating value of 12105 B.t.u. per pound. The final 5 compels attention and one wonders why the heating value could not ~~be~~ at least have been given as 12100. As a matter of fact 12000 would probably have expressed the value just as accurately. The idea of calculating results to a limit of accuracy which cannot possibly be obtained is illogical. The results can be expressed with the same degree of accuracy and a much greater degree of mathematical reason by approximations in the shape of similar round figures. It is unscientific to to publish figures implying a precision that is unattainable.

We have not had time while carrying on this investigation to go into the ultimate analysis of the Southeast Kansas coals, and would suggest that this field is a fruitful one for future investigation. We also believe that the last word has not yet been said regarding the practices pursued there, but that future work will not materially change the results already obtained.

(For results of this work, see Table 4.)

TABLE 4.

ANALYSIS OF SOUTHEASTERN KANSAS COALS By W. Bohnstengel

Sample No.	Moist Coal Per Cent: Moisture	Moist Coal Per Cent: Volatile Matter	Moist Coal Per Cent: Fixed Carbon	Moist Coal Per Cent: Ash	Moist Coal Per Cent: Total	Dry Coal Per Cent: Volatile Matter	Dry Coal Per Cent: Fixed Carbon	Dry Coal Per Cent: Ash	Dry Coal Per Cent: Total	Combustible: Volatile Matter	Combustible: Fixed Carbon	Combustible: Total	Heat Value BTU's Per Pound: Moist Coal	Heat Value BTU's Per Pound: Dry Coal	Heat Value BTU's Per Pound: Combustible	Per Cent Combustible in Moist Coal	Sulphur Per Cent: Moist Coal	Sulphur Per Cent: Dry Coal	Remarks
1	2.20	34.10	56.75	6.90	100.00	34.95	58.00	7.05	100.00	37.60	62.40	100.00	13385	13675	14740	90.90	2.65	2.71	Pittsburg
2	3.90	29.50	56.10	10.50	100.00	30.70	58.30	11.00	100.00	34.50	65.50	100.00	12710	13220	14850	85.60	3.58	3.72	Scammon.
3	1.30	33.80	57.45	7.70	100.00	33.95	58.20	7.80	100.00	36.85	63.15	100.00	13030	13195	14320	90.95	3.02	3.05	Weir City
4	2.00	32.85	57.50	7.65	100.00	33.50	58.70	7.80	100.00	36.40	63.60	100.00	12945	13195	14320	90.35	3.28	3.34	Fleming
5	1.20	32.15	58.10	8.55	100.00	32.50	58.85	8.65	100.00	35.70	64.30	100.00	13015	13175	14400	90.25	4.76	4.82	Frontenac.
6	1.15	31.90	57.20	9.75	100.00	32.25	57.85	9.90	100.00	35.75	64.25	100.00	12880	13030	14440	89.10	3.70	3.75	Fleming
7	1.10	31.70	57.95	9.25	100.00	32.00	58.65	9.35	100.00	35.35	64.65	100.00	12845	12995	14340	89.65	4.06	4.11	Scammon
8	1.45	29.95	60.45	8.25	100.00	30.35	61.30	8.35	100.00	33.05	66.95	100.00	12765	12940	14130	90.30	3.79	3.85	Frontenac
9	1.25	31.10	56.70	10.75	100.00	31.50	57.60	10.90	100.00	35.30	64.70	100.00	12505	12655	14210	88.00	4.32	4.38	Scammon
10	2.55	27.60	55.60	14.20	100.00	28.40	57.00	14.60	100.00	33.20	66.80	100.00	12230	12650	14680	83.25	3.41	3.50	"
11	3.70	29.50	53.25	13.55	100.00	30.60	55.30	14.10	100.00	35.60	64.40	100.00	12105	12570	14680	82.75	4.16	4.33	Weir City
12	1.75	32.50	55.25	10.50	100.00	33.05	56.25	10.70	100.00	37.05	62.95	100.00	12235	12550	14660	87.75	4.01	4.08	Scammon
13	1.65	33.80	53.95	10.60	100.00	34.40	54.85	10.75	100.00	38.60	61.40	100.00	12335	12535	14060	87.75	4.83	4.91	Humble
14	2.75	28.60	53.30	15.35	100.00	29.35	54.80	15.85	100.00	34.90	65.10	100.00	12155	12445	14830	81.90	4.56	4.68	Frontenac
15	4.10	28.40	53.20	14.30	100.00	29.60	55.55	14.85	100.00	34.80	65.20	100.00	11970	12480	14660	81.60	4.05	4.23	Pittsburg
16	1.30	31.20	56.60	10.40	100.00	31.60	57.35	11.05	100.00	35.50	64.50	100.00	12210	12365	13900	87.80	6.98	7.07	Fleming
17	1.15	31.00	53.45	14.40	100.00	31.40	54.10	14.50	100.00	36.70	63.30	100.00	12120	12260	14340	84.45	4.48	4.54	Scammon
18	1.00	32.05	52.65	14.25	100.00	32.40	53.20	14.40	100.00	37.85	62.15	100.00	12050	12175	14230	84.70	4.81	4.86	Pittsburg
19	1.25	29.55	[illegible]	14.80	100.00	29.95	55.05	15.00	100.00	35.20	64.80	100.00	11970	12115	14260	83.95	4.17	4.23	Fleming
20	4.45	27.55	50.50	17.00	100.00	29.00	53.20	17.80	100.00	35.30	64.70	100.00	11495	12090	14700	78.05	5.29	5.56	Scammon
21	1.50	30.75	54.95	12.80	100.00	31.20	55.80	13.00	100.00	35.85	64.15	100.00	11910	12085	13900	85.70	4.27	4.33	Frontenac
22	1.40	29.90	52.00	16.70	100.00	30.30	52.75	16.95	100.00	36.50	63.50	100.00	11895	12065	14500	81.90	3.98	4.03	Mulberry
23	1.90	33.75	51.25	13.10	100.00	34.45	52.25	13.30	100.00	39.70	60.30	100.00	11790	12015	13860	85.00	4.42	4.51	Scammon
24	1.25	30.00	53.80	15.35	100.00	31.00	53.45	15.55	100.00	36.70	63.30	100.00	11820	11975	14170	83.40	5.22	5.29	Frontenac
25	1.40	31.40	53.20	14.00	100.00	31.80	53.95	14.25	100.00	37.10	62.90	100.00	11800	11965	13950	84.60	4.62	4.69	Scammon
26	1.15	31.55	54.55	12.75	100.00	31.95	55.15	12.90	100.00	36.65	63.35	100.00	11770	11905	13660	86.10	3.85	3.90	Weir City
27	1.90	29.75	52.25	16.10	100.00	30.30	53.25	16.45	100.00	36.30	63.70	100.00	11565	11790	14100	82.00	3.55	3.61	Scammon.
28	1.40	28.30	52.05	18.25	100.00	28.75	52.75	18.50	100.00	35.20	64.80	100.00	11535	11690	14340	80.35	4.30	4.36	Fleming
29	1.65	30.70	50.00	17.65	100.00	31.20	50.85	17.95	100.00	38.05	61.95	100.00	11275	11465	13450	80.70	4.48	4.56	Pittsburg
30	1.40	28.80	50.80	19.00	100.00	29.30	51.40	19.30	100.00	36.30	63.70	100.00	11025	11175	13850	79.60	4.15	4.21	Scammon.
31	1.00	29.10	49.55	20.35	100.00	29.35	50.10	20.55	100.00	37.00	63.00	100.00	11050	11160	14040	78.65	4.14	4.18	Frontenac
32	1.25	28.90	49.85	20.00	100.00	29.30	50.45	20.25	100.00	36.70	63.30	100.00	10930	11070	13890	78.75	4.19	4.24	"
33	1.70	26.75	44.90	26.65	100.00	27.25	45.65	27.10	100.00	37.35	62.65	100.00	10150	10325	14160	71.65	2.49	2.53	Fleming
34	1.40	28.15	42.65	27.80	100.00	28.60	43.20	28.20	100.00	39.80	60.20	100.00	9935	10080	14000	70.80	2.42	2.46	Weir City

RESUME OF INVESTIGATIONS.

SHOT FIRING. Shot firing in the Southeastern Kansas field presents one of the most serious problems to the operator. Until quite recently this work has been preformed by men employed as shot-firers, whose only task has been to light the fuses leading to the shots. The practice is a dangerous one because in case of blown out shots, premature explosions, gas, and afterdamp, the shot firers are kept continually in danger of serious, if not fatal injury. The miner is allowed to have 25 lbs. of powder with him, the same being delivered at his switch by the company; in addition much dynamite is used and this helps to increase the danger which confronts the shot firer. That the practice is dangerous is attested to by the fact that from 1902 to 1913, 66 shot firers were killed, while during the winter of 1911 and 1912 alone, ten shot firers were killed. If the number killed since 1913 were added to the list the total would be greater. The practice seems to become fixed in the district so that any attempt to change from it is met with opposition from the miners who seem to think there is no other system. Recently however, the Hamilton Coal and Merchantile Company installed an electric shot firing system in their mine No. 8 at Arma, Kansas, which since some minor defects have been overcome, has proven quite successful. The system is now in operation in another mine, and it is hoped that further installation will be made.

It would seem that there should be some way of eliminating the danger from shot firing and to us either the electric shot firing or a system whereby the shot firer loads and stems the shots seem to offer the only solutions. Of the two, the former is by far the more desirable.

LABOR CONDITIONS. Labor conditions in the field are in general on a par with the conditions in other coal mining areas. The workmen are strongly unionized, so much so in fact that they hold the union as a club over the heads of the operators, to enforce their demands. Eight hour day is in force and has been for many years past. Wages are relatively high, more so in fact than in some other fields. The "Safety First" movement has not yet been thoroughly organized amoung either the miners or the operators but the general trend of opinion is toward this movement. In general the miners are foreigners, who still cling to the customs of their native lands. The miner's contract with the operators lasts for two years after each general strike. Petty strikes are of daily occurance and are based on the most trivial as well as matters of considerable importance. Arbitration of labor difficulties is provided for, but there is no good way of enforcing the terms of agreement reached by arbitration. It is probable that if the operators and the miners had a better understanding of each others position that the labor conditions would be immediately improved.

SHOOTING OFF THE SOLID. The practice of mining or shooting the coal off the solid is still carried on in this district although an inferior grade of coal is produced by this system of working. The coal is much broken and in some cases the amount of slack coal produced will reach 50 or 60 percent of the total output. This slack coal is hard to sell, especially when the demand for coal is light, and the disposal of it becomes a big problem in some cases even at the very low price for which it sells. The use of dynamite also increases the amount of slack coal made. Both of these conditions; shooting off the solid and using dynamite increase the danger to the workmen by shattering the pillar coal, and the roof in some cases, making falls of rock more frequent.

Many of the state's laws require the coal to be cut before shooting, either by an undercutting or by a vertical shear. So far this has not been enforced in this district. Also we believe this condition could be improved by paying the miners on a screened coal basis rather than on a run of mine basis as in now done.

This would be an incentive for the miners to produce more lump coal. Also we have heard that the mines in which the electrical shot firing systems have been installed, produce a better grade of coal.

STEAM SHOVEL WORK. Steam shovel work began in this district in April, 1910. Since which time some thirty or forty steam shovels, among which is the largest steam shovel in existence, have been put in operation. In 1913 some 301621 tons were produced by steamshovels, while in 1914 the production was well over double that amount. The steamshovel has already begun to curtail the shaft output, so that for the next ten or fifteen years the shaft mines will not produce the tonnage that they have been producing.

COAL WASHING. Coal washing is done at the two washeries of the Central Coal and Coke Co. at Edson, Kansas, which so far as we have been able to find, are the only washeries in the district, as well as the State. Slack is washed in order to increase its sale by removing the slate, bone, and other impurities. The capacity of the plants is far in excess of the present demands. The plants seldom work more than one or two days per week, because of the light demand for washed coal.

USE OF MINING MACHINERY. Mining machines are not used in this district. The occurence of horsebacks and rolls throughout the district has been such as to discourage the practice of undercutting the coal. Pick machineswere used for awhile in a nime at Radley, but they have been discarded because of the bad roof and the too frequent occurence of horsebacks. We believe that machines could be used but that there has not been a sincere attempt to install them owing to the prevailing practice of shooting coal off the solid.

ELECTRICAL EQUIPMENT. All mines using electrical shot firing apparatus must have a small generating set to supply current for the shooting circuit. Electrical haulage was used in a few of the mines some years ago, but at this time we are not able to say just how extensive electrical haulage is used. We think however, that such a system of haulage is not used at present in the district.

GASOLENE HAULAGE. Gasolene motor haulage is used in one mine near Cherokee, Kansas. The motor has proven to be quite successful. We see no reason why a haulage system of this kind should not be installed, provided good mine ventilation can be properly maintained. The gasoline motor is self contained, is practically fool-proof, and is a relatively cheap means of hauling.

SHAFT SINKING. Shaft sinking is in general done by contractors at a cost of $15. to $20 per foot, with an average of about $17. per foot. This low cost of sinking is due to the fact that rock is seldom met with during the sinking operations. Shafts are generally three compartment, two for hoisting and one for ladder road, pipe lines, electric conduits, etc. Timber is furnished by the coal companies, but is put in place by the contractors. In general about forty-five days are required to sink and timber a 165 foot shaft.

KANSAS PRODUCTION OF COAL

Year	tons	Average No. of men employed	Tons produced per fatal Accident
1869	36891		
1870	32938		
1875	150000		
1880	771442		
1885	1440057	4175	160006
1890	2516054	4523	314506
1895	3190843	9021	319084
1900	4269716	10673	213845
1905	6374671	12109	176322
1906	5754613	10175	191820
1907	6591013	11957	126750
1908	5588016	11334	180258
1909	5727653	10542	150728
1910	5135391	10619	205415
1911	6254228	10918	------
1912	6350396	11264	171578
1913	7030579	12506	253235
1914	7200000	---	----

OUTPUT OF THE STATE

From State Mine Inspector's Report 1913.

Year	PRoduction	Crawford Cp/	% of total.
1897	3291206	1590620	48.32
1900	4269716	2335998	54.71
1909	5727653	3586766	61.39
1910	5135391	3374069	65.91
1912	6350396	3818750	60.13
1913	7090579	4318731	60.90

Year	Cherokee Co.	% of Total	Combined % of total.
1897	1061620	32.24	80.64
1900	1357631	31.79	85.50
1909	1796734	31.36	92.75
1910	1453809	28.31	94.22
1912	2154372	33.92	94.05
1913	2332920	32.90	93.80

SOUTHEASTERN KANSAS COALS

Sample No.	Chemical Analysis					Bailey
	Water	Volatile Matter	Fixed Carbon	Ash	Total	Remarks
1	1.54	38.06	53.44	6.96	100.00	Cherokee
2	1.26	35.60	52.20	10.94	100.00	"
3	1.37	37.19	50.23	11.21	100.00	"
4	2.59	39.12	51.54	6.75	100.00	"
5	1.35	36.11	50.94	11.60	100.00	"
6	2.49	34.59	54.11	8.81	100.00	"
7	2.76	36.21	54.91	6.12	100.00	"
8	2.75	36.76	53.08	7.41	100.00	"
9	1.33	37.33	51.59	9.75	100.00	"
10	2.25	34.17	49.51	14.07	100.00	Cherokee Upper Vein
11	2.07	34.37	50.21	13.35	100.00	"
12	1.91	37.44	46.19	14.46	100.00	"

ANALYSIS OF SOUTHEASTERN KANSAS COALS By W.R. Crane

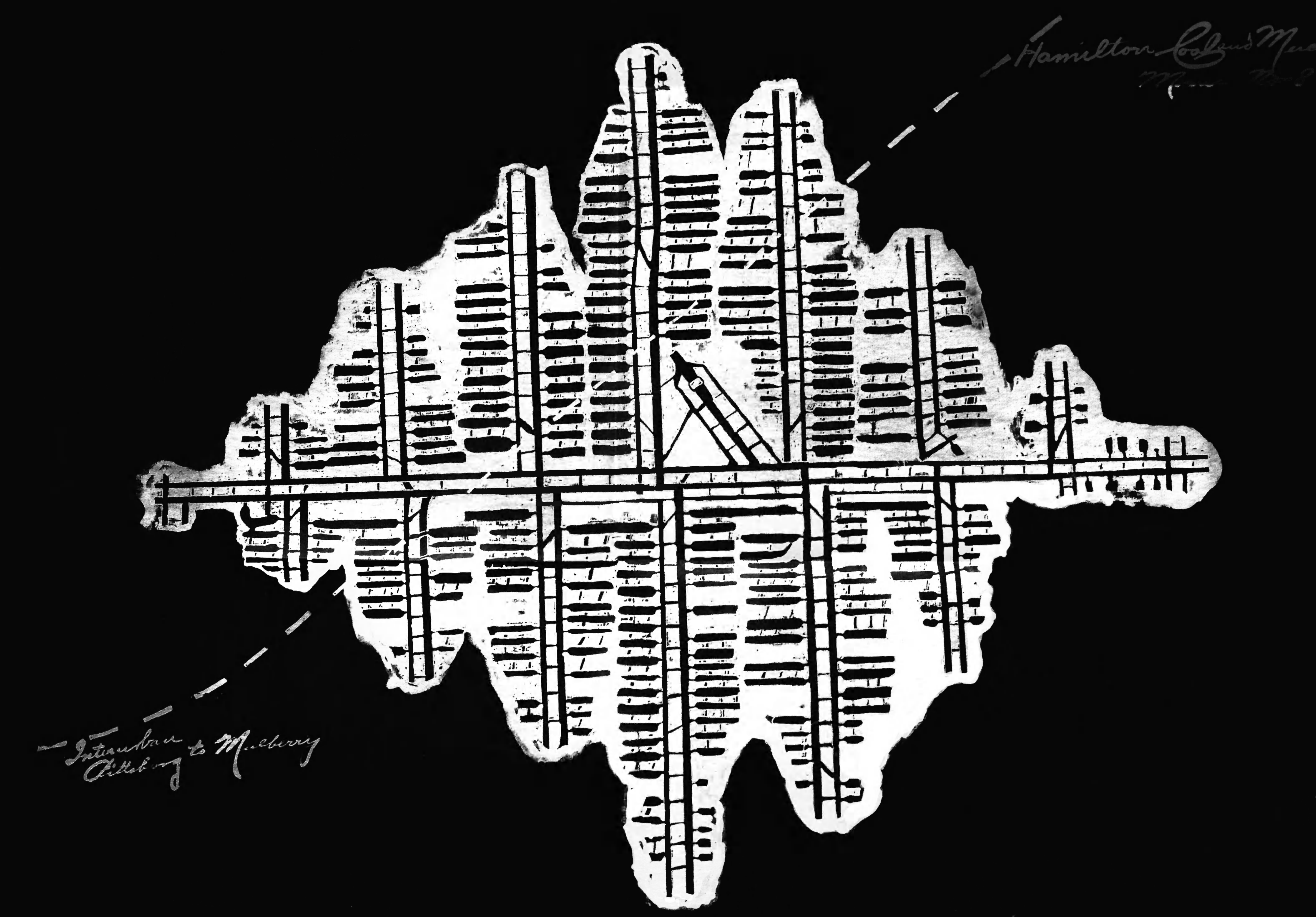
Sample No.	Moist Coal Per Cent					Dry Coal Per Cent				Combustible			Heat Value B.T.U's Per Pound			Per Cent Combustible in Moist Coal	Sulphur Per Cent		Remarks
	Moisture	Volatile Matter	Fixed Carbon	Ash	Total	Volatile Matter	Fixed Carbon	Ash	Total	Volatile Matter	Fixed Carbon	Total	Moist Coal	Dry Coal	Combustible		Moist Coal	Dry Coal	
1	2.15	32.42	58.38	7.05	100.00	33.13	59.76	7.11	100.00	35.68	64.32	100.00	11400	Not Calculated		90.80	1.01	1.11	Mineral
2	1.35	36.85	52.40	9.40	100.00	37.35	53.12	9.53	100.00	41.29	58.71	100.00	11500	”	”	89.25	2.68	3.00	Cherokee
3	1.96	40.62	53.30	4.12	100.00	41.43	54.36	4.21	100.00	43.25	56.75	100.00	13145	”	”	93.92	1.46	1.55	”
4	2.13	36.71	57.55	3.61	[illegible]	37.51	58.80	3.69	100.00	39.00	61.00	100.00	12850	”	”	94.26	0.68	0.72	Steppville
5	3.03	33.77	57.48	5.72	100.00	34.83	59.27	5.90	100.00	37.01	62.99	100.00	12070	”	”	91.25	1.89	2.07	Scammon.
6	3.33	35.91	54.70	6.06	1[illegible]	37.15	56.58	6.27	100.00	39.63	60.37	100.00	10720	”	”	90.61	1.62	1.78	”
7	3.77	35.94	60.48	9.81	100.[illegible]	37.34	52.46	10.20	100.00	41.59	58.41	100.00	10530	”	”	86.42	1.29	1.49	Cherokee
8	3.57	36.96	51.84	7.63	[illegible]	38.33	53.76	7.91	100.00	41.60	58.40	100.00	11500	”	”	88.80	2.55	2.86	Weir City
9	3.16	39.21	53.87	3.76	100.00	40.49	55.63	3.88	100.00	42.12	57.88	100.00	11980	”	”	93.08	0.76	0.81	”
10	2.34	36.88	55.69	5.09	100.00	37.87	57.02	5.11	100.00	39.91	60.04	100.00	11300	”	”	92.57	1.06	1.14	”
11	2.75	34.22	57.22	5.79	100.00	35.19	58.84	5.97	100.00	37.42	62.58	100.00	—	”	”	91.44	0.99	1.08	Fleming
12	2.63	38.80	53.74	4.83	[illegible]	39.95	55.19	4.86	100.00	41.99	58.01	[illegible]	11690	”	”	92.54	1.24	1.34	Weir City
13	3.14	34.87	55.39	6.60	[illegible]	36.00	57.18	6.82	100.00	38.63	61.37	100.00	11110	”	”	90.26	2.56	2.83	”
14	2.57	36.34	54.99	6.10	100.00	37.29	56.44	6.27	100.00	39.78	60.22	100.00	11210	”	”	91.33	2.79	3.05	”
15	2.58	36.73	55.02	5.62	[illegible]	37.70	56.46	5.84	100.00	40.04	59.96	100.00	11210	”	”	91.75	1.71	1.86	”
16	3.17	34.83	55.10	6.90	100.00	35.97	56.90	7.13	100.00	38.73	61.27	100.00	11300	”	”	89.93	1.38	1.53	Chicopee
17	3.06	35.92	54.89	6.13	100.00	37.05	56.62	6.33	100.00	39.55	60.45	100.00	10920	”	”	90.81	2.33	2.57	Frontenac
18	3.32	34.57	57.08	5.03	100.00	35.76	59.04	5.20	100.00	37.72	62.28	10[illegible]	11300	”	”	91.65	1.87	2.04	Pittsburg
19	2.51	33.70	56.06	7.73	10[illegible]	34.57	57.50	7.93	100.00	37.55	62.45	100.00	10820	”	”	89.76	1.51	1.68	”
20	2.44	33.64	56.83	7.09	100.00	34.48	58.25	7.27	100.00	37.18	62.82	100.00	10820	”	”	90.47	3.06	3.38	Midway
21	3.10	34.76	55.86	6.28	100.00	35.87	57.65	6.48	100.00	38.35	61.65	100.00	10920	”	”	90.62	1.56	1.72	Cornell
28	5.13	38.41	52.03	4.03	100.00	40.59	54.85	4.56	100.00	42.53	57.47	100.00	—	”	”	90.44	1.02	1.12	Pittsburg
23	2.55	33.42	56.22	7.81	100.00	34.29	57.69	8.02	100.00	37.27	62.73	[illegible]	11791	”	”	89.64	2.37	2.64	Arcadia

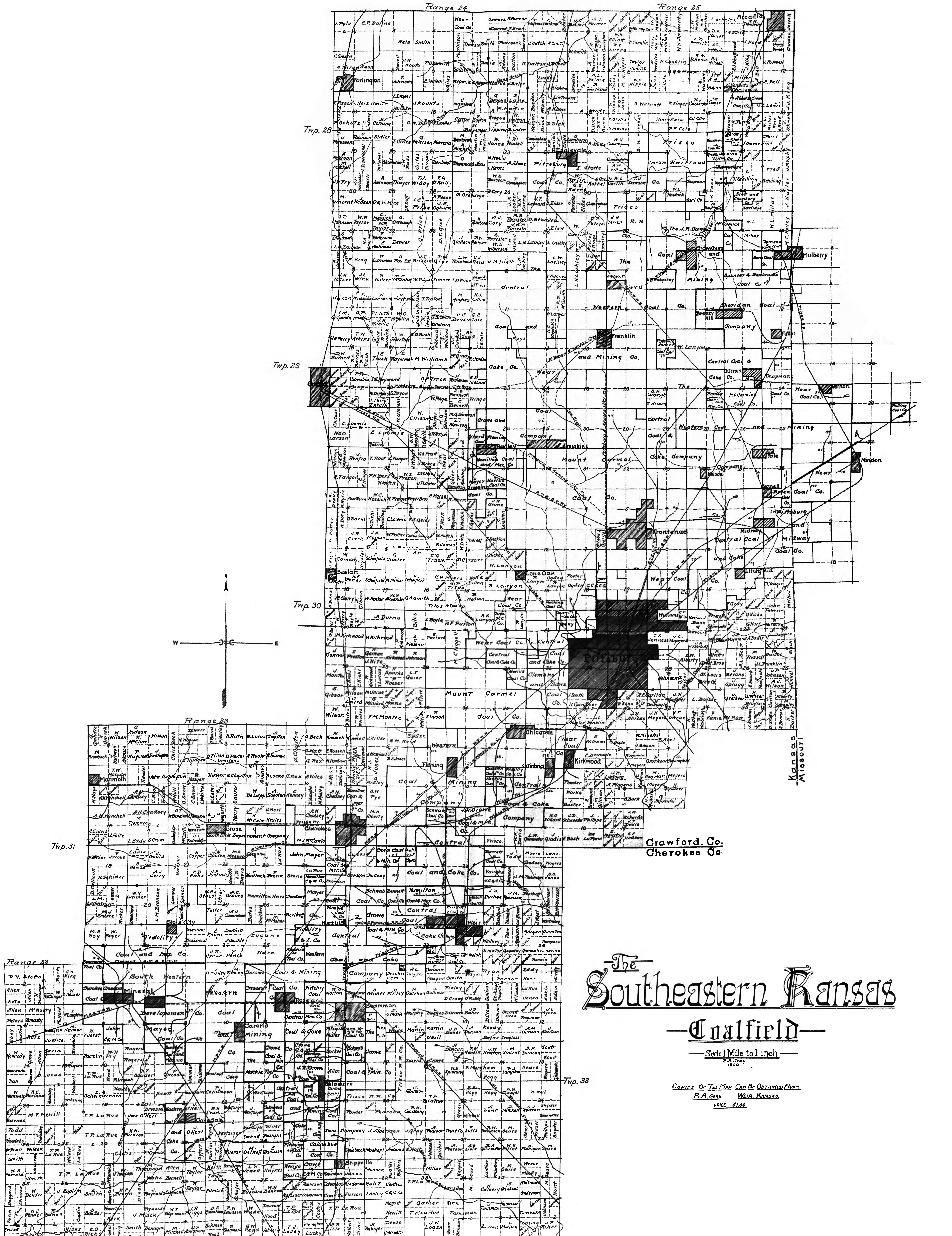
ANALYSIS OF SOUTHEASTERN KANSAS COALS By W. Bohnstengel

Sample No.	Moist Coal Per Cent: Moisture	Moist Coal: Volatile Matter	Moist Coal: Fixed Carbon	Moist Coal: Ash	Moist Coal: Total	Dry Coal Per Cent: Volatile Matter	Dry Coal: Fixed Carbon	Dry Coal: Ash	Dry Coal: Total	Combustible: Volatile Matter	Combustible: Fixed Carbon	Combustible: Total	Heat Value B.T.U's Per Pound: Moist Coal	Heat Value: Dry Coal	Heat Value: Combustible	Per Cent Combustible in Moist Coal	Sulphur Per Cent: Moist Coal	Sulphur: Dry Coal	Remarks
1	2.20	34.15	56.75	6.90	100.00	34.95	58.00	7.05	100.00	37.60	62.40	100.00	13385	13675	14740	90.90	2.65	2.71	Pittsburg
2	3.90	29.50	56.10	10.50	100.00	30.70	58.30	11.00	100.00	34.50	65.50	100.00	12710	13220	14850	85.60	3.58	3.72	Scammon.
3	1.30	33.50	57.45	7.75	100.00	33.95	58.20	7.85	100.00	36.85	63.15	100.00	13030	13195	14320	90.95	3.02	3.05	Weir City
4	2.00	32.85	57.50	7.65	100.00	33.50	58.70	7.80	100.00	36.40	63.60	100.00	12945	13195	14320	90.35	3.28	3.34	Fleming
5	1.20	32.15	58.10	8.55	100.00	32.50	58.85	8.65	100.00	35.70	64.30	100.00	13015	13175	14400	90.25	4.76	4.82	Frontenac.
6	1.15	31.90	57.20	9.75	100.00	32.25	57.85	9.90	100.00	35.75	64.25	100.00	12880	13030	14440	89.10	3.70	3.75	Fleming
7	1.10	31.70	57.95	9.25	100.00	32.00	58.65	9.35	100.00	35.35	64.65	100.00	12845	12995	14340	89.65	4.06	4.11	Scammon
8	1.45	29.85	60.45	8.25	100.00	30.35	61.30	8.35	100.00	33.05	66.95	100.00	12765	12940	14130	90.30	3.79	3.85	Frontenac
9	1.25	31.10	56.90	10.75	100.00	31.50	57.60	10.90	100.00	35.30	64.70	100.00	12505	12655	14210	88.00	4.32	4.38	Scammon
10	2.55	27.65	55.60	14.20	100.00	28.40	57.00	14.60	100.00	33.20	66.80	100.00	12230	12650	14680	83.25	3.41	3.50	"
11	3.70	29.50	53.25	13.55	100.00	30.60	55.30	14.10	100.00	35.60	64.40	100.00	12105	12570	14630	82.75	4.16	4.33	Weir City
12	1.75	32.50	55.25	10.50	100.00	33.05	56.25	10.70	100.00	37.05	62.95	100.00	12235	12550	14660	87.75	4.01	4.08	Scammon
13	1.65	33.80	53.95	10.60	100.00	34.40	54.85	10.75	100.00	38.60	61.40	100.00	12335	12535	14060	87.75	4.83	4.91	Humble
14	2.75	28.60	53.30	15.35	100.00	29.35	54.80	15.85	100.00	34.90	65.10	100.00	12155	12495	14830	81.90	4.56	4.68	Frontenac
15	4.10	28.40	53.20	14.30	100.00	29.60	55.55	14.85	100.00	34.80	65.20	100.00	11970	12480	14660	81.60	4.05	4.23	Pittsburg
16	1.30	31.20	56.60	10.90	100.00	31.60	57.35	11.05	100.00	35.50	64.50	100.00	12210	12365	13900	87.80	6.98	7.07	Fleming
17	1.15	31.00	53.45	14.40	100.00	31.40	54.10	14.50	100.00	36.70	63.30	100.00	12120	12260	14340	84.45	4.48	4.54	Scammon
18	1.05	32.05	52.65	14.25	100.00	32.40	53.20	14.40	100.00	37.85	62.15	100.00	12.050	12.175	14230	84.70	4.81	4.86	Pittsburg
19	1.25	29.55	54.40	14.80	100.00	29.95	55.05	15.00	100.00	35.20	64.80	100.00	11970	12115	14260	83.95	4.17	4.23	Fleming
20	4.95	27.55	50.50	17.00	100.00	29.00	53.20	17.80	100.00	35.30	64.70	100.00	11495	12090	14700	78.05	5.29	5.56	Scammon
21	1.50	30.75	54.95	12.80	100.00	31.20	55.80	13.00	100.00	35.85	64.15	100.00	11910	12085	13900	85.70	4.27	4.33	Frontenac
22	1.40	29.90	52.00	16.70	100.00	30.30	52.75	16.95	100.00	36.50	63.50	100.00	11895	12065	14500	81.90	3.98	4.03	Mulberry
23	1.90	33.75	51.25	13.10	100.00	34.45	52.25	13.30	100.00	39.70	60.30	100.00	11790	12015	13860	85.00	4.42	4.51	Scammon
24	1.25	30.60	52.80	15.35	100.00	31.00	53.45	15.55	100.00	36.70	63.30	100.00	11820	11975	14170	83.40	5.22	5.29	Frontenac
25	1.40	31.40	53.20	14.00	100.00	31.80	53.95	14.25	100.00	37.10	62.90	100.00	11800	11965	13950	84.60	4.62	4.69	Scammon
26	1.15	31.55	54.55	12.75	100.00	31.95	55.15	12.90	100.00	36.65	63.35	100.00	11770	11905	13660	86.10	3.85	3.90	Weir City
27	1.90	29.75	52.25	16.10	100.00	30.30	53.25	16.45	100.00	36.30	63.70	100.00	11565	11790	14100	82.00	3.55	3.61	Scammon.
28	1.40	28.30	52.05	18.25	100.00	28.75	52.75	18.50	100.00	35.20	64.80	100.00	11535	11690	14340	80.35	4.30	4.36	Fleming
29	1.65	30.70	50.00	17.65	100.00	31.20	50.85	17.95	100.00	38.05	61.95	100.00	11275	11465	13950	80.70	4.48	4.56	Pittsburg
30	1.40	28.80	50.80	19.00	100.00	29.30	51.40	19.30	100.00	36.30	63.70	100.00	11025	11175	13850	79.60	4.15	4.21	Scammon.
31	1.00	29.10	[illegible]	20.35	100.00	29.35	50.10	20.55	100.00	37.00	63.00	100.00	11050	11160	14040	78.65	4.14	4.18	Frontenac
32	1.25	28.90	[illegible]	20.00	100.00	29.30	50.45	20.25	100.00	36.70	63.30	100.00	10930	11070	13890	78.75	4.19	4.24	"
33	1.70	26.75	44.90	26.65	100.00	27.25	45.65	27.10	100.00	37.35	62.65	100.00	10150	10325	14160	71.65	2.49	2.53	Fleming
34	[illegible]	28.15	42.65	27.80	100.00	28.60	43.20	28.20	100.00	39.80	60.20	100.00	9935	10080	14000	70.80	2.42	2.46	Weir City

ANALYSIS OF SOUTHEASTERN KANSAS COALS By C.B.Carpenter and H.R.Brown

Sample No.	Moist Coal Per Cent					Dry Coal Per Cent				Combustible			Heat Value B.T.U's Per Pound			Per Cent Combustible in Moist Coal	Remarks	
	Moisture	Volatile Matter	Fixed Carbon	Ash	Total	Volatile Matter	Fixed Carbon	Ash	Total	Volatile Matter	Fixed Carbon	Total	Moist Coal	Dry Coal	Combustible			
1	3.47	32.69	54.72	9.12	100.00	33.86	56.68	9.46	100.00	37.39	62.61	100.00	12800	13360	14750	87.41	Skidmore.	Shovel
2	1.87	33.95	48.61	15.57	100.0	34.59	49.52	15.88	100.00	41.12	58.88	100.00	12000	12220	14530	82.56	Skidmore	″
3	2.18	35.27	50.49	12.06	100.0	36.05	51.61	12.34	100.00	41.13	58.87	100.00	12700	12980	14810	85.76	Steppville	Shaft
4	2.41	34.99	53.72	8.88	100.00	35.86	55.04	9.10	100.00	39.45	60.55	100.00	13400	13730	15100	88.71	Skidmore	″
5	2.16	31.91	48.26	17.67	100.00	32.61	49.33	18.06	100.00	39.79	60.21	100.00	11000	11240	13720	80.17	Scammon.	″
6	2.44	30.54	47.40	19.62	100.00	31.30	48.59	20.11	100.00	39.18	60.82	100.00	11600	11890	14880	77.94	Scammon.	″
7	1.78	34.11	51.05	13.06	100.00	34.72	51.96	13.32	100.00	40.05	59.95	100.00	12700	12930	14910	85.16	Scammon.	″
8	2.24	33.58	50.92	13.26	100.00	34.35	52.08	13.57	100.00	39.74	60.26	100.00	12000	12280	14220	84.50	West Mineral	″
9	1.88	34.86	48.58	14.68	100.00	35.42	49.51	15.07	100.00	41.70	58.30	100.00	12600	12840	15100	83.44	Roseland.	″
10	1.92	34.25	50.03	13.80	100.00	34.92	51.01	14.07	100.00	40.64	59.36	100.00	12900	13150	15310	84.28	Radley	″
11	2.39	33.22	48.96	15.43	100.00	34.03	50.16	15.81	100.00	40.42	59.58	100.00	12200	12490	14840	82.18	Radley	″
12	2.10	34.18	48.80	14.92	100.00	34.91	49.95	15.14	100.00	41.14	58.86	100.00	12400	12760	15010	82.98	Radley	″
13	2.84	33.43	49.15	14.58	100.00	34.41	50.59	15.00	100.00	40.48	59.52	100.00	12500	12760	15060	82.58	Ringo	″
14	1.73	34.38	51.30	12.58	100.00	34.98	52.20	13.82	100.00	39.43	60.57	100.00	12800	13020	14930	85.68	Ringo	″
15	2.14	35.63	51.36	10.87	100.00	36.41	52.47	11.12	100.00	40.97	59.03	100.00	13080	13370	15040	86.99	Edson	″
16	3.41	35.58	53.70	7.31	100.00	36.83	55.59	7.58	100.00	39.85	60.15	100.00	13500	13970	15120	89.28	Edson.	Washery
17	3.16	32.61	49.74	14.49	100.00	33.67	51.36	14.97	100.00	39.59	60.41	100.00	12200	12590	14810	82.35	Franklin	Shaft
18	1.45	38.49	48.88	11.18	100.00	39.06	49.59	11.35	100.00	44.06	55.94	100.00	12500	12680	14300	87.37	Franklin	″
19	3.17	35.96	47.72	13.15	100.00	37.13	49.28	13.59	100.00	42.96	57.04	100.00	12700	13110	15170	83.68	Breezy Hill.	″


Hamilton Coal and Mu
Interurban
Pittsburg to Mulberry


The Southeastern Kansas Coalfield
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Western Coal and Mining Co.